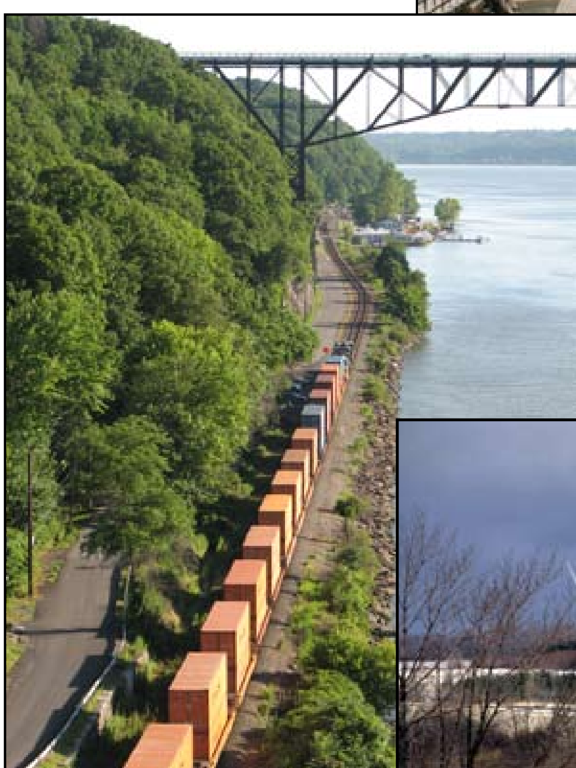
New York State Climate Action Council

Climate Action Plan Interim Report



David A. Paterson, Governor
November 2010

Photos courtesy of the Department of Environmental Conservation or
the New York State Energy Research and Development Authority, unless otherwise indicated.

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Executive Summary
New York State Climate Action Plan
Interim Report

The Challenge and the Opportunity

Climate change, resulting primarily from the combustion of fossil fuels and other human activities, is a significant threat to our environment, economy, and communities. Climate change is already occurring; its adverse effects are well documented across the globe and throughout our region. That realization, combined with the economic and national security vulnerability associated with our current, finite, fossil-based energy system, has created a sense of urgency in advancing a sustainable low-carbon energy future.

Rooftop solar panels provide renewable power for many buildings across New York State. Here, the array on the Dormitory Authority's Albany headquarters. (Photo courtesy of DASNY)

New York State can turn this challenge into an opportunity by working aggressively to become a hub of the new clean energy economy and by making policies and investments that bring low-carbon choices to our citizens and future generations. Success will bring dramatic co-benefits in economic development, jobs, technological innovation, energy security, and cleaner air and water.

New York has shown leadership in clean energy policy, and is taking actions to reduce emissions of the greenhouse gases (GHGs) that cause human-induced climate change. Governor Paterson's issuance of Executive Order 24 in August 2009 formally established a State goal of reducing GHG emissions 80 percent below 1990 levels by 2050 (or 80 by 50), and named the Climate Action Council to determine how to meet the goal. The Council was also tasked with developing a plan to increase New York's resiliency to a rapidly changing climate.

State agencies then launched a process that has brought together more than 100 technical experts and stakeholders and the broader public to define a vision of New York that can achieve this aggressive goal, to identify and examine both mitigation and adaptation policy options, and to analyze the costs and benefits of adopting these policies.

New York could become a hub of clean technology industry and innovation – creating good jobs for New Yorkers.

While the climate planning process is not complete, and in many ways will be an ongoing effort, the initial analysis documented in this Climate Action Plan Interim Report makes clear that achieving the 2050 GHG reduction goal will require dramatic change. New York State's government, its residents, and businesses must embrace the goal of wise use of clean energy. To meet this goal, we must transform the way we make and use energy—we must maximize efficiency and make a major shift toward zero-GHG emissions in electricity generation, smart electric transmission and distribution systems, low-carbon buildings, and zero-emission vehicles, and increase options for alternative modes of travel and land use.

Reducing Greenhouse Gas Emissions in New York State

A variety of policy options and strategies can build on New York's experience in advancing clean energy and further reduce GHG emissions in New York State, while providing other benefits to New Yorkers.

The village and town of Ossining, both Climate Smart Communities, serve residents with a new library, the state's first public building to meet the Leadership in Energy and Environmental Design (LEED) standard. (Photo courtesy of Amiaga Photo, Inc)

- **Buildings and Industry Sector Policy Options:** Substantially reduce GHG emissions from the existing building stock, which will be in place for years to come, and ensure that new buildings meet the highest performance standards. To maintain a robust economy, we will need to ensure that our industrial sector can grow and be economically competitive, while reducing GHG emissions per unit output. Policy options include enhanced performance-based building codes and appliance standards; building commissioning; and additional consumer incentives for efficiency and renewable energy. The combination of voluntary incentives and aggressive codes and standards, along with new financing mechanisms and critical enabling policies (such as education and outreach, electric rate design, workforce development, and technology research and development), could lead to a substantial reduction in emissions in this sector over time. This sector is the largest source of GHGs in New York, accounting for about 40 percent of the state's GHG emissions.

Hybrid electric buses reduce GHG emissions and fuel costs for New York City's public transportation fleet. The world's first hybrid electric bus was developed in New York State through a public-private partnership.

- **Transportation and Land Use Sector Policy Options:** Reduce the GHG intensity of fuel, improve vehicular efficiency, and improve travel and system efficiency. Policy options include the continued development of a regional low-carbon fuel standard; more aggressive efficiency and carbon dioxide (CO_2) vehicle standards; light-duty and heavy-duty vehicle incentives or disincentives to promote efficiency, e.g., feebate; demand-management investments; and smart growth practices. Electrification of our transportation sector holds great promise in both reducing GHG emissions in New York and reducing the petroleum dependency of this sector. Investments in transit and high-speed rail appear to offer additional opportunities to reduce GHG emissions and enable a low-carbon future, while providing very significant co-benefits. These policies could reduce GHG emissions from the fastest growing source of emissions in our economy—transportation.

- **Power Supply and Delivery Sector Policy Options:** Accelerate the introduction of zero- or low-carbon sources of power, such as renewable energy and potentially nuclear energy, while maintaining the reliability of the electric grid. Policy options include a more aggressive renewable portfolio standard potentially evolving into a low-carbon portfolio standard; expansion of the Regional Greenhouse Gas Initiative; GHG emission standards for new power plants; policies to facilitate the siting of new power plants; and policies to encourage repowering of existing fossil fuel plants. These policies, combined with investments to improve and maintain the performance of the grid (e.g., transmission and distribution network upgrading, energy storage) could reduce the GHG emissions from this important sector, which is the backbone of a low-carbon future.

The 321-MW Maple Ridge Wind Farm in Lewis County, New York is one of the largest wind farms east of the Mississippi River.

- **Agriculture, Forestry, and Waste Sector Policy Options:** Promoting sustainable production and conversion of biomass feedstocks; improving land management to maximize carbon uptake; supporting on-farm renewable energy and energy efficiency; increasing the availability of locally produced foods; and reducing waste are some of the key policies in this sector. While a small source of GHG emissions in New York, this sector is unique in that it can serve as a sink for carbon and as a potential source for low-carbon biofuels.

This Interim Report also presents preliminary quantitative analysis of the costs, savings, and GHG emission reduction potential for individual mitigation policy options relative to a mid-point 40 by 30 benchmark target, i.e., 40 percent reduction in GHG emissions by 2030. While further economic analysis is needed, some general observations can be made from the analysis to date:

- No single policy can deliver the level of emission reduction needed to achieve a 40 by 30 target. A portfolio of policies will be needed to reduce emissions from the many different GHG sources throughout our economy.
- A linear path to achieving 80 by 50 may not be feasible nor optimal for a state like New York, which is already one of the most carbon-efficient states in the country on a per capita basis. We may need to ratchet up the stringency of the policies over time to increase the rate of emission reduction as technologies and markets mature.
- There are a number of policies—particularly in the Buildings, Industry, and Transportation sectors— that represent cost-effective ways to take a meaningful step toward a low-carbon future. These “No Regrets” policies, which are primarily efficiency policies, represent

options for early action. Further analysis of benefits and costs, and strategies to finance and/or fund, will be needed.

- Energy efficiency policies alone, however, will not deliver the level of emission reduction needed to achieve a 40 by 30 target (and ultimately 80 by 50). To make appreciable progress toward these aggressive goals and to break our dependence on finite fossil-fuel resources, the State will need to continue to strategically advance low-carbon energy supply-side policies and infrastructure investments, particularly focusing on policies that provide significant co-benefits to New Yorkers (e.g., improvements in local air quality, opportunities for economic development, and job creation).

As a single state attempting to address a global problem, maximizing the co-benefits in New York State associated with GHG mitigation policies will be necessary to maintain public support for GHG reduction investments.

New York will need to work in partnership with other states to craft regional solutions, and to have the federal government as an active and financially supportive partner.

Creating the clean energy economy requires clear and consistent public policies, and sustained and significant public and private investment. To achieve aggressive GHG reduction goals and reap the benefits, New York will need to be resolute in pursuing forward-looking policies and continuing to advance technology. New York will need to work in partnership with other states to craft regional solutions, and to have the federal government as an active and financially supportive partner.

To turn climate policy into an engine for economic growth, we will need to ensure that the State's economic development policies are focused on emerging growth markets; that State policies foster a robust technology development and commercialization system; that we have a skilled workforce and a dynamic workforce development system; and that public and private sectors are fully engaged as partners.

Managing the Risks in New York State Associated with a Changing Climate

Climate change has already put in motion certain environmental impacts in New York, and further changes are likely. According to the latest assessment from a team of scientists at the NASA Goddard Institute, Columbia University, Cornell University, and the City University of New York—the average air and water temperatures in New York and the region are projected to increase significantly over the coming decades and heat waves are expected to become more frequent and more intense. Summertime rain is expected to fall more often as heavy downpours, leading to more flooding; at the same time, the periods between these rainstorms are likely to be drier, leading to droughts. By the year 2100, sea levels along our coast and the Hudson River estuary are projected to rise between 12 and 55 inches, increasing storm-related coastal flooding. The projected rate of change in our climate is unprecedented in our human history. And only through aggressive global action will we be able to change this path.

Measures to increase the resilience of our communities must begin now. Common sense actions, such as vulnerability assessments and emergency preparedness, are required to protect a range of sectors, from agriculture to public health to utilities. Adaptation can be thought of simply as responsible planning, incorporating the most current information about projected climate change into a variety of decisions. This Interim Report identifies a number of policy options and actions that could increase the resiliency our natural systems, our built environment, and key economic sectors—focusing on agriculture, vulnerable coastal zones, ecosystems, water resources, energy infrastructure, public health, telecommunications and information infrastructure, and transportation.

A 400-kW fuel cell (grey box) meets 85 percent of the energy needs of this Price Chopper supermarket in Albany. The installation reduces the building's carbon footprint by 71 tons, provides energy security for perishable items, and saves more than 4 million gallons of water each year. (Photo courtesy of UTC Power)

Public and private entities will need to assess whether new investments in infrastructure, particularly long-lived infrastructure like power plants and transportation, will be consistent with a low-carbon future, both in terms of GHG emissions and in terms of vulnerability to a changing climate. We should avoid investments that are not highly adapted to a modified climate, such as infrastructure sited in low-lying floodplains.

Managing Uncertainty and Taking the Long View

While some of the policy options offered for consideration in this Interim Report rely on technologies that are still rapidly evolving, others make use of technologies readily available today, such as energy efficiency measures in new and existing buildings, wind, and solar power, investments in public transportation systems, and smart land-use planning that, by promoting mixed use and transportation-centered development, naturally results in less vehicle travel. New York can begin now to consider climate change in decisions, setting us on the path to a low-carbon, climate-resilient future.

> *Climate change will affect New York's economy, communities, and natural systems. Measures to increase resiliency must begin now.*

Responding to the challenge of climate change is an imperative for government. Effective response includes reducing emissions, unleashing innovation, capitalizing on the economic opportunity of a clean energy economy, reducing reliance on petroleum (stemming the flow of billions of energy dollars out of state), and helping communities become as well-prepared and resilient to climate change as possible. Significant economic and environmental co-benefits will flow from this response, satisfying important economic and public health goals.

An effective response will not be easy. It will require long-term dedication and a willingness to make the public and private investments to keep moving in the right direction (especially challenging in today's fiscal climate). But ignoring the need for action will be dramatically more costly over the long term, and New York will miss a great opportunity to be in the forefront of the emerging low-carbon, clean energy economy.

Next Steps

With this Interim Report, the Climate Action Council is seeking stakeholder and public response to the initial climate action planning work, including input on the mitigation and adaptation policy options. During 2011, work will continue to complete the required analyses of the policy options, which will inform a final Climate Action Plan.

New York State will then need to develop more specific near-term implementation strategies to effectuate policy and practice. The State will need to establish clear targets and evaluate progress toward those targets. A mechanism to update this long-term plan on a regular basis will be needed, as the technology, the state-of-science, and the broader public policy environment will continue to change.

Further, given the strong linkages between GHG emissions and energy policy, strategies to reduce GHG emissions will also need to be considered further in the development of New York's State Energy Plan as well as in other planning processes, such as State implementation plans for various co-pollutants.

The recently enacted Article 6 of the Energy Law requires the State Energy Plan to include an inventory of greenhouse gas emissions, and strategies for facilitating and accelerating the use of low-carbon energy sources and carbon mitigation measures. Thus, the State Energy Plan will become a mechanism to deliberate and advance appropriate energy policy that fully accounts for the climate change impacts from New York energy production and use.

Overview
Climate Action Plan Interim Report

1.0 Climate Change and the Imperative for Action

Humans are conducting a vast experiment on Earth's systems. Combustion of fossil fuels and land use change on a global scale are driving alterations to the Earth's climate. Human-made global climate change is underway. Scientists have spent the past several decades intensively studying our planet's temperature and climate history, assessing how our natural climate has changed and projecting how future human emissions of greenhouse gases (GHGs) will trap still more excess heat in the Earth's land, ocean, and atmosphere, further changing the climate. Key findings include the following:

- That our climate is changing is no longer in question. Worldwide temperature measurements of land, oceans, and air document that the average temperature of the earth is rising. A considerable portion of this temperature rise is attributed to human activities—primarily deforestation and the combustion of fossil fuels.
- Natural processes required hundreds of millions of years to turn the stored carbon from ancient plants into our fossil fuels. In the short time (geologically speaking) since the Industrial Revolution, fossil fuel combustion has injected large amounts of this long-stored carbon into our atmosphere as heat-trapping carbon dioxide, while other modern industrial practices have increased emissions of powerful GHGs such as methane and nitrous oxide. The additional heat that these GHGs trap is altering our climate system.
- Although heat already trapped by past emissions of GHGs will continue to increase global temperatures for some decades, actions taken now can dramatically decrease impacts for current and future generations. Decisive emission reduction that keeps atmospheric GHG concentrations below threshold levels could mean the difference between climate changes to which humans can likely adapt and very severe impacts. Scientists forecast that an 80 percent reduction in GHG emissions, achieved by mid-century, has a good chance of minimizing the worst of the potential impacts. Integrating climate adaptation into current decision making can reduce the costs and disruption of the unavoidable impacts already built into the climate system.

Scientists conclude that an 80 percent reduction of GHG emissions is needed by mid-century to avoid potentially catastrophic climate change impacts.

- The best available information suggests that, for the most part, the "new" climate that will result if emissions continue on today's path will be less hospitable to human civilization than the climate that has prevailed for millennia—possibly different enough to lead to widespread social disruptions, and certainly enough to impose huge costs.
- In New York State, climate change has begun to affect, and will continue to affect the natural resources that support our economy and quality of life: air quality, water quality, marine and freshwater fisheries, plant and wildlife species, salt and freshwater wetlands, surface and subsurface drinking water supplies, forests, and other wildlife habitats.

- Our economy, communities, and natural systems are vulnerable to higher temperatures, rising sea level, and more variable, intense weather: agriculture and forestry (e.g., new pests, reductions in crop yields and viability); electric transmission efficiency and power demands (e.g., hotter days mean more air cooling); communications and transportation infrastructure, especially structures in low-lying areas; public health (e.g., increases in heat-related deaths and in cardiovascular, respiratory, and vector-borne illness); and interruptions in food and drinking water availability.

The human role in planetary warming and climate change gives us both the opportunity and the responsibility to avert or limit the impending changes. Climate science suggests that we can avoid the worst consequences of climate change if we mitigate (reduce or sequester) our emissions of GHGs and take measures to adapt to unavoidable climate change.

Major Greenhouse Gases Emitted from Human Activities

Carbon dioxide (CO_2)
Methane (CH_4)
Halocarbons
(Industrial gases)
Nitrous Oxide (N_20)
Sulfur hexafluoride (SF_6)

Climate change is a global problem requiring global solutions and local action. Businesses and communities, states and nations are beginning to respond to the challenge by fostering low-carbon energy and economic development patterns. Leaders of this response are positioned to reap economic and social benefits from the transition, while rigid, inflexible economies risk losing competitive positions in the global marketplace. If we fail to reduce GHG emissions and adapt to unavoidable changes, future generations will be forced to bear significant consequences.

2.0 Responding to Climate Change: Climate Action Planning in New York

New York State is leading a candid discussion of responses to the threats and opportunities of a changing climate. The context for this discussion is the goal established by Executive Order 24 for a reduction of GHG emissions by 80 percent below 1990 levels by 2050 (80 by 50). This goal is based on the consensus of the scientific community that this magnitude of emission reduction is needed to avoid potentially catastrophic impacts from climate change.

This Interim Report is an important element in the planning process. It presents for consideration by decision makers, businesses and citizens the overarching goals and initial outcomes of New York's climate planning process:

- A long-term vision for a climate-resilient, low-carbon, clean energy future for New York
- The long-term 80 by 50 goal and a mid-term benchmark target of reducing GHG emissions by 40 percent by the year 2030 (40 by 30)
- A preliminary list of policy options that, if broadly adopted, have the potential to dramatically reduce emissions and increase resiliency to a changing climate, while providing other benefits to New Yorkers in the near term
- Initial expert analysis on the relative costs of different GHG mitigation policy options

- Initial strategies to link climate and energy policy with economic development opportunities, in particular those associated with growing a clean energy economy.

In 2011, the Climate Action Council will further refine these preliminary ideas, finalize cost information and economic potentials, analyze the macroeconomic impacts of the policies, and outline a strategy for implementation.

As climate change is a long-term issue that touches on many facets of our society and economy, New York's climate planning process must be ongoing and iterative—establishing needs; raising and refining ideas, action plans, and cost estimates; adopting policies at various time scales; and checking to see whether the policies are accomplishing the goals. The Climate Action Plan is intended to lead and motivate a sustained effort by business, government, and individuals to mitigate GHG emissions, adapt to a changing climate, and reap the societal and economic benefits of a low-carbon economy.

Policies to address climate change cannot be developed in isolation. Using energy has been characterized as "the metabolism of modern industrial society." As such, development of climate policies cannot be separated from energy security, energy affordability, economic activity, and overall quality of life. These linkages and constraints must be considered in formulating and developing realistic policy options.

Transformation of our fossil fuel economy into a clean energy economy will be the work of a generation, involving large numbers of investors and workers, a wide variety of skills, and action and support by both public and private sectors. The Council recognizes the magnitude of the 80 by 50 challenge and acknowledges that New York's success in achieving the economy-wide GHG reduction goal ultimately depends on coordinated policy and action by federal, state and local governments.

> *Using energy is the metabolism of modern industrial society.*
>
> *Daniel Sarewitz, Arizona State University*

Overarching Goals of New York's Climate Action Plan

- Provide a set of long-term objectives to guide State decision making.
- Set out the policies that will enable both climate change adaptation and mitigation, helping to ensure that New York State does not make decisions in the near term that will lock in a high-carbon future or increase our vulnerability to changes in climate (such as building long-lived infrastructure that is carbon intense or climate vulnerable).
- Identify core solutions and strategically allocate available funding to effectively reduce GHG emissions and stimulate economic activity, while promoting constructive responses by other states and the nation as a whole.
- Provide a foundation for New York to gain advantage in the emerging low-carbon, clean energy economy, advancing the state's economic and strategic interests in the short and long term.

New York State Climate Action Policy Options

At the center of this Interim Report are policy options to achieve GHG emissions mitigation and climate change adaptation. The policies were selected for their potential to minimize costs, maximize co-benefits, and integrate environmental justice and other important public policy objectives. Additional analysis and further development of these policies will be carried out in the next phase of climate action planning.

Mitigation: policy options to reduce emissions cover four categories of GHG emission sources: Residential, Commercial/Institutional and Industrial buildings and processes (RCI); Transportation and Land Use (TLU); Electric Power Supply and Distribution (PSD); and Agriculture, Forestry, and Waste (AFW).

Adaptation: policy options to increase climate resiliency cover eight sectors (Agriculture, Coastal Zones, Ecosystems, Energy, Public Health, Transportation, Telecommunications, and Water Resources).

The Climate Action Council's website,* www.nyclimatechange.us, *provides access to New York's climate planning process.

These policy options were developed through a collaborative process that included more than 100 technical experts and stakeholders, along with staff experts from 13 State agencies. The Climate Action Council convened New York stakeholders, calling on experts from New York and beyond to take part in Technical Work Groups and an Integration Advisory Panel. Since February 2010, these groups have been examining mitigation and adaptation policy options available to the State. The Council's comprehensive web site offers detailed information about the process at www.nyclimatechange.us.

This Interim Report builds on extensive previous work. Data on emissions and policy design came from New York's experience with programs supporting development of renewable energy systems and energy efficiency and the development of the Regional Greenhouse Gas Initiative (RGGI). In particular, the *2009 New York State Energy Plan* significantly advanced understanding of GHG mitigation, through preliminary technical assessments of greenhouse gas science, emissions, and the scope of needed mitigation actions. The State Sea Level Rise Task Force, the *Assessment for Effective Climate Change Adaptation Strategies in New York State* (ClimAID), PlaNYC, and New York City's extensive adaptation analyses provide foundational data for statewide adaptation recommendations.

Public Input, Further Planning Work, and Implementation

With this Interim Report, the Climate Action Council is seeking stakeholder and public response to the initial climate action planning work, including input on the policy options. During 2011, the Council will complete additional analyses and design of the policy options and transmit its recommendations in a Climate Action Plan. That plan will include the following:

- Economic assessments, including both the cost of inaction and macroeconomic impacts in New York, such as creating jobs and retaining some of the $38 billion dollars that is exported annually from New York to pay for energy imports

- Refinement of policy options based on public comment
- Assessment of policy interactions (reinforcement and conflicts) among individual policy options; there are many such interactions, given the multi-sector nature of aggressive GHG mitigation policies
- Creation of a mitigation cost curve (comparing net costs and reduction potentials of individual climate policy options)
- Assessment of the GHG reduction potential of the full policy package, and determining whether it puts New York on the path to meet the 40 by 30 benchmark target and the 80 by 50 long-term goal
- Further analysis of funding options and availability of capital, as well as of societal benefits and externalities.

Implementation of policies to achieve a transformation as significant as 80 by 50 will require substantial investments in some sectors of the economy. Although many policy options offer substantial savings to consumers, there are notable exceptions that demonstrate deep carbon emissions reductions but come at a cost to achieve.

Climate Smart Communities

More than 80 New York villages, towns, and counties have declared themselves *Climate Smart Communities*, working to reduce energy use, protect the climate, and save taxpayer dollars.

Across New York, Climate Smart Communities are

- Inventorying greenhouse gas emissions, setting reduction goals and developing action plans.
- Carrying out projects that reduce emissions from municipal facilities and vehicles.
- Reducing community emissions through more efficient municipal services, such as traffic systems and waste disposal.

To learn more about Climate Smart Communities, visit: http://www.dec.ny.gov/energy/50845.html

To fund some policy proposals, New York State will need to identify new funding mechanisms of sufficient magnitude and duration to catalyze a change in how we produce or use energy. Such funding sources could be created by a combination of carbon pricing, federal cost sharing, and public-private partnerships. Leveraging private capital will be absolutely critical to achieving a goal as bold as 80 by 50. Public funding should come from sources that directly link revenue generation to GHGs, promoting efficiency and low-carbon technologies, and avoiding burdens on desired activities such as economic activity and employment.

Policies must be crafted in a way that promotes clean energy and low-carbon investment, optimizes public investment dollars, and places New York at a competitive advantage both nationally and globally. Recognizing the current fiscal constraints, the Council recommends a staged or phased approach to this grand challenge.

3.0 A Clean Energy Economy in New York

New York could become the regional, national, and international hub of clean technology industry and innovation—creating good jobs for New Yorkers. A portfolio of State policies strategically designed to support the critical building blocks of a clean energy economy would maximize economic development potential, turning climate policy into an engine for economic growth.

> ***NYS Climate Action Plan Energy Terminology***
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> Low-carbon and near-zero-carbon energy refer to energy from sources whose carbon intensity (CO_2 emitted per unit of energy) is significantly lower than that of traditional fossil fuels. Low-carbon sources include renewables (solar, hydroelectric, sustainable biomass, wind, marine, tidal, and geothermal power), nuclear power, and energy produced by processes that capture and sequester CO_2 from fossil fuel combustion.
>
> The term clean energy includes the suite of environmentally sustainable energy supply and demand technologies and systems in all industries. It includes renewable energy, energy storage, and efficient transportation technology, as well as technologies and systems that improve energy efficiency.

Much has been written about the potential growth of the burgeoning clean energy economy and the competition for these emerging markets is fierce and global. New York is well positioned to compete in this economic race: New York has long been a leader in energy technology innovation and commercialization, with a well established world-class research infrastructure and a major financial and venture capital industry. New York has a superior higher education system, natural resources necessary to power a low-carbon economy, and a productive and skilled labor force that can readily transition into new energy industries and markets.

The clean energy economy includes these critical building blocks:

1. Robust Market Demand for Clean Energy Products and Services: Strong market demand must exist to motivate companies to make investments in facilities, manufacturing, services infrastructure, and research and development. Policies at the international, national, and state level can help create this demand. Such policies include market-pull policies (e.g., a Renewable Portfolio Standard, or RPS), financial incentives/disincentives (e.g., a price on carbon emissions), regulations/codes, procurement guidelines, and a variety of other mechanisms analyzed in this Interim Report. Market demand is the critical foundation for advancing a clean energy economy.

2. Skilled Clean Energy Workforce and Dynamic Workforce Development System: A skilled workforce will help companies to grow and locate in New York State. In an innovation-based economic model, a full spectrum of skill levels is needed—from the technician servicing customers' repair and installation needs to the CEO who attracts investment and runs the company. A dynamic workforce development system meeting the needs of a clean energy economy must take a long view to develop the human capital needed to prepare New York to capture the benefits of a clean energy economy.

Jobs involved with weatherizing buildings and other aspects of the clean energy economy keep energy dollars in the local community.

3. Technology Innovation and Commercialization Ecosystem: To provide more options and lower cost solutions, substantial and sustained investment in energy technology research and development and new approaches to accelerate technology

Working to reduce the cost of mounting and installing solar arrays, this start-up company is part of the New York City Accelerator for a Clean and Renewable Economy (NYC ACRE), a joint effort of New York State, New York City, the investment community, and several universities. NYC ACRE is developing entrepreneurs and innovative local businesses that provide climate and energy solutions while growing the clean technology sector and creating jobs in New York. Located in Buffalo, Rochester, Syracuse, Albany, Long Island and New York City, New York's six Clean Energy incubators support a total of 72 clean energy start-up companies. (Photo courtesy of Polytechnic Institute of NYU.)

commercialization must be developed. A fully integrated network of inventors, entrepreneurs, financiers, and market experts—with many vital connections much like a natural ecosystem—will together spur creation of new clean energy companies that will take the risks needed to produce new products and services. New York has the key ingredients for robust job-creating, energy-technology innovation. With State policies that support the entire innovation ecosystem, New York could reap substantial economic gains by developing and manufacturing high-value clean energy products for local use and for international markets.

4. **Focused and Sustained Economic Development Strategies that Support Clean Energy:** New York must embrace a model for economic development that builds on its strengths as a knowledge-based economy and that recognizes that the state will struggle to compete in low-cost commoditized markets. State economic development policies should support the retention of jobs and the creation of new businesses and jobs in emerging high-growth markets, such as clean technology industries. Economic development policies must embrace the new emerging economy of the 21st century— an economy whose growth is based on innovation, knowledge, and entrepreneurship.

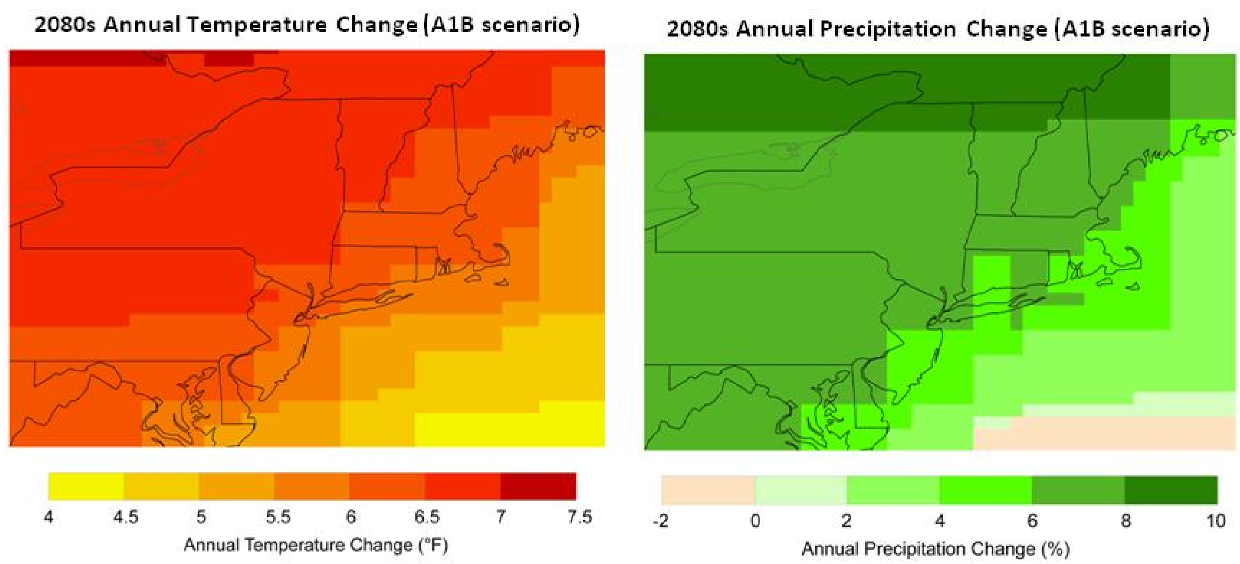
5. **Fully Engaged Private and Public Sector:** Achieving a goal as transformational as 80 by 50 is possible only with the full and sustained commitment of all levels of the public and private sectors. The clean energy revolution will ultimately depend on linkages and support from the federal government, State government, businesses, academic institutions, not-for profits and municipal governments—each of which plays an important role in the transformation to a clean energy economy. And support from the public at large is a prerequisite for policymakers in New York to advance and sustain the climate-energy policy options presented here.

4.0 Potential Climate Change Impacts and Vulnerabilities in New York

Global climate models project that the Earth will warm in the next century, in a consistent geographical pattern. This climate change threatens New York's natural resources, economy, and the health and lifestyle of its residents. For example, New York State's average air temperatures are projected to increase significantly over the coming decades, and heat waves are expected to become more frequent and intense. Summertime rain is expected to fall more often as heavy downpours, leading to more flooding; at the same time, the periods between these rainstorms are likely to be drier, leading to droughts. By the year 2100, sea levels along our coast and the Hudson River estuary are projected to rise between 12 and 55 inches, increasing storm-related coastal flooding.

The *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State* (ClimAID) is a comprehensive project to provide New York State decision makers with the best available climate science and other information on the state's vulnerability to, and possible benefits from, climate change. The study also aims to facilitate development of adaptation strategies informed by both local experience and scientific knowledge. To make it easier to assess potential impacts under future conditions, the ClimAID team developed a set of climate change scenarios for New York State. Figure OV-1, from ClimAID, shows the projected changes in average annual temperature and precipitation for New York for a mid-level emission scenario of future greenhouse gas emissions. A synthesis report summarizing the findings of ClimAID can be found in Appendix H to the Interim Report.

Figure OV-1. Projected changes in annual temperature and precipitation for the 2080s in the Northeast, under the A1B ("middle") emissions scenario, relative to the 1970-1999 baseline



Many climate changes projected by scientists are already occurring, with impacts to New York State's society, economy, and natural ecosystems. The summaries presented here by sector list some of the expected specific impacts to New York State as the climate continues to change.

Apple crops are vulnerable to late spring freezes and other weather aberrations that accompany climate change.

Agriculture

Some crops may have yield or quality losses associated with increased frequency of drought, increased summer high temperatures, increased risk of freeze injury as a result of more variable winters, and increased pressure from weeds, insects, and disease. Dairy milk production per cow will decline in the region as temperatures and the frequency of summer heat stress increase. Warmer temperatures, a longer growing season, and increased atmospheric carbon dioxide could create opportunities for farmers who are able to transition to new crops.

Coastal Zones

Sea level rise will greatly amplify risks to coastal populations and will lead to permanent inundation of low-lying areas, more frequent flooding by storm surges, and increased beach erosion. Saltwater could reach farther up the Hudson River and into estuaries, contaminating urban water supplies. Tides and storm surges may propagate farther up the Hudson River, increasing flood risk far from the coast.

Tidal wetlands are expected to be flooded by rising seas faster than new wetlands can establish themselves further inland.

Ecosystems

Widespread shifts in species composition will occur in the state's forests and other natural landscapes, with the loss of spruce-fir forests, alpine tundra, and boreal plant communities. Warmer temperatures will favor the expansion of some invasive species into New York. Some habitat and food generalists (such as white-tailed deer) may also benefit. Higher levels of carbon dioxide may increase the growth rate of fast-growing species, which are often weeds and invasive species. Lakes, streams, inland wetlands, and associated aquatic species will be increasingly vulnerable to changes in the timing, supply, and intensity of rainfall and snowmelt, groundwater recharge, and duration of ice cover. Increasing water temperatures will negatively affect brook trout and other native coldwater fish. Sea level rise will lead to loss of coastal wetlands, reducing populations of fish and shellfish.

Energy Systems

More frequent heat waves will cause an increase in the use of air conditioning, stressing power supplies and increasing peak demand loads. Transformers and distribution lines for both electric and gas supply are vulnerable to extreme weather events, temperature, and flooding. Coastal infrastructure in downstate areas is vulnerable to flooding as a result of sea level rise and severe storms. Hydropower is vulnerable to drought and changes in precipitation patterns while power plant efficiencies may be reduced due to increased air and water temperatures.

Public Health

Heat-related illness and death are projected to increase, while cold-related deaths will likely decrease. Increases in heat-related death are projected to outweigh reductions in cold-related death. Cardiovascular and respiratory-related illness and death will be increased by worsening air quality, including more smog, wildfires, pollens, and molds. Allergy and asthma cases are projected to increase and become more severe. Vector-borne diseases, such as those spread by mosquitoes and ticks, may expand or their distribution patterns may change. Water- and food-borne diseases are likely to increase. Water supply, recreational water quality, and food production will be at increased risk due to increased temperatures and changing precipitation patterns. More intense storms and flooding could lead to increased stress and mental health impacts and impaired delivery of public health and medical services. Demand for health services and the need for public health surveillance and monitoring are likely to increase.

Telecommunications and Information Infrastructure

Communication service delivery is vulnerable to hurricanes, lightning, ice, snow, wind storms, and other extreme weather events, some of which are projected to change in frequency and/or intensity. Communication lines and other infrastructure are vulnerable to the observed and projected increase in heavy precipitation events and resulting flooding and/or freezing rain. In coastal and near-coastal areas, sea level rise in combination with coastal storm surge flooding will be a considerable threat especially later this century. The delivery of communication services is reliant on the electric power grid, which may experience increased stress resulting from the additional demand associated with heat waves.

Transportation

Low-lying transportation systems such as subways and tunnels, especially in coastal and near-coastal areas, are at particular risk of flooding as a result of sea level rise and heavy-precipitation events. Materials used in transportation infrastructure, such as asphalt and train rails, are vulnerable to increased temperatures and frequency of extreme heat events. The Great Lakes may see a shorter season of winter ice cover, leading to a longer shipping season. However, reduced ice cover is also likely to mean an increase in "lake effect" snow events, which often cause transportation-related problems. Air- and land-based transportation systems are vulnerable to ice and snowstorms, although requirements for salting and snow removal may decrease as snow tends to turn more often into rain. The number of freeze/thaw cycles, which disturb roadbeds, may increase as winter temperatures rise.

Railroad tracks that run only a few feet above the Hudson River illustrate the vulnerability to climate change and sea level rise of infrastructure located near water bodies. Tidal as far north as Troy, the Hudson will directly experience higher ocean levels and storm surges.

Water Resources

Increasing water temperatures in rivers and streams will affect aquatic health and reduce the capacity of streams to assimilate effluent from wastewater treatment plants. Heavy downpours have increased over the past 50 years and this trend is projected to continue, causing an increase in localized flash flooding in urban areas and hilly regions. Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable development within floodplains. At the same time as downpours occur more often, more moderate rain events are expected to become less frequent during the summer, resulting in additional and possibly longer summer dry periods and stressing water supply systems with limited storage. Reduced summer flows on large rivers and lowered groundwater tables could lead to conflicts among competing water users.

Economic Impacts

The economic cost associated with climate change mitigation and adaptation is a growing concern for national, state, and local governments around the world. While the cost of combating climate change often impedes action on this threat, inaction has its own significant costs.

Some economic sectors in New York State are more at risk from climate change than others. Because of heavy concentrations of assets in coastal areas, the largest financial impacts likely will occur there, including impacts on transportation, energy, and other coastal infrastructure, as well as natural areas. Other likely costs include decreased agricultural crop yield and dairy production, as well as tourism dollars lost in the winter-recreation industry.

5.0 New York State's GHG Emissions

Emission inventories and projections provide the basis for identifying GHG emissions reduction opportunities and for planning to minimize the economic and environmental impacts of policies.

New York's Emissions Inventory

In 2005, the latest year for which global emissions data are available, New York's share of emissions within the U.S. (3.8 percent) was smaller than its share of the U.S. population (6.5 percent). In contrast, the U.S. share of the world's GHG emissions (18 percent) was much greater than its share of the 2005 population (4.6 percent). Nonetheless, New York's GHG emissions accounted for 0.7 percent of the world's GHG emissions in 2005, while its share of global population was 0.3 percent.

In 2008, New York emitted approximately 254 million metric tons of carbon dioxide equivalent (CO_2e), an average of a little more than 13 metric tons of CO_2e for each state resident. New York's per capita GHG emissions are considerably (43 percent) below the U.S. average.

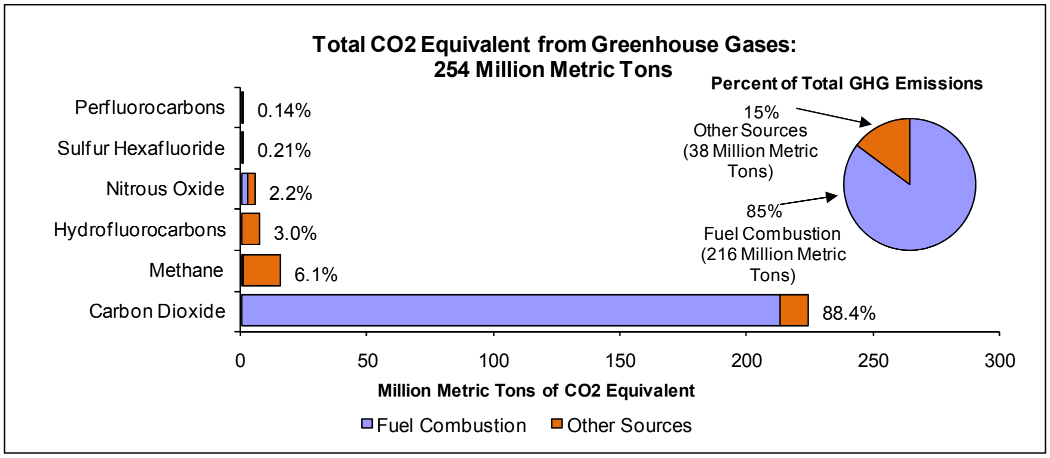
For each of the six major GHGs, Figure OV-2 depicts the portions of New York's emissions that result from fuel combustion and from other sources. Prominent non-fuel combustion GHG sources are cement production, ozone depleting substitutes, natural gas leakage, landfills, agricultural animals, municipal waste combustion, municipal wastewater, and agricultural soil management.

Carbon Dioxide Equivalent (CO_2e)

Because GHGs vary in their ability to retain heat, GHG emission inventories and projections are given in the metric CO_2e. CO_2e expresses any GHG's global warming potential as a multiple of the potential of carbon dioxide (CO_2).

For instance, methane has a CO_2e of approximately 22 – that is, methane in the atmosphere produces about 22 times as much warming as the same weight of CO_2.

Figure OV-2. 2008 Percentage of GHG Emissions by Gas and Source (Includes Net Imports of Electricity)



CO_2 = carbon dioxide; GHG = greenhouse gas

As Figure OV-2 shows, carbon dioxide (CO_2) is the predominant GHG emitted in New York (88 percent, including both combustion and non-combustion emissions). Methane is second (6 percent); most of New York's methane results from non-fuel combustion sources such as municipal waste and natural gas leakage. The state's small amounts of nitrous oxide emissions (2 percent of total emissions) are mostly attributable to automotive fuel combustion. Other industrial gases make up the remaining GHG emissions.

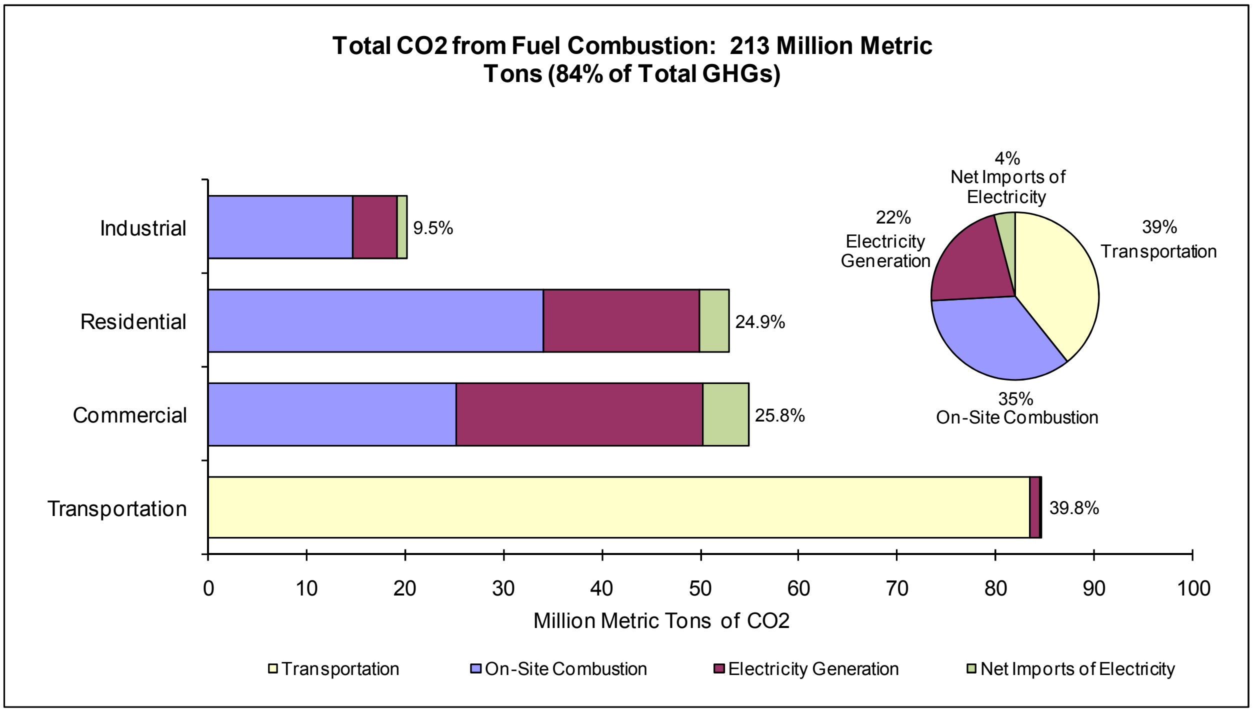
Combustion of fossil fuels is the dominant source CO_2 emissions—CO_2 from fuel combustion makes up 84 percent of New York's GHG emissions. Fossil fuel combustion occurs in power plants to generate electricity, on building sites for space heat and industrial process power, and in vehicles to transport goods and people.

Carbon Dioxide Emissions from the Major Economic Sectors

The GHG inventory divides CO_2 emissions into four main end-use sectors: industrial, residential, commercial/institutional, and transportation. The emissions inventories for the residential, commercial/institutional, and industrial sectors include the emissions resulting from each sector's share of electricity generation, whereas the Climate Action Plan policy option analysis separates out electricity sector emissions because they must be mitigated within the power supply and distribution sector.

Figure OV-3 details 2008 CO_2 emissions from fossil fuel combustion by end-use sector. The transportation sector accounts for approximately 40 percent of CO_2 emissions from fuel combustion; the residential and commercial/institutional sectors are each responsible for roughly 25 percent of fuel combustion CO_2 emissions, including emissions from the share of electricity generation required by each of these sectors. The residential sector shows greater emissions from fuel combustion on-site than from electricity generation or imported electricity, while the commercial/institutional sector shows the reverse—emissions from electricity generation and imported electricity are higher than emissions from on-site fuel combustion. The industrial sector's fuel combustion CO_2 emissions are the lowest (approximately 10 percent), with most of these emissions coming from on-site fuel combustion.

Figure OV-3. 2008 CO_2 Emissions from Fuel Combustion by End Use Sector (Includes Net Imports of Electricity)



CO_2 = carbon dioxide; GHG = greenhouse gas.

Of the different fuels, natural gas, which is burned in all fuel combustion sectors, accounts for the largest amount of fuel combustion CO_2 emissions (almost 30 percent). The transportation sector emits nearly as much fuel combustion CO_2 (28 percent), from burning gasoline in vehicles.

Trends in Emissions and GHG Sinks

New York's gross GHG emissions increased by about 2 percent (or 6 million metric tons of CO_2e) between 1990 and 2008, with a peak around the year 2000. New York's transportation sector showed by far the greatest growth in gross GHG emissions, with an annual increase of 14 million metric tons from 1990 to 2008. In contrast, during this same period annual CO_2e emissions from electricity generated in-state decreased by about 18 million metric tons, although emissions associated with electricity imported from other states grew.

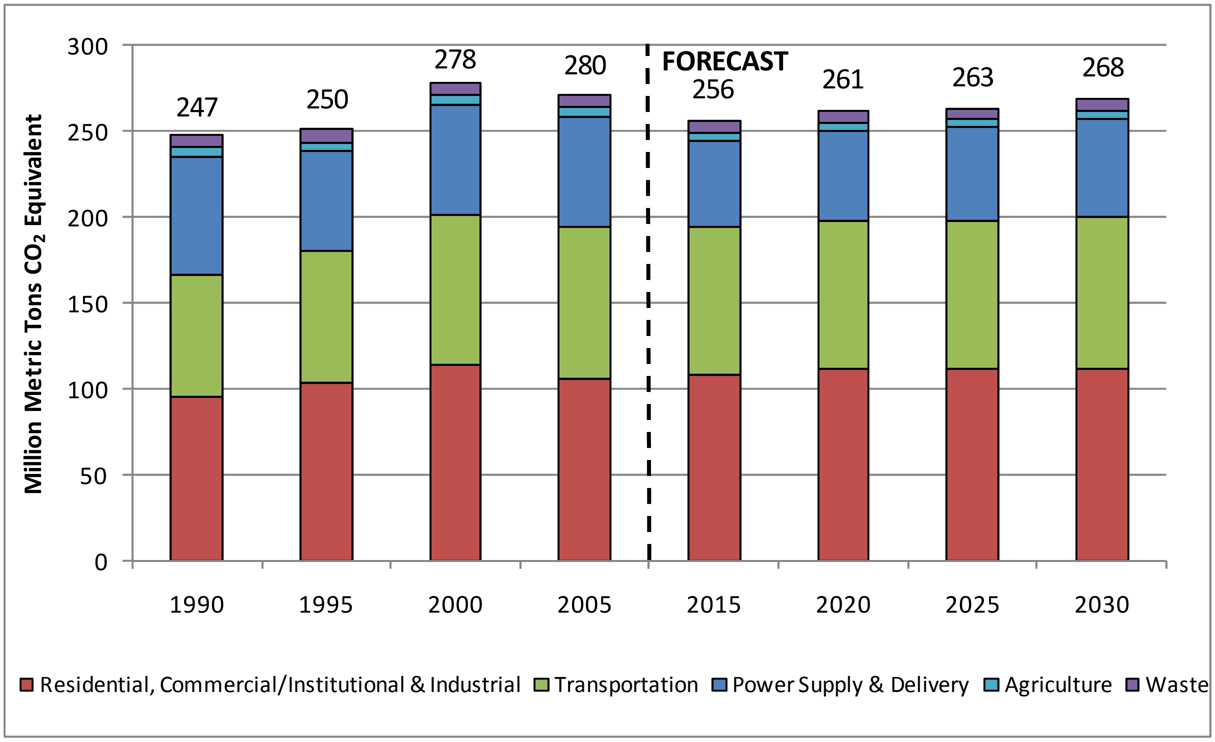
It should be noted that gross emission figures do not take into account uptake of carbon by GHG sinks, while net emissions do. New York's forests, including urban forests, wetlands, and fields, function as sinks of CO_2 emissions. Agricultural cultivation practices also are found to contribute to removal of CO_2 from the atmosphere.

Greenhouse Gas Emissions Forecast through 2030

Relying on a variety of sources for forecasts (as described in Chapter 3 of the full Interim Report on Inventory and Forecast), a reference case forecast of GHG emissions through 2030 was developed. The reference case assumes implementation of policies that are currently approved and funded at the state and federal level. It assumes no additional policy action, and is sometimes referred to as a "business-as-usual" scenario.

Figure OV-4 shows estimates of annual GHG emissions through 2030 (based on forecasts for Mid-Atlantic fuel demand, along with natural gas projections). Forecasts for on-highway diesel and gasoline fuel use were based on forecasts of New York vehicle miles of travel provided by the Department of Transportation and federal projections of vehicle fuel economy. The forecasts do not take into account the effects of a changing climate.

Figure OV-4. Greenhouse Gas Emissions by Source Category, 1990–2030



Under the reference case forecasts, New York's gross GHG emissions decrease slightly from 2005 over the forecast period, to about 268 million tons of CO_2e by 2030, or 8 percent above 1990 levels. Relative to 2005, the shares of 2030 emissions associated with residential, commercial/institutional and industrial sector fuel use, transportation, and power supply and delivery are still the highest, in the same order. The greatest increase in the share of emissions is in the transportation sector, with an increase from 29 percent of total gross emissions in 2005 to 33 percent in 2030.

Growth rates of fuel use for space heating, industrial processes, transportation, and electricity demand, the principal determinants of New York's future GHG emissions, are driven by economic, demographic, and land-use trends, which are difficult to predict. Improving forecasts of growth patterns and transportation system impacts will be a crucial task for climate planners going forward.

6.0 Visioning

New York's 2050 Analysis

The 80 by 50 goal and the year 2050 vision drive New York's Climate Action Plan. In the 2050 vision, with GHG emissions at only 20 percent of today's level, New York would boast a vibrant economy, its resilient communities and natural resources meeting citizens' needs in a changing climate and thriving as the nation's and the world's low-carbon economy matures.

To give definition and specificity to this 2050 vision, the Climate Action Council conducted a visioning exercise. The visioning exercise made use of four tools:

- **2050 Scenario development**, based on a coupled energy-sector model and sets of assumptions about future energy demand, patterns of energy use, and low-emission technologies that might reasonably be available to power the low-carbon economy
- **Visioning workshop,** held at the New York Academy of Sciences on January 5, 2010; full session and presentations available online at http://nyclimatechange.us/2050
- **White paper** incorporating workshop outcomes and information from other expert sources: *Envisioning a Low-Carbon 2050 for New York State*, Brookhaven National Laboratory (Appendix F).
- **2050 Sectoral visions** developed by the Technical Work Groups for each sector of New York's economy: Residential, Commercial/Institutional and Industrial (buildings and processes); Power Supply and Delivery; Transportation and Land Use; Agriculture, Forestry, and Waste (with Materials Management). Detailed discussions of the visions for each sector are part of the mitigation sector chapters of this Interim Report.

The City of Syracuse, a Climate Smart Community, sets an example and achieves GHG reduction by partnering in a car sharing program through which residents rent low-emission hybrid vehicles for short time periods. (Photo courtesy of City of Syracuse)

This visioning exercise led to the following key findings:

- Meeting the 80 by 50 goal will require substantial investments in new energy systems and infrastructure that have very low- or zero-net carbon emissions. Changes in patterns of energy use also will be needed.
- Transportation systems and buildings (residential and commercial) will have to move away from reliance on combustion of fossil fuels to alternate sources with significantly lower carbon or no carbon emissions.
- A broad shift from reliance on fossil fuels to generate electricity to carbon-free low- or zero-carbon sources will be needed with a concurrent increase in energy storage and generation capacity. Local fossil fuel combustion yields to electrification and other alternate technologies.

- Energy efficiency must be aggressively pursued today, but it alone is not sufficient to achieve New York's 80 by 50 GHG emission reduction goal.
- Development and redevelopment based on smart growth principles, along with efficient building design practices, building technologies, and construction methods, can significantly reduce the energy demand for buildings and transportation.
- An informed and engaged citizenry that values wise, efficient use of clean energy as part of their everyday lives is absolutely critical to achieving New York's 80 by 50 goal. The goal must be pursued in part through extensive, long-term partnering among all levels of government and across the region, and between the public and private sectors. It will take sustained, unprecedented effort on the part of all.

The Climate Smart Community of New Castle informs and engages its citizens and helps to reduce GHG emissions with an e-waste recycling day. (Photo courtesy of Town of New Castle)

7.0 Greenhouse Gas Mitigation Options

The Technical Work Groups explored policy options to reduce GHG emissions in four key energy-related sectors of New York's economy, as shown in Figure OV-5: Power Supply and Delivery; Residential, Commercial/Institutional and Industrial; Transportation and Land Use; and Agriculture, Forestry, and Waste. The Technical Work Groups developed policy options after reviewing technologies and projections of future demand and screening a large number of possible State policies. As the figure shows, the policy options target all the core 80 by 50 strategies developed in the visioning process.

Figure OV-5. Policy Options and Vision Strategies Map

POLICY OPTIONS	**CORE VISIONING STRATEGIES**						
	Maximize Energy Efficiency & Conservation	Near- Zero-Carbon Electricity Generation	Smart Electric Transmission, Distribution & Storage	Carbon-Free Transportation Systems	Net Energy-Neutral Buildings	Low-Carbon Liquid Fuels	Carbon Sink Maintenance / Enhancement
RESIDENTIAL, COMMERCIAL/INSTITUTIONAL, AND INDUSTRIAL							
Building Codes, Appliance Standards, & Enforcement, RCI-7	■	■		■	■		
Building Commissioning, Benchmarking, & Upgrades, RCI-8	■				■		
Energy Efficiency Incentives, RCI-2	■				■		
Customer-Sited Renewable Energy Incentives, RCI-3		■			■	■	
Industrial Process Incentives, RCI-11	■	■			■		
Workforce Training & Development, RCI-6	■	■	■	■	■	■	■
Outreach, Education, and Behavior Change RCI-5	■	■	■	■	■	■	■
Rate Restructuring & Flexible Metering, RCI-10	■	■	■	■	■		
Energy Efficiency and Clean Energy Fund, RCI-1	■	■	■		■	■	
Tax Structure & Private Financing, RCI-4	■	■			■	■	
Research, Development, & Demonstration, RCI-9	■	■	■		■	■	
TRANSPORTATION & LAND USE							
Vehicle Efficiency, TLU-1	■		■	■		■	
Vehicle Incentives & Disincentives, TLU-2	■		■	■		■	
Fleet Incentives & Disincentives, TLU-3	■			■			
Alternative Fuel & Infrastructure, TLU-4	■		■	■		■	
Research, Development, & Demonstration, TLU-5	■			■		■	
Decreased Travel & Less Commuting, TLU-6	■			■			
Mass Transit & Rail, TLU-7	■			■			
Freight Strategies, TLU-8	■			■			
Priority Growth Centers, TLU-9	■			■			■
Transit-Oriented Development, TLU-10	■			■			■
Location Efficient Land Use, TLU-11	■			■			■
Intergovernmental & Regional Initiatives, TLU-12	■		■	■			
POWER SUPPLY & DELIVERY							
Renewable Portfolio Std & Renewable Incentives, PSD-2		■		■	■		
Cap-and-Invest & Low-Carbon Portfolio Std, PSD-6	■	■	■	■	■	■	■
Siting and Permitting of New Generation, PSD-1		■		■	■		
New Facility Emissions and Nuclear Power, PSD-10	■	■		■	■		■
Existing Fossil Plant Policies, PSD-8	■	■		■	■		
Distribution Network Upgrade, PSD-4	■	■	■	■	■		
Transmission Network Upgrade, PSD-5	■	■	■	■	■		
Energy Storage, PSD-3		■	■	■	■		
Research, Development, & Demonstration, PSD-9	■	■	■	■	■	■	■
AGRICULTURE, FORESTRY, & WASTE							
Production of Sustainable Feedstock for Bio-Energy, AFW- 1		■		■	■	■	■
Conversion of Sustainable Feedstock for Bio-Energy, AFW-2		■		■	■	■	
Maximize Waste Reduction, AFW-3	■						
Integrated Farm Management, AFW-4	■	■					■
Farm Efficiency & Renewable Energy, AFW-6	■	■			■		■
Conserve Open Space, AFW-5							■
Improved Forest Management, AFW-7				■			■
Local Food Production, AFW-8	■						
Research, Development, & Demonstration, AFW-9	■	■				■	■

Figure OV-5 lists the policy options by sector (each option is designated throughout the Interim Report by a combination of sector initials and numbers). Greater detail about the policy options is available in the Interim Report mitigation chapters (Chapters 6 through 9). Evaluating policy option effectiveness, their net cost and the interactions among them, and selecting policies for final recommendations to the Governor, will be the work of the second phase of New York's Climate Action Plan.

Analyzing Cost and Potential Emission Reductions from the Policy Options

Where possible, the cost and/or savings associated with a policy and the total GHG emissions expected by the 2030 benchmark year were quantified. The 1990 baseline emission levels (referenced in Executive Order 24), along with current levels, are presented in Figure OV-6. The 2030 forecasted GHG emission level, 268 million metric tons ($MMtCO_2e$), is also presented, along with the emission limits implied by the 2030 benchmark target (148 $MMtCO_2e$) and the 2050 goal (50 $MMtCO_2e$). The required emission reduction for 2030 is therefore 120 $MMtCO_2e$, as shown in Figure OV-6. While the precise pathway to the 80 by 50 goal cannot be known, the benchmark goal does provide a plausible mid-point target for the purpose of policy evaluation.

Figure OV-6. GHG Emissions Reductions to Meet the 80 by 50 Goal

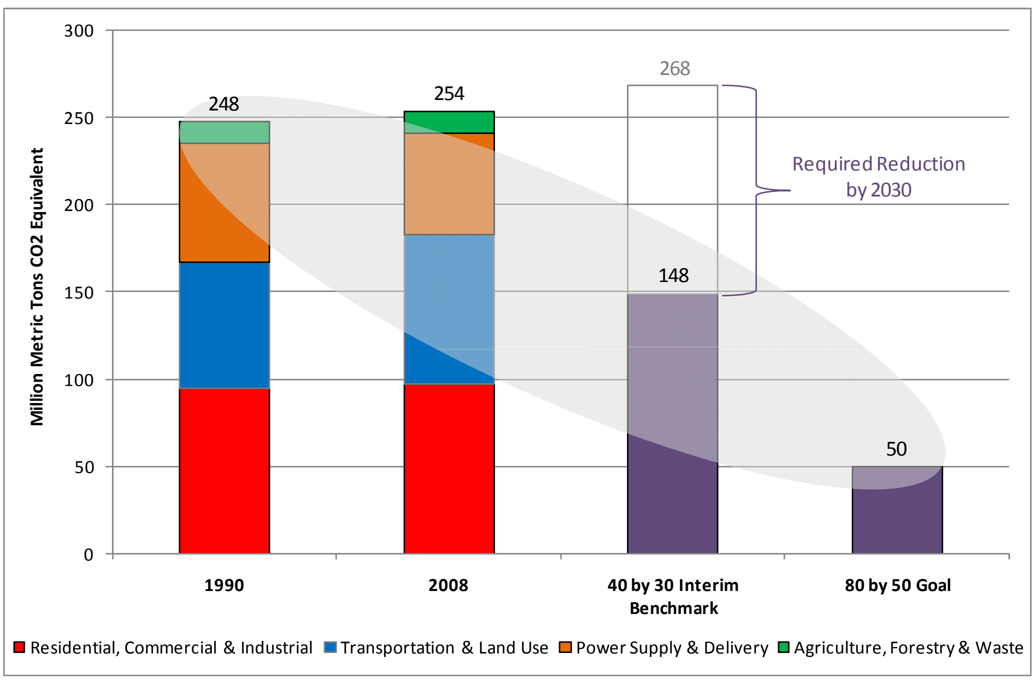


Figure OV-7 presents quantitative analysis of the Interim Report's mitigation policy options over the study period (2011-2030). The preliminary analytical results presented here describe the potential effectiveness of the mitigation policy options on a stand-alone basis, without considering interactions among policies or overlapping emissions reductions. Figure OV-7 presents an estimate of the annual GHG emission reduction anticipated by 2030 of the individual policy options (i.e., as measured by Million Metric Tons CO_2e). To make this estimate, the Technical Work Groups developed specific targets (policy scenarios), where possible, for individual policy options. (Note that not all policy options are amenable to this type of quantification.) The results also present an estimate of the total cost or savings of the policy option through 2030, as measured by net present value (NPV). NPV reflects the total capital costs, anticipated operation and maintenance costs/savings, and fuel costs/savings associated with the policy. A negative NPV reflects a savings and implies an economically desirable investment. Figure OV-7 also presents a rough indicator of cost-effectiveness for the policy option, as measured by \$/ton CO_2e avoided, to determine which policy options will deliver the most CO_2e on a dollar-for-dollar basis. As with NPV, a negative \$/ton CO_2e implies that we save money as we reduce GHGs.

While further analysis is needed to better understand the full range of economic impacts and to eliminate potential overlap, some general observations can be made from the analysis to date:

- No single policy can deliver the level of emission reduction needed to achieve a 40 by 30 target. A portfolio of policies will be needed to reduce emissions from the many different GHG sources throughout our economy.
- A linear path to achieving 80 by 50 may not be feasible nor optimal for a state like New York, which is already one of the most carbon-efficient states in the country on a per capita basis. We may need to ratchet up the stringency of the policies over time to increase the rate of emission reduction as technologies and markets mature.
- There are a number of policies—particularly in the Buildings, Industry, and Transportation sectors—that represent cost-effective ways to take a meaningful step toward a low-carbon future. These No Regrets policies, which are primarily efficiency policies, could represent options for early action. Further analysis of benefits and costs, and strategies to finance and/or fund, will be needed.
- Energy efficiency policies alone, however, will not deliver the level of emission reduction needed to achieve a 40 by 30 target (and ultimately the 80 by 50 goal). To make appreciable progress toward these aggressive goals and to break our dependence on finite fossil-fuel resources, the State will need to continue to strategically advance low-carbon energy supply-side policies and infrastructure investments, particularly focusing on policies that provide significant co-benefits to New Yorkers (e.g., improvements in local air and water quality, opportunities for economic development and job creation).

Figure OV-7. Preliminary Analysis of Mitigation Policy Options: Greenhouse Gas Reduction Potential and Costs and Savings Estimates

***Note: Negative values denote a savings**.

Policy No.	Policy Option	Annual GHG Reductions by 2030 (Million Metric Ton CO_2e)	Net Present Value: Cost/Savings* (Million $)	Net Cost/Savings per Avoided Emissions* ($/ Metric ton CO_2e)
RCI-2	Energy Efficiency Incentives	17	-$29	$0
	Combined Heat and Power (CHP) Incentives	1.1	$14	$2
RCI-3	Solar Electricity Incentives	3.3	$4,400	$200
	Solar Thermal Incentives	2.8	$2,600	$130
	Bioenergy Incentives	5.1	-$5,100	-$61
RCI-7	Building Codes, Appliance Standards, and Enforcement	6.3	-$1,200	-$27
RCI-8	Building Commissioning, Benchmarking, and Upgrades	3.3	-$790	-$23
RCI-11	Industrial Process Incentives	2.6	-$2,500	-$95
TLU-1	Vehicle Technology and Operations	17	$7,900	$62
TLU-2	Vehicle Incentives and Disincentives	2.0	-$2,300	-$120
TLU-3	Fleet Incentives and Disincentives	0.6	-$750	-$130
TLU-4	Alternative Fuel-Related Measures and Infrastructure—Low Carbon Fuel Standard (LCFS)	8.5	$6,700	$79
TLU-6	Commuter & Traveler assistance	1.0	-$15,000	-$870
	Parking Pricing — Upstate NYMTC Region	0.3 0.4	$720 -$480	$1,400 -$610
	Telecommuting	1.0	-$15,000	-$870
	Congestion Pricing	0.2	-$1,100	-$460
TLU-7	Expanded Transit	4.9	$25,000	$390
TLU-9	Priority Growth Centers	0.3	-$1,600	-$610
TLU-10	Transit-Oriented Development/ Transit Supportive Development	0.5	-$5,000	-$870
TLU-11	Location Efficient Land Use	1.2	-$15,000	-$870
PSD-2	Renewable Portfolio Standard (RPS) and Incentives for Grid-Based Renewable Generation	7.9	$1,700	$27
PSD-4	Distribution System Upgrades	0.8	-$460	-$73
PSD-6	Low Carbon Portfolio Standard (LCPS): High penetration of renewables	29	$5,600	$26
AFW-3	Maximize Waste Reduction, Recycling, and Composting—In-State Only	0.7	$280	$35

Policy No.	Policy Option	Annual GHG Reductions by 2030 (Million Metric Ton CO_2e)	Net Present Value: Cost/Savings* (Million $)	Net Cost/Savings per Avoided Emissions* ($/ Metric ton CO_2e)
AFW-4	Integrated Farm Management Planning and Application	0.6	–$201	–$31
AFW-5	Conserve Open Space, Agricultural Land and Wetlands	5.5	$1,500	$16
AFW-6	Increase On-Farm Energy Efficiency and Production of Renewable Energy	0.4	$3	$1
AFW-7	Forest Restoration	4.7	$290	$6
	Urban Forestry	2.0	$3,200	$140
	Reforestation	2.4	$1,200	$36

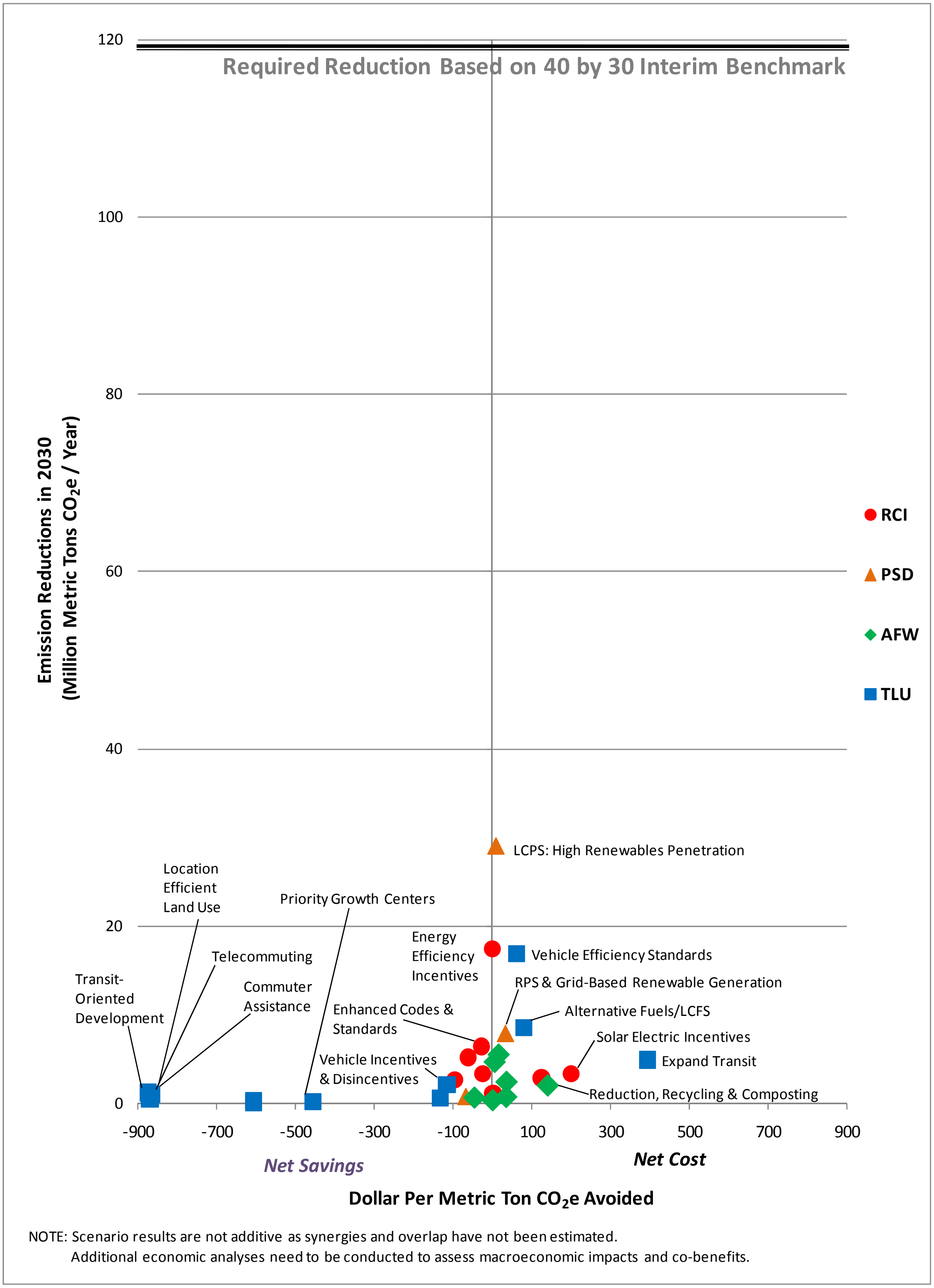
***Note: Negative values denote a savings**.

The data presented in Figure OV-7 are also illustrated in Figure OV-8. Figure OV-8 shows the potential annual emission reductions in 2030 and the net-savings or net-cost per ton CO_2e avoided for each policy. The 2030 benchmark goal has been drawn as a line in the figure to provide a basis for judging effectiveness of each policy. Some general observations can be provided:

- Policies that provide the largest potential emission reductions in 2030 include the low-carbon fuel standard for vehicle fuels (TLU-4), increased vehicle fuel efficiency and/or CO_2 emission standards (TLU-1), building energy efficiency incentives (RCI-2), and a low-carbon portfolio standard for electricity generation (PSD-6).
- Polices that provide the largest savings per avoided metric ton of emissions include smart growth policies (TLU-9, -10, and -11) and commuter assistance (TLU-6).
- Policies that provide both significant emission reductions and net savings include building energy efficiency incentives (RCI-2), improved building codes, appliance standards, and enforcement (RCI-7), and vehicle incentives (TLU-2).

The Interim Report also presents estimates of fuels savings associated with these policies, where appropriate. Based on the estimated reductions in 2030 derived from the policy option and on current consumption levels, RCI-2 would save enough electricity to power 4.6 million homes and enough home heating oil and natural gas to heat more than 1.9 million homes for a year. Similarly, based on the estimated reductions in 2030 derived from the scenario analysis and on current consumption levels, TLU-1 would save enough motor gasoline to power 7.3 million cars for a year.

Figure OV-8. Preliminary Analysis of Mitigation Policy Options Relative to 40 by 30 Benchmark Target



7.1 Residential, Commercial/Institutional and Industrial Sector (RCI)

RCI Sector Vision for 2050

New Yorkers will enjoy safe, comfortable, well-functioning, and sustainable buildings and communities whose construction and renovation activities, building operations, and industrial processes are designed and operated to maximize energy and resource efficiency, to minimize fossil fuel inputs, and to meet remaining energy needs from a mix of local low-carbon resources and low-carbon imports.

Reaching the Vision: Transforming the Residential, Commercial/Institutional, and Industrial Sector

To reduce GHG emissions 80 percent by 2050, New York's residential, commercial/institutional, and industrial buildings and industrial processes will need to adopt technologies, management efficiencies, and operational practices that support maximum energy and resource efficiency, while substituting low- and zero-carbon sources for fossil fuel in meeting their remaining energy needs.

The City of Schenectady is sponsoring construction of affordable, highly efficient homes to replace deteriorating buildings.

New York has instituted policies that will provide the clean electricity needed for the reduced energy needs of efficient buildings and industrial processes; for example, the 45 by 15 clean energy policy challenges the state to reduce electricity end-use in 2015 by 15 percent below forecasted levels, while simultaneously meeting 30 percent of electricity supply needs through renewable resources. While these policies are among the most progressive in the country, they barely begin to address the level of GHG reduction needed in RCI to achieve the State's 80 by 50 goal.

Long Island Green Homes is an energy efficiency retrofit program created by the Town of Babylon. This program is saving residents an average of $1,085 per year on utility bills by providing upfront funds to upgrade insulation, boilers, furnaces, water heaters, ventilation, air sealing, ducts and weatherstripping. (Photo courtesy of Town of Babylon LIGH Program)

RCI Policy Options

The Technical Work Group identified ten key policy options with the potential to transition New York's buildings and industrial sector to use significantly less energy, improve resource efficiency, and reduce fossil fuel inputs, with additional energy supplied from low- or zero-carbon imports. Chapter 6 of this Interim Report gives technical information, specific targets, and preliminary estimates of cost and effectiveness for each policy option based on the 2030 benchmark; more definitive economic analyses will be developed during the next planning phase.

Figure OV-9. RCI Policy Options with Brief Descriptions

RCI Policy Options and Descriptions
Building Codes, Appliance Standards, and Enforcement (RCI-7) Establish more aggressive codes regarding energy use, including movement to performance-based codes. Provide a statewide "stretch code" that encourages municipalities to achieve additional savings and informs the building sector of planned future changes. Continue to establish and update energy efficiency performance standards for products that are not federally preempted, as specified under Article 16 of the Energy Law, and lobby the federal government to increase performance standards for those appliances with federal preemption.
Building Commissioning, Benchmarking, and Upgrades (RCI- 8) Measure and provide information about buildings' energy use, increasing incentive to reduce energy consumption. Require regular energy audits and cost-effective energy efficiency measures.
Energy Efficiency Incentives (RCI-2) Provide incentives and resources for greater energy efficiency in new buildings and better energy performance in existing buildings. Employ whole-building integrated analysis and design to identify high performance efficiency measures.
Customer-Sited Renewable Energy Incentives (RCI-3) Provide incentives and resources for greater penetration of solar electricity, solar thermal, and low-carbon bioenergy solutions.
Industrial Process Incentives (RCI-11) Assess and reduce industrial process energy use. Provide funding and resources to reduce GHG emissions per unit of industrial production.
Workforce Training and Development (RCI-6) Assess and develop workforce capabilities in New York to meet the needs of a low-carbon future.
Education, Outreach, and Behavior Change (RCI-5) Change energy use behaviors by affecting retail purchase patterns, education in schools, increasing New York State government lead-by-example, and providing information and resources to New York State communities and individuals.
Rate Restructuring and Flexible Metering (RCI-10) Redesign electric rates to vary by time-of-use for all electricity users and expand installation of meters that provide real-time electric cost/use information.
Research, Development, and Demonstration (RCI-9) Invest in next-generation technologies that will produce lower cost solutions to achieve climate-energy goals in the RCI sector and advance a clean energy economy in New York State.
Efficiency and Clean Energy Fund (RCI-1) Fund efficiency and clean energy programs that reduce GHG emissions; build on existing funding sources and explore expanding to include all fuels.
Tax Structure and Private Financing (RCI-4) Conduct a two-phase comprehensive financing and tax policy review that will indentify changes needed to support GHG emission reduction and encourage both public and private investment in low-carbon energy.

How the RCI Policy Options Would Work

At the core of the RCI policies are two statutory and regulatory policies that will produce long-term emission reductions in code-compliant new and renovated existing buildings: Building Codes, Appliance Standards, and Enforcement (RCI-7), and Building Commissioning, Benchmarking, and Upgrades (RCI-8). By promoting upgraded building envelopes and equipment, furnished with energy-saving appliances governed by State or federal energy efficiency performance standards, these policies will reduce building operating costs and achieve substantial energy savings and emission reductions.

Solar panels on the Town Hall roof in the Climate Smart Community of Red Hook are reducing power bills so successfully that the town has applied to expand the installation and develop renewable energy improvement projects for other local government facilities. (Photo courtesy of Town of Red Hook)

Because the RCI policy options do not require most existing buildings to undergo code-mandated improvements, incentives for voluntary upgrades will be vital to meeting New York's GHG emission reduction goals. It is important to note that by 2030, the total building stock in New York State is not expected to increase by more than 6 percent. Therefore, reducing emissions from existing buildings will be absolutely critical to reducing emissions from this sector.

Energy Efficiency Incentives (RCI-2) would promote whole-building, integrated analysis to identify high performance efficiency measures for existing and new buildings. Customer-Sited Renewable Energy Incentives (RCI-3) would increase use of onsite renewable energy, and Industrial Process Incentives (RCI-11) would enhance industrial activity and reduce carbon intensity through more efficient, productive, and cost-effective operations.

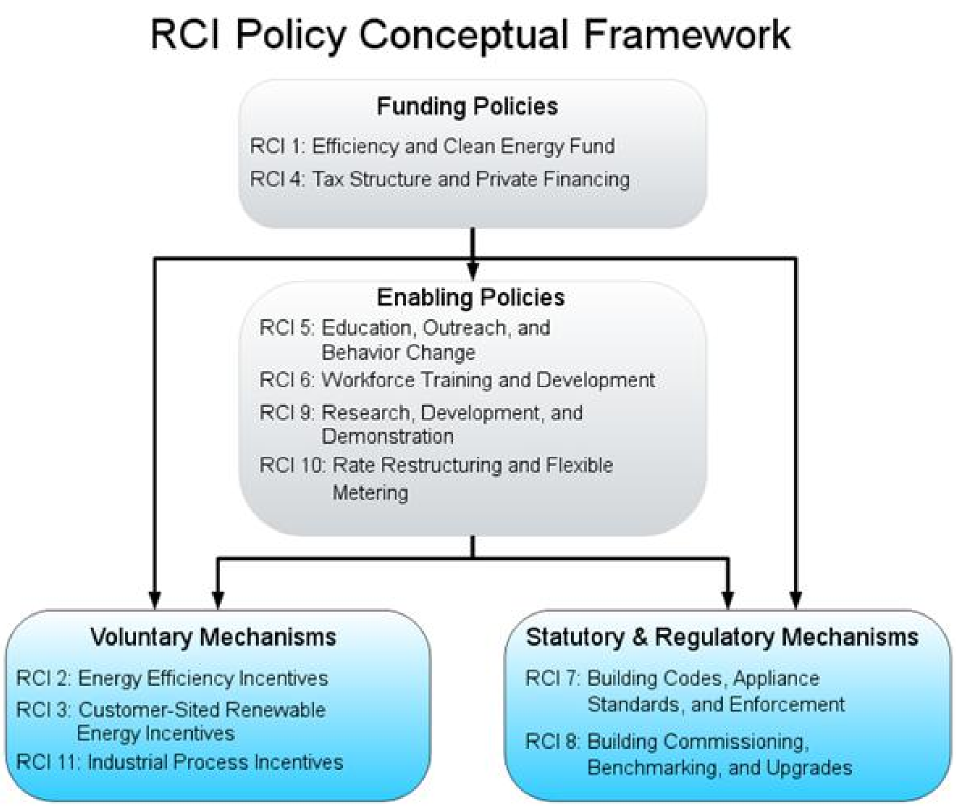
Six supporting policies promote developments that are critical to successful statutory and voluntary emissions reduction in buildings, including developing a workforce with the knowledge, skills, and ability to directly meet the energy service demands driven by other RCI policies (RCI-6), and investing in next-generation technologies that will produce lower cost solutions to achieve climate-energy goals (RCI-9).

Weatherizing buildings reduces building heating/cooling needs and GHG emissions, and also provides employment to local workers.

Consumers play a key role in investing in energy efficiency and renewable energy equipment and infrastructure. Education, Outreach, and Behavior Change (RCI-5) will promote consumer and State agency staff awareness of the benefits of clean energy and energy efficiency. Redesign of electric rates to vary by time-of-use for most electricity users, along with expanded installation of "smart" meters that provide real-time information about electricity consumption and cost, would provide more effective price signals reflecting time-of-use and the GHG burden of source fuels, enabling customers to reduce electricity consumption, and save money in Rate Restructuring and Flexible Metering (RCI-10).

Dedicated and continuous funding is essential for the overall success of the RCI policy options and attainment of long-term carbon reduction goals. An Energy Efficiency and Clean Energy Fund (RCI-1) and Tax Structure and Private Financing (RCI-4) initiatives would work in unison to leverage public funding and private financing for low-carbon energy activities. Figure OV-10 illustrates how the RCI policies cover all aspects of a developing low-carbon RCI sector to accomplish significant GHG emission reductions.

Figure OV-10. Residential, Commercial/Institutional, and Industrial Policy Framework



The next phase of climate action planning will evaluate policy interactions, preparing the way for policymakers to select, design, and efficiently implement policies that will avoid conflicting outcomes and make the most of beneficial interactions.

7.2 Transportation and Land Use Sector (TLU)

TLU Sector Vision for 2050

Most New Yorkers will live in smart growth communities and have access to an efficient, reliable, extensive transit network with a variety of modes of low-carbon public and mass transportation within and between communities. Smart Growth will be the predominant land use and development pattern, minimizing GHG emissions by 1) enabling and supporting widespread use of public transit and 2) mixing land uses to minimize the need for driving. Individuals will travel in low-carbon, highly efficient vehicles powered by electricity, hydrogen fuel cells, or sustainably derived biofuels. A significant portion of freight will move on low-carbon modes like rail and barge; trucks will become more efficient and use alternative fuels.

Getting to the Vision: Transforming the Transportation and Land Use Sector

A low-carbon transportation future for New York requires transforming all factors that determine GHG emissions when people and goods are transported: vehicles, fuels, travel activity, and transportation system efficiency. The TLU policies deal with both transportation and land use—deployment of new transportation technologies, provision of new transit choices, and adoption of land use patterns that allow people to meet their daily needs with less vehicle travel.

Climate Smart Community New Rochelle, New York is working to raise the efficiency of its municipal vehicle fleet. (Photo courtesy of City of New Rochelle)

TLU Policy Options

The Technical Work Group identified 12 Transportation and Land Use policy options with the potential to guide a transition to a low-carbon transportation system. Chapter 7 of the full Interim Report gives technical information, specific targets, and preliminary estimates of cost and effectiveness for each policy option based on the 2030 benchmark; more definitive economic analysis will be developed during the next planning phase.

Figure OV-11. TLU Policy Options with Brief Descriptions

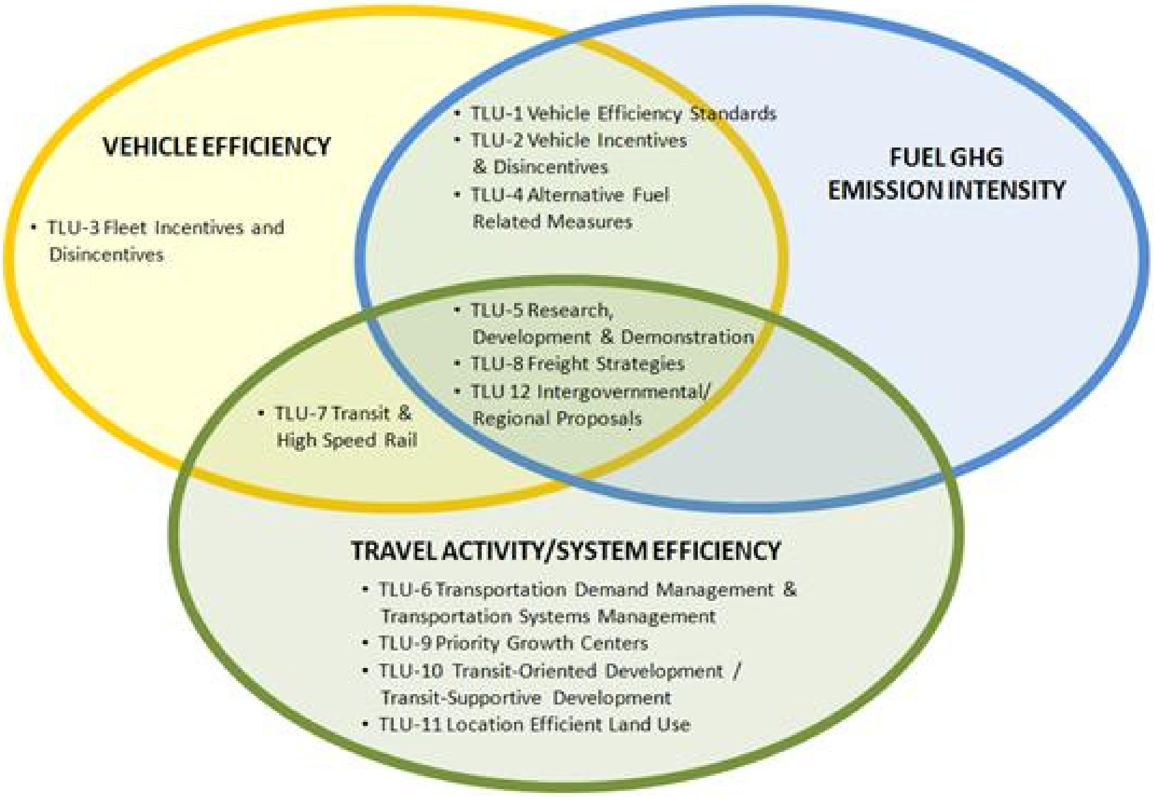
TLU Policy Options and Descriptions
Vehicle Efficiency (TLU-1) Advocate for and implement strict vehicle emissions standards that move vehicle fleet to near zero-carbon emissions.
Vehicle Incentives and Disincentives (TLU-2) Establish feebate system to provide incentive for New Yorkers to purchase more efficient light-duty vehicles.
Heavy-Duty Fleet Incentives and Disincentives (TLU-3) Establish public low-interest revolving loan fund to facilitate the accelerated turnover of fleet vehicles, especially heavy-duty vehicles.
Alternative-Fuel Related Measures and Infrastructure (TLU-4) Establish a regional low-carbon fuel standard to reduce fuel carbon intensity.

TLU Policy Options and Descriptions
Research, Development and Demonstration (TLU-5) Invest in next-generation technologies that will produce lower cost solutions to achieve climate-energy goals in the TLU sector and advance a clean energy economy in New York State.
Travel Demand Management and Transportation Systems Management (TLU-6) Implement measures that reduce dependency on vehicles, encourage and facilitate the use of shared modes of transportation, and allow for the more efficient use of vehicles.
Transit and High Speed Rail (TLU-7) Invest in the maintenance, enhancement, and expansion of public transit systems, including high speed rail.
Freight Strategies that Promote GHG Reductions (TLU-8) Invest in freight rail infrastructure, and research and implement the optimal freight system; provide other incentives for freight mode-shift; promote more efficient or alternatively fueled trucks.
Priority Growth Centers (TLU-9) Promote centralized growth to reduce vehicle miles traveled (VMT).
Transit Oriented Development (TOD)/Transit Supportive Development (TSD) (TLU-10) Promote growth where transit is available to provide transportation choices and reduce VMT.
Location Efficient Land Use (TLU-11) Implement mixed-use, smart growth land-use, and planning policies that result in communities that require less driving.
Intergovernmental/Regional Proposals (TLU-12) Coordinate regional initiatives, including multi-state land use planning incentives, multi-state transportation system GHG allowance system, coordination of high speed rail planning and investment, and federal advocacy.

How the TLU Policy Options Would Work

The policy options identified by the technical work group would seek to influence the future mix of technologies in New York's fleet of vehicles (low-carbon vehicles, or vehicle efficiency) and the fuels used (low-carbon fuels, or fuel GHG emission intensity), and would aim to reduce total vehicle-miles travelled and system energy loss (travel activity/system efficiency). Vehicle Miles Traveled, or VMT, is a key measure of travel activity and transportation system efficiency—a smaller VMT means a more efficient system. Figure OV-12 portrays the relationships among transportation and land use policy options.

Figure OV-12. Transportation and Land Use (TLU) Policy Options



7.3 Power Supply and Delivery Sector (PSD)

PSD Sector Vision for 2050

New York will have a safe, reliable, diverse, and extremely low-emitting electric power system that meets the needs of all citizens and accommodates the widespread conversion of buildings and transportation from fossil fuel to electricity in a manner that maximizes societal benefits, minimizes societal costs, and avoids imposing an undue burden on any community.

Getting to the Vision: Transforming the Power Supply and Delivery Sector

Reducing GHG emissions 80 percent by 2050 economy-wide means that by mid-century, close to 100 percent of New York's electricity must come from *low-carbon* sources—sources with near zero-carbon emissions. Existing State policies have begun this crucial transformation: by 2015, the State's electricity grid is expected to be powered 60 percent by renewable or other low-carbon sources, as a result of the 30-percent renewable energy from the renewable portfolio standard combined with the 30 percent of power currently provided by nuclear power plants. By 2018, the current RGGI cap requires electric power sector emissions to be 10 percent below historic levels. However, these existing programs alone cannot reach the 80 by 50 goal.

PSD Policy Options

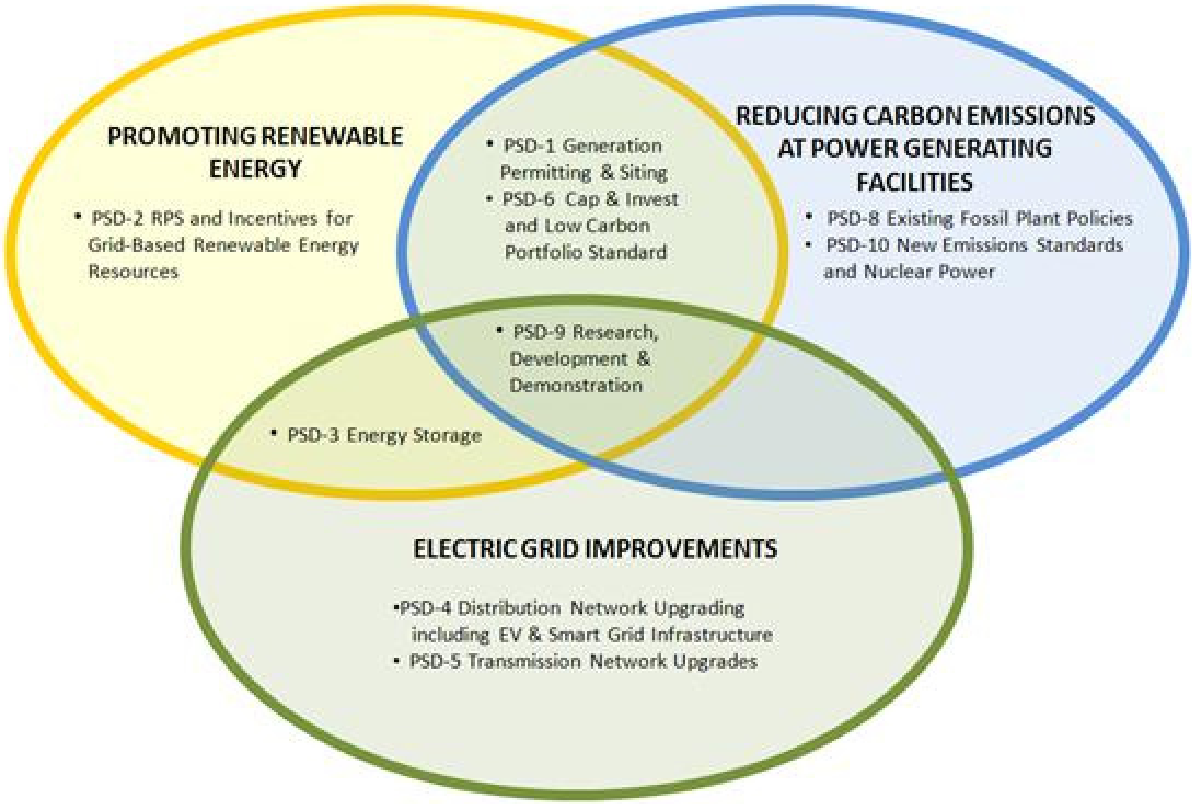
The Technical Work Group identified nine policy options with potential to transition power supply and delivery from its current status of more than 50 percent essentially carbon-free sources (including nuclear, hydroelectric, and other renewable power) to nearly 100 percent. This transition will require substantial investments to maintain system reliability. Chapter 8 of this Interim Report gives technical information, specific targets, and preliminary estimates of cost and effectiveness for each policy option based on the 2030 benchmark; more definitive economic analyses will be developed during the next planning phase.

Figure OV-13. PSD Policy Options with Brief Descriptions

PSD Policy Options and Descriptions
Incentives for Grid-Based Renewable Generation (PSD-2) Promote renewable energy with a goal of increasing the renewable energy attributable to the Renewable Portfolio Standard by 130-140%
GHG Reduction Market Mechanisms: Low Carbon Portfolio Standard, Cap & Invest (PSD-6) Require 75% low-carbon power by 2030 via utilities and other load-serving entities. Cap and reduce emissions across the economy.
Generation Infrastructure Permitting and Siting (PSD-1) Create a new plant siting process that facilitates public participation.
New Facility Emissions Standard and Nuclear Power (PSD-10) Establish standards for new facilities based on GHG emissions from state-of-the-art natural gas-fired plants.
Existing Fossil Plants Policies (PSD-8) Encourage repowering of existing plants, so that they meet emission standards after 2030.
Distribution Network Upgrade Including EV and Smart Grid Infrastructure (PSD-4) Promote smart grid and other distribution system improvements, facilitating electric vehicles and distributed generation.
Transmission Network Upgrades And Loss Reductions (PSD-5) Upgrade electric transmission system to facilitate the low-carbon grid.
Energy Storage (PSD-3) Encourage energy storage techniques that accommodate the variability of renewable energy sources.
Research, Development, and Demonstration (PSD-9) Invest in next-generation technologies that will produce lower-cost solutions to achieve climate-energy goals in the PSD sector and advance a clean energy economy in New York State.

Figure OV-14 portrays the relationships among PSD policies.

Figure OV-14. Power Supply and Delivery (PSD) Policy Options



How the Power Supply and Delivery Policy Options Would Work

Three policy options would lead to most of the emission reductions from the electricity sector:

- **Extension and expansion of the State's existing Renewable Portfolio Standard (RPS)**, a policy that seeks to increase the proportion of renewable electricity delivered to retail customers. The expanded RPS will more than double by 2030 the amount of electricity provided by new renewable energy, including off-shore wind energy and solar energy. The policy also would include complementary measures providing early support to bring low-carbon renewable sources on line.
- **A low-carbon portfolio standard** that will build on the RPS, requiring regulated utilities and other load-serving entities to procure an increasing amount of low-carbon energy.
- **Building upon and strengthening the RGGI program**, working with New York's regional partners to convert RGGI into a multi-sector cap-and-invest program that caps and reduces carbon emissions region-wide, sets a price on carbon emissions, and invests proceeds from allowance auctions in building the clean energy economy in New York.

The remaining policy options focus on lowering emissions from fossil-fueled power generation, modernizing the electric grid, and advancing technology to cost-effectively build the clean energy economy.

- **To ensure relatively low emissions from existing or new fossil-fired plants** by 2030, State policies initially can facilitate siting of new lower carbon power-generating facilities and ensure that all new plants meet a GHG emission standard based on the performance of modern, efficient natural gas-fired plants. After 2030, existing plants also would meet lower emission levels; incentives would encourage the repowering or replacement of older plants with more efficient, lower-emitting technology earlier than 2030.

Wind power is an important and growing source of low-carbon electric power. The Fenner Wind Power Facility, located in Madison County, New York, generates 89 million kilowatt hours of electricity each year.

- **To ensure electricity grid reliability** when drawing increasingly on renewable and other low-carbon power sources, policy options include extensions and upgrades to the electricity distribution system, along with continued deployment of smart grid technologies. These grid modernization options enable increased use of distributed renewable energy sources and electric vehicles, as well as efficient transmission from new renewable and low-carbon generation facilities to areas of high demand. Additional energy storage will help accommodate the variability that characterizes most renewable electricity sources.
- **To cost-effectively transition to a low-carbon power sector**, policy options emphasize continued investment in research, development, demonstration, and deployment. Options for Technology Research and Development are detailed in Chapter 10 of this Interim Report.

The next phase of climate action planning will evaluate any interactions among these policies, preparing the way for policymakers to select, design, and efficiently implement policies that will avoid conflicting outcomes and make the most of beneficial interactions.

7.4 Agriculture, Forestry, and Waste Sectors (AFW)

AFW Sector Vision for 2050

Agriculture: *A carbon-negative New York agricultural sector will help to meet the state's food and fiber needs, while also making a significant contribution to the energy supply mix. Farms will be profitable, valued by society, and highly adapted to a changing climate. Farms will be managed as multiple-resource concerns, successfully competing in a fossil-fuel dependent world that is undergoing major climate shifts.*

Forests: *Rural forest land conversion will be rare and long-term forest storage of carbon will realize its maximum potential. Urban green space and trees will reduce building heating and cooling loads. Working together, land owners, government officials, and the public will maximize the long-term carbon sequestration and bio-energy potential of the state's forests. Forests will deliver co-benefits that are vital to the economy and to New Yorkers' quality of life, maximizing the value of forest lands to private forest owners and to the public.*

Waste: *New York will have a sustainable and energy-efficient materials economy where environmental stewardship is pursued as a common societal value and where environmental considerations inform purchasing, production, and materials management, minimizing waste and reducing risks to human health and the environment. Materials management systems and infrastructure will maximize the recovery and re-use of water, wastewater, and other materials in ways that capture their economic value, conserve embedded energy, and minimize net life-cycle emissions of greenhouse gases and other pollutants.*

Getting to the Vision: Transforming the Agriculture, Forestry, and Waste Sector

Climate Smart Community North Hempstead targets schools (Manhasset School District, shown here), libraries and parks with a vigorous recycling program. Recycled materials do not require energy-intensive disposal, and re-manufacturing takes less energy than using virgin materials. (Photo courtesy of Town of North Hempstead)

The agriculture, forestry, and waste sectors all involve management and stewardship of resources. These sectors contribute only a small portion of total state GHG emissions (about 6 percent), but offer potential for relatively low-cost and low-technology GHG mitigation and sequestration policies. Policy options in the agriculture, forestry, and waste sectors would add GHG reduction as a goal of managing energy production and use, natural resources, materials management and waste. Intensive resource management offers significant environmental, economic, and social benefits beyond GHG reductions, including improved water and air quality, increased agricultural and forest productivity, and job creation.

AFW Policy Options

The Technical Work Group identified eight Agriculture, Forests, and Waste policy options with the potential to develop economically vibrant resource and materials management in New York, with sustainable production of food, fiber and fuel; energy-efficient operation; maximum GHG sequestration; and effective stewardship of New York's soils, natural resources, materials, and energy. Chapter 9 of this Interim Report gives technical information and preliminary estimates of cost and effectiveness for each policy option based on the 2030 benchmark; more definitive economic analysis will be developed during the next planning phase.

Figure OV-15. AFW Policy Options with Brief Descriptions

AFW Policy Options and Descriptions
Production of Sustainable Feedstock for Bio-energy (AFW-1) Encourage development of sustainability criteria and use of best management systems to minimize environmental, economic and social impacts.
Conversion of Sustainable Feedstock for Bio-energy (AFW-2) Advance development and commercialization of low-carbon biomass conversion processes.
Maximize Waste Reduction (AFW-3) Develop and provide tools designed to reduce waste and divert materials for reuse, recycling and composting.
Integrated Farm Management (AFW-4) Develop comprehensive farm-specific plans to reduce GHG emissions, increase carbon sequestration, and address agricultural adaptation challenges.
Conserve Open Space, Agriculture Land, and Wetlands (AFW-5) Support improved land management and land-use protection programs to maintain or increase forestland acreage and protect and restore freshwater and tidal wetlands.
On-Farm Energy Efficiency and Production of Renewable Energy (AFW-6) Increase on-farm energy efficiency and renewable energy production via comprehensive energy audits and coordination of energy services for the agriculture sector.
Improved Forest Management (AFW-7) Provide incentives, education, technical assistance, and support programs to improve forest health, sequester additional carbon, reduce fossil fuel energy consumption, and increase green infrastructure.
Locally Produced Food (AFW-8) Increase the availability of locally produced foods to help reduce the energy required for transportation, packaging and marketing.

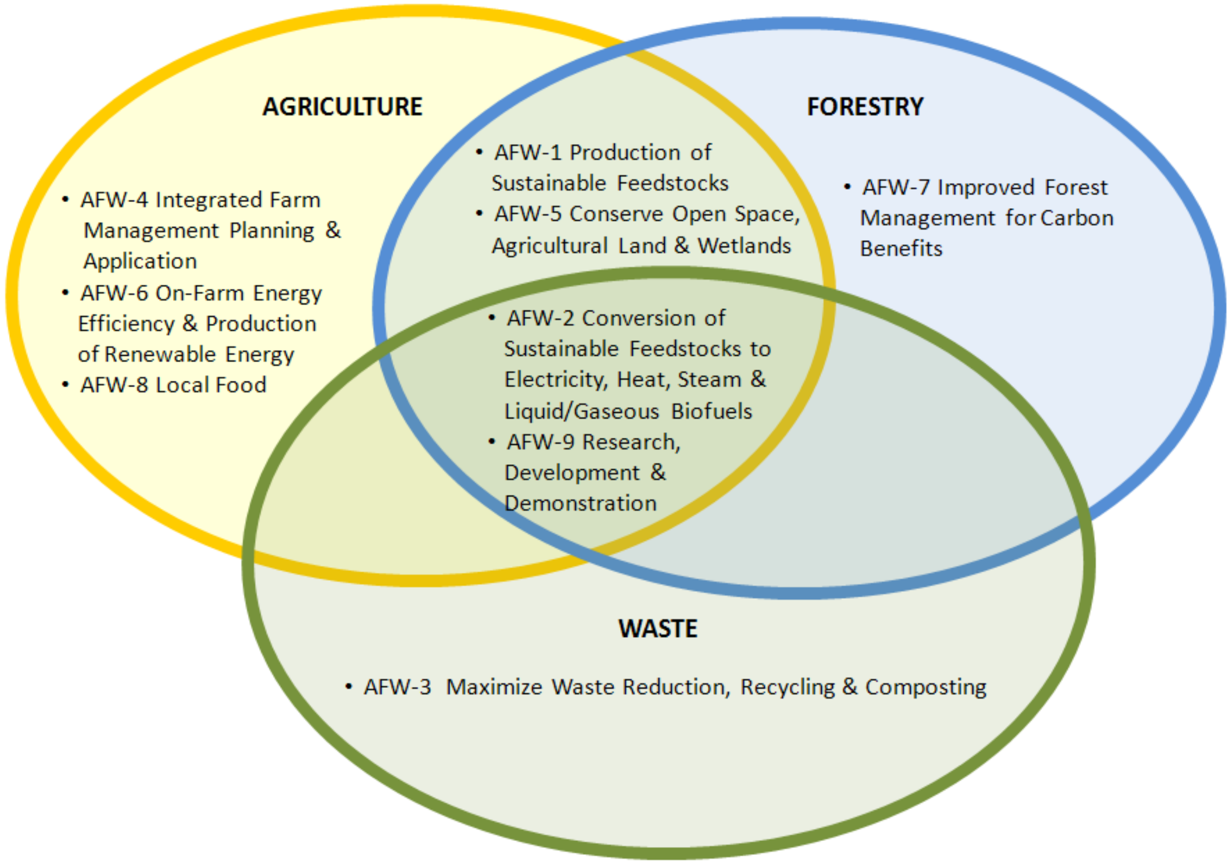
How the AFW Policy Options Would Work

Overall, the policy options seek to accomplish the following:

- Reduce energy-related emissions through the deployment of renewable energy technologies, including low-carbon bio-based energy solutions, and energy efficiency policies and measures that address direct and embedded energy usage.
- Conserve the embedded energy in materials by maximizing reuse and recycling.
- Reduce emissions of methane and nitrous oxide, both potent GHGs, from agricultural and waste-related activities by deploying a combination of systems.
- Capitalize on the large carbon storage capability of agriculture and forests, which sequester carbon from the atmosphere via natural processes.
- Coordinate climate change adaptation strategies with mitigation strategies wherever possible.

Figure OV-16 portrays the relationships among agriculture, forestry, and waste policies.

Figure OV-16. Agriculture, Forestry, and Waste (AFW) Policy Options



The next phase of climate action planning will evaluate any interactions among the policy options, preparing the way for policymakers to select, design, and efficiently implement policies that will avoid conflicting outcomes and make the most of beneficial interactions.

8.0 Research, Development, and Demonstration Investments for a Low-Carbon Future

Experts are calling for a three-to-five-fold increase in global public and private investment in energy technology research, development, and demonstration (RD&D) to develop lower cost solutions to the climate-energy challenge and to capitalize on the opportunities associated with new energy markets. This recommendation is strongly supported by a range of stakeholders including business leaders, academic leaders, the National Academy of Sciences, and the United Nations.

New York's Climate Action Plan must include a commitment to promote and support RD&D, in a coordinated partnership with the federal government and the private sector, to ensure continual development of innovative technologies necessary to cost-effectively reduce GHG emissions and promote the economic strength of local clean energy businesses. Statewide RD&D investments, across all economic sectors, must be targeted to provide demonstrable benefits for New York companies.

Development of this RD&D investment strategy represents a critical follow-on task that will build upon the high-level policy options in this Interim Report. The investment strategy will further define New York's technological strengths, establish multi-disciplinary collaborative teams between universities and industry, and identify opportunities to further leverage limited in-state resources with federal and private sector funds.

The New York Battery and Energy Storage Technology Consortium (NY-BEST™) is a private-public coalition building a vibrant, world-class advanced battery and energy storage sector from R&D to commercialization.

Chapter 10 in the Interim Report provides an overview of the RD&D needs of the four mitigation sectors, identifies technology areas where New York can best leverage its investments and capabilities to benefit local businesses, and presents "order-of-magnitude" funding estimates to support a technical innovation network and advance low-carbon technologies. It is expected that any State-funded RD&D program established to support implementation of New York's 80 by 50 goal would be supported by a broad array of public stakeholders throughout the state – with active private sector involvement.

The Interim Report provides the following observations and recommendations:

- RD&D and innovation are responsible for over half the economic growth in this country over the past century.
- The energy industry invests only about 0.2 percent of its revenues on energy RD&D, while the average industrial investment in RD&D is closer to 2.6 percent.
- Federal investments in low-carbon energy R&D should increase five-fold from $5 billion per year to $25 billion according to many experts.
- Energy RD&D investment in New York State, currently $50 million per year, must be increased substantially to pursue a low-carbon future and stimulate a clean energy economy in New York.
- New York energy RD&D funds should be targeted toward helping New York businesses develop low-carbon technologies while also addressing local energy and infrastructure needs, thereby helping to stimulate a clean energy economy in the state.
- The State must actively promote innovation and commercialization to bring the fruits of RD&D investment to the market and to realize local economic benefits, as described further in Chapter 13 on the Clean Energy Economy.
- RD&D needs for buildings and industry of relevance to New York include deep-retrofit strategies for existing buildings, onsite energy storage systems, building-scale renewables, active power management, consumer behavior modification, whole-building/zero energy buildings, and non-fossil-fuel based industrial process technologies.

- RD&D needs related to transportation and land use include intelligent transportation systems, alternative fuel vehicles, and related infrastructure—in particular electric vehicle infrastructure, vehicle efficiency optimization for urban duty cycles, smart growth pilots, and improvements in electrified rail.
- RD&D needs in power supply and delivery include marine-based resource development, including off-shore wind, advanced wind resource forecasting, carbon capture and sequestration assessments, grid integration of large-scale solar and smart grid.
- RD&D needs in agriculture, forestry, and waste include carbon sequestration in agriculture and forest lands, and sustainable biomass resource development.

It is important to note that New York State cannot support the entire technology development process (*basic research*, *technology development*, *large-scale demonstration*, *commercial adoption*) on its own. The Interim Report acknowledges a clear role must be established for the federal government and the private sector that efficiently optimizes limited resources, appropriately assigns technical and business risk, and ensures a consistent and stable flow of investment capital to finance advanced energy technologies. Any State-level investment strategy must function as an advocacy tool to drive national RD&D energy policy and leverage private-sector RD&D investments.

9.0 Adapting New York to Climate Change

In this historic photo, storm surge is poised to wash over Battery Park in New York City. Rising sea levels will bring more dangerous storm surges, not only for communities at sea level, but also for upland communities near tidal rivers, such as the Hudson.

To create a more climate-resilient New York State, the Climate Action Plan places a strong emphasis on adaptation. Climate change already is affecting New York's society, economy, and natural ecosystems, and these impacts are expected to increase. Past climate is no longer a reliable guide to the future. New climate conditions and unpredictability in the climate affect all of New York's social and economic systems, particularly agriculture, infrastructure, public health, and natural resources.

Adaptation: Planning for a Changing Climate in New York State

Adaptation can be thought of simply as responsible planning, incorporating the most current information about projected climate change into a variety of decisions. Adaptation strategies can include changes in policies, operations, management, or infrastructure that reduce risk of harm and/or take advantage of potential opportunities associated with climate change.

Adaptation can take place at the individual, household, community, organizational, and institutional levels. New York State as a whole is generally considered to have significant resources and capacity for effective adaptation, but the costs and benefits of adaptation will not be evenly distributed throughout the State.

Climate Risks and Adaptation Planning

Incorporating adaptation into decision making requires the following:

- Understanding how the climate in New York State might change
- Identifying potential vulnerabilities to a changing climate—infrastructure or resources that could be harmed if the climate changes
- Assessing the risk levels of those vulnerabilities
- Developing adaptation strategies that will help to minimize those risks
- Prioritizing adaptation strategies and developing an adaptation plan that coordinates with GHG mitigation strategies and economic development.

Past climate conditions alone are no longer a reliable guide when planning for the future.

Prerequisites to Successful Adaptation Planning

The Adaptation Technical Work Group identified seven themes that emerged for all sectors as important first steps to implementation of adaptation policy options. These themes are summarized below:

- Develop a process to maintain, disseminate and explain to decision makers a set of best-available climate projections, potentially via a New York State Climate Science Institute.
- Identify and track key climate change indicators important to New York.
- Develop a framework to monitor, assess, and share progress on local, state, and federal government adaptation planning and implementation.
- Initiate research to develop new adaptation strategies and provide detail and confidence to support adaptation strategy decisions.
- Evaluate emergency preparedness, management and response capabilities (such as emergency warning systems, cooling centers, emergency evacuation, and preparation for power and/or communication outages) in light of climate projections, to determine where these capabilities will be compromised by climate threats in New York.
- Initiate widespread education and outreach, including both school curricula and community outreach, to build public support and awareness.
- Develop adaptation policies that protect those citizens and communities most vulnerable to the impacts from climate change.

The following sections outline the adaptation vulnerabilities and policy options developed by the Adaptation Technical Work Group for eight sectors of New York's economy and natural resources.

9.1 Agriculture Sector Adaptation

Agriculture Climate Vulnerabilities

Farmers are on the front lines of climate change, but the direct impacts on crops, livestock, and pests and the costs of farm adaptation will cascade throughout New York's economy. While climate change will create unprecedented challenges, there are likely to be new opportunities as well, such as possible new markets for food and energy crops suited to a longer growing season and warmer temperatures.

New York's agriculture sector encompasses more than 34,000 farms that occupy about one-quarter of the state's land area (more than 7.5 million acres) and contribute $4.5 billion annually to its economy. Many New York crops benefit from the state's historically relatively temperate climate. The state's farming community includes many large-scale wholesale operations, as well as small farms that are vital to the economy of rural areas.

Dairy farming, New York's top agricultural activity, is vulnerable to climate change because milk yields decrease in warmer temperatures.

Figure OV-17. Agriculture Adaptation Policy Options with Brief Descriptions

Agriculture Adaptation Policy Options
1: Support research, development, and deployment of agricultural adaptation strategies that simultaneously manage on-farm GHG emissions and adaptation concerns. A. Support the introduction of existing varieties and the development of new varieties that can take full advantage of the beneficial effects of climate change. B. Develop improved methods of responding to extreme weather events (frost, freeze, heat, precipitation). C. Develop improved responses to increased weed, disease, and insect threats. D. Increase the accuracy of the existing real-time weather warning systems. E. Support the development of decision-making tools to help the agricultural community adapt. F. Increase climate change impact education and outreach efforts to agricultural producers. G. Ensure equity is incorporated into programs targeting agricultural adaptation.
2: Incorporate anticipated increases in the incidence of weeds, diseases, and insect threats due to climate change in current detection, monitoring, and integrated pest management efforts. A. Evaluate the capacity of existing federal, state and local agriculture and forestry programs that are focused on identifying and monitoring weed, disease, and insect threats attributable to a changing climate. B. Develop and deploy pest-resistant plant varieties, regional coordination for early detection, and rapid-response approaches to emerging threats.

Agriculture Adaptation Policy Options
3: Evaluate and develop mechanisms to more effectively protect livestock from the effects of greater temperature variability and extremes. A. Continue research, development, and deployment of livestock protection measures and climate-related modifications to feed management systems and approaches. B. Increase installation of energy-efficient cooling systems and other structural or mechanical interventions.

9.2 Coastal Zones Adaptation

Coastal Zones Climate Vulnerabilities in New York

New York's coastal zone includes the shoreline, coastal wetland areas, and adjacent inland areas likely to be affected by sea level rise and coastal storms. Even in a densely populated urban environment such as New York City, coastal ecosystems provide numerous functions and values.

Adapting to climate change is urgent for coastal cities and communities. New York City already is planning for rising sea levels. Communities on the Hudson River also recognize that they are vulnerable to storm surges that propagate up the river.

Sea level rise will greatly amplify risks of permanent inundation of low-lying coastal areas, more frequent flooding by storm surges, and increased beach erosion. Saltwater could reach farther up the Hudson River, contaminating urban water supplies; increased water depth could allow faster propagation of tide and storm surges up the Hudson, increasing flood risk far from the coast.

Sea level rise will progressively affect both human and natural systems as it changes water levels on the ocean and estuarine coastline, shortens flood-recurrence intervals, and increases risk and geographic extent of coastal hazards such as storm-surge-related flooding, erosion, and groundwater intrusion.

Figure OV-18. Coastal Zones Adaptation Policy Options with Brief Descriptions

Coastal Zones Adaptation Policy Options
1: New York State should endorse a coordinated set of projections for sea level rise and associated changes in flood recurrence intervals in all coastal areas, including the Hudson River estuary, for use by state and local agencies and authorities for planning and decision-making purposes.
2: Integrate sea level rise and flood recurrence interval projections into all relevant agency programs and decisions.

Coastal Zones Adaptation Policy Options
3: Identify and map areas of greatest current risk from coastal storms and sea level rise to support risk reduction actions in those areas.
4: Reduce vulnerabilities in coastal areas at risk from sea level rise and storms (coastal risk management zone) and support increased reliance on non-structural measures and natural protective features to reduce impacts from coastal hazards. A. Develop Coastal Resilience Plans B. Assist in funding measures to reduce risk
5: Develop a long-term interagency mechanism to regularly evaluate climate change science; set research priorities to foster adaptation; coordinate actions; and assess progress

9.3 Ecosystems Adaptation

Ecosystems Climate Vulnerabilities in New York

New York State includes 47,047 square miles of land, 1,894 square miles of inland lakes and rivers, and 3,988 square miles of Great Lakes. Variation in topography and proximity to water bodies causes large climatic variations, and distinct ecological zones support biological diversity and provide important ecosystem services, including harvested products (food, timber, biomass, and maple syrup), clean water, flood control, soil conservation, carbon sequestration, genetic resources, recreation, wild places, and heritage sites.

Initial impacts of climate change on species are already apparent, with documented accounts of species range shifts and changes in the seasonal timing of bud-break or flowering. Climate change creates risks to biodiversity, net primary productivity, vegetation water use, and biogeochemical cycles, but to date, there is not unequivocal evidence of impacts on ecosystem services such as carbon sequestration or water storage and quality in New York State.

New York's brook trout population, already at risk from increasing temperatures, is likely to be severely reduced by continued warming.

Within the next several decades New York State is likely to see widespread shifts in plant species composition. Warmer temperatures will favor the expansion of some invasive species into New York, some habitat and food generalists (such as white-tailed deer) may benefit. Climate factors could increase the productivity of some hardwood tree species, provided growth is not limited by other factors such as drought or nutrient deficiency.

Figure OV-19. Ecosystems Adaptation Policy Options with Brief Descriptions

Ecosystems Adaptation Policy Options
1: Support the implementation of the recommendations of the Invasive Species Task Force to mitigate potential damage from climate change-induced growth of invasive species.
2: Ensure that New York State's ecosystems sustain healthy, diverse, well-distributed, and abundant populations of fish, wildlife, plants, and human communities that are adapted to survive in a changing climate. A. Support State agency efforts to incorporate an Ecosystem Based Management approach that factors ecosystem function, services, and biodiversity into decision making, including management plans, funding decisions, and policies. B. To enable ecosystems to better respond to changing climate conditions, incorporate adaptive management principles, techniques, and approaches into New York's forest management policies and programs. C. Protect and enhance the stability and function of stream, river, and aquatic coastal systems to accommodate changing climate conditions.
3: Develop a research and monitoring plan to detect, record, and analyze changes in species, habitat composition, natural cycles, and fish and wildlife health, and effectively address current and future threats in changing climate conditions.
4: Expand climate change education and outreach initiatives on the potential impacts of climate change to natural areas and ecosystem services.

9.4 Energy Adaptation

Energy Vulnerabilities in New York

Reliable energy systems are critical to commerce and quality of life. New York State's electricity and gas supply and distribution systems are highly reliable, but extreme weather events, temperature, and flooding can damage equipment, disrupt fuel supply chains, reduce power plant output levels or increase demand beyond the energy system's operational capacity. Downstate coastal energy infrastructure is vulnerable to flooding by sea level rise and storm surges. Renewable generation can be affected by drought, changes in precipitation patterns, cloud cover, or other factors characteristic of climate change.

Figure OV-20. Energy Adaptation Policy Options with Brief Descriptions

Energy Adaptation Policy Options
1: Ensure the accuracy of demand forecasting for planning purposes and build resilience for meeting peak demand. A. Incorporate best available projections of changes in seasonal average temperatures and increased frequency of extreme heat events in near and longer-term demand forecasting for electricity and natural gas. B. Plan for meeting regional demand growth and improved system resiliency through local implementation of demand response and energy efficiency measures, greater use of localized distributed generation, energy storage, other energy supply technologies, and smart-grid technologies, beyond those efforts already underway and planned.
2: Increase utilities' and energy providers' resiliency to climate-related impacts. A. Ensure that best available projections concerning the frequency and severity of extreme storm events are incorporated into State and regional emergency response plans. B. Ensure that detailed statewide maps are available to assist in identifying areas and infrastructure at high risk from storm and flood damage. C. Work with organizations such as the Electric Power Research Institute (EPRI) and NYSEARCH (a voluntary sub-organization within the Northeast Gas Association) to survey and assess utility industry best practices for increasing resilience to climate change.

9.5 Public Health Adaptation

Public Health Vulnerabilities in New York

Some current health conditions are considered sensitive to the changing climate. Cardiovascular disease, the leading cause of death in the state, is made worse by extreme heat and poor air quality. Childhood asthma, an important health challenge in many parts of New York State, especially New York City, is made worse by poor air quality. Several vector-borne diseases (those spread by carriers such as mosquitoes and ticks) have emerged in the past few decades.

A diverse state with populations spread unevenly over urban and rural service areas, New York relies primarily on a county-based system for public health service delivery. This highly decentralized system leads to non-uniform provision of core services, making public health adaptation measures more difficult to coordinate.

Figure OV-21. Ecosystems Adaptation Policy Options with Brief Descriptions

Public Health Adaptation Policy Options
1: Improve or establish robust public health mechanisms to reduce the potential for heat-related morbidity and mortality in New York State. A. Assess the adequacy of existing heat warning systems and, as necessary, expand the capacity of existing cooling center programs. B. Enhance existing education and outreach activities, employing multilingual and culturally sensitive approaches and targeting particularly vulnerable populations. C. Coordinate with utilities to develop an approach to address the public health needs resulting from power disruptions associated with extreme heat events. D. Establish and expand community-based volunteer networks, and identify and assist vulnerable populations. E. Develop and implement a statewide “Green Cool-down Plan” to reduce the “heat-island effect,” with a particular focus on the most vulnerable communities.
2: Educate the public regarding the public health consequences of climate and take actions to reduce or eliminate those consequences. A. Raise the awareness of policy makers, State and local government officials, community leaders, businesses, institutions, health care providers, and the general public about the public health significance and related costs of climate change. B. Work with communities to create effective outreach materials and mechanisms focused on vulnerable and/or hard-to-reach populations.
3: Assess and improve the capacity of existing public health preparedness, response, and recovery programs to respond to climate-related impacts. A. Assess and enhance the capacity of existing preparedness programs. B. Determine how existing telecommunications technology and social networking systems can be better integrated into early warning and evacuation systems.
4: Build community resilience and integrated public health capacity to reduce human health impacts of climate change. A. Consider possible public health impacts of climate change in planning, programs, policies, and regulations. B. Increase the resilience of communities by providing additional support for healthy-built environment concepts, such as smart growth and green infrastructure, and for local and urban agriculture initiatives that strengthen food security. C. Require that emergency preparedness plans include coordination and communication among critical stakeholders.
5: Evaluate and enhance, monitoring and surveillance programs for diseases and disease-causing agents and respond to the anticipated climate change-related increase in such public health threats. A. Evaluate the capacity of existing public health programs that control disease-causing agents. B. Provide necessary assistance to local governments. C. Expand analytical laboratory capacity.
6: Assess and prepare for the significant public health risks associated with hazards related to sea level rise.

Public Health Adaptation Policy Options

7: Support research to better understand the public health consequences associated with climate change in New York State.

A: Develop a priority research agenda that includes making use of health impact assessments, developing appropriate health indicators, and assessing the effectiveness of adaptation technologies.

B: Assess effectiveness, accessibility, and quality of public health-related climate change adaptation programs.

9.6 Transportation Adaptation

Transportation Vulnerabilities in New York

Climate change has significant consequences for the transportation sector. Over the next few decades, heat waves, heavy precipitation events, and windstorms will likely be the dominant causes for moderate, frequent transportation problems such as flooded streets and mass transit delays. By 2050 at the latest, sea level rise and storm surge will become more significant threats. By the latter half of this century, these threats will be so severe that major adaptations will have to be in place, not only in the coastal zone, but all the way to cities in the way of sea level rise and storm surges propagating up the tide-controlled Hudson River. Low-lying transportation systems like subways and tunnels, especially in coastal and near-coastal areas, are at particular risk of flooding from sea level rise and heavy-precipitation events.

Transportation may be disrupted more often and more severely as heavier rains flood roads and bridges located near New York's many rivers and streams.

Materials used in transportation infrastructure, such as asphalt and train rails, are vulnerable to increased temperatures and extreme heat events. Air conditioning requirements in buses, trucks, and trains and ventilation requirements for tunnels will increase. Some aircraft runways may require lengthening, since hotter air provides less lift, necessitating higher takeoff speeds.

Figure OV-22. Transportation Adaptation Policy Options with Brief Descriptions

Transportation Adaptation Policy Options
1: State, regional, and local transportation agencies and authorities should prepare detailed inventories and climate vulnerability assessments of critical transportation infrastructure. A. Designate key transportation corridors, based on the critical movement of people and/or freight and their importance to intra- and interstate travel. B. Endorse a coordinated set of climate change projections and provide these to transportation agencies and authorities and other transportation stakeholders. C. Integrate climate change into vulnerability assessments, including analyses of potential financial and social impacts based on climate projections endorsed by New York State. D. To facilitate investment decisions, evaluate which freight and passenger transport systems are most resilient to climate change.
2: Prioritize transportation infrastructure that is essential for emergency preparedness and response capabilities.
3: Incorporate State-endorsed climate change projections into all relevant decisions. A. State transportation agencies and authorities should develop specific design criteria and operational guidance based on climate change projections in transportation projects and investments. B. Stormwater management techniques and approaches should be incorporated wherever possible. C. Assist local governments in implementing adaptive measures for priority transportation infrastructure.
4: The State's transportation master plan should consider and incorporate State-endorsed climate change projections. A. Policy direction for the siting, design, operation, and maintenance of key transportation infrastructure elements should include climate change projections.
5: Transportation investments in New York State should be consistent with smart growth/transit-oriented development principles. A. Infrastructure investments should be designed and constructed to protect and preserve natural resources and ecosystems that provide essential climate adaptation services. B. Incorporate redundancy and travel choices into the transportation system.

9.7 Telecommunications/Information Infrastructure Adaptation

Telecommunications/Information Vulnerabilities in New York

Telecommunications infrastructure is vital to New York State's economy and welfare; its capacity and reliability are essential to the effective functioning of global commerce and the state's economy and is especially vital during emergencies.

Communication service delivery is vulnerable to hurricanes, lightning, ice, snow, wind storms, and other extreme weather events, some of which are projected to change in frequency and/or intensity. Communication lines and other infrastructure are vulnerable to the observed and projected increase in heavy precipitation events and resulting flooding and/or freezing rain. In coastal and near-coastal areas, sea level rise in combination with coastal storm surge flooding will be a considerable threat later this century. The delivery of communication services is sensitive to power outages, such as those resulting from the increased demand associated with heat waves, which are expected to increase with climate change.

Figure OV-23. Telecommunications Adaptation Policy Options with Brief Descriptions

Telecommunications Adaptation Policy Options
1: Prepare detailed inventories of telecommunications facilities, network, and corridor-critical infrastructure, and complete vulnerability assessments of critical infrastructure and corridors. A. Prioritize infrastructure that is essential to support critical State and local functions such as emergency preparedness and response capabilities. B. Vulnerability assessments should use accepted climate change projections to assess the impact of projected climate change on high priority communication infrastructure.
2: Incorporate climate change projections into decision-making within New York State's telecommunication and information infrastructure sector. A. State agencies responsible for the management of communication infrastructure should develop specific design and operational guidance based on climate change projections, and incorporate it into communication projects and investments. B. Direct funding as available for adaptive changes to existing critical communication networks used for emergency preparedness and response that are at greatest risk from climate impacts. C. Develop models, guidance and standards, and financial support where possible to help local governments implement adaptive measures for priority communication infrastructure.
3: Where feasible and cost effective, reduce vulnerability of telecommunications infrastructure to extreme weather events. A. Foster a shift toward a more distributed network of communication infrastructure, including expansion of wireless services. B. Planning for investments in communications infrastructure or operational changes planning should support and be coordinated with adaptation and operations of other sectors, particularly the energy sector (e.g., smart grid). C. Ensure system redundancies for communications infrastructure at high risk of flooding and high winds, including communication towers.
4: Improve the dialogue on climate resiliency between State agencies and private telecommunications service providers and provide increased accountability for service disruptions. A. To provide increased accountability carriers and other communication service providers should be required to report compliance with the Federal Communications Commission's standards.

9.0 Water Resources Adaptation

Water Resources Vulnerabilities in New York

The state's water and wastewater treatment infrastructure is in dire need of repair and upgrade, requiring some $36 billion for water treatment and $40 billion for wastewater treatment improvements. Challenges associated with a changing climate will only exacerbate these needs.

New York is experiencing growing demand for water, both for human consumption and for energy production. As other parts of the country experience more frequent and intense drought, New York's water resources may become a defining economic asset, drawing people and businesses into the state and presenting new water resource management challenges.

Figure OV-24. Water Resources Adaptation Policy Options with Brief Descriptions

Water Resources Adaptation Policy Options
1: Enact into law Governor's Program Bill 2010 #51- Water Withdrawal Regulation (S.8280-A/A.11436-B) to authorize implementation of a comprehensive statewide water withdrawal permitting program.
2: Build greater resilience to projected climate change impacts into drinking water and wastewater infrastructure systems. A. Prepare detailed inventories of critical water infrastructure and conduct climate vulnerability assessments. B. State and local agencies should update permit and design standards for drinking water and wastewater infrastructure to factor in projected climate impacts.
3: Adopt statewide and region-wide comprehensive sustainable water resources management strategies that consider climate change. A. All water-related permit programs and policies should minimize alterations and disruptions to the natural hydrologic cycle to the extent possible. B. Create mechanisms to foster development and state approval of regional intermunicipal watershed management plans that address expected climate change impacts.
4: Allow "room for rivers." Acknowledge the dynamic nature of rivers on the landscape and strive to reduce risk to critical infrastructure and human development as the risk of flooding increases with climate change. A. Coordinate with key federal and local stakeholders such as the Federal Emergency Management Agency (FEMA), U.S. Department of Agriculture, and county soil and water conservation districts to identify and map areas of greatest current risk from riverine flooding and erosion due to movement of rivers across the landscape. B. Work with federal agencies to reduce new development in areas at high risk of riverine flooding and undertake long-term managed relocation or elevation of existing structures in these areas. Restructure disaster recovery policies to ensure that redevelopment efforts strive to reduce long-term risk.
5: Incorporate water-related climate projections into state and local emergency management planning.

10.0 Identification of Cross-Sector Policies & Issues

Many issues associated with mitigating and adapting to climate change relate to more than one of the sectors examined in this planning process. To date, the climate planning process has identified several important cross-sector issues:

- Environmental justice and community-based concerns;
- Near- and long-term workforce training for a clean energy economy;
- Education, outreach, and behavior change;
- The transition to increased use of electric vehicles.

The second phase of climate action planning will seek to identify additional policy interactions among the final recommendations.

Environmental Justice and Community-Based Concerns

The Climate Action Council made a determined effort throughout the planning process to integrate input from community-based groups, regional/community focused organizations, and environmental justice (EJ) groups. These groups served as members of Technical Work Groups and of the Integration Advisory Panel; in addition, the council held statewide videoconferences and a series of teleconferences and surveyed community and EJ organizations on proposed policy options. Details of this discussion and the inputs that resulted are available in Chapter 12 of this Interim Report.

Effective Community Engagement and Public Participation

One of the key ingredients in communities across the world that have successfully engaged on climate change-related issues is the presence of strong and sustained local leadership. Local dialogues educate community members, build support for climate policies and facilitate the shift to a low-carbon economy. Acknowledging and addressing past concerns of the EJ community with official decisions and planning processes were identified as critical to developing and implementing the Climate Action Plan.

The plan's statewide awareness-raising is designed to include tools and guidance to help communities frame climate-related risks within a local context, along with resources and technical assistance for community capacity building.

Permitting, Siting, and Environmental Impact Assessment

Climate policy approaches should respect hard-won procedural safeguards designed to ensure adequate access to official decision making in areas such as permitting, the siting of facilities and infrastructure, and conducting environmental impact assessments. As part of the climate action planning process, EJ stakeholders emphasized the importance of assessing the cumulative risks and impacts of different types of stressors, facilities, and infrastructure on the health and quality of life of communities and adequately analyzing the public health implications of proposed policies. Transparency and timely access to information were advanced as critical in all the policy areas.

Waterfront Facilities and Public Health

Waterfront facilities, especially wastewater treatment plants, petroleum/chemical bulk storage sites, and solid waste management facilities, are particularly vulnerable to climate change impacts and represent risks to surrounding communities. Particular attention should be given to the medium- and long-term contamination and public health consequences associated with coastal flooding.

Fair Share of Burdens and Benefits

No single neighborhood or group should be forced to bear a disproportionate share of the environmental consequences resulting from industrial, commercial, or municipal operations or from the execution of government programs and policies. Community/EJ stakeholders pointed out that a nuanced approach could help to balance the legacy of environmental pollution and burdens in EJ communities, such as awarding overburdened communities a greater proportion of beneficial climate projects and policy initiatives.

Near- and Long-Term Workforce Training for a Clean Energy Economy

The Residential, Commercial/Institutional, and Industrial (RCI) Technical Work Group identified **near-term** workforce training and development as a priority policy option (RCI-6). However, because workforce issues cut across all sectors, near-term training needs for all mitigation sectors are incorporated into the Workforce Training and Development Policy (RCI-6) (see Chapter 6). As we implement new clean energy technologies and practices and make permanent changes in the way we use resources, we need a trained workforce for projects in energy efficiency; site-based clean and renewable energy resources; power supply and demand; smart grid technologies; codes and standards; agriculture, forestry, and waste; transportation; and manufacturing and other related areas. Chapter 6 of this Interim Report summarizes the workforce policy discussion and details opportunities to expand upon current workforce training, continuing education, credentialing, licensing, on-the-job training, and recruitment and job placement.

Long-term workforce training is addressed in the Building Block #2 section of Chapter 13: *Stimulating a Clean Energy Economy in New York*. Over the long term, training must enable New York to identify and respond to workforce development needs as they arise and to prepare future generations of workers for the low-carbon economy.

The innovation-based model that will underlie New York's low-carbon economy requires a full spectrum of educational support. From the K-12 system, grounding is needed in math, science, environmental sustainability and alternatives to a carbon-based economy, and preparation for entrepreneurship. From higher education, new curricula, certifications and degrees for low-carbon technologies, and access for current workers to skills upgrades as technologies evolve are critical.

Education, Outreach, and Behavior Change

Government must lead by example and take responsibility for developing an implementation strategy that meets the 80 by 50 goal and guides the transition to a low-carbon economy in a cost-effective and politically and socially acceptable manner.

The first step for State agencies and local governments is internal outreach and education promoting the Climate Action Plan and making climate change considerations part of routine government activities and decisions. At the same time, robust, well-funded, and effective external outreach, education, and awareness raising should acquaint all citizens with the substantial economic, social, and environmental benefits the Climate Action Plan will generate.

Transition to Electric Vehicles

At present, the transportation sector produces nearly 40 percent of New York's combustion-based GHG emissions, the vast majority from gasoline-fueled light-duty vehicles. Plug-in electric vehicles (EV), plug-in hybrid electric vehicles (PHEV), and fuel cell vehicles powered by hydrogen derived from electrolysis could displace a significant portion of this petroleum consumption by using electricity for all or portions of vehicle trips. If this electricity had a low or near-zero-carbon intensity, the carbon footprint from this segment could be nearly eliminated.

A cross-sectoral vehicle subgroup worked on a comprehensive, multisectoral strategy to achieve EV penetration as part of the Climate Action Plan, integrating issues applying to power supply generation, transmission and distribution, vehicles, and vehicle charging infrastructure. The following items were among its findings:

Fuel mileage of 125 mpg is the promise of this plug-in hybrid, newly introduced as a way to reduce GHG emissions and petroleum consumption. This year, several auto manufacturers are commercially introducing electric vehicles.

- PHEVs, EVs, and fuel cell vehicles having acceptable performance for many applications are a reality, and vehicles deriving their fuel from the electric grid are likely to become a cost-effective means of achieving carbon-free mobility.
- Through the mid-term (2025) New York's transmission grid has adequate capacity to accommodate the maximum (30 percent) anticipated penetration of EV and PHEVs with smart charging. Minor upgrades in the distribution system could be needed on a very localized basis.
- Policy and regulations should encourage the development of a variety of business models for charging/re-fueling, and policies should encourage off-peak charging to maximize benefits. In the near term, incentives will likely be necessary to induce EV adoption.

The full report of the Electric Vehicle Subgroup is found in Appendix G of this Interim Report.

11.0 National and Regional Action and Coordination

To successfully reduce the impacts a changing climate will have on New York's people, environment, and economy will require coordinated policy and action by all levels of government—federal, state, and local. Given the global nature of the climate change challenge, U.S. federal government action will be essential to successfully position the American economy in an evolving international marketplace and to enable the United States to lead efforts to achieve a global solution. Federal action will create a fertile arena for development of the new technologies that will be needed to achieve the scale of emission reductions needed, and it will enable New York businesses to compete on a level playing field with businesses in other states and nations.

New York's domestic energy, environment, and economic development interests can be successfully augmented through participation in regional efforts that achieve more change, in a more equitable manner, than New York acting alone. National and regional programs can result in greater reductions at a lower marginal cost than programs implemented by a single state, and State actions also are most effective when coordinated with local government activities.

Finally, climate change is, at its core, a global issue that will require the dedicated action and attention by all governments, industries, and citizens. New York already is working and should continue to work with other states, subnational entities, and other nations to achieve an international solution to climate change.

This chapter makes the following specific recommendations and observations:

- New York should seek implementation of national or regional market mechanisms to price carbon and reduce emissions. A national program can be implemented through Congressional action or a collaborative effort between states and EPA under the Clean Air Act.
- Leveraging the opportunities available under federal programs such as production and investment tax credits and a national renewable electricity standard can help create a robust market demand for clean energy.
- National electricity transmission policy should facilitate achievement of New York's climate goals rather than providing an avenue for importing coal-fired power.
- New York should take advantage of the federal government's advanced energy technology investment policy. Developing new clean energy technologies requires a substantial and sustained commitment from the federal government.
- Federal investment in, and support for, nuclear technology and carbon capture and sequestration will help New York achieve its climate protection goals, while preserving system reliability. Given the financial commitment needed to advance the technology in these areas, the federal government is best positioned to make the necessary investments.
- Regional and national transportation initiatives will be essential to achieving New York's climate goals, including strong national vehicle emission and fuel economy standards and regional low-carbon fuel standards, regional transportation pricing strategies, and regional rail initiatives.
- New York should advocate for strict national standards for appliances and other products that are sources of greenhouse gas emissions.
- Federal agencies should cooperate to create and implement regulatory frameworks that foster energy efficiency and distributed renewable energy. For example, the federal government should facilitate Property Assessed Clean Energy (PACE) financing.
- National education policy to foster innovation and technology is important to achieving New York's climate protection goals.
- The federal government should target infrastructure investments that advance climate change objectives, such as high-speed rail and a more intelligent electricity grid.
- Federal and state policy should engage localities and communities as active participants in achieving climate goals.

> *Climate change is a global issue that will require dedicated action and attention by all governments, industries and citizens.*

- New York should support efforts to achieve an international solution to climate change. New York can play a critical role in providing an example of the policies that can be implemented worldwide to mitigate climate change.

Achieving a comprehensive solution to global climate change requires New York to collaborate with regional partners and the federal government on emission reduction strategies, and to seek action across the community of nations. Although comprehensive federal legislation is preferable, until such legislation is in place, the federal government should seek to target its broad suite of policies and programs toward promoting low-carbon technology and behavior.

12.0 Next Steps

With this Interim Report, the Climate Action Council is seeking stakeholder and public response to the initial climate action planning work, including input on the mitigation and adaptation policy options. During 2011, work will continue to complete the required analyses of the policy options, which will inform a final Climate Action Plan.

New York State will then need to develop more specific near-term implementation strategies to effectuate policy and practice. The State will need to establish clear targets and evaluate progress toward those targets. A mechanism to update this long-term plan on a regular basis will be needed, as the technology, the state-of-science, and the broader public policy environment will continue to change.

Further, given the strong linkages between GHG emissions and energy policy, strategies to reduce GHG emissions will also need to be considered further in the development of New York's State Energy Plan as well as in other planning processes, such as state implementation plans for various co-pollutants.

The recently enacted Article 6 of the Energy Law requires the State Energy Plan to include an inventory of greenhouse gas emissions, and strategies for facilitating and accelerating the use of low-carbon energy sources and carbon mitigation measures. Thus, the State Energy Plan will become a mechanism to deliberate and advance appropriate energy policy that fully accounts for the climate change impacts from New York energy production and use.

Chapter 1
Background

There is scientific consensus that emissions of greenhouse gases (GHG) are affecting the Earth's climate. That consensus is represented by the work of the U.S. Global Change Research Program (USGCRP) and the Intergovernmental Panel on Climate Change (IPCC), a body established by the World Meteorological Organization and the United Nations to assess scientific, technical, and socio-economic information relevant for the understanding of climate change, its potential impacts, and options for adaptation and mitigation. On May 19, 2010, the U.S. National Academies of Science (Academies) released three reports emphasizing why the U.S. should act now to reduce GHG emissions and develop a national strategy to adapt to the inevitable effects of climate change. "Climate change is occurring, is caused largely by human activities, and poses significant risks for — and in many cases is already affecting — a broad range of human and natural systems," the report concluded.

The IPCC's Fourth Assessment Report, released in November of 2007, states, "Warming of the climate system is unequivocal, as is now evident from observation of increases in average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." More recently, the U.S. National Aeronautics and Space Administration (NASA) reported, "All three major global surface temperature reconstructions show that Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981 and with all 10 of the warmest years occurring in the past 12 years. Even though the 2000s witnessed a solar output decline resulting in an unusually deep solar minimum in 2007-2009, surface temperatures continue to increase."[1] Although the year is not over as of the release of this Interim Report, 2010 is on track to be one of the warmest years on record, globally, in the United States and in New York.

The IPCC, USGCRP, and the Academies concluded that these increased temperatures are largely attributable to human activities that result in emissions of GHGs that contribute to global warming. These gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and several industrial gases including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and hydrofluorocarbons (HFCs). Other climate forcing agents, such as aerosols including sulfate (SO_4) and black carbon (soot) also affect our climate.

The New York State Energy Research and Development Authority (NYSERDA) is currently funding an assessment of the potential effects of climate change and possible adaptation strategies specific to New York State, *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State*, known as the ClimAID project, the findings of which have informed the development of this plan. A summary of the ClimAID project can be found in Appendix H.

[1] http://climate.nasa.gov/evidence/

In addition to ClimAID, other scientific organizations have studied climate change effects for several regions of the U.S.[2,3] These reports indicate that northeastern U.S. is likely to experience the following climate-related changes:

- Extreme heat and declining air quality are likely to pose increasing problems for human health, especially in urban areas.
- Agricultural production, including that of dairy products, fruit, and maple syrup, is likely to be adversely affected as favorable climates shift.
- Severe flooding due to sea level rise and heavy downpours is likely to occur more frequently.
- Reduction in snow cover will adversely affect winter recreation and the industries that rely upon it.
- Sea level rise will threaten coastal groundwater supplies of fresh water.

Creation of the New York Climate Action Council

In August of 2009, Governor David A. Paterson signed Executive Order 24 establishing the goal of reducing GHG emissions from all New York State sources to 80% below 1990 levels by 2050 (hereafter referred to as 80 by 50) and creating the New York State Climate Action Council (Council). The Council is made up of 13 agency heads in addition to representatives from the Governor's Office. The purpose of the Council is to assist New York in identifying the best opportunities to mitigate and adapt to climate change, reduce costs associated with climate change activities, and foster economic growth in New York.

The Council prepared the Interim Report with assistance from NYSERDA, the Department of Environmental Conservation (NYS DEC), and other Council member-agency staff. The Council convened three external advisory panels to assist and advise in areas requiring special expertise or knowledge: technical analysis, multi-sector integration, and 2050 Visioning. The 2050 Visioning Advisory Panel, the Integration Advisory Panel, and five Technical Work Groups (participants listed in Appendix C) have provided direct input to the Interim Report.

The Council has approved a final New York State GHG emissions inventory and forecast, and this Climate Action Plan Interim Report. Following receipt of public comment on this report and the completion of additional research and macroeconomic analysis, the final Climate Action Plan will be developed and issued in 2011.

Approach to Climate Planning

The New York State Climate Action Plan process relies heavily upon earlier and ongoing work performed by New York State and others. For example, in addition to ClimAID, NYSERDA funded an assessment of the technical potential for GHG emissions reductions and costs of

[2] Frumhoff, P.S., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). 2007. http://www.climatechoices.org/ne/resources_ne/nereport.html

[3] The Committee on the Environment and Natural Resources National Science and Technology Council. Scientific Assessment of the Effects of Global Change on the United States. 2008. http://www.climatescience.gov/Library/scientificassessment/Scientific-AssessmentFINAL.pdf

mitigation technologies and best practices in New York, *Development of New York State Greenhouse Gas Abatement Cost Curves*, which supported the analysis of mitigation policy options recommended here. Other notable reports are the *Renewable Fuels Roadmap* (NYSERDA, Pace University), *2009 New York State Energy Plan* (New York State Energy Planning Board), *Report of the Sea Level Rise Task Force* (NYS DEC), *PlaNYC* (New York City Mayor's Office), and *Envisioning a Low-Carbon 2050 for New York State* (Brookhaven National Laboratory).

The three advisory panels brought outside perspectives and expertise to the process. The Integration Advisory Panel reviewed and integrated the sector-focused work of the Technical Work Groups to ensure that the policy options took account and advantage of policy interactions and synergies. Council member designees were represented on the Integration Advisory Panel, which also included stakeholders representing public, private, and NGO interests.

The Technical Work Groups served as advisors to the Council and consisted of Council member-agency staff and additional public, private, and non-profit sector stakeholders with specific interest and expertise. Members of the public were invited to observe and provide input at all meetings of the Integration Advisory Panel and Technical Work Groups, in addition to attending public informational meetings held around the tate during the process. Planning process documents, including deliberative and analytical products, were posted to the project's public Web site (www.nyclimatechange.us).

Prior to the organizational meetings of the Council and Integration Advisory Panel, the appointed participants attended a "2050 Visioning Conference" hosted by the New York Academy of Sciences and organized by Brookhaven National Laboratory. The focus of the conference was to place the challenge of the 80 by 50 goal into real-world context and, by example, to illustrate the kinds of transformational change needed to achieve the goal.

The Council began the formal deliberative process at the first meeting of the Integration Advisory Panel and Technical Work Groups on January 14, 2010. The Integration Advisory Panel met in person five times, and the five Technical Work Groups met in person and by teleconference on a bi-weekly basis since January 2010. The five Technical Work Groups considered potential policy options and were organized by the following sectors:

- Residential, Commercial/Institutional, and Industrial (RCI)
- Transportation and Land Use (TLU)
- Power Supply and Delivery (PSD)
- Agriculture, Forestry, and Waste Management (AFW)
- Adaptation

Policy options contained in this Interim Report are principally the product of Technical Work Group deliberations, with feedback and guidance from the Integration Advisory Panel, Council designees and the public. The Technical Work Groups that were charged with developing policies to reduce GHG emissions and enhance carbon sequestration potential in New York's soil, trees and wetlands, developed policy options through a stepwise process:

- 2050 Visioning;
- Identifying potential policies;
- Evaluating policy attributes and metrics, including co-benefits;
- Selecting priority policies;
- Developing New York-specific policy designs;
- Quantifying draft policy GHG reduction potentials and costs;
- Refining policy options;
- Presenting policy options to the Council for inclusion in the Interim Report.

Figure 1-1 illustrates the Climate Action Plan process and where this Interim Report fits within the overall effort. This report presents the results of the policy selection, development, and preliminary cost analysis. The analytical results presented describe the potential effectiveness of the mitigation policies on a stand-alone basis and do not consider interactions among policies or overlapping emissions reductions.[4] Assessment of interactions will be done in the next phase of the analysis. It is therefore not appropriate to sum up the reductions or costs associated with individual policies in this report to estimate a cumulative result. A detailed explanation of the process employed for policy option development can be found in Appendix B.

The Adaptation Technical Work Group, as outlined in Figure 1-2, followed a slightly different process to build a foundation for New York State climate change adaptation planning:

- Evaluating the best available information on how the climate in New York State will change;
- Identifying potential vulnerabilities to a changing climate;
- Assessing risk levels of those vulnerabilities;
- Developing adaptation strategies that will help to minimize those risks;
- Prioritizing strategies, considering other adaptation tools, and developing an overall adaptation plan that is coordinated with GHG mitigation efforts.

The Adaptation Technical Work Group formed subgroups to evaluate eight sectors: agriculture, coastal zones, ecosystems, energy, public health, transportation, telecommunications and information infrastructure, and water resources. Evaluation of New York's climate-related risks and vulnerabilities were based on the latest climate projections and other information provided by the ClimAID project. As potential adaptation strategies were being developed, the sector workgroups spent much time reviewing and analyzing the efficacy, need, cost, environmental justice considerations, and timing of each proposed recommendation. A full description of the Adaptation Technical Work Group process is found in Chapter 11.

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[4] An example would be an energy efficiency measure in RCI that reduces the demand for electricity, and a PSD policy that makes electricity generation cleaner. The GHG reduction benefits associated with clean generation would be decreased by an overall reduction in demand for electricity. Failure to take this interaction into account would result in 'double counting' or overstating the reduction benefits of the two policies operating together.

Citizens living in economically disadvantaged communities have been represented and their concerns voiced through formal integration of environmental justice concerns throughout the process. Through the appointment of environmental justice advocates to the Integration Advisory Panel and Technical Work Groups, and by incorporating written comments and guidance at key junctures in the deliberations, the authors of these policy options have heard and sought to incorporate these concerns into the policy designs.

Challenges of Climate Action Planning

Development of a Climate Action Plan for New York is a unique challenge in policy planning. Forty year planning, necessary to meet the 80 by 50 goal, is an unusually long time horizon, and the uncertainty associated with key variables—e.g. future prices of conventional and alternative fuels and technologies—complicates the analysis of policy options to a greater extent than is typical. This complication extends to the analysis of the cost of these policies and the cost of not taking action on climate change. Both are very difficult to estimate.

Another challenge is that while both the cost and cost-effectiveness metrics developed for each mitigation policy option are long-term societal costs, New York decision makers often must focus on short-term public costs, that is, the required State investment. Although many of these policy options have low or no cost to the State, there are notable exceptions: expanding and improving public transportation systems; investing in a clean energy and all-fuels efficiency fund for buildings; providing incentives to attract private capital to produce abundant low-carbon energy; enhancing New York's rail infrastructure for both people and freight; and investing in the research, development, and deployment necessary to grow the next generation of technologies and fuels and promote a clean energy economy.

To cover the investment necessary for these types of policy options, New York State would need to identify a funding mechanism—a difficult challenge in the current fiscal crisis. While this Interim Report generally does not propose specific mechanisms for supporting these types of policy options, there are some principles that should be adhered to in the next stage of climate action planning:

- Policies that set a price for carbon and largely allow the market to dictate actions will be the most efficient and will likely bring about the most benefit, both by reducing emissions at least-cost and raising revenue for reinvestment in GHG reduction programs that have an overall societal benefit;
- State investment in research and development should be strategic given limited resources, and should focus on those activities that overcome a critical barrier and offer significant co-benefits such as attracting clean energy investment to New York or creating jobs.
- For each sector, it will be important for New York to pursue a federal advocacy strategy to bring the resources of the U.S. government to bear on research, development, and infrastructure investment.
- Any necessary mechanisms to raise revenue should be carefully crafted not to put New York State at a competitive disadvantage. This may imply a multi-state strategy. It could also imply the application of an environmental tax shifting approach. This tax structure would provide a "double dividend" leading to a decrease of an undesired polluting activity while

simultaneously increasing government revenue. This increase in government revenue would reduce the tax burden currently placed on desired activities (e.g. employment or economic activity).

- Revenue generation mechanisms should be directly linked to the relevant activity (GHG emissions) and dedicated to the desired outcome (reduction of GHG emissions). Research has shown that these types of "green" fees dedicated to specified uses garner more public support than generalized revenue sources and uses. This approach also recognizes and harnesses the systems benefit dynamic whereby financial support benefits both the direct recipient and the entire system (e.g. transportation system, electricity system).
- Funding for projects and proposals throughout the Climate Action Plan will require substantial private investments in addition to the public funding detailed above. Coordinated public-private partnerships will play an integral role in attracting increased venture capital, a critical component of an economic transition of this magnitude.

In some cases, the policy options described in the Interim Report could be designed and implemented either as a revenue-neutral mechanism or a revenue-generating mechanism. To demonstrate just one example, a revenue-neutral feebate system to influence vehicle purchasing behavior would be structured so that the total amount offered as an incentive is equal to the amount charged as a disincentive. The rebates disbursed could be slightly smaller than the fees collected, with a small amount reserved to cover administrative cost. In contrast, a vehicle purchase incentive program could also be designed to be revenue generating (e.g. gas-guzzler sales tax surcharge), or to be revenue-negative (e.g. tax credit for purchase of electric cars). In any case, for the variety of potential pricing mechanisms, both the amount of GHG emissions reductions and the amount of revenue that will result depends upon the size and scope of the pricing mechanism, and the elasticity of demand for the technology or activity.

2011 Final Climate Action Plan

The next phase of the planning process will consider all mitigation policy interactions and produce an integrated projection for action plan emission reduction potentials and costs. Also to be included in the next phase is a macroeconomic analysis of the potential for climate change policies to expand New York's clean energy economy. Costs and savings associated with policies in this report consider only the direct costs and savings to society, defined as within the geographic boundaries of New York State. Direct costs include capital, operating, maintenance, or other costs directly associated with the implementation of the policy or technology. Direct savings are typically reduced fuel consumption, but may also include reduced labor, operations, maintenance, etc. Secondary, indirect, or macroeconomic effects on statewide employment, income, energy price, and gross state product will be examined in the next phase of the plan with the results presented in the final report.

Critical to the charge of Executive Order 24 is developing the policies necessary to achieve the 80 by 50 goal. The quantitative analyses conducted for the Interim Report cover the period from 2010 through 2030. Some key policy options consider GHG reduction needed for the period from 2030 through 2050, but cost estimates are limited to the next twenty years due to the increasing uncertainty associated with longer-range projections. The final Climate Action Plan will include an analysis of whether the 80 by 50 goal can be achieved by implementing the policy options presented in the Interim Report.

The Interim Report (see Chapter 12) brings together policy options that involve regional or national policy actions or interactions. The final Climate Action Plan will expand upon these interactions and lay the groundwork for strategic policy implementation, which will address not only the needs and opportunities for partnerships with the federal government and neighboring states and provinces, but also the specific actions New Yorkers must take to realize the environmental, economic and security benefits of a low carbon economy.

Figure 1-1. New York State Climate Change Mitigation Planning Process Flowchart

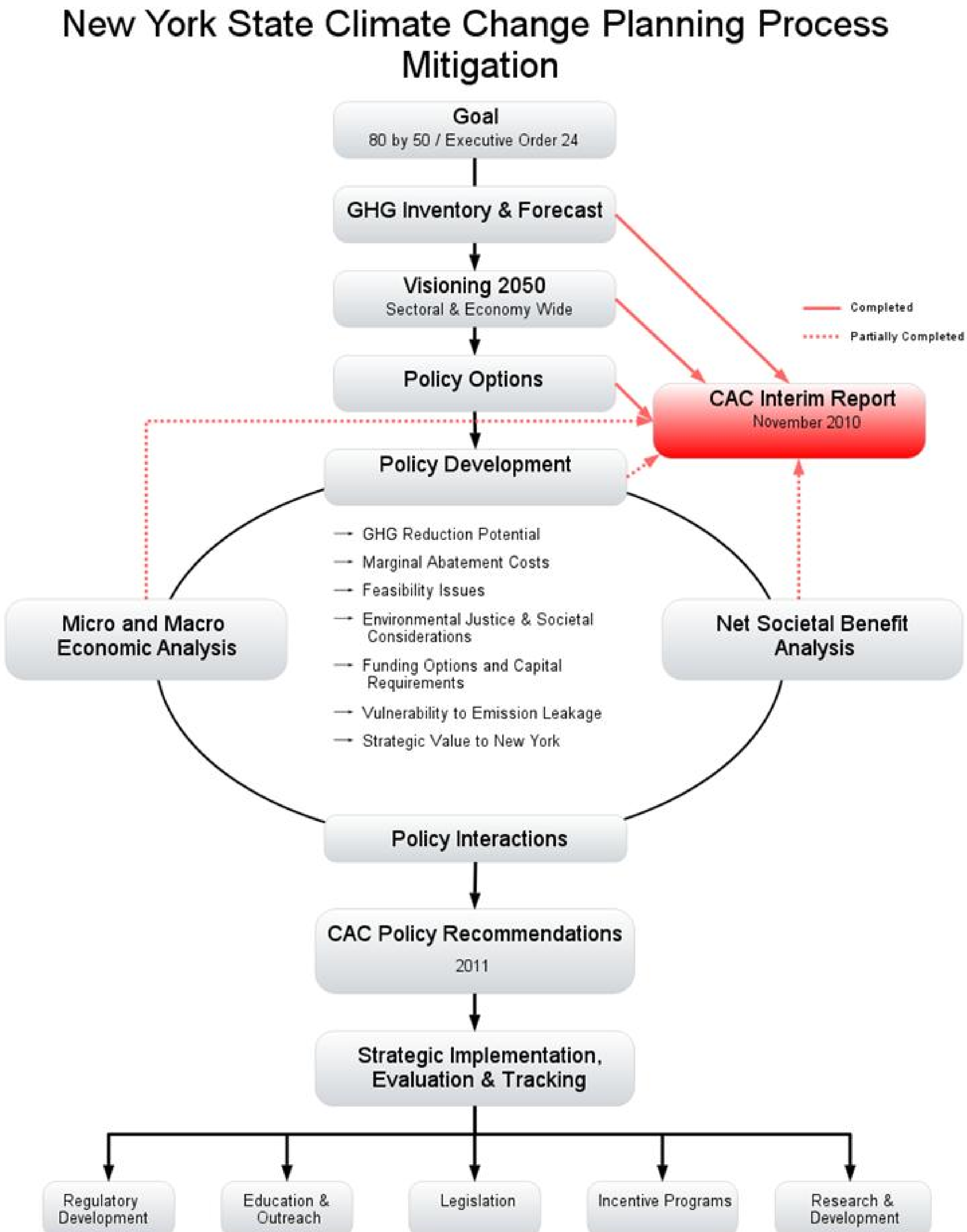
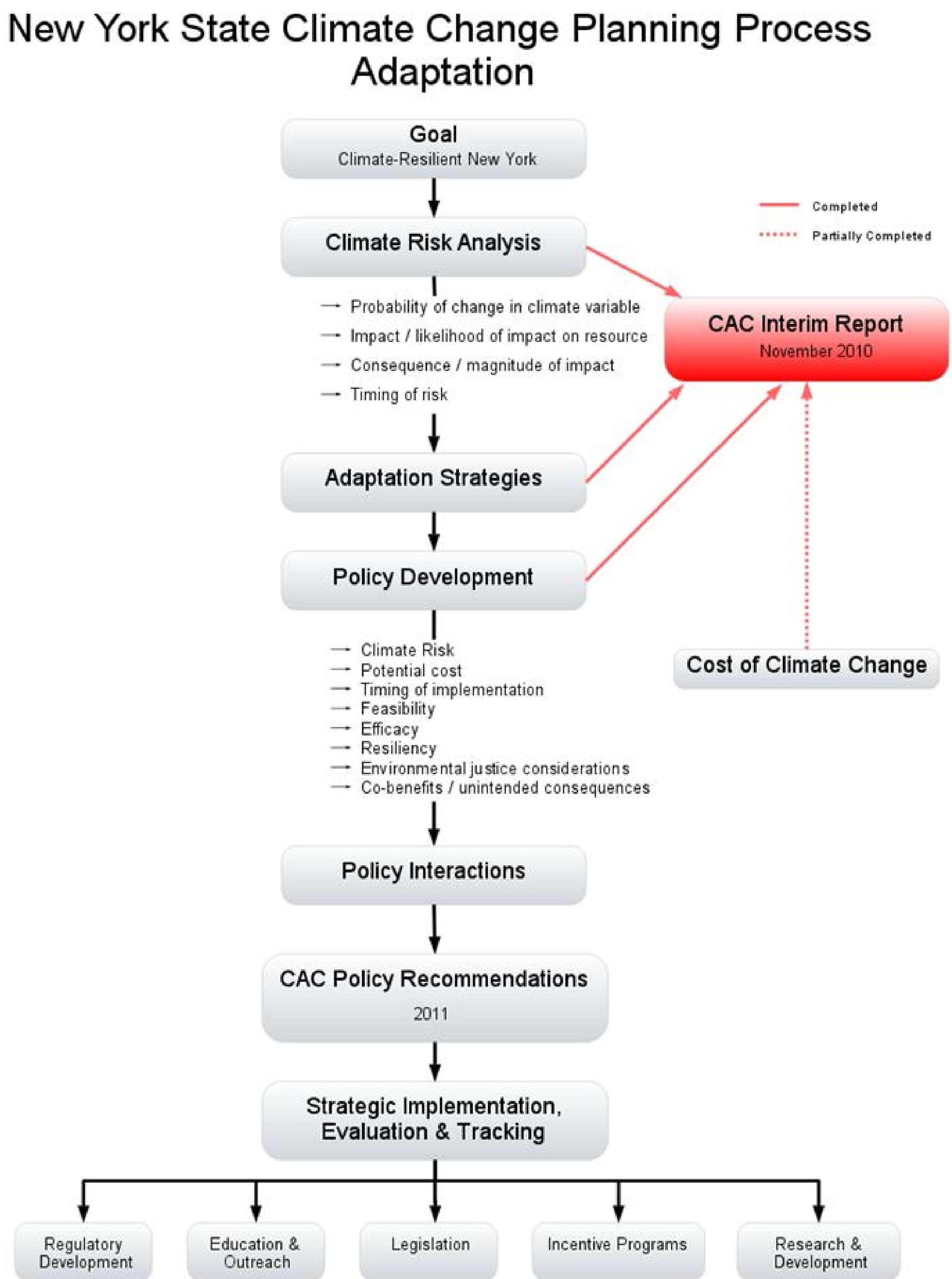


Figure 1-2. New York State Climate Change Adaptation Planning Process Flowchart



Chapter 2
Climate Projections and Vulnerabilities

Introduction to Climate Change[1,2]

Climate change is occurring in New York and around the globe. Global mean temperatures and sea levels have been increasing for the last century, accompanied by other changes in the Earth's climate. While Earth's climate is subject to natural variation, the changes we currently see in our climate result largely from human activities, which have increased atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs), as well as aerosols (black carbon and sulfate). The natural greenhouse effect keeps the Earth warm enough to support life, but higher amounts of GHGs from human activities have increased average global temperatures and led to other climate changes and effects. Relatively small increases in average global temperature can cause large changes in the Earth's climate system. Warming of the Earth is unequivocal, documented by observations of higher global average air, land surface, and ocean temperatures; widespread melting of mountain glaciers and ice sheets; and rising global average sea level.[3] Figure 2-1 depicts the trends of these key climate indicators.[4]

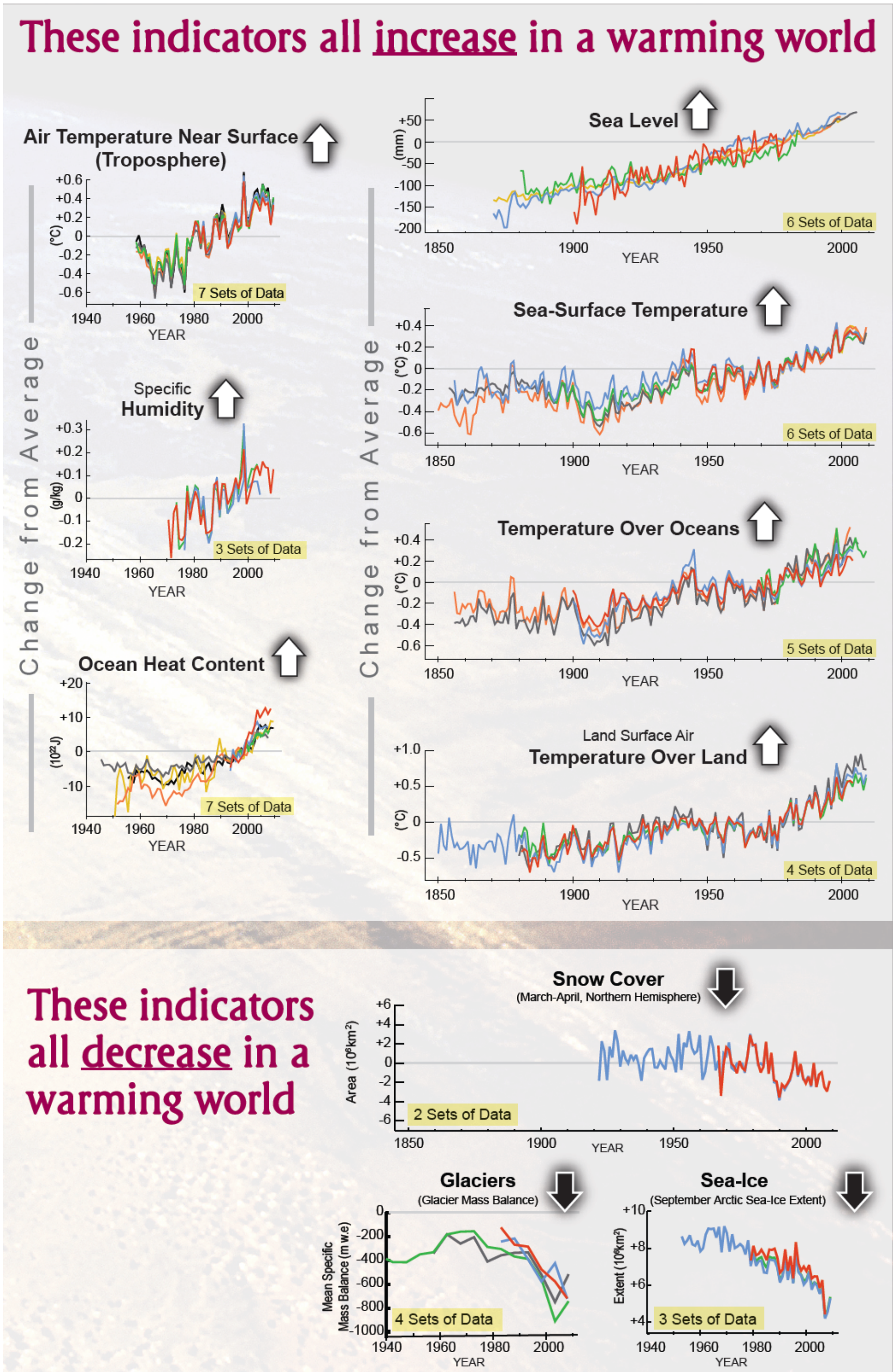
[1] Climate science is complex and evolving. Much of the text in this chapter on New York's climate and vulnerability to climate change is from the ClimAID project (see Appendix H for the draft summary report). For a more thorough description of climate change in New York State, including references, please see the draft of the full ClimAID report available at www.nyserda.org/programs/environment/emep/home.asp . For additional information on climate science and national and global impacts of climate change we recommend the reader consult summary documents from the US National Academy of Sciences, the Intergovernmental Panel on Climate Change (IPCC), United States federal agencies including the National Oceanic and Atmospheric Administration (NOAA) and Environmental Protection Agency (EPA), and peer reviewed scientific literature.

[2] Definitions of many climate science terms can be found in an appendix at the end of this chapter.

[3] Intergovernmental Panel for Climate Change. *Climate Change 2007: Synthesis Report; Summary for Policymakers*. 2007. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

[4] National Oceanic and Atmospheric Administration. *The State of the Climate Highlights*. 2009. http://www.ncdc.noaa.gov/bams-state-of-the-climate/

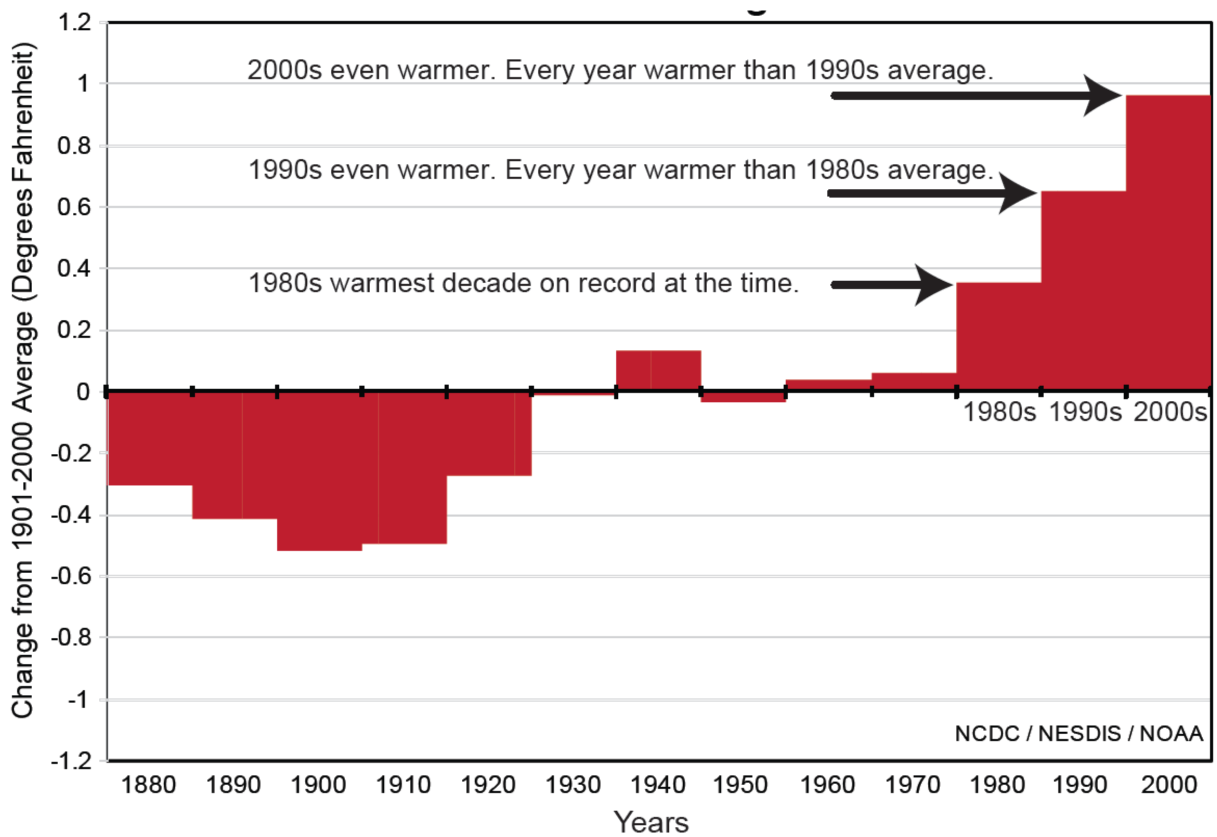
Figure 2-1. Indicators of a Warming World



The panels show changes in climate indicators over several decades. Each of the different colored lines in each panel represents an independently analyzed dataset. *Source: The State of the Climate Highlights: National Oceanic and Atmospheric Administration (NOAA), 2009.*

In the approximately 150 years since industrialization began, concentrations of GHGs in the Earth's atmosphere have risen to higher levels than at any time in the past 800,000 years; atmospheric concentrations of CO_2 are now more than one-third higher than in pre-industrial times. The most rapid rates of warming have occurred during the past 35 years. Each of the last three decades has been much warmer than the decade before it, with each one setting a new and significant record for the highest global temperature. Figure 2-2 depicts this decade-to-decade warming.

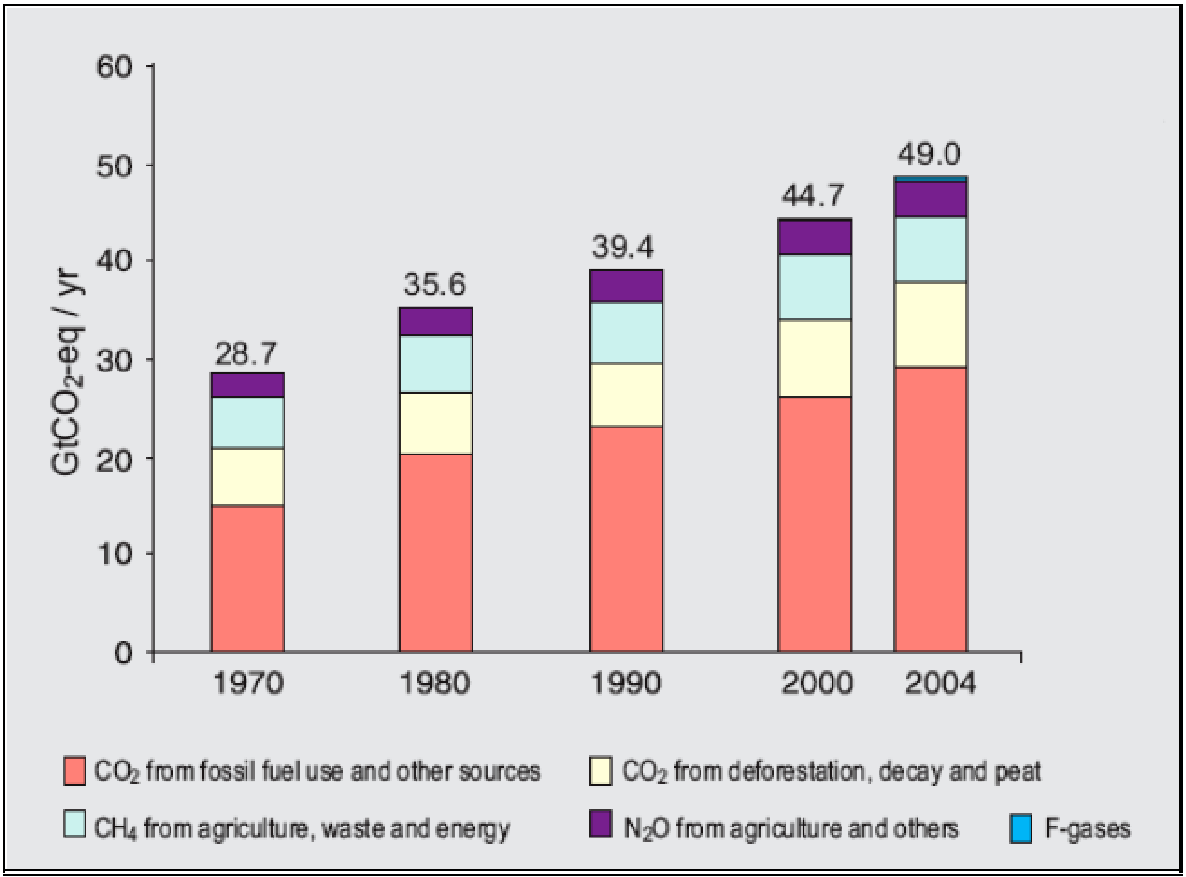
Figure 2-2. Global Temperature Change, Decade Averages



Source: *The State of the Climate Highlights: National Oceanic and Atmospheric Administration*, 2009.

Many human activities contribute GHGs to the atmosphere, but the primary contributor is combustion of fossil fuels (coal, oil, and natural gas), which releases large amounts of CO_2 to the air. Particulate emissions (such as black carbon) from the combustion of fossil fuels and biomass, while short-lived in the atmosphere, also contribute to climate change. Other GHGs, especially methane, nitrous oxide, and halocarbons such as fluorocarbons (F-gases in Figure 2-3), are also released to the atmosphere by human activities, primarily due to fuel combustion and agricultural and industrial processes. As shown in Figure 2-3, global annual emissions of anthropogenic GHGs have increased significantly since 1970.

Figure 2-3. Global Emissions of Anthropogenic Greenhouse Gases, 1970 to 2004



Global annual emissions of anthropogenic GHGs increased significantly from 1970 to 2004. Source: IPCC. *Climate Change 2007: Synthesis Report, Summary for Policymakers*, Figure SPM3 [modified], p.5.

Efforts to lessen the severity of climate change by limiting levels of anthropogenic GHG emissions are already underway in some areas around the globe. However, because the added GHGs will remain in the atmosphere for centuries and some parts of the climate system respond gradually, awareness is growing that some additional climate changes are inevitable. Responses to climate change have grown beyond a focus solely on *mitigating* the amount of GHGs released into the atmosphere to include *adaptation* measures that minimize and prepare for the *effects* of anticipated climate change.

Projections of Future Global Climate Change

Climate scientists use analyses of historical climate conditions combined with complex, computer-based, global climate models to project how the climate will respond in the future to natural and anthropogenic forcings, such as increased GHG concentrations. The models run many different scenarios of future GHG emissions based on estimates of economic and social growth. Model output provides ranges of future temperature increases, rather than point estimates, primarily due to uncertainty regarding which future scenario will occur and limitations in knowledge of how the climate system will respond. Despite the uncertainties, all global climate models project that the Earth will warm in the next century, with a consistent geographical pattern.

Climate model experiments show that even if no additional GHGs were added to the atmosphere, further warming still would occur due mainly to a lag in ocean temperature response. Many of the GHGs currently being added to the Earth's atmosphere have long residence times. For example, 33 percent of the anthropogenic CO_2 added to the atmosphere today will remain in the air for at least 100 years, and 19 percent will remain at 1,000 years.[5] This means that GHGs added now to the atmosphere will continue to warm the planet for hundreds and, possibly, even thousands of years.

Stabilizing Atmospheric Greenhouse Gas Concentrations

To stabilize the atmospheric concentrations of GHGs, GHG emissions must approach equilibrium—a state of balance between GHG sources and sinks. The likelihood and extent of many climate change impacts in New York and elsewhere depend, in part, upon the global concentration of atmospheric GHGs. Generally, the higher the concentrations at which GHGs are stabilized, the greater the average global temperature increase.

Climate Science is the Basis for GHG Stabilization Goals

Since GHGs exert their climate-altering properties on a global scale, emission reductions must occur not only in New York, but globally. In 1992, 154 nations, including the United States, agreed to a series of overarching goals to minimize the risks from climate change, embodied in the United Nations Framework Convention on Climate Change (UNFCCC). Article 2 of the UNFCCC establishes the treaty's long-term objective of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the Earth's climate system."

Scientific evidence suggests that limiting the global average temperature increase to approximately 3.6°F (2°C) above pre-industrial temperatures may minimize the likelihood of the most severe climate impacts and is consistent with the UNFCCC goal of avoiding dangerous climate change.[6] Figure 2-4[7] illustrates the range of potential physical impacts at varying levels of global temperature change. For each impact category, a colored arrow indicates the possible temperature range for a specific physical change to occur: an unbroken arrow with redder color indicates greater likelihood and severity of the physical event. It is important to note that the most severe effects, or "Abrupt and Major Irreversible Changes," may be prevented if the rise in global average temperature is limited to approximately 3.6°F (2°C). Climate change impacts also depend upon the vulnerability and adaptive capacity of natural systems and human populations. Effective management of climate change risks requires policy and decision makers to take flexible, yet significant and sustained actions to reduce GHG emissions and build the state's resiliency to climate change impacts; to learn from new research, monitoring data and scientific assessments; and to adjust future actions accordingly.

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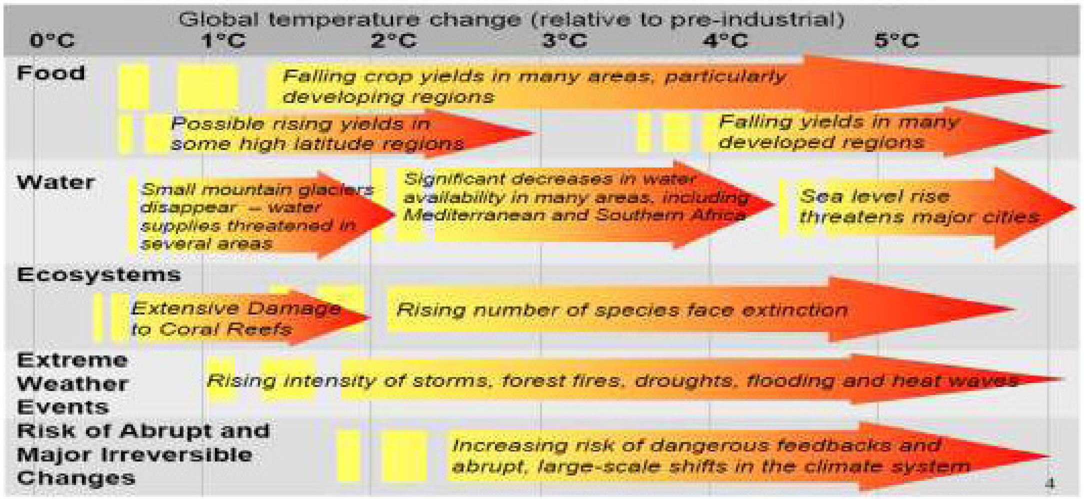
[5] Hansen, J. et. al., (46 co-authors). Dangerous Human-Made Interference with Climate: A GISS Model Study: Figure 9(a) Carbon Cycle Constraints (a) Decay of Pulse CO2 Emissions. *Atmospheric Chemistry and Physics*, 7: 1-262007b. . http://www.atmoschem-phys.org

[6] Parry, M.L., O.F. Canziani, J.P. Palutikof, and Co-authors Technical Summary. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. 2007.http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-ts.pdf

[7] Stern, N. *The Economics of Climate Change: The Stern Review: Executive Summary*. Figure 2, pp v. 2007. http://www.hmtreasury.gov.uk/sternreview_index.htm

Figure 2-4. Projected Impacts of Climate Change



Source: The Economics of Climate Change: The Stern Review, Cambridge University Press, 2007.

The atmospheric GHG concentration that will result in a 3.6°F (2°C) increase in global temperatures cannot be known with great accuracy. The best scientific estimates available, including estimates from the 2007 IPCC Report, indicate that if atmospheric GHG concentrations are stabilized in the atmosphere at approximately 450 ppm of carbon dioxide equivalent (CO_2e), or total GHGs, there is a medium likelihood that warming will not exceed 3.6°F (2°C).[8] To achieve stabilization of atmospheric concentrations at this level, the IPCC estimates that net global GHG emissions must approach zero by the end of this century.[9,10] The interim targets along the pathway to a 450 ppm CO_2e stabilization level require global emissions to peak no later than 2015 and to decrease to 85 percent below year 2000 levels by 2050.[11] The IPCC did not evaluate intermediate reductions for timeframes other than year 2050.

Apportioning GHG Reductions

Determining how much individual states or nations should reduce emissions through mid-century requires consideration of allocation equity and reduction effectiveness.[12] The UNFCCC approach to apportioning GHG emission reduction requirements between developed and

[8] The concentration of greenhouse gases in the atmosphere is already at approximately 375 ppm CO_2e and currently rising at roughly 2.5 ppm every year. IPCC. 2007.

[9] Using paleoclimate evidence and observations of current rates of global change, some recent studies suggest that today's atmospheric GHG concentrations already are too high to maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted. See: Hansen et al. *Target Atmospheric CO_2: Where Should Humanity Aim?* 2008. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter3.pdf

[10] Fisher, B.S., N. Nakicenovic, K. Alfsen, J. Corfee Morlot, F. de la Chesnaye, J.-Ch. Hourcade, K. Jiang, M. Kainuma, E. LaRovere, A. Matysek, A. Rana, K. Riahi, R. Richels, S. Rose, D. van Vuuren, R. Warren. Issues Related to Mitigation in the Long Term Context. In *Climate Change 2007: Mitigation*. 2007. p. 199

[11] Meinshausen, M. (edited by Schellnhuber et. al.) What Does a 2°C Target Mean for Greenhouse Gas Concentration? In *Avoiding Dangerous Climate Change*, 2006.

[12] As previously discussed, global emissions of GHGs must eventually be in quasi-equilibrium with GHG removal mechanisms to allow for stabilization of atmospheric GHG concentrations.

developing nations considers a broad spectrum of parameters, including population, gross domestic product (GDP), GDP growth, and global emission pathways that lead to climate stabilization.[13] Applying these parameters, the UNFCCC concludes that, to reach the 450 ppm CO_2e stabilization target, developed countries must reduce GHG emissions by 80 to 95 percent from 1990 levels by 2050. This is the basis for the Executive Order 24 greenhouse gas reduction goal of 80 by 50.

Summary of the ClimAID Report - Climate Change and New York State

Initiated in 2008, the Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State (ClimAID) was funded by the New York State Energy Research and Development Authority (NYSERDA) as part of its Environmental Monitoring, Evaluation, and Protection (EMEP) Program. The ClimAID team was made up of university and research scientists who are specialists in climate change science, effects, and adaptation. Researchers came primarily, but not exclusively, from Columbia University, Cornell University, and Hunter College of the City University of New York. The goals of the ClimAID project are to provide New York State decision makers with cutting-edge information on the state's vulnerability to, and its ability to derive benefits from, climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge. Further aims of ClimAID are to identify data gaps and monitoring needs to help guide future efforts. As part of the project, the ClimAID team evaluated a set of climate change scenarios for New York State to facilitate the assessment of potential impacts under future conditions.

New York State is vulnerable to a changing climate but, at the same time, has a great potential to adapt to its effects. From the Great Lakes to Long Island Sound, from the Adirondacks to the Susquehanna Valley, climate change will increasingly affect the people and resources of New York State. *Climate hazards* include higher temperatures and more frequent and intense heat waves leading to greater incidence of heat morbidity and mortality, decreased air quality and increased health risks for those with medical conditions such as cardiovascular disease, renal disease, emphysema, and others; increased short-duration warm season droughts and extreme rainfall events affecting food production, natural ecosystems, and water resources; and sea level rise, resulting in both gradual inundation of natural and human habitats and greater risk of damage from coastal storms.

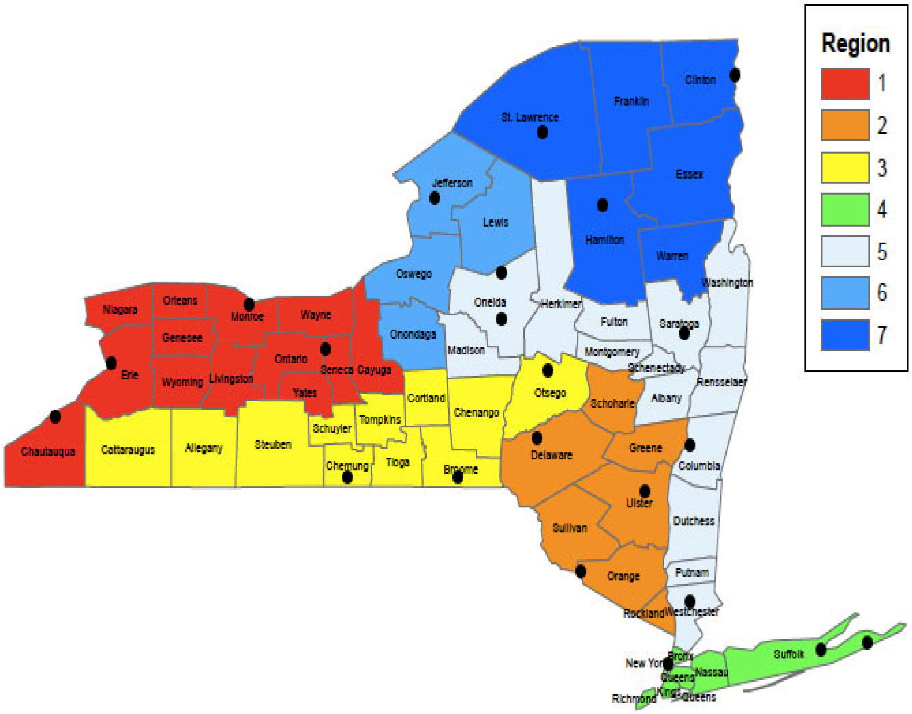
The uncertainties inherent in climate projections and the complex linkages among climate change, physical and biological systems, and socioeconomic factors pose special challenges for New York State decision makers. However, there is a large amount of local and scientific knowledge on climate change that is critical to understanding not only the necessary urgency and magnitude of GHG mitigation, but to reducing vulnerability and building adaptive capacity to respond to the changing climate as well.

The ClimAID researchers divided New York State into seven regions, shown below in Figure 2-5. Historical climate trends and future projections were analyzed for each region and the state as

[13] UNFCCC. *Synthesis of Information Relevant to the Determination of the Mitigation Potential and to the Identification of Possible Ranges of Emission Reduction Objectives of Annex 1 Parties: An Update.* 2008. http://unfcccbali.org/unfccc/images/document/technical_papper.pdf

a whole. Understanding how New York's climate has changed in the past and is projected to change in the future allows for the exploration and identification of potential effects.

Figure 2-5. Regions of New York State used in the climate assessment



Dots represent meteorological stations used in climate analysis. Source: ClimAID.

The current climate in New York State can be described as humid and continental. Key features of New York State's climate include the following:

- Temperature varies widely across the state. Average annual temperature varies from 40°F in the Adirondacks to near 55°F in the New York City metropolitan region.
- Precipitation amounts also vary. Average annual precipitation ranges from approximately 30 inches in Western New York to nearly 50 inches in the New York City region, Tug Hill Plateau, and Adirondacks.
- A variety of extreme events occurs throughout the state:
  - Heat waves, defined as three consecutive days with maximum temperatures above 90°F, are common in urban areas, especially in the southern parts of the state.
  - Short-duration flooding, which can result from heavy rainfall and runoff from snowmelt, affects the entire state.
  - Lake effect snow is a major climate hazard in western and central New York State.
  - Areas along the Atlantic coast and Hudson River Valley are especially prone to coastal storms and their associated effects, including heavy precipitation, high winds, and coastal flooding.

Observed Climate Trends

Temperature and Precipitation

Temperatures in New York State have risen over the course of the 20th century, with the greatest warming coming in recent decades. There has also been an increase in the number of extreme hot days (days at or above 90ºF) and a decrease in the number of cold days (days at or below 32ºF). Statewide, there has been no discernable trend in annual precipitation, which is characterized by large variability, both from year to year and over decades. Table 2-1 shows observed 20th century trends in temperature and precipitation for select meteorological stations in New York.

Table 2-1. 1900-1999 Temperature and Precipitation Trends in New York State

Temperature (°F / decade)

	Annual	Spring	Summer	Fall	Winter
Albany	0.18**	0.25**	0.13*	0.06	0.29**
Elmira	0.01	- 0.02	- 0.09	0.00	0.17
Indian Lake	0.15**	0.13	0.05	0.14*	0.29*
NYC	0.39**	0.45**	0.33**	0.28**	0.53**
Port Jervis	0.06	0.09	0.02	- 0.08	0.20*
Rochester	0.20**	0.26**	0.19**	0.10	0.25*
Watertown	0.17**	0.17*	0.15**	0.08	0.31**

Precipitation (inches / decade)

	Annual	Spring	Summer	Fall	Winter
Albany	1.13**	0.33	0.34	0.36**	0.10
Elmira	0.30	0.01	- 0.08	0.26	0.11
Indian Lake	- 0.06	- 0.01	- 0.04	0.08	- 0.10
NYC	0.47	0.24	- 0.05	0.25	0.04
Port Jervis	0.11	0.15	- 0.21	0.12	0.04
Rochester	0.29	0.01	0.15	0.20*	- 0.07
Watertown	0.35	- 0.01	0.05	0.23*	0.09

* Significant at the 95% level; ** Significant at the 99% level

Sea Level Rise

Sea level in the coastal waters of New York State and up the Hudson River has been steadily rising over the 20th century. As global temperatures have increased, rates of sea level rise have increased as well. During the 20th century, global sea level rise was primarily the result of thermal expansion of ocean waters. Sea level rise in New York coastal regions is a factor of both global sea level rise and local changes in height of the land relative to the height of the continental land mass. Over the 20th century, the rate of sea level rise for the New York coastal region was 1.2 inches per decade. The difference between this rate and the rate of global sea level rise (0.7 inches per decade) was due primarily to local subsidence.

ClimAID Projections of Future New York State Climate Conditions

For the assessment, investigators developed *projections* of temperature, precipitation, and extreme events for each of the seven climate regions and New York State as a whole. For sea level rise, projections were developed for the marine coastal region and the Hudson River estuary. These projections were based on climate data from 16 (seven for sea level rise) *global climate models* (GCMs) and three GHG *emission scenarios*. In addition to these climate projections, for eight sectors across the state (corresponding to the sectors discussed in the Adaptation chapter of the Interim Report), sector-specific climate risks were defined with stakeholder input, and “tailored products” were developed for use in the sector assessments (e.g., the number of heating-degree days in future years was projected for use in the energy sector assessment).

The combination of multiple GCMs and emissions scenarios produced a range of possible outcomes for each future time period and *climate variable*. The results constitute "model-based" probability functions and are presented as a probabilistic range across the potential outcomes.

What is an emission scenario?

An emissions scenario is plausible representation of future global greenhouse gas emissions. Each emissions scenario represents a unique blend of demographic, social, economic, technological, and environmental assumptions. The ClimAID analysis used three scenarios:

A2: Relatively rapid population growth and limited sharing of technological change combine to produce emissions growth throughout the century and high greenhouse gas levels by the end of this century.

A1B: Effects of economic growth are partially offset by introduction of new technologies and decreases in global population after 2050. This trajectory is associated with relatively rapid increases in greenhouse gas emissions and the highest overall carbon dioxide levels for the first half of this century, followed by a gradual decrease in emissions after 2050.

B1: This scenario combines the A1 population trajectory with societal changes tending to reduce greenhouse gas emissions growth. The net result is the lowest greenhouse gas emissions of the three scenarios, with emissions beginning to decrease by 2040.

Higher average annual temperatures and sea level rise are extremely likely for New York State. For temperature and sea level rise, all climate models analyzed project continued increases over the coming century, with a high likelihood of more rapid temperature increases and sea level rise than occurred over the 20th century. Although most projections indicate small increases in precipitation, some do not, and decade-by-decade precipitation variability is large; therefore, precipitation projections are less certain than temperature projections.

New York State Temperature and Precipitation Projections

Figure 2-6 shows the projected changes in average annual temperature and precipitation for the state, averaged across the 16 GCMs for one of the three scenarios for possible future GHG emissions. Although only a single emission scenario is shown (the A1B "middle" emissions scenario), the spatial pattern is similar for the other two scenarios. Table 2-2 shows specific mean annual change projections for seven regions of the state.

Figure 2-6. Projected changes in annual temperature and precipitation for the 2080s in the Northeast, under the A1B ("middle") emissions scenario, relative to the 1970-1999 baseline

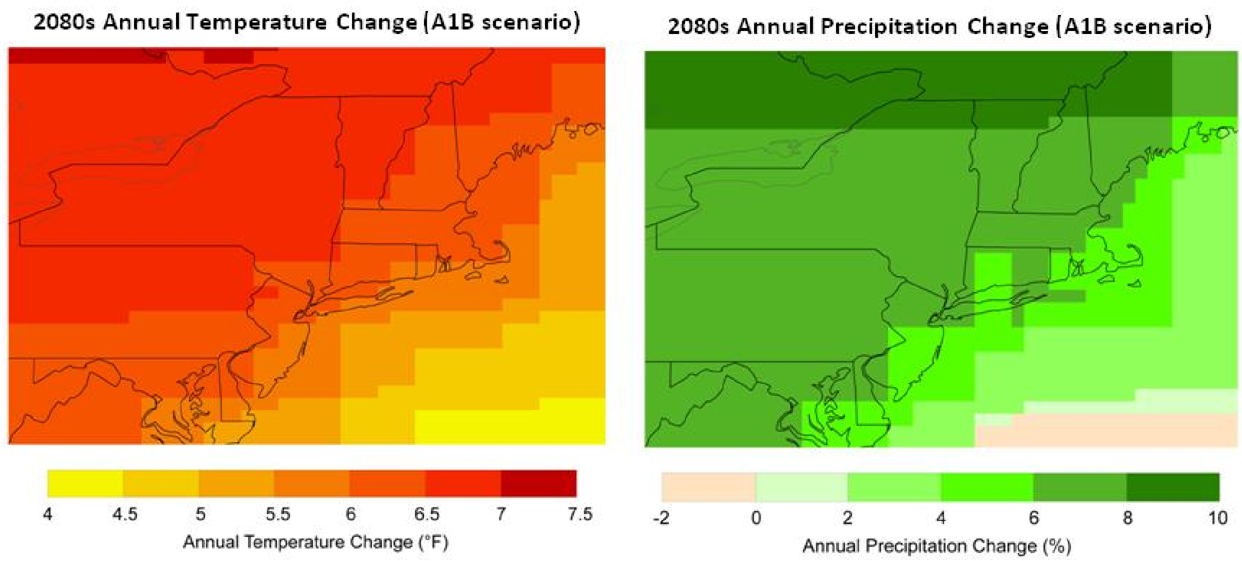


Table 2-2. Temperature and Precipitation Projections for the Seven ClimAID Regions

Region 1	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	48° F	+1.5 to 3.0° F	+3.0 to 5.5° F	+4.5 to 8.5° F
Precipitation Central Range	37 in	0 to +5 %	0 to +10 %	0 to 15 %

Stations used for Region 1 are Buffalo, Rochester, Geneva, and Fredonia.

Region 2	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	48° F	+1.5 to 3.0° F	+3.0 to 5.0° F	+4.0 to 8.0° F
Precipitation Central Range	48 in	0 to +5 %	0 to +10 %	+5 to 10 %

Stations used for Region 2 are Mohonk Lake, Port Jervis, and Walton.

Region 3	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	46° F	2.0 to 3.0° F	+3.5 to 5.5° F	+4.5 to 8.5° F
Precipitation Central Range	38 in	0 to +5 %	0 to +10 %	+5 to 10 %

Stations used for Region 3 are Elmira, Cooperstown, and Binghamton.

Region 4	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	53° F	+1.5 to 3.0° F	+3.0 to 5.0° F	+4.0 to 7.5° F
Precipitation Central Range	47 in	0 to +5 %	0 to +10 %	+5 to 10 %

Stations used for Region 4 are New York City (Central Park and LaGuardia Airport), Riverhead, and Bridgehampton.

Region 5	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	50° F	+1.5 to 3.0° F	+3.0 to 5.5° F	+4.0 to 8.0° F
Precipitation Central Range	51 in	0 to +5 %	0 to +10 %	+5 to 10 %

Stations used for Region 5 are Utica, Yorktown Heights, Saratoga Springs, and the Hudson Correctional Facility.

Region 6	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	44° F	+1.5 to 3.0° F	+ 3.5 to 5.5° F	+4.5 to 9.0° F
Precipitation Central Range	51 in	0 to +5 %	0 to +10 %	+5 to 15 %

Stations used for Region 6 are Boonville and Watertown.

Region 7	Baseline[1] 1971-2000	2020s	2050s	2080s
Air temperature Central Range[2]	42° F	+1.5 to 3.0° F	+3.0 to 5.5° F	+4.0 to 9.0° F
Precipitation Central Range	39 in	0 to +5 %	0 to +10 %	+5 to 15 %

Stations used for Region 7 are Wanakena, Indian Lake, and Peru.

[1] The baselines for each region are the average of the values across all the stations in the region.

[2] Shown are the central ranges (middle 67%) of values from model-based probabilities; temperature ranges are rounded to the nearest half-degree and precipitation to the nearest 5%.

Sea Level Rise

In 2007, the IPCC concluded that global sea level will likely rise between 7 and 23 inches by the end of the century (2090-2099), relative to the base period (1980-1999), not counting unexpected rapid changes in ice flow from the Greenland and Antarctic ice sheets. These projections do not consider all ice sheet melting processes or cover the full likely range of global temperature increase given in the IPCC Fourth Assessment Report (up to 11.5 ºF). The “rapid ice-melt” scenario is an alternative method to estimate future sea level rise that incorporates observed and longer-term historical melt rates, and documented rates of melting in past climate eras, and includes the possibility of accelerated melting of land-based ice sheets and glaciers. Projections based on this scenario are higher than the IPCC projections.

For the ClimAID assessment, a set of projections for the ocean coastal area of New York State (including the tidal extent of the Hudson River north to Troy) was developed based on IPCC global climate models and methods.[14] A set of higher projections for a “rapid ice melt scenario” was also developed. These projections are provided in Table 2-3.

Table 2-3. Sea Level Rise Projections (relative to 2000-2004 baseline)

Region 4: Lower Hudson Valley, New York City, & Long Island	2020s	2050s	2080s
Sea Level Rise[1] Central Range	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Sea Level Rise[1,2] Rapid Ice Melt	+ 5 to 10 in	+ 19 to 29 in	+ 41 to 55 in
Region 5: Mid-Hudson Valley & Capital Region	**2020s**	**2050s**	**2080s**
Sea Level Rise[1] Central Range	+ 1 to 4 in	+ 5 to 9 in	+ 8 to 18 in
Seal Level Rise[1,2] Rapid Ice Melt	+ 4 to 9 in	+ 17 to 26 in	+ 37 to 50 in

[1] Shown are the central ranges (middle 67%) of values from model-based probabilities rounded to the nearest inch.
[2] The rapid ice melt scenario is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic ice sheets and paleoclimate studies.

Changes in Extreme Events

Extreme climate events, such as heat waves and heavy rainstorms, significantly impact New York’s communities and natural resources and often have disproportionate effects on urban and rural systems. Probabilities of the future occurrence of extreme events in New York State were developed, based on climate models. The following are likely to occur during the 21st century:

- Heat waves are expected to become more frequent and intense.
- Intense precipitation events are expected to become more frequent.
- Storm-related coastal flooding is expected to increase due to rising sea levels.

[14] The 2009 New York City Panel on Climate Change sea level rise projections for the New York City area are identical to the ClimAID projections for Region 4.

As an example, projections for such events in Central New York (Region 3) are shown in Table 2-4.

Table 2-4. Projections of changes in extreme events: minimum/maximum; central range* for Central New York (Region 3)

	Extreme Event	Baseline	2020s	2050s	2080s
Heat waves & Cold Events	# of days per year with max temperature at or above:				
	90°F	10	11/25; 14 to 19	15/45; 21 to 33	19/70; 26 to 56
	95°F	1	2/7; 2 to 4	2/18; 4 to 10	4/38; 7 to 24
	# of heat waves per year[2]	1	1/3; 2 to 3	2/6; 3 to 4	2/9; 3 to 8
	average duration (in days)	4	4/5; 4 to 5	4/5; 4 to 5	4/7; 5 to 5
	# of days per year with min temperature at or below 32°F	152	116/145; 122 to 124	86/168; 106 to 122	68/124; 87 to 114
Intense Precipitation	Number of days per year with rainfall exceeding:				
	1 inch	6	5/8; 6 to 7	5/8; 6 to 7	5/10; 6 to 8
	2 inches	0.6[1]	0.5/1; 0.6 to 0.9	0.5/1; 0.6 to 1	0.4/2; 0.7 to 1

* The minimum, central range (middle 67%), and maximum of values from model-based probabilities across the GCMs and GHG emissions scenarios are shown.

[1] Decimal places shown for values less than 1, although this does not indicate higher precision/certainty. More generally, the high precision and narrow range shown here are due to the fact that these results are model-based. Due to multiple uncertainties, actual values and range are not known to the level of precision shown in this table.

[2] Defined as three or more consecutive days with maximum temperature exceeding 90°F

There is potential for changes in other climate variables as well. However, because quantitative information is either unavailable or considered less reliable, the changes in these variables are described qualitatively at this time. ClimAID researchers developed confidence levels for these projections using a system similar to that used by in the IPCC's Fourth Assessment Report (Table 2-5). These ratings are based on the correspondence between climate model projections and observed climate, agreement among climate models, and expert judgment.

Table 2-5. Explanation of ClimAID Confidence Level Terminology

Term	Probability of Occurrence
Extremely likely	**> 95%**
Very likely	**> 90%**
Likely	**> 66%**
More likely than not	**> 50%**

Table 2-6 shows the probable direction of change over the 21st century for New York City and Long Island, as well as the likelihood associated with the qualitative projection. For these variables, which can have large effects on infrastructure, quantitative projections are not possible due to insufficient information.

Table 2-6. Qualitative changes in extreme events for New York City and Long Island (Region 4)

Extreme Event	Probable Direction Throughout 21st Century	Likelihood[1]
Heat index[2]	↑	Very likely
Ice storms/ freezing rain	*Unknown*	
Snowfall frequency & amount	↓	Likely
Downpours (precipitation rate/hour)	↑	Likely
Lightning	*Unknown*	
Intense hurricanes	↑	More likely than not
Nor'easters	*Unknown*	
Extreme winds	↑	More likely than not

[1] Likelihood definitions found in Table 2-5

[2] The National Weather Service uses a heat index related to temperature and humidity to define the likelihood of harm after "prolonged exposure or strenuous activity" (http://www.weather.gov/om/heat/index.shtml).

Longer-term Projections

Consideration of climate projections past the year 2100 is beyond the current planning horizons of most infrastructure managers. However, planning for some long-lived infrastructure, which, for example, could include new aqueducts and subway lines, may need to consider the climate during the next century. Furthermore, many pieces of infrastructure intended only to have a useful lifespan within this century may remain operational beyond their planned lifetimes. It is also possible that future projects aimed specifically at climate change mitigation or adaptation might benefit during their planning stages from long-term climate guidance.

Because the climate of the 2100s is highly uncertain, only qualitative projections are possible, especially at a local scale. Despite uncertainties, at least two key climate variables, sea level rise and temperature, will in all probability continue to increase into the next century. Additionally, if evidence over the next decade continues to show accelerated melting of the ice sheets on Greenland and West Antarctica, it would greatly increase the probability that these ice sheets would contribute significantly to sea level rise in the next century, even if GHG concentrations, and perhaps even global temperatures, were to stabilize at some point during this century.

Uncertainty and Likelihoods

Projections of future climate conditions are characterized by large uncertainties. At the global scale these uncertainties can be divided into two main categories:

- Uncertainties in future land-use changes and emissions of GHG gases and other climate drivers, such as aerosols and black carbon
- Uncertainties regarding the sensitivity of the climate system to GHG concentrations and other climate drivers.

When considering future changes at local and regional, geographic scales, uncertainties increase, for two additional reasons:

- Climate variability, such as precipitation extremes, can be especially large over small regions, partially masking more uniform effects of climate change.
- Changes in local atmospheric processes that operate at small scales, such as land or sea breezes, may not be captured by the global climate models used to make projections.

Uncertainties may be reduced by using projections generated from a range of global climate models and GHG emissions scenarios as was done with ClimAID, but they cannot be fully eliminated. Additionally, averaging the projections over 30-year time periods and showing changes in climate through time, rather than absolute climate values, reduces the local- and regional-scale uncertainties. However, these techniques do not address the possibility that local processes may change with time.

New York State's Vulnerability to Climate Change

Climate change is already impacting New York State's society, economy, and natural ecosystems. With changes in temperature, precipitation patterns, and sea level projected to continue, the impacts to New York State are likely to increase. Presented here are the eight sectors of the state considered in the ClimAID assessment, including some of the sector-specific impacts expected as the climate continues to change.

Agriculture

Agriculture is a significant component of the New York economy and includes large wholesale grower-shippers selling products nationally and internationally, a substantial dairy industry, and thousands of small farm operations selling direct retail and providing communities throughout the state with local, fresh produce. Farmers will be on the front lines of coping with climate change, but the direct impacts on crops, livestock, and pests, and the costs of farmer adaptation will have cascading effects beyond the farm gate and throughout the New York economy.

Climate change presents both economic challenges and opportunities for agriculture in New York State. Warmer temperatures, a longer growing season, and increased atmospheric carbon dioxide could create opportunities for farmers with enough capital to take risks on expanding production of warmer temperature-adapted crops (e.g., European red wine grapes, peaches, tomato, watermelon) assuming a market for new crops can be developed. However, the dairy industry as well as many of the high-value crops that currently dominate the state's agriculture economy (e.g., apples, cabbage, potatoes), benefit from the state's historically relatively cool climate. As New York's climate changes, some crops may have yield or quality losses associated with increased frequency of drought; increased summer high temperatures; increased risk of freeze injury as a result of more variable winters; and increased pressure from weeds, insects, disease, or other factors. Dairy milk production per cow will decline in the region as temperatures and the frequency of summer heat stress increase.

The impacts from climate change will occur on top of non-climate stressors already affecting the sector. For example, as with many other businesses in New York and elsewhere, agriculture is sensitive to the volatile and rising costs of energy. Also, New York farmers are affected by rapidly changing consumer preferences and demands of supermarket buyers; increasingly, farmers must consider global market forces and international competition as well as competition from neighboring states. As a final example, too much as well as too little rainfall is currently a recurrent problem for farmers in New York. Currently, summer precipitation is insufficient to fully meet the water needs of non-irrigated crops most years, while brief, intense rainfall events can have detrimental effects on crops. Climate change is likely to exacerbate these challenges.

Coastal Zones

For the ClimAID assessment, the coastal zone is defined as the shoreline of New York State, including coastal wetland areas and inland areas adjacent to the shoreline that are likely to be affected by sea level rise and coastal storms. Also considered are the potential effects of climate change up the Hudson River estuary to the Troy Dam.

Global sea level rise due to climate warming will have a significant impact on New York's coastal areas, in addition to other impacts like ocean circulation changes and higher water temperatures. The effects of global sea level rise will be amplified in New York State due to coastal subsidence caused by ongoing adjustments of the Earth's crust to the melting of the ice sheets that began 20,000 years ago.

New York's coastal zones, including the New York City metropolitan region, are becoming more developed, further increasing their vulnerability to flooding, coastal erosion, and sea level rise. Sea level rise will greatly amplify risks to coastal populations and will lead to permanent inundation of low-lying areas, more frequent flooding by storm surges, and increased beach erosion. Saltwater could reach farther up the Hudson River and into estuaries, contaminating urban water supplies. Tides and storm surges may propagate farther up the Hudson River increasing flood risk far from the coast.

High water levels, strong winds, and heavy precipitation resulting from strong coastal storms already cause billions of dollars in damages and disrupt transportation and power distribution systems. Barrier islands are being dramatically altered by strong coastal storms as ocean waters over wash dunes, create new inlets, and erode beaches. Warming ocean waters have the potential to produce stronger storms by increasing the source of energy for these storms.

Non-climate-related stresses will compound the effects of climate change. In the coastal region, most of these are associated with human consumption of natural resources and land-use practices. For example, coastal development, construction of organized drainage, and impervious surfaces have led to a reduction in groundwater recharge and degraded coastal water quality. The interconnection among precipitation, land use, and local fish populations has also been documented, suggesting that increased urbanization may lead to a reduction in stream biodiversity. In addition to water-quality-related stresses, fish stocks and other marine ecosystems may be affected by harvesting practices, disease, normal population dynamics (increased predation), and recruitment processes. Over-development along the coast increases the demand for groundwater, which could lead to drawdown of the aquifer and increased saltwater intrusion. Coastal infrastructure also inhibits natural migration of marine systems, including wetlands and barrier islands.

The most economically significant risks and vulnerabilities in the coastal areas are the multifaceted risks from higher sea levels and consequent higher storm surges. Substantial economic losses can be expected in buildings, infrastructure (including underground infrastructure for utilities, such as gas lines and telecommunications cables), natural areas, and recreation sites. Other impacts from precipitation changes, higher temperatures, higher ocean temperatures and ocean acidification will also have significant impacts.

Ecosystems

Ecosystems, as defined here, encompass the plants, fish, wildlife, and other biotic resources of all natural and managed landscapes (e.g., forests, grasslands, aquatic systems) in New York State except those land areas designated as agricultural or urban. This sector includes timber and maple syrup industries, as well as tourism and recreation businesses conducted within natural and managed ecosystems. It also encompasses wetlands, waterways, and lakes as well as their associated fisheries. Ecosystems services provided by New York's landscapes include preservation of freshwater quality, flood control, soil conservation, carbon sequestration, biodiversity support, recreation, and preservation of wild places and heritage sites.

The initial impacts of climate change on natural systems are already apparent, with documented accounts of changes in the seasonal timing of events like bud-break or flowering and species range shifts across the Northern Hemisphere. Within the northeastern United States, researchers have documented earlier bloom dates of woody perennials, earlier spring arrival of migratory birds, and other biological and ecological responses. Species and ecosystems are responding directly to climate drivers and indirectly to secondary effects, such as changes in timing and abundance of food supply, changes in habitat, and increased pest, disease, and invasive species pressure. Ultimately, biodiversity, net primary productivity, and biogeochemical cycles could be affected by climate change. To date, however, there is not yet clear evidence of climate change impacts on important ecosystem services such as carbon sequestration, or water storage and quality in New York State; our understanding of climate change impacts diminishes as projections are scaled up from individual species and ecosystem structure to ecosystem function and services.

Within the next several decades, New York State is likely to see widespread shifts in species composition in the state's forests and other natural landscapes, with the loss of spruce-fir forests, alpine tundra, and boreal plant communities. Warmer temperatures will favor the expansion of some invasive species into New York, such as the aggressive weed kudzu and the insect pest hemlock woolly adelgid. Some habitat and food generalists (such as white-tailed deer) may also benefit. Additionally, higher levels of carbon dioxide tend to preferentially increase the growth rate of fast-growing species, which are often weeds and other invasive species. Both of these climate factors could also increase the productivity of some hardwood tree species, provided growth is not limited by other factors such as drought or nutrient deficiency.

Lakes, streams, inland wetlands, and associated aquatic species will be highly vulnerable to changes in the timing, supply, and intensity of rainfall and snowmelt; groundwater recharge; and duration of ice cover. Increasing water temperatures will negatively affect brook trout and other native coldwater fish.

In coastal areas, sea level rise may become the dominant stressor acting on vulnerable salt marshes. Loss of coastal wetlands reduces fish and shellfish populations. Higher water temperatures also affect these populations. Some marine species, such as lobsters, are shifting their ranges north out of New York State, while other species, such as the blue claw crab, are increasing in the warmer waters.

The impacts of climate change cannot be viewed in isolation, as other stressors are also affecting ecosystems and will affect vulnerability to climate change. While society and policy makers are likely to focus on ecosystem services, adaptation interventions by natural resource managers often will be implemented at the level of species, communities, and habitats. As climate changes and the habitable zones of wild species continue to shift northward and/or up in elevation throughout the century, natural resource managers will face new challenges in maintaining ecosystem services and difficult decisions regarding changes in species composition of natural communities.

For revenue-generating aspects of the ecosystem sector, including winter tourism and recreational fishing, climate change may impose obvious economic costs. For other facets, such as forest-related ecosystem services, heritage value of alpine forests, and habitat for endangered species, the economic costs associated with climate change are real but more difficult to quantify.

Energy

New York State’s electricity and gas supply and distribution systems are highly reliable. As they are designed to operate under a wide range of temperature and weather conditions, the system is deliberately robust and resilient. However, threshold conditions (as opposed to the mean or standard conditions) or shifts in thresholds caused by climate change can create vulnerability within the energy sector and substantially increase the cost of maintaining reliability.

Climate change is anticipated to impact the energy sector in several ways: First, energy demand will change due to a changing combination of heating and cooling needs, stressing power supplies and increasing peak demand loads. With higher mean temperatures and increased numbers of extremely hot days, the cost of maintaining a reliable supply of electricity is likely to increase in all parts of the state. In particular, climate change will place additional pressures on New York City, where the system is already taxed during very hot summer days. Extreme weather events may also increase costs of meeting electricity demand.

Second, the physical structures (power plants, electrical lines, etc.) will be affected by changing climate conditions. Increased air and water temperatures may affect the operation of some power plants. Transformers and distribution lines for both electricity and gas supply are vulnerable to extreme weather events, temperature, and flooding. Coastal infrastructure is vulnerable to flooding as a result of sea level rise and severe storms.

Renewable generation may also be affected. Hydropower is vulnerable to drought and changes in precipitation patterns. The availability and reliability of solar power systems are vulnerable to changes in cloud cover (although this may be offset by advances in technology), and wind power systems are similarly vulnerable to changes in wind speed and direction. The extent to which cloud cover and wind will be affected by climate change is currently unclear. The effect of climate change on low-carbon biomass as an energy feedstock is also unclear, though it is important to note that biomass availability depends to some degree on the suitability of weather conditions during the growing season.

Additional indirect impacts on the energy sector, such as the financial impacts on investors or insurance companies linked to vulnerable energy system assets or on customers forced to grapple with more volatile energy prices resulting from changing climate conditions, may be even more important than the direct impacts. New York's energy and electricity sector is a key focus for a variety of the mitigation policy options presented in the Interim Report. Reliance on this sector to help power the clean-energy economy must consider the expected impacts from an already changing climate.

Public Health

Climate change vulnerabilities in the public health sector are, to a large extent, ones in which public health and environmental agencies are already engaged. However, climate change places an additional resource and cost burden on public health agencies. Climate-related risk factors include heat events, extreme storms, disruptions of water supply and quality, decreased air quality, changes in timing and intensity of pollen and mold seasons, and alterations in patterns of infectious disease vectors and organisms. Demand for health services and the need for public health surveillance and monitoring will increase as climate continues to change.

As a result of these climate risks, some climate-related health vulnerabilities have emerged. Heat-related illness and death are projected to increase, while cold-related death is projected to decrease. Increases in heat-related death are projected to outweigh reductions in cold-related death. Cardiovascular and respiratory-related illness and death will be affected by worsening air quality, including possibly more smog, wildfires, pollens, and molds.

Vector-borne diseases, such as those spread by mosquitoes and ticks (such as West Nile virus), may expand or their distribution patterns change. Water- and food-borne diseases are likely to increase without adaptation intervention. Water supply, recreational water quality, and some food production will be at increased risk due to increased temperatures and changing precipitation patterns.

More intense storms and flooding could lead to increased stress and mental health impacts, impaired ability to deliver public health and medical services, increased respiratory diseases such as asthma, and increased outbreaks of gastrointestinal diseases.

These vulnerabilities span a range from the relatively direct, data-rich and well understood to more complex, multi-factorial systems for which both data and models are currently underdeveloped. Uncertainties pervade any effort to predict either direct or indirect health impacts of climate change. These uncertainties increase the importance of building resilience into the public health system to cope with inevitable surprises to come.

Telecommunications and Information Infrastructure

Telecommunications infrastructure is vital to New York State's economy and welfare; its capacity and reliability are essential to the effective functioning of global commerce and the state's economy and is especially vital during emergencies. The sector has important public functions, but it is largely privately operated. The sector poses special challenges to climate change analysis. Businesses in the sector are reluctant to disclose some classes of information that would be relevant to climate change assessments because of competitive pressures.

The rapid technological changes inherent in technology and information systems mean that the planning horizons and life spans for much of its infrastructure are at best on the order of a decade. The sector is tightly coupled to the energy sector, with power outages affecting the reliability of communication services; many of its communication lines also are located on the same poles as power lines. Modern digital technologies, including communication services based on fiber optics, broadband, and the Internet, can be more vulnerable to power outages than traditional landline technology.

A central concern of the communication infrastructure sector is how to ensure that the perpetual introduction of new technologies enhances the reliability and uninterrupted access to services. Such a focus is essential both now and in the future, when the risks from climate change may increase.

Communication service delivery is vulnerable to hurricanes, lightning, ice, snow, wind storms, and other extreme weather events, some of which are projected to change in frequency and intensity. Communication lines and other infrastructure are vulnerable to the observed and projected increase in heavy precipitation events and resulting flooding and freezing rain. In coastal and near-coastal areas, sea level rise in combination with coastal storm surge flooding will be a considerable threat especially later this century. The delivery of communication services is sensitive to power outages, such as those resulting from the increased demand associated with heat waves, which are expected to increase with climate change.

Under current climate conditions and severe weather events, there are already serious vulnerabilities that often prevent the telecommunications sector from delivering services to the public.

Transportation

There is a very large range of potential climate change impacts on the state's transportation system, but the primary impacts and costs will be on infrastructure investment and management of rising sea levels and the accompanying increase in storm surges for coastal areas.

The highest concentration of transportation infrastructure is located in regions that are population centers and vital drivers of the New York economy. Climate change threatens many of these dense metropolitan transportation systems. Ground transportation systems (roads and rails) in coastal population centers, for example, are often placed underground in tunnels very close to or below sea level and are vulnerable to sea level rise. Since transportation is a networked system, delays, failures, and catastrophic failures in one system often have cascading effects on other parts of the system.

Over the next few decades, heat waves, heavy precipitation events, and windstorms are likely to dominate the causes for moderate, more frequent transportation problems such as flooded streets and delays in mass transit. By 2050 at the latest, sea level rise and storm surge will become more significant threats. By later this century, these threats will be so severe that major adaptations will have to be in place, not only in the coastal zone, but up the Hudson River estuary to cities including Troy and Albany. Low-lying transportation systems such as subways and tunnels, especially in coastal and near-coastal areas, are at particular risk of flooding as a result of sea level rise and heavy-precipitation events.

Materials used in transportation infrastructure, such as asphalt and train rails, are vulnerable to increased temperatures and frequency of extreme heat events. Air-conditioning requirements in buses, trucks, and trains, and ventilation requirements for tunnels will increase. Runways may require lengthening in some locations since hotter air provides less lift, necessitating higher speeds for takeoff.

The Great Lakes may see a shorter season of winter ice cover, leading to a longer shipping season. However, reduced ice cover is also likely to mean an increase in "lake effect" snow events, which cause various transportation-related problems.

Air- and land-based transportation systems are vulnerable to ice and snowstorms, although requirements for salting and snow removal may decrease as snow tends to turn more often into rain. Freeze/thaw cycles that disturb roadbeds may increase as winter temperatures rise. Currently, New York State has the most days per year of freezing rain in the nation, affecting air and ground transportation directly and also indirectly through electric and communication outages.

Water Resources

New York State's water resources are managed by an array of large and small agencies, governments, and institutions, with little statewide coordination. In 2000, New York State's 19 million residents consumed approximately 2,200 million gallons per day of fresh surface water and 890 million gallons per day of fresh groundwater for public water supply, irrigation, and industrial uses. This water comes from a diverse range of sources, each with different levels of vulnerability to climate change.

Although there are several water quality concerns directly linked to average air temperatures, in general, hydrologic processes are dependent on multiple interacting climate factors. In addition to temperature, possible future changes in timing and quantity of snow, rainfall, and evaporation may have the following impacts on the state's water resources:

- Rising air temperatures intensify the water cycle by driving increased evaporation and precipitation. The resulting altered patterns of precipitation include more rain falling in heavy events, often with longer dry periods between rain events. Such changes can have a variety of effects on water resources.
- Increasing water temperatures in rivers and streams will affect aquatic heath and reduce the capacity of streams to assimilate effluent from wastewater treatment plants.
- Heavy downpours have increased over the past 50 years and this trend is projected to continue, causing an increase in localized flash flooding in urban areas and hilly regions. Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable development within floodplains.
- At the same time as downpours occur more often, more moderate rain events are expected to become less frequent during the summer, resulting in additional and possibly longer summer dry periods and affecting water supply systems with limited storage. Reduced summer flows on large rivers and lowered groundwater tables could lead to conflicts among competing water users.

Although New York is a water-rich state, it is already experiencing water resource challenges. The most economically significant risks may be to coastal infrastructure, including wastewater treatment plants and water supply systems (ground and surface) from rising sea levels and associated storm surges. The state's water and wastewater treatment infrastructure is in dire need of repair and upgrade; the anticipated challenges associated with a changing climate will only exacerbate the situation.

Inland flooding is also an important risk. Other economically important risks and vulnerabilities include the costs of droughts of potentially increased intensity and frequency, losses in hydropower production, and increased costs of water quality treatment. If there are more-frequent climate-related power losses, this could be costly in both economic and regulatory terms to water supply and wastewater treatment plants.

Demand for water continues to grow, including for human consumption, agricultural use, and energy production. As other parts of the country experience large changes in drought frequency and intensity, New York's water resources may become a defining economic asset resulting in the migration of people and businesses into the state. This may bring some economic benefits, but will present new challenges as pressure on water resources increases.

Conclusion

The impacts of climate change in New York State will vary across sectors. However, it is likely that significant societal and natural resource disruption will result, and associated costs incurred in all sectors if the climate change threat is not addressed. Adaptation planning and GHG mitigation efforts can reduce the potential economic impacts.

Chapter 3 Inventory and Forecast of New York State's Greenhouse Gas Emissions

Introduction

This chapter summarizes New York's greenhouse gas (GHG) emissions and sinks (carbon storage) from 1990 to 2030. The inventory and reference case forecasts were prepared to inform the climate action planning effort outlined in Chapter 1 by providing a comprehensive understanding of current and possible future GHG emissions. The information in this chapter reflects the information presented in the *New York Greenhouse Gas Emissions Inventory and Forecast* report (hereafter referred to as the Inventory and Forecast report).

Historical GHG emissions estimates (1990 through 2008)[1] were developed using a set of generally accepted principles and guidelines for state GHG emissions inventories, relying to the extent possible on New York-specific data and inputs. The reference case forecasts (2009- 2030) are based on a compilation of various existing forecasts of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the final Inventory and Forecasts report.

Several demographic trends[2] that could affect future emissions are not fully captured in the current approach to developing New York's energy demand forecasts. Current patterns suggest per capita emissions could fall as the downstate population grows and as the population increases in age. Per capita emissions are generally lower downstate than upstate, and people over 65 generally live in smaller housing units and travel less than people under 65. However, total statewide emissions are expected to rise, driven by increased total population, growth in economic activity, aging housing stock and increased vehicle miles traveled.

The average age of housing stock could increase as the proportion replaced declines. However, new housing units that are built may be smaller on average than the current stock to accommodate increased numbers of smaller families and empty nesters. Given that relatively few new housing units are expected to be built in the next thirty years, opportunities to achieve emissions reductions through improved transportation and land use planning may be limited.

The Inventory and Forecast report covers the six types of gases included in the U.S. GHG inventory:[3] carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalent (CO_2e), which indicates the relative

[1] The last year of available historical data for each sector varies between 2005 and 2008.

[2] See box, Demographic Trends, in Ch. 4.

[3] U.S. Environmental Protection Agency. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008*.April 2010. EPA430-R-08-006. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential-weighted basis.[4]

It is important to note that the emissions estimates reflect the GHG emissions associated with the electricity sources used to meet New York's demands, corresponding to a consumption-based approach to emissions accounting that includes emissions from imported electricity. Another way to look at electricity emissions is to consider the GHG emissions produced by electricity generation facilities in the state, a production-based method. The study covers both methods of accounting for emissions, but for consistency, all total results are reported as consumption-based.

New York GHG Emissions: Sources and Trends

Figure 3-1 shows the relative apportionment of New York's GHG emissions in comparison with the rest of the U.S. as well as the world, all for 2005 (the latest year for which global emissions data were available). New York's share of emissions within the U.S. (3.8 percent) was smaller than its share of the U.S. population (6.5 percent). In contrast, the U.S. share of the world's GHG emissions in 2005 (18 percent) was much greater than its share of the 2005 population (4.6 percent). Nonetheless, New York's GHG emissions accounted for 0.7 percent of the world's GHG emissions in 2005.

[4] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth–atmosphere system. Holding everything else constant, increases in GHG concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth). See: Boucher, O., et al. "Radiative Forcing of Climate Change." Chapter 6 in *Climate Change 2001: The Scientific Basis*. Contribution of Working Group 1 of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

Figure 3-1. 2005 National and Global Context for Greenhouse Gas Emissions

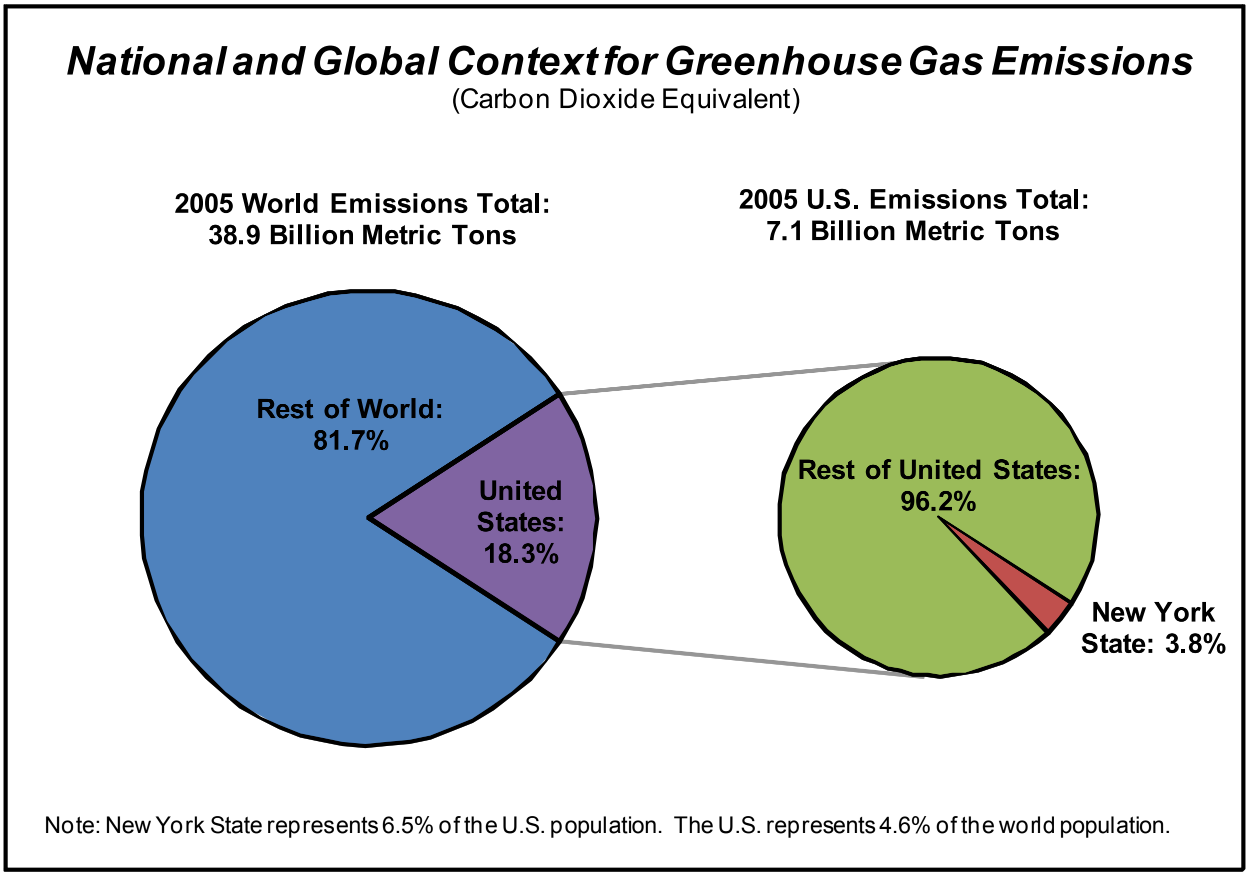


Table 3-1 provides a summary of GHG emissions estimated for New York by sector and gas in 2008, the most recent year for which historical data were available for most sectors. Since the six major greenhouse gases—CO_2, CH_4, N_2O, PFC, HFC, and SF_6—have different global warming potentials the emissions are stated in CO_2e to give a common frame of reference. The sections that follow discuss GHG emissions sources and sinks, trends, forecasts, and uncertainties.

Table 3-1. 2008 New York State Greenhouse Gas Inventory ($MMtCO_2e$)

Sources	CO_2	CH_4	N_2O	PFC	HFC	SF_6	Total (inc. Net Imports of Electricity)	% of Total (inc. Net Imports of Electricity)
Fuel Combustion (inc. Net Imports of Electricity)	**212.81**	**0.73**	**2.39**	**-**	**-**	**-**	**215.94**	**85.16%**
Fuel Combustion (exc. Net Imports of Electricity)	**204.21**	**0.73**	**2.36**	**-**	**-**	**-**	**207.30**	**81.75%**
Electricity Generation	46.44	0.01	0.11	-	-	-	46.57	18.37%
Net Imports of Electricity	8.61	0.01	0.03	-	-	-	8.64	3.41%
Transportation	83.59	0.15	2.05	-	-	-	85.79	33.83%
Residential	34.20	0.42	0.11	-	-	-	34.74	13.70%
Commercial	25.27	0.12	0.05	-	-	-	25.43	10.03%
Industrial	14.70	0.02	0.04	-	-	-	14.77	5.82%
Other Sources	**11.32**	**14.68**	**3.24**	**0.36**	**7.51**	**0.53**	**37.64**	**14.84%**
Power Supply & Delivery	***2.42***	***-***	***0.06***	***-***	***-***	***0.53***	***3.00***	***1.18%***
Electricity Distribution	-	-	-	-	-	0.53	0.53	0.21%
Municipal Waste Combustion	2.42	-	0.06	-	-	-	2.48	0.98%
Agriculture, Forestry & Waste Management	***-***	***9.00***	***3.18***	***-***	***-***	***-***	***12.19***	***4.81%***
Agricultural Animals	-	2.70	-	-	-	-	2.70	1.06%
Agricultural Soil Management	-	-	1.80	-	-	-	1.80	0.71%
Landfills	-	4.46	-	-	-	-	4.46	1.76%
Manure Management	-	0.53	0.24	-	-	-	0.76	0.30%
Municipal Wastewater	-	1.33	1.15	-	-	-	2.47	0.98%
Industrial Processes & Manufacturing	***8.90***	***5.68***	***-***	***0.36***	***7.51***	***-***	***22.45***	***8.85%***
Aluminum Production	-	-	-	0.26	-	-	0.26	0.10%
Cement Production	7.91	-	-	-	-	-	7.91	3.12%
Iron & Steel Production	0.63	-	-	-	-	-	0.63	0.25%
Limestone Use	0.20	-	-	-	-	-	0.20	0.08%
Natural Gas Leakage	-	5.68	-	-	-	-	5.68	2.24%
Ozone-Depleting Substances Substitutes	-	-	-	-	7.51	-	7.51	2.96%
Semiconductor Manufacturing	-	-	-	0.10	-	-	0.10	0.04%
Soda Ash Use	0.16	-	-	-	-	-	0.16	0.06%
Total (inc. Net Imports of Electricity)	**224.14**	**15.41**	**5.63**	**0.36**	**7.51**	**0.53**	**253.58**	**100%**
% of Total (inc. Net Imports of Electricity)	88.39%	6.08%	2.22%	0.14%	2.96%	0.21%	100%	-
Total (exc. Net Imports of Electricity)	**215.53**	**15.41**	**5.60**	**0.36**	**7.51**	**0.53**	**244.94**	**-**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; CH_4 = methane; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; PFC = perfluorocarbons; HFC = hydrofluorocarbons; SF_6 = sulfur hexafluoride

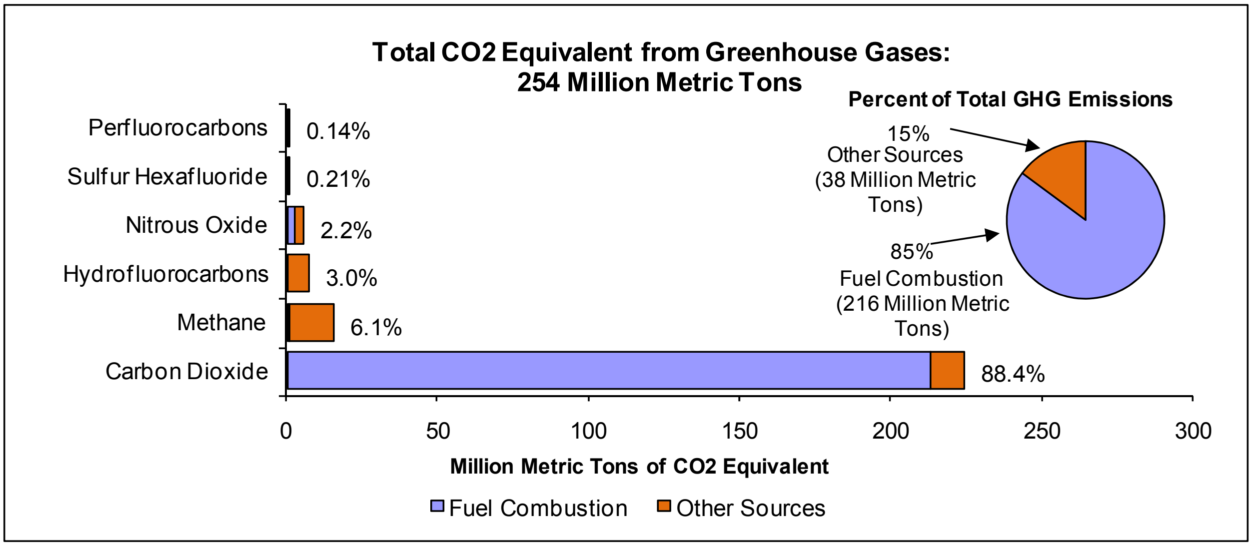
Historical Emissions

Overview—2008 Inventory

As shown in Table 3-1, on a gross emissions consumption basis (i.e., excluding carbon sinks), New York accounts for approximately 254 million metric tons of carbon dioxide equivalent (MMtCO_2e) emissions in 2008, an amount equal to 3.7 percent of total U.S. gross GHG emissions.[5] This estimate includes emissions from net imports of electricity.

Figure 3-2 shows the breakdown of New York's 2008 gross GHG emissions by gas. This figure shows that 85 percent of the gross GHG emissions in 2008 are from fuel combustion, with most of these emissions coming from CO_2. The remaining 15 percent of the 2008 GHG emissions, the majority of which are CH_4, are from other non-fuel combustion sources.

Figure 3-2. 2008 Percentage of GHG Emissions by Gas and Source (Includes Net Imports of Electricity)

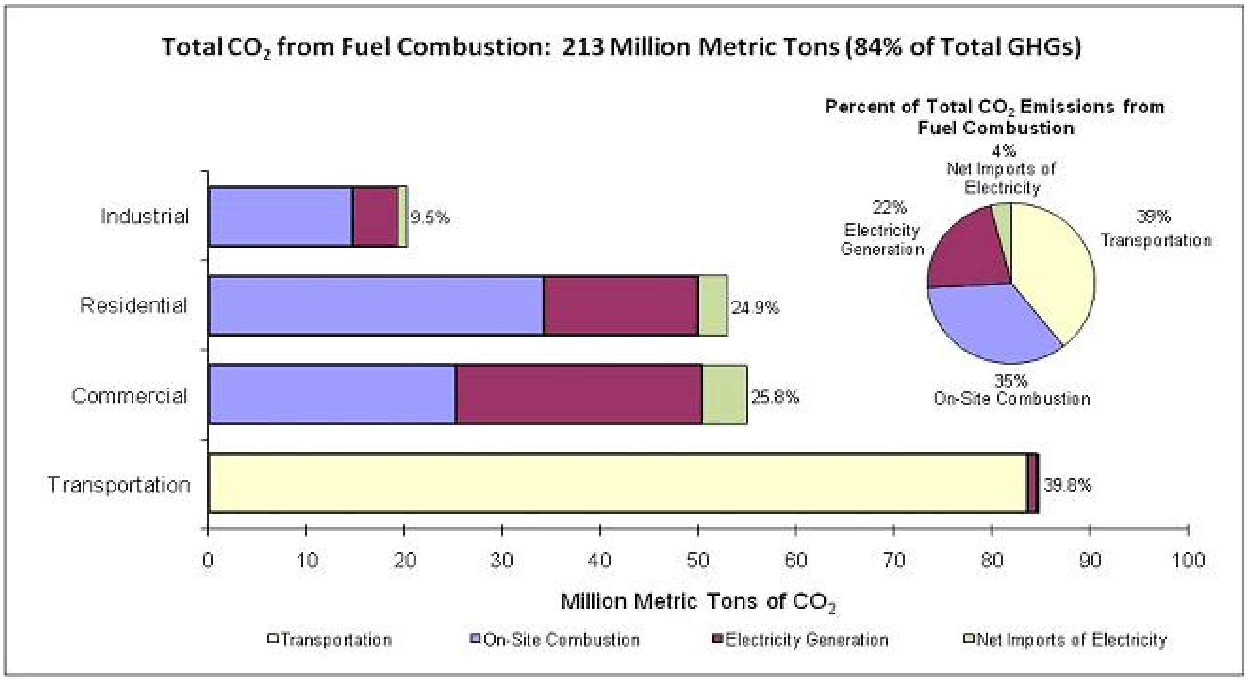


CO_2 = carbon dioxide; GHG = greenhouse gas.

Figure 3-3 provides a further breakdown of the CO_2 emissions from fuel combustion. As shown in this figure, the transportation sector accounts for approximately 40 percent of the CO_2 emissions from fuel combustion. The residential and commercial sectors are each responsible for roughly 25 percent of the CO_2 fuel combustion emissions, including emissions from the share of electricity generation required by each of these sectors. The residential sector shows greater emissions from fuel combustion on-site than from the emissions associated with electricity generation or imported electricity, while the commercial sector shows the reverse—emissions for this sector from electricity generation and imported electricity are higher than the emissions from on-site fuel combustion. The industrial sector contributes the lowest amount of CO_2 emissions from fuel combustion, accounting for approximately 10 percent of the CO_2 fuel combustion emissions in New York, with a majority of these emissions coming from on-site fuel combustion.

[5] The national emissions used for these comparisons are based on 2008 emissions from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008*, April 2010, EPA430-R-08-006. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

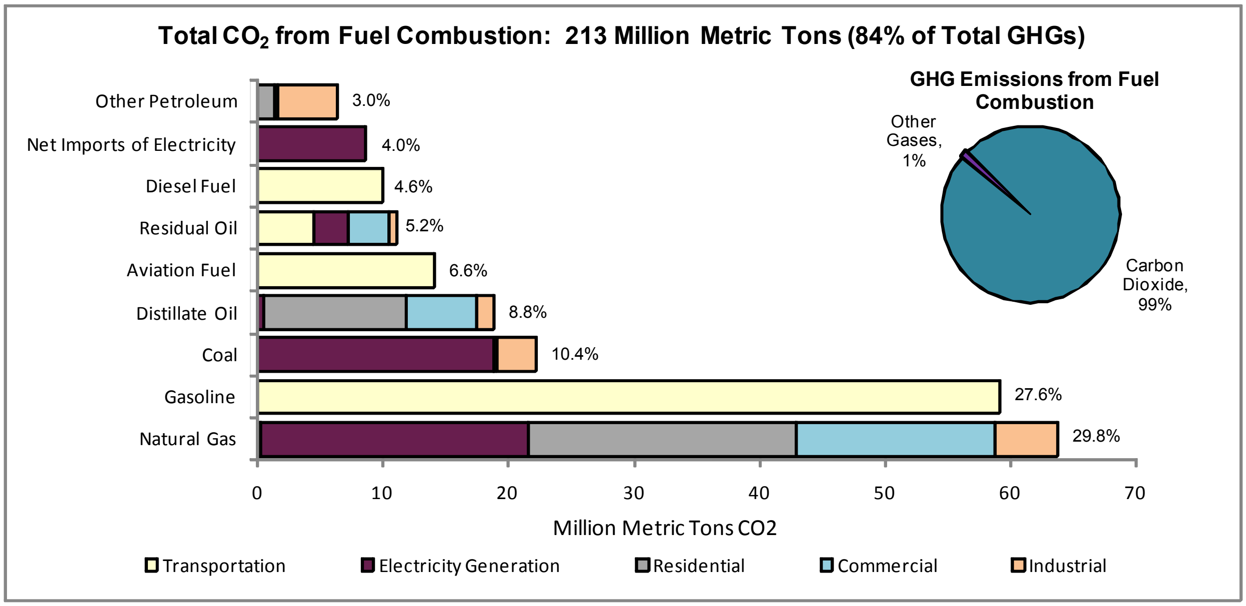
Figure 3-3. 2008 CO_2 Emissions from Fuel Combustion by End Use Sector (Includes Net Imports of Electricity)



CO_2 = carbon dioxide; GHG = greenhouse gas.

Figure 3-4 shows the fuels that contribute to the CO_2 fuel combustion emissions in 2008 in New York. This figure shows that natural gas accounts for the largest amount of CO_2 fuel combustion emissions, with emissions occurring in all five fuel combustion sectors (transportation, electricity generation, residential, commercial, and industrial). An additional 28 percent of the CO_2 fuel combustion emissions result from the burning of gasoline by the transportation sector. The remaining fuel combustion emissions result from the burning of coal, distillate oil, aviation fuel, residual oil, diesel, and other petroleum sources as well as imported electricity. In addition to releasing CO_2, these fuel combustion sources also emit a small amount of N_2O and CH_4, accounting for about 1 percent of the 2008 New York GHG emissions from fuel combustion.

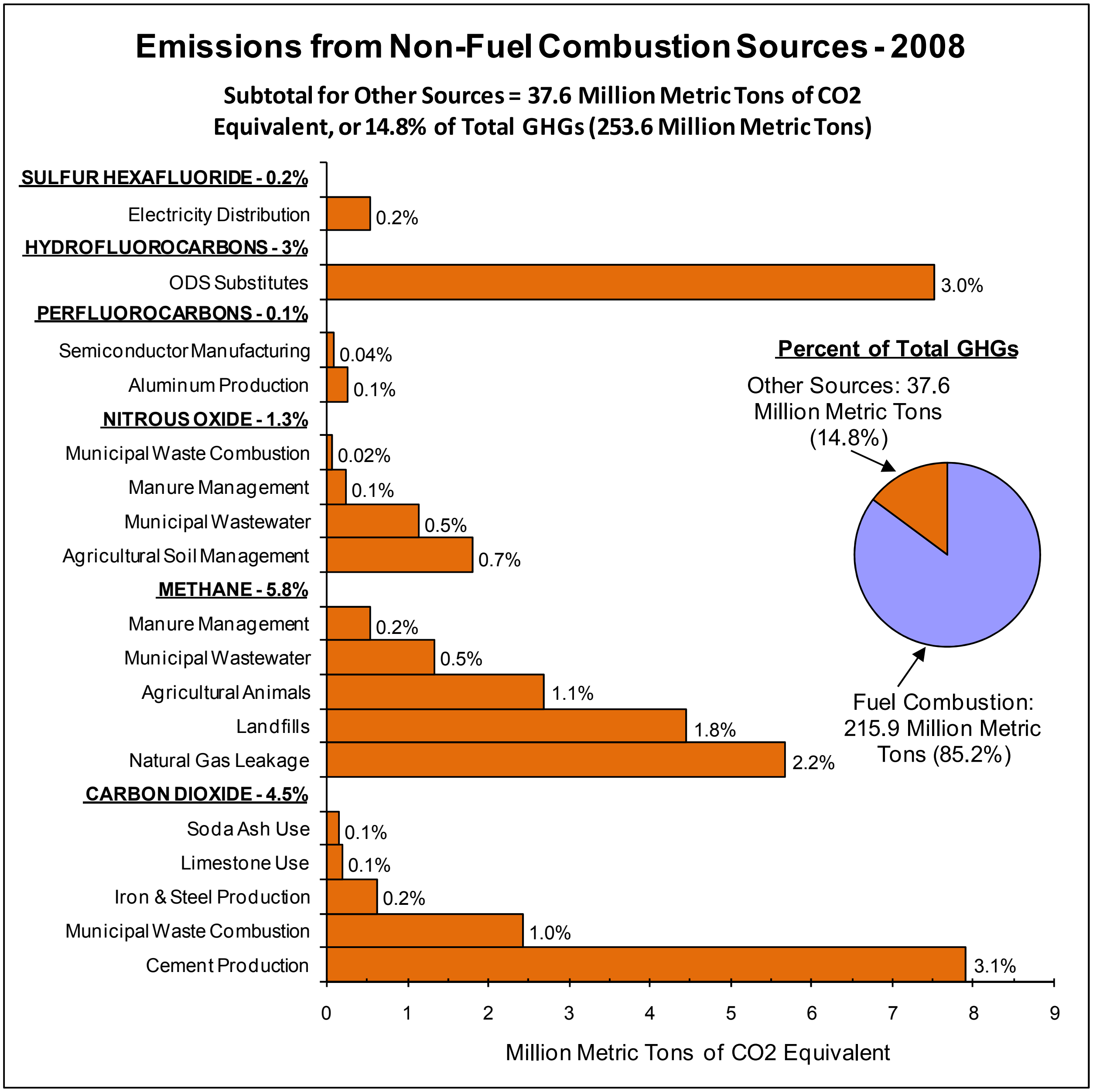
Figure 3-4. 2008 CO_2 Emissions from Fuel Combustion by Fuel Type (Includes Net Imports of Electricity)



CO_2 = carbon dioxide; GHG = greenhouse gas.

The origin of emissions from the non-fuel combustion or "other sources" category is shown in Figure 3-5. This figure includes emissions from all 6 of the GHG gases, with CH_4 accounting for the greatest portion of GHG emissions from these other sources at 5.8 percent of the gross GHG emissions in 2008. The major sources that emit CH_4 are natural gas leakage (at 2.2 percent of the 2008 gross GHG emissions) and landfills (at 1.8 percent of the 2008 gross GHG emissions). The sectors with the greatest non-fuel combustion emissions are cement production, which produces CO_2 emissions accounting for 3.1 percent of the total 2008 GHG emissions, and the use of ozone-depleting substance (ODS) substitutes, which contributes HFC emissions that account for 3.0 percent of the 2008 gross GHG emissions.

Figure 3-5. 2008 Emissions from Non-Fuel Combustion Sources (Total Emissions Include Net Imports of Electricity)



CO_2 = carbon dioxide; GHG = greenhouse gas; ODS = ozone-depleting substance.

Emissions Trends

Table 3-2 shows the trend in New York's historical GHG emissions in 5-year increments from 1990 to 2005, as well as for the reference case forecasts from 2015 to 2030. New York's gross GHG emissions, in total, increased by about 9 percent (or 23 $MMtCO_2e$) from 1990 to 2005, with a peak around 2000. This compares to a national increase in gross GHG emissions of 16 percent from 1990 to 2005.

The sectors that showed the greatest increase during this time period were the ODS substitutes category (more than 27 fold increase),[6] imported electricity (more than quadrupling), semiconductor manufacturing (more than doubling), and municipal waste combustion (nearly doubling).

In terms of the magnitude of emissions growth, the transportation sector showed by far the greatest growth, with emissions increasing by 17 $MMtCO_2e$ from 1990 to 2005. In contrast, emissions from electricity generated in-state decreased by about 10 $MMtCO_2e$ during this same period.

Table 3-2. New York Gross GHG Emissions, Historical and Reference Case Forecast ($MMtCO_2e$)*

Gas and Category	1990	1995	2000	2005	2015	2020	2025	2030
Carbon Dioxide	**224.73**	**223.99**	**248.23**	**241.45**	**223.47**	**225.27**	**226.92**	**231.67**
Fuel Combustion	***214.76***	***212.93***	***236.92***	***230.13***	***212.12***	***213.92***	***215.57***	***220.32***
Electricity Generation	64.01	51.39	55.99	54.19	39.83	41.51	42.91	46.34
Net Imports of Electricity	1.63	4.24	5.66	6.52	6.61	7.06	7.61	7.61
Transportation	68.11	72.17	83.05	85.89	85.18	85.05	85.25	86.85
Residential	33.65	34.29	39.30	39.10	35.14	34.50	34.10	33.92
Commercial	26.61	26.99	31.99	28.57	29.34	29.90	29.85	29.83
Industrial	20.75	23.85	20.93	15.86	16.01	15.89	15.86	15.78
Other Sources	***9.97***	***11.06***	***11.31***	***11.32***	***11.35***	***11.35***	***11.35***	***11.35***
Municipal Waste Combustion	1.26	1.54	1.87	2.37	2.41	2.41	2.41	2.41
Cement Production	6.68	7.63	7.98	7.94	7.91	7.91	7.91	7.91
Iron and Steel Production	1.65	1.55	1.07	0.63	0.65	0.65	0.65	0.65
Limestone Use	0.17	0.16	0.21	0.21	0.21	0.21	0.21	0.21
Soda Ash Use	0.20	0.19	0.18	0.17	0.16	0.16	0.16	0.16
Methane	**14.22**	**15.91**	**16.44**	**15.22**	**15.00**	**15.10**	**14.76**	**14.63**
Fuel Combustion	***0.84***	***0.90***	***1.10***	***0.75***	***0.70***	***0.71***	***0.72***	***0.74***
Electricity Generation	0.03	0.02	0.02	0.03	0.01	0.01	0.01	0.02
Net Imports of Electricity	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Transportation	0.36	0.33	0.26	0.18	0.13	0.14	0.16	0.17
Residential	0.31	0.40	0.60	0.39	0.40	0.40	0.39	0.39
Commercial	0.09	0.13	0.18	0.13	0.13	0.13	0.13	0.13
Industrial	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02
Other Sources	***13.38***	***15.01***	***15.34***	***14.46***	***14.30***	***14.39***	***14.04***	***13.89***
Agricultural Animals	2.83	2.69	2.67	2.65	2.54	2.45	2.35	2.27
Landfills	4.90	5.30	5.31	4.77	4.32	4.27	3.81	3.42
Manure Management	0.35	0.39	0.44	0.50	0.50	0.48	0.46	0.44
Municipal Wastewater	1.21	1.22	1.28	1.30	1.39	1.44	1.49	1.54
Natural Gas Leakage	4.08	5.41	5.66	5.23	5.55	5.76	5.93	6.22
Nitrous Oxide	**7.00**	**7.46**	**7.80**	**6.51**	**4.68**	**4.50**	**4.61**	**4.71**
Fuel Combustion	***3.74***	***4.38***	***4.61***	***3.21***	***1.39***	***1.17***	***1.23***	***1.29***
Electricity Generation	0.19	0.14	0.16	0.15	0.11	0.11	0.11	0.11
Net Imports of Electricity	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
Transportation	3.31	4.01	4.14	2.82	1.05	0.82	0.89	0.95
Residential	0.09	0.11	0.16	0.12	0.11	0.11	0.10	0.10
Commercial	0.05	0.06	0.06	0.06	0.05	0.05	0.05	0.05
Industrial	0.09	0.06	0.07	0.05	0.05	0.05	0.05	0.05

[6] Emissions from ODS substitutes are expected to grow in line with national forecasts at over 5% a year.

Gas and Category	1990	1995	2000	2005	2015	2020	2025	2030
Other Sources	***3.26***	***3.08***	***3.19***	***3.29***	***3.29***	***3.33***	***3.38***	***3.42***
Agricultural Soil Management	1.93	1.74	1.78	1.88	1.81	1.82	1.83	1.84
Manure Management	0.30	0.27	0.26	0.24	0.22	0.21	0.21	0.20
Municipal Waste Combustion	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Municipal Wastewater	0.98	1.02	1.10	1.12	1.20	1.24	1.29	1.33
Perfluorocarbons	**0.43**	**0.39**	**0.44**	**0.36**	**0.36**	**0.36**	**0.36**	**0.36**
Aluminum Production	0.38	0.31	0.33	0.27	0.26	0.26	0.26	0.26
Semiconductor Manufacturing	0.04	0.07	0.11	0.09	0.10	0.10	0.10	0.10
Hydrofluorocarbons	**0.02**	**1.97**	**4.80**	**6.54**	**12.14**	**15.89**	**16.10**	**16.35**
ODS Substitutes	0.02	1.97	4.80	6.54	12.14	15.89	16.10	16.35
Sulfur Hexafluoride	**1.28**	**0.93**	**0.63**	**0.58**	**0.53**	**0.53**	**0.53**	**0.53**
Electricity Distribution	1.28	0.93	0.63	0.58	0.53	0.53	0.53	0.53
TOTAL	**247.68**	**250.65**	**278.34**	**270.65**	**256.19**	**261.65**	**263.28**	**268.25**
All Gases by Source Category								
Fuel Combustion	219.35	218.20	242.63	234.10	214.21	215.79	217.53	222.35
Electricity Generation	64.24	51.54	56.18	54.36	39.96	41.64	43.03	46.47
Net Imported Electricity	1.63	4.26	5.69	6.55	6.64	7.09	7.64	7.64
Transportation	71.78	76.50	87.44	88.89	86.36	86.02	86.30	87.96
Residential	34.06	34.80	40.05	39.61	35.64	35.00	34.60	34.42
Commercial	26.75	27.17	32.23	28.75	29.52	30.09	30.03	30.01
Industrial	20.88	23.93	21.04	15.93	16.09	15.96	15.93	15.85
Other Sources	28.34	32.44	35.71	36.55	41.97	45.85	45.75	45.90
TOTAL	**247.68**	**250.65**	**278.34**	**270.65**	**256.19**	**261.65**	**263.28**	**268.25**

NOTE: Values for 1990–2005 are based on historical data, while values for 2015–2030 are forecasted.

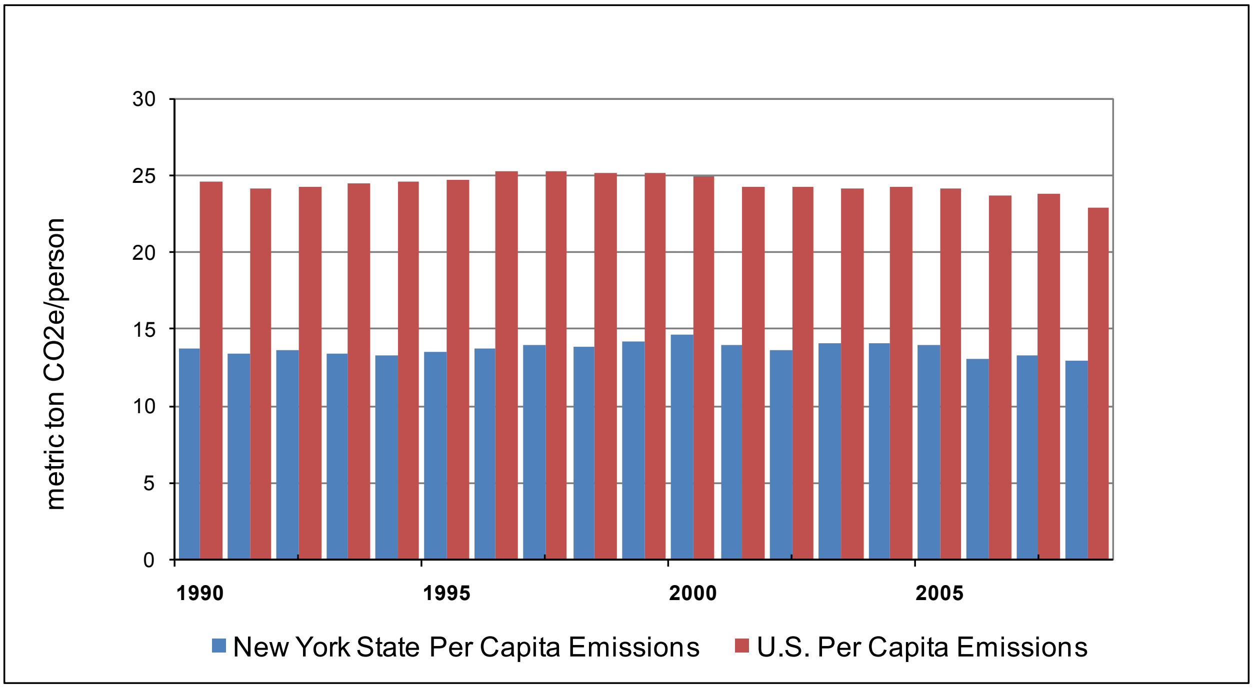
GHG = greenhouse gas; MMTCO_2e = million metric tons of carbon dioxide equivalent.

* Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

As illustrated in Figure 3-6, on a per-capita basis, New York residents emitted about 13.7 metric tons (t) of gross CO_2e on average from 1990 to 2008, which is much lower than the national average of about 24.4 tCO_2e over the same time period. Both New York and national per-capita emissions remained relatively constant during this period. This indicates New York's population increase of about 8 percent from 1990 to 2008 resulted in a similar increase in overall gross GHG emissions during this time.

Figure 3-7 compares New York's emissions intensity with that of the United States from 1990 to 2008. This emissions intensity represents GHG emissions per unit of economic output—gross state product (GSP) for New York and gross domestic product (GDP) for the United States. As with emissions per capita, emissions per dollar GSP is much lower in New York than in the U.S. throughout this historical period, with an average of 0.09 kilograms (kg) CO_2e per dollar GSP in New York and 0.74 kg CO_2e per dollar GDP in the United States. In both New York and the nation as a whole, economic growth exceeded emissions growth throughout the 1990–2008 period. From 1990 to 2008, emissions per unit of gross product dropped by 31 percent nationally, and by 36 percent in New York.[7]

Figure 3-6. New York and U.S. Gross GHG Emissions per Capita



[7] Based on real gross domestic product (chained 2000 dollars) that excludes the effects of inflation. U.S. Department of Commerce, Bureau of Economic Analysis. "Gross Domestic Product by State." Available at: http://www.bea.gov/regional/gsp/.

Figure 3-7. New York and U.S. Emissions Intensity

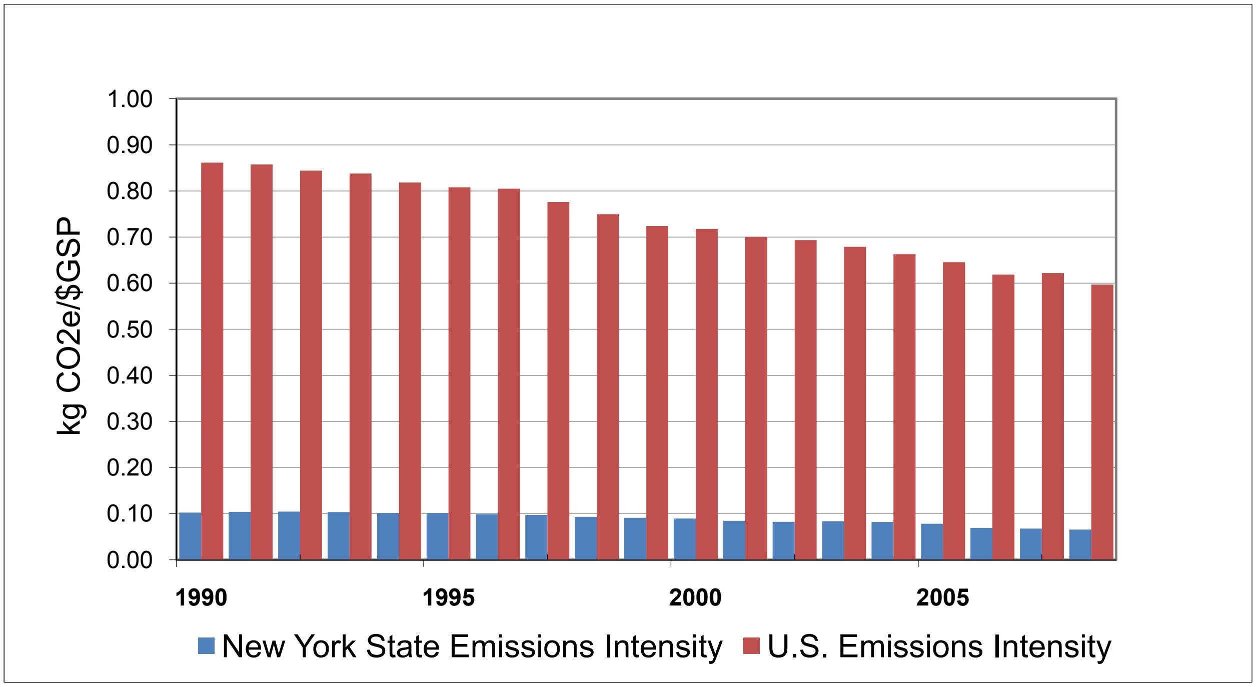
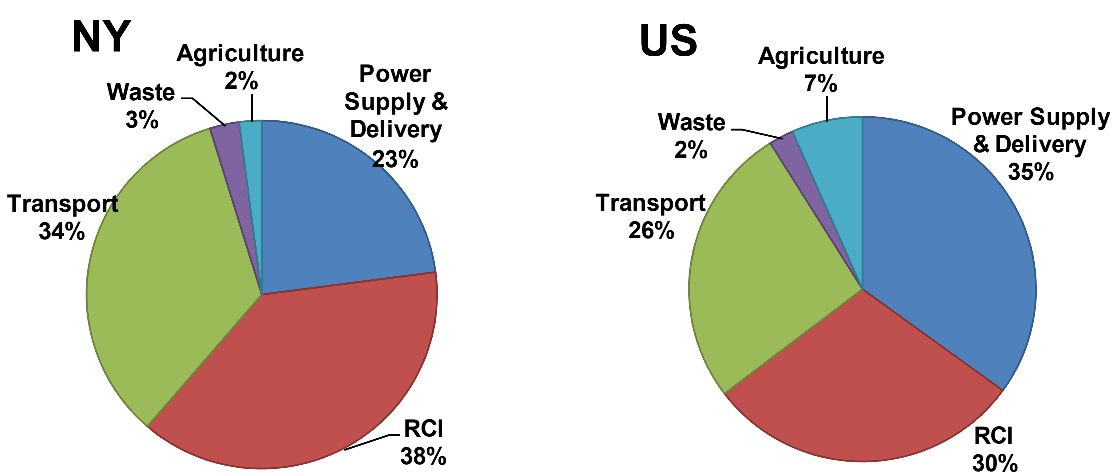


Figure 3-8 compares emissions by major sector in 2008 from New York and the United States. The principal sources of New York's GHG emissions in 2008 are the residential, commercial/institutional, and industrial sector; the transportation sector; and the power supply and delivery sector. These account for 38 percent, 34 percent, and 23 percent of New York's gross GHG emissions, respectively. These are also the three largest emitting sectors in the US, but in a different order, with the power supply and delivery sector at 35 percent, the RCI sector at 30 percent, and the transportation sector at 26 percent. In New York, emissions from waste and agriculture combine to account for the remaining 5 percent of gross GHG emissions in 2008, while these two sectors account for 9 percent of gross GHG emissions in the US.

Figure 3-8. 2008 Gross GHG Emissions by Sector: New York and U.S.



Notes: RCI = Residential, commercial/institutional, and industrial sector. Emissions for the residential, commercial, and industrial fuel use sectors are associated with the direct use of fuels (natural gas, petroleum, coal, and wood) to provide space heating, water heating, process heating, cooking, and other energy end-uses in the residential, commercial/institutional, and industrial sectors. This sector also accounts for GHG emissions from non-fuel sources in the industrial sector, such as CO_2 emissions from cement production, as well as emissions from the fossil fuel industry (e.g., natural gas leakage). The transportation sector accounts for emissions associated with fuel consumption by all on-road and non-highway vehicles. Non-highway vehicles include jet aircraft, gasoline-fueled piston aircraft, railway locomotives, boats, and ships. Emissions from non-highway agricultural and construction equipment are included in the RCI sector. The power supply and delivery sector includes emissions associated with electricity generated within the state and electricity imported from outside of New York as well as the emissions associated with municipal waste combustion (waste-to-energy facilities) and electricity transmission and distribution. The waste category includes emissions from landfills and wastewater. The U.S. agriculture emissions also include CH_4 and N_2O emissions from forest fires.

Trends in Emissions Sinks

New York's forests serve as sinks of GHG emissions, as shown in Table 3-3. The forestry sector includes both forested lands as well as urban forestry. The largest sink is due to the net CO_2 flux[8] from forested lands in New York. In addition to the forestry sector, Table 3-3 shows that cultivation practices in the agriculture sector are also found to be sinks of CO_2e emissions in New York.

Table 3-3. New York GHG Emissions Sinks, Historical and Reference Case Forecast ($MMtCO_2e$)

Emissions Sinks	1990	1995	2000	2005	2015	2020	2025	2030
Soil Carbon (Cultivation Practices)	–1.20	–1.20	–1.36	–1.36	–1.36	–1.36	–1.36	–1.36
Compost	–0.11	–0.11	–0.11	–0.11	–0.11	–0.11	–0.11	–0.11
Forest Carbon Flux	–19.61	–23.60	–23.60	–23.60	–23.60	–23.60	–23.60	–23.60
Urban Trees	–1.97	–2.09	–2.21	–2.33	–2.38	–2.38	–2.38	–2.38
Landfilled Yard Trimmings and Food Scraps	–1.66	–0.92	–0.72	–0.61	–0.51	–0.51	–0.51	–0.51
TOTAL	**-24.55**	**-27.92**	**-28.00**	**-28.01**	**-27.96**	**-27.96**	**-27.96**	**-27.96**

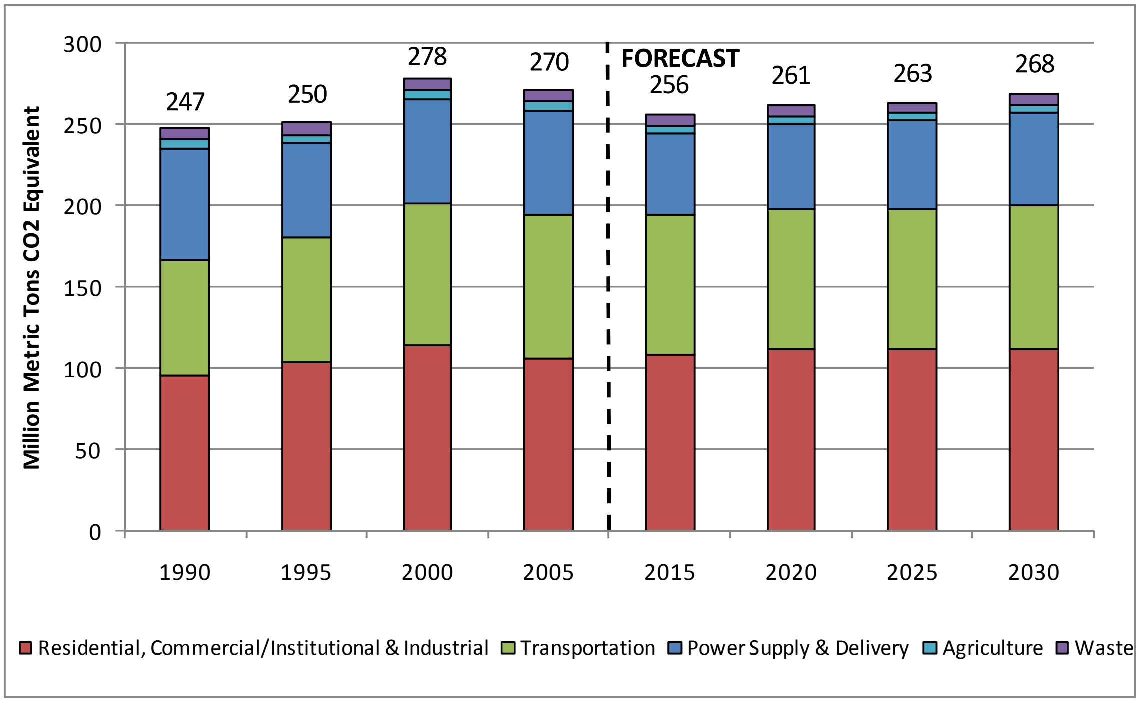
GHG = greenhouse gas; $MMTCO_2e$ = million metric tons of carbon dioxide equivalent; N_2O = nitrous oxide.

Reference Case Forecasts

Relying on a variety of sources for forecasts, a simple reference case forecast of GHG emissions through 2030 was developed. As illustrated in Figure 3-9 and shown numerically in Tables 3-1 and 3-2, under the reference case forecasts, New York's gross GHG emissions increase by about 12 $MMtCO_2e$ from 2008 over the forecast period to reach about 268 $MMtCO_2e$ by 2030, or 8 percent above 1990 levels. This equates to a 0.2 percent annual rate of growth from 1990 to 2030. Relative to 2008, the share of emissions associated with the transportation, RCI, and power supply and delivery sectors are still forecasted to be the highest, in the same order.

[8] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

Figure 3-9. Greenhouse Gas Emissions by Source Category, 1990–2030



A Closer Look at the Major Source of Emissions: Fuel Combustion

The transportation sector accounts for the largest share of GHG emissions in New York, at 34 percent of New York's gross GHG emissions in 2008. Emissions from this sector rose at an average annual growth rate of 1.0 percent from 1990 to 2008. In 2008, motor gasoline, used by on-road vehicles and recreational marine vehicles, accounts for the majority of transportation GHG emissions; jet fuel contributes the second-highest transportation GHG emissions; and diesel fuel, used by on-road vehicles, commercial marine vehicles, and locomotives, ranks third among fuels contributing to transportation emissions. Residual fuel, liquefied petroleum gas, and other transportation fuels account for the remaining transportation GHG emissions in 2008. Emissions from the transportation sector are forecasted to increase at an average annual growth rate of 0.1 percent from 2008 to 2030, growing from 86 MMtCO2e to 88 MMtCO2e during that time. The mix of GHG-emitting transportation fuels in 2030 is expected to be relatively similar to the 2008 mix.

Activities in the RCI[9] fuel combustion sector produce GHG emissions when fuels are combusted to provide space heating, process heating, and other applications. Fuel combustion within the RCI sector accounts for 30 percent of New York's gross GHG emissions in 2008. From 1990 to 2008, emissions from RCI fuel combustion decreased at an annual rate of 0.5 percent. In 2008, the residential sector's contribution toward the total RCI emissions from direct fuel use was 46 percent (35 MMtCO_2e), while the commercial/institutional sector accounted for 34 percent (25 MMtCO_2e) and the industrial sector accounted for 20 percent (15 MMtCO_2e). Overall, emissions

[9] The industrial sector includes emissions associated with agricultural energy use and fuel used by the fossil fuel production industry.

from fuel combustion within the RCI sector are expected to increase by 0.3 percent annually between 2008 and 2030. Fuel combustion emissions from the commercial/institutional and industrial sectors are forecasted to annually increase by 0.75 percent and 0.32 percent between 2008 to 2030,respectively. In contrast, fuel combustion emissions from the residential sector are forecasted to decrease by 0.04 percent annually during that time. Total GHG emissions from fuel combustion in the RCI sector are expected to be 80 $MMtCO_2e$ in 2030.

In 2008, emissions from fuel combustion associated with New York's electricity consumption (55 $MMtCO_2e$) are 8 $MMtCO_2e$ higher than those associated with in-state electricity production (47 $MMtCO_2e$). The higher level for consumption-based emissions reflects GHG emissions associated with net imports of electricity from other states to meet electricity demand.[10] Electricity generation in New York is dominated by natural gas and nuclear-powered units, with coal, oil, and hydro also important sources of historical generation in New York.

Forecasts of electricity sales for 2008–2030 indicate that New York will remain a net importer of electricity. Emissions from electricity imports are forecasted to decrease slightly (by approximately 1 $MMtCO_2e$) from 2008 to 2030. In contrast, the reference case forecast indicates that production-based emissions (associated with electricity generated in-state) in 2030 will be approximately the same as those in 2008. Given these trends, it is anticipated that consumption-based emissions (associated with electricity consumed in-state) will only decrease slightly during that time period, from 55 $MMtCO_2e$ in 2008 to 54 $MMtCO_2e$ in 2030.

Key Uncertainties

Some data gaps exist in this inventory, particularly in the reference case forecasts. Key tasks for future refinement of this inventory and forecast include review and revision of key drivers, such as the transportation, RCI fuel use, and electricity demand growth rates that will be major determinants of New York's future GHG emissions. These growth rates are driven by uncertain economic, demographic, and land-use trends (including growth patterns and transportation system impacts), all of which deserve closer review and discussion.

[10] Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer demand. The current estimate reflects some very simple assumptions, as described in Appendix A of the Inventory and Forecast report.

Chapter 4
Envisioning a Low-Carbon Future – 2050

This chapter describes the visioning process employed by the Climate Action Council as one of the foundational components for New York's Climate Action Plan. *Envisioning a Low-Carbon 2050 for New York State,* a white paper prepared by Brookhaven National Laboratory, details much of the Climate Action Plan visioning work and is included as Appendix F of this report.

New York State Demographic Trends

Future economic activity and population growth in New York State are important factors in estimating the greenhouse gas emission reductions necessary to meet the 80 by 50 goal. Current projections suggest that New York's population and housing stock will continue growing through 2030, although the rate of growth will slow slightly compared to current trends. Economic activity, as measured by the gross state product, and vehicle miles traveled (VMT) are expected to continue their recent growth rates over the same period.

Population: The state population is expected to increase by approximately 800,000, or 4%, from 19.6 million to 20.4 million people over the next 20 years, but this statewide projection masks two distinct regional trends. The downstate population (New York City, Nassau, Suffolk, Westchester, Putnam, and Rockland counties) is projected to increase by 1.1 million people, from 12.7 million to 13.8 million; the upstate population, however, is projected to decrease by 300,000 people, from 6.9 million to 6.6 million.[1] A substantial shift in age distribution of the population is also expected as the proportion of the population over 65 will grow faster than the rest of the population, both upstate and downstate. The total number of people over 65 is expected to increase by 1.1 million, from 2.5 million to 3.6 million as the number of people under 65 falls by 300,000 statewide, from 17.1 million to 16.8 million.

Gross State Product (GSP): New York's economy is expected to continue growing by 25 to 30 percent each decade through 2030 as it has for the past two decades with GSP reaching $6.4 trillion in 2000 dollars by 2030, from $3.9 trillion in 2010.[2] GSP is expected to continue growing significantly faster than the state's population, implying significant productivity gains and rising per capita income.

Housing Stock: The number of housing units in the state is growing faster than the population, reflecting smaller family sizes and an increasing proportion of "empty-nesters" in the population. This trend is a factor of both new home construction and decreased rates of removal of units from the total housing stock. A simple trend analysis of population, number, and age of housing units, and number of new housing units built conducted by NYSERDA suggests that New York's housing stock will increase by about 6%, from 8 million to 8.5 million, between 2010 and 2030.[3] The housing stock will also get older, on average, as fewer old homes are removed from use and the percentage of homes built in the previous 20 years continues to decline. The proportion of New York's housing units less than 20 years old fell from 21% in 1990 to 15% by 2000, and projections suggest that only 8 to 10% of housing units (approximately 700,000) will be less than 20 years old by 2030.

Vehicle Miles Traveled (VMT): On-road VMT are expected to continue growing by 15 to 20 percent each decade for the next 20 years, as they have for the past 20 years, reaching 202.6 billion per year by 2030, from 149.7 billion per year in 2010.[4] VMT per capita will continue to grow quickly with increased economic activity per capita. This trend will be offset somewhat by increases in both the proportion of residents living downstate and in the proportion of residents over 65, both groups that tend to drive fewer miles per person than the state average.

Trends in GHG Emissions: Current patterns suggest per capita emissions could fall, given the trends for an aging population and overall population growth in downstate areas. Per capita emissions are generally lower downstate than upstate, and people over 65 generally live in smaller housing units and travel less than do people under 65. However, total statewide emissions are likely to rise, driven by increased total population, growth in economic activity, aging housing stock and increased VMT.

These trends underscore the need for New York to seek optimal strategies to reduce the carbon intensity of its economy (tons of CO_2 emitted per dollar of GSP).

For example, if VMT increases as expected, New York State will have to achieve even greater improvements in vehicle efficiency or reductions in the carbon intensity of fuels to be able to reduce total GHG emissions from the transportation sector. The population trends and housing stock projections provide an opportunity for reducing VMT growth through implementation of smart growth strategies: For example, a growing and aging downstate population could benefit from new development close to public transportation and designed around mixed residential-commercial areas, which typically have lower VMT per capita than other areas.

[1] Cornell University Program on Applied Demographics, "New York State and County Population Projections by Age and Sex – Preliminary Population Projections by Age and Sex, New York State and 62 counties, 2005-2035," http://pad.human.cornell.edu/che/BLCC/pad/data/projections.cfm

[2] NYSERDA projections for State Energy Plan

[3] U.S. Census Bureau, Census 1990 and 2000 Form DP-4: Profile of Selected Housing Characteristics, 2000, http://www.census.gov/census2000/dp_comptables.html

U.S. Census Bureau, Census 2000 Population and Housing Unit Counts, New York, http://www.census.gov/prod/cen2000/phc-3-34.pdf

U.S. Census Bureau, Housing Unit Estimates: 2000-2009, http://www.census.gov/popest/housing/HU-EST2009.html

[4] NYSDOT Vehicle Miles Traveled projections 2007-2033

Visioning Process and Approach

The ability to visualize a sustainable New York by 2050 and to explore its implications is as vital to achieving that future as the clean energy technologies and policies, best management practices, and behavioral changes that will constitute the Climate Action Plan. The Climate Action Council and its technical and integration working groups began their planning task by building a shared vision of a low-carbon, clean energy future in an 80 by 50 New York. Through a formal visioning process, the council explored technologies and greenhouse gas management strategies.

New York's formal visioning process worked backward from an imagined mid-century New York with far lower greenhouse gas (GHG) emissions than today, using four tools:

- **Scenario development**, which was based on a coupled energy-sector model and sets of assumptions about future energy demand, patterns of energy use, and low-emission technologies that might reasonably be available to power the low-carbon economy;
- **Visioning workshop** at the New York Academy of Sciences (conducted January 5, 2010 – full session and presentations available online at http://www.nyas.org/Events/WebinarDetail.aspx?cid=e7a4211c-fd9e-4683-8491-29c46fe03651;
- **White paper** (Appendix F) incorporating workshop outcomes and information from other expert sources: Envisioning a Low-Carbon 2050 for New York State, submitted to the New York State Climate Action Council; by Gerry Stokes and Patrick Looney, Brookhaven National Laboratory, Upton, NY.
- **Sectoral visions** developed by the technical work groups for each sector of the economy. Guided by the visioning workshop and scenario information, each Technical Work Group developed an 80 by 50 vision for each mitigation sector: Power Supply and Delivery; Transportation and Land Use; Agriculture; Forestry; Waste/Materials Management; and Residential/Commercial/Institutional/Industrial Buildings. Summaries of this visioning work appear in the sector chapters of this report; the full vision documents as drafted by the work groups are available online at http://www.nyclimatechange.us.

The visioning process continues to enable examination of possible technologies with research and development needs, assessment of technical issues, design of policies to reduce GHG emissions, and identification of necessary management and societal changes. The formal visioning technique supports discussion of option if other interested parties generate their own 80 by 50 scenarios and develop analyses based on them, meaningful comparisons among options are possible.

New York's visioning process revealed that reaching the 80 by 50 goal required aggressive assumptions and transformative change, but is potentially achievable, at least from a technical point of view.

Scenarios

Scenarios are sets of assumptions describing conditions in 2050 that should yield total GHG emissions 80 percent lower than those of 1990.

Carbon dioxide and other GHGs [total GHGs are expressed as carbon dioxide equivalent (CO_2e)] are emitted by millions of homes, vehicles, farms, businesses, institutions and other sources. So in New York, achieving 80 by 50 would mean that total GHG emissions from these numerous and varied sources would fall from the current (i.e., year 2008) 254 million metric tons of CO_2e to approximately 50 million metric tons per year. Scenario analysis is commonly used as a tool for exploring options and contingencies in such complex situations.

New York's visioning process used three scenarios to explore the technical feasibility of reaching the 80 by 50 goal through energy efficiency, new energy conversion technologies, fuel switching, best practices, and other measures to shape a low-carbon future.

The three scenarios use different sets of assumptions about future energy demand, patterns of energy use, technologies available to supply energy with reduced emissions and their levels of performance. The specific assumptions making up each scenario, along with the modeling and other methodologies used to develop estimates for energy demand and technology performance, are described in detail in the Brookhaven National Laboratory white paper and its appendices.

The three scenarios are the same in several important ways:

- An end state is postulated for each major energy-consuming sector of the economy—Transportation; Electricity Production and Distribution; Residential Buildings, Commercial Buildings, Institutional Buildings, and Industrial Buildings. This end state includes low carbon-emitting central generation of electricity, as well as transportation and building sectors approaching zero carbon emissions, and accounts for emissions from non-energy producing activities. The scenarios constrain emissions and energy production to within the borders of New York State.
- Implications of the postulated technology options are examined. For example, one scenario evaluates GHG emissions assuming adoption of electricity as a transportation fuel and explores how electricity generation could be expanded to meet the increased demand while limiting emissions; another scenario considers the same for hydrogen.
- Each scenario's outcome is compared with the business-as-usual forecast in which no additional carbon mitigation measures are taken.

The model used to analyze GHG reductions for the technical strategies considers interactions—how switching technologies in one sector may raise or lower energy demand in another (an example would be higher demand for electricity if electric vehicles were widely adopted). However, the model does not take into account whether technologies are scalable, nor does it include economic, regulatory, and other social barriers to technology adoption. The model also does not include full lifecycle GHG analyses of nuclear power and renewable energy, possible effects of a changing climate on energy use or technology performance, or detailed analysis of the feasibility of transition rates or of rates of implementation.

All the scenarios include **four core strategies** to reduce GHG emissions:

- **Energy conservation** through energy efficiency, which is the simplest and the most cost-effective strategy.
- **Reducing combustion of fossil fuels**, another obvious strategy because combustion accounts for about 85 percent of all GHG emissions in New York State. All scenarios minimize point sources of combustion (such as vehicles and oil or natural gas heating appliances), and rely principally on low-emission electricity. The scenarios assume combustion of fossil fuels only when and where necessary, or with controls to effectively limit GHG emissions.
- **Fuel switching** to minimize the GHG footprint where combustion must still be used, as in aviation and cement production.
- **Local, point-of-use renewable energy technologies** (such as solar) employed to reduce the reliance of homes and businesses on centrally generated electricity.

Summary of Scenario Assumptions

All scenarios recognize the importance of commercial and industrial sectors to the overall economic health of the state and preferentially "invest" emissions in these sectors.

The **Yellow Scenario** assumes the most obvious emission-reduction strategies: significant energy conservation; significant changes to the light-duty vehicle fleet with a mix of high mpg conventional, hybrid-electric, and plug-in electric vehicles; very significant increases in utility-scale renewable electricity generation, with widespread adoption of carbon capture and storage on the remaining fossil-fired generating plants; replacement of most fossil fuel used in buildings with electricity, and significant reductions in non-CO_2 greenhouse gases. Although it assumes significant changes to current practices, this scenario falls far short of achieving 80 percent emissions reduction by 2050.

The **Deep Blue Scenario** begins with all the reductions in the Yellow scenario, but makes a dramatic shift of the entire light-duty vehicle fleet to hydrogen fuel produced with nuclear or other low-carbon electricity (including fossil fuel combustion with carbon capture and sequestration). Additional measures include elimination of fossil fuel combustion in the residential/commercial/industrial sector and significant use of locally-sourced biofuels for trucks and aircraft. This scenario (79 percent reduction) essentially meets the 80 percent reduction goal by 2050.

The **Ultraviolet Scenario** adds to the reductions in the Yellow scenario but makes a dramatic shift of the entire light-duty vehicle fleet to all plug-in hybrids. Ninety-five percent of all vehicle miles traveled are assumed to be all-electric miles, with the remainder in-state-sourced biofuels. It assumes elimination of residential and commercial fossil fuel combustion, with part of the resultant increase in electricity demand met through local, point-of-use solar and much of the remainder with low-carbon generation and the wide-spread use of carbon-capture and sequestration. This scenario meets the 80 by 50 goal.

Visioning Workshop

The Climate Action Council formed a 2050 Visioning Advisory Panel of experts from many fields. The panel was convened at a workshop held on January 5, 2010, entitled *Envisioning a Low-Carbon Clean Energy Economy in New York*.

Led by subject matter experts, workshop participants explored strategies for meeting the state's energy needs, reducing energy demand, managing GHG emissions, driving technological change, and creating economic opportunities for "green technology" in New York. The workshop considered the three scenarios not to validate a particular pathway to reaching the goal, but rather to explore possibilities and implications, and to identify obstacles to achieving the goal.

The Visioning Advisory Panel consisted of 13 experts in diverse elements of New York's energy and climate future:

Geoff Anderson, President and CEO, Smart Growth America

Katharine Frase, Vice President, Industry Solutions and Emerging Business, IBM Research; Member, National Academy of Engineering

Peter Goldmark, Program Director, Climate and Air, Environmental Defense

Nathan Lewis, George L. Argyros Professor of Chemistry, California Institute of Technology

Patrick Looney, Assistant Laboratory Director, Strategic Planning, Brookhaven National Laboratory

Elizabeth Malone, Joint Global Change Research Institute

James Misewich, Associate Laboratory Director for Basic Energy Sciences, Brookhaven National Laboratory

John Novak, Executive Director, Federal and Industrial Activities, Electric Power Research Institute

William Sisson, Director of Sustainability, United Technologies Corporation; Co-Chair, World Business Council for Sustainable Development Energy Efficiency in Buildings Project

Gerald Stokes, Associate Laboratory Director for Global and Regional Solutions, Brookhaven National Laboratory

Larry Walker, Professor and Director, Biomass Conversion Laboratory, Cornell University

Johanna Wellington, Technology Leader for Sustainable Energy, General Electric Global Research

Rae Zimmerman, Professor of Planning and Public Administration, New York University

Links to a webinar of the workshop sessions, workshop presentations in PDF format and the visioning white paper, *Envisioning a Low-Carbon 2050 for New York State,* are available at http://nyclimatechange.us/2050_Visioningn.cfm.

Outcomes of the Visioning Process

The visioning process makes it clear that an 80 by 50 New York requires low-carbon technologies serving an economy and society that have moved beyond dependence on fossil fuels to accept the true value and cost of energy. The recurring themes of the visioning discussion include technological elements that can be realized only with vigorous economic and social support:

- Maximum energy efficiency and conservation,
- Near-zero-carbon electricity generation,
- "Smart" electric transmission/distribution system with energy storage,
- Carbon-free energy carriers for transportation systems,
- Net energy-neutral buildings, including homes,
- Low-carbon liquid fuels,
- Carbon sink maintenance/enhancement.

Specifics and Insights

Exploration of these visioning themes led to more nuanced conclusions about the interactions of technology with the state's economy and society as we move through the next four decades. To illustrate the insights that flow from the visioning process, a selection of these conclusions is given here. The full list is found in the white paper.

- The 80 by 50 goal is very ambitious, and achieving it will require investments in new energy systems and infrastructure that have very low or no net carbon emissions. Patterns of energy use will also need to change radically.
- As policies and plans to meet the 80 by 50 goal are adopted, they need to be informed by the directions of the state's economy. The scenarios developed are consistent with the energy needs of a 21st-century economy based on clean energy technology, information technology, biotechnology, and nanotechnology.
- Incremental, short-term planning cannot achieve the goal. Near-term decisions—both those taken and not taken—can foreclose longer-term options, such as infrastructure projects with long lead times. Key climate strategies must reflect this inexorable reality.
- Major decisions are necessary to achieve the 80 by 50 goal, and many of those decisions must be made soon, as they deal with long-lead-time projects, such as infrastructure investments and research and development strategies, which can help or hinder progress.

- The goal must be pursued in part through extensive, long-term partnering among all levels of government and across the region, and between the public and private sectors. Achieving 80 by 50 will take sustained effort on the part of all.
- Energy efficiency is an essential, but not sufficient, strategy for reaching the 80 by 50 goal. It can be aggressively pursued today. A broad shift from reliance on burning fossil fuels to electricity or possibly hydrogen generated from low- or no-carbon sources, or widespread use of carbon capture and sequestration, will be needed.
- Electrification as a substitute for fossil fuel combustion is an essential strategy that will lead to a significant increase in demand and change in the patterns of electricity generation, transmission, and distribution. Therefore, ongoing planning for the smart grid and associated technologies, and storage of energy from intermittent energy resources must be part of the Climate Action Plan strategy.
- Transportation and buildings (residential and commercial) will have to move from reliance on fossil fuel combustion to use of alternate sources with significantly lower carbon or no carbon emissions. The buildings sector can reach net zero emissions through efficiency, electrification, energy storage technologies, and integration of renewable energy sources like solar and geothermal.
- Development and redevelopment based on smart growth principles, along with efficient building design practices, technologies, and construction methods, can reduce energy demand for buildings and transportation.
- Smarter means for shipping goods, including greater use of intermodal transportation and rail for freight movement, will save significant energy and reduce GHG emissions.
- All scenarios call for the phase-out of fossil fuel generation that free-vents carbon to the atmosphere. The schedule for this phase-out needs to be developed soon.
- Centrally-generated electricity must be decarbonized. This means that renewable energy generation must expand; existing nuclear power plants must be re-licensed or replaced; and carbon capture and storage added to any remaining fossil fuel-fired plants.
- Reducing vehicle miles traveled requires increased availability of mass transit, as well as travel-efficient community design, development, and redevelopment.
- Transformation to a hydrogen economy would require a new infrastructure for producing and delivering hydrogen to consumers.
- The interdependencies—and consequent vulnerabilities—of transportation, water, energy, and communication systems have direct consequences for system performance and thus for climate change adaptation and mitigation. System managers and operators must be helped to understand and manage those interdependencies.
- Greenhouse gas reduction has pervasive interconnections with the state‘s economy and social fabric: local, state and federal policies may facilitate or hinder achievement of the 80 by 50 goal. For example, interstate commerce (tourism, freight, and aviation) is shaped by federal policy, while large-scale renewable energy involves local land-use choices.

Chapter 5
Overview of Mitigation Policy Development

To assist with the development of policy options, the Climate Action Council (Council) convened three external advisory panels to assist and advise in areas requiring special expertise or knowledge: technical analysis, multi-sector integration, and 2050 visioning. The 2050 Visioning Advisory Panel, the Integration Advisory Panel, and five Technical Work Groups have provided direct input to the Climate Action Plan.

The Technical Work Groups served as advisors to the Council and consisted of Council member-agency staff and additional public, private, and non-profit sector stakeholders with specific interest and expertise. Policy options described in this interim report are principally the product of Technical Work Group deliberations, with feedback and guidance from the Integration Advisory Panel, Council, and public commenters. The Technical Work Groups, which were charged with developing policies to reduce greenhouse gas (GHG) emissions or enhance sequestration of carbon dioxide (CO_2), developed policy option scenarios that were analyzed in order to estimate GHG reduction potentials and net savings or costs.

Policy Options and Vision Map

The development of policy options has been informed by the results of the visioning process described in Chapter 4. The portfolio of policy options provides New York State with a comprehensive set of choices that could place the state on the path to the vision of a low-carbon future. A ‘mapping’ of policy options and the core vision strategies is presented as Figure 5-1.

Figure 5-1 –Policy Options and Vision Strategies Map

POLICY OPTIONS	CORE VISIONING STRATEGIES						
	Maximize Energy Efficiency & Conservation	Near- Zero-Carbon Electricity Generation	Smart Electric Transmission, Distribution & Storage	Carbon-Free Transportation Systems	Net Energy-Neutral Buildings	Low-Carbon Liquid Fuels	Carbon Sink Maintenance / Enhancement
RESIDENTIAL, COMMERCIAL/INSTITUTIONAL AND INDUSTRIAL							
Building Codes, Appliance Standards, & Enforcement, RCI-7	■	■		■	■		
Building Commissioning, Benchmarking, & Upgrades, RCI-8	■				■		
Energy Efficiency Incentives, RCI-2	■				■		
Customer-Sited Renewable Energy Incentives, RCI-3		■			■	■	
Industrial Process Incentives, RCI-11	■	■			■		
Workforce Training & Development, RCI-6	■	■	■	■	■	■	■
Outreach, Education, and Behavior Change RCI-5	■	■	■	■	■	■	■
Rate Restructuring & Flexible Metering, RCI-10	■	■	■	■	■		
Energy Efficiency and Clean Energy Fund, RCI-1	■	■	■		■	■	
Tax Structure & Private Financing, RCI-4	■	■			■	■	
Research, Development, & Demonstration, RCI-9	■	■	■		■	■	
TRANSPORTATION & LAND USE							
Vehicle Efficiency, TLU-1	■		■	■		■	
Vehicle Incentives & Disincentives, TLU-2	■		■	■		■	
Fleet Incentives & Disincentives, TLU-3	■			■			
Alternative Fuel & Infrastructure, TLU-4	■		■	■		■	
Research, Development, & Demonstration, TLU-5	■			■		■	
Decreased Travel & Less Commuting, TLU-6	■			■			
Mass Transit & Rail, TLU-7	■			■			
Freight Strategies, TLU-8	■			■			
Priority Growth Centers, TLU-9	■			■			■
Transit-Oriented Development, TLU-10	■			■			■
Location Efficient Land Use, TLU-11	■			■			■
Intergovernmental & Regional Initiatives, TLU-12	■		■	■			
POWER SUPPLY & DELIVERY							
Renewable Portfolio Std & Renewable Incentives, PSD-2		■		■	■		
Cap-and-Invest & Low-Carbon Portfolio Std, PSD-6	■	■	■	■	■	■	■
Siting and Permitting of New Generation, PSD-1		■		■	■		
New Facility Emissions and Nuclear Power, PSD-10	■	■		■	■		■
Existing Fossil Plant Policies, PSD-8	■	■		■	■		
Distribution Network Upgrade, PSD-4	■	■	■	■	■		
Transmission Network Upgrade, PSD-5	■	■	■	■	■		
Energy Storage, PSD-3		■	■	■	■		
Research, Development, & Demonstration, PSD-9	■	■	■	■	■	■	■
AGRICULTURE, FORESTRY & WASTE							
Production of Sustainable Feedstock for Bio-Energy, AFW- 1		■		■	■	■	■
Conversion of Sustainable Feedstock for Bio-Energy, AFW-2		■		■	■	■	
Maximize Waste Reduction, AFW-3	■						
Integrated Farm Management, AFW-4	■	■					■
Farm Efficiency & Renewable Energy, AFW-6	■	■			■		■
Conserve Open Space, AFW-5							■
Improved Forest Management, AFW-7				■			■
Local Food Production, AFW-8	■						
Research, Development, & Demonstration, AFW-9	■	■				■	■

Analysis Methodology

The analysis of policy scenarios is intended to establish the potential GHG reductions for the policies amenable to quantitative analysis and the direct costs to achieve those reductions. The approach to the analysis was full transparency—all data sources, methods, key assumptions, and key uncertainties were documented and subjected to stakeholder review. The Interim Report presents the first stage of the analysis, which consists of evaluating each policy on a stand-alone basis. The next stage will evaluate the policies on an integrated basis (i.e., after accounting for any overlaps between the policies). A third stage will consist of a macroeconomic analysis that will include consideration of indirect effects on employment, income, gross state product, and consumer energy costs.

The details of the stand-alone analysis methodology are presented in the Quantification Memo found in Appendix E and are summarized below.

Overall framework for the Analysis: The overall framework for the analysis of individual options was consistent across all four Work Group areas: Power Supply and Delivery (PSD); Residential, Commercial/Institutional and Industrial (RCI); Transportation and Land Use (TLU); and Agriculture, Forestry and Waste Management (AFW). It is important to note that not all options were deemed amenable to analysis (e.g., R&D and other enabling policies). Hence the framework below applies only to a subset of policies.

Analysis period: The overall period of analysis is 2011 through 2030.

Baseline GHG emissions: As a starting point, the analysis relies on the comprehensive inventory and forecast of New York State GHG emissions summarized in Chapter 3 and described in great detail in the *New York Greenhouse Gas Emissions Inventory and Forecast* report. This Inventory and Forecast is based upon a GHG emissions inventory for 2008 and forecast to 2030 for all emission source sectors prepared by NYSERDA. The GHG reduction impact of each policy is measured relative to this baseline. The forecast assumes New York does not adopt any new policies or measures to mitigate GHG emissions beyond those already in place or recent actions that have been approved but for which emissions reductions have not yet been realized. The forecast does not take into account the effects of a changing climate.

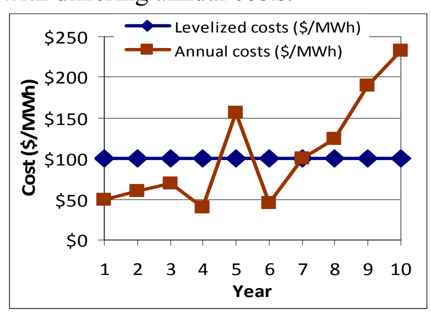
Emissions Coverage: The analysis considers six GHGs: CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions are presented using a common metric, carbon dioxide equivalent (CO_2e), which accounts for the relative contribution of each gas to global average radiative forcing. Emission factors are used based on the assumptions used by NYSERDA in the development of the baseline and can be found in Appendix E.

Geographic distribution of emission reductions: Emission reductions associated with policies in the Climate Action Plan are presented based upon the direct emissions at the point of release to provide an apples-to-apples comparison with the Inventory and Forecast. For many policies these direct emissions can seriously understate the GHG benefits, so in the detailed Policy Options Documents developed by the Technical Work Groups, emissions reductions were also tracked regardless of where they occur. Referred to as a "fuel cycle" approach, this framework allows for the quantification of the GHG reduction impact of policies no matter where they occur, either within or beyond New York State borders.

Costing approach: Estimating the costs of achieving GHG reductions for the options focused on the direct (or microeconomic) costs and savings borne by New York State households and businesses (e.g., the additional cost of energy efficient equipment and the fuel savings associated with that equipment). Indirect (or macroeconomic) costs such as the number of jobs created and lost or the impact on Gross State Product are not considered in this report but will be included in the final report.

Analytical Outputs: There are several key outputs of the analysis, namely annual GHG reductions for the years 2020 and 2030; cumulative GHG reductions over the 2011-2030 period; the net cost or savings to achieve these reductions on a present value basis; and the cost per metric ton of CO_2e avoided. Note that net savings are shown as 'negative costs' throughout this report.

Box 1: Overview of levelized costs
Levelized cost is defined as a constant annual cost that is equivalent on a present value basis to the actual annual costs. That is, if one calculates the present value of levelized costs over a certain period, its value would be equal to the present value of the actual costs of the same period. This is illustrated in the figure below. The present value of the levelized costs is exactly equal to the present value of the annual costs. Levelized costs allows for a ready comparison of technologies in any year, something that would be more difficult to do with differing annual costs.



Methodological Approach

The methodological approach applied to the analysis of options in all Work Groups is briefly described in the bullets below.

- *Major cost categories:* These include net capital/equipment costs, operations and maintenance (O&M), fuel, interconnection costs, and costs of financing.
- *Discounting:* Discounting begins in the initial year of the analysis period (2011) and applies a 5% real annual discount rate. The discount rate is kept constant for the evaluation of all GHG mitigation options. Risk and uncertainty are accounted for by calculating option-specific cash flows that account for policy, practice, or technology differences.
- *Treatment of capital costs:* Capital investments are represented in terms of their "levelized cost" over the project period (see Box 1 for an overview of the concept of levelized costs). In the case of certain technologies (e.g., solar photovoltaics) where capital costs have been declining, technology learning effects were included.
- *Emission Reductions:* Emission reductions for individual policies are calculated relative to baseline emissions based on the change (reduction) in emissions activity (e.g., physical energy units) or sequestration that the policy achieves.
- *Cost-effectiveness:* The cost effectiveness for each quantified policy is determined by dividing the present value cost by the cumulative (undiscounted) reduction in tons of GHG emissions.

- *End effects:* For GHG mitigation options whose lifetimes extend beyond the end of the analysis period (i.e., beyond 2030), only costs and benefits that fall within the analysis period are included in the analytical results.
- *Non-GHG (external) impacts and costs:* Environmental co-benefits such as reductions in criteria air pollutants that lead to improved public health outcomes are considered in a qualitative manner only in this report. The final report will include an in-depth examination of the major environmental co-benefits of these policy options.
- *Uncertainty / Sensitivity Analysis:* Key uncertainties and feasibility issues were identified and where possible subjected to sensitivity analysis on a policy by policy basis. These include energy and carbon price forecasts, discount rate[1], cost and performance assumptions, technology learning, and other parameters. Given the uncertainty surrounding federal climate legislation, the analysis assumed no future cost of carbon.

When quantifying the GHG emission reduction potentials of several of the PSD, RCI, and TLU mitigation policies, direct emission calculations exclude CO_2 emissions associated with the use of bioenergy, which includes the combustion of biogenic materials such as ethanol, biodiesel, and woody biomass. Historically, many national and international reporting protocols treat bioenergy as "carbon neutral." While there is now general scientific consensus that this assumption is incorrect, consensus on how to properly assign the appropriate carbon intensity is lacking.

On June 3, 2010, EPA published the final Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule. In that Rule, EPA acknowledged the Agency did not have sufficient information to address the issue of the carbon neutrality of biogenic materials and has called for a rigorous review of carbon accounting procedures. New York State will continue to follow the development of carbon accounting procedures and will update the GHG emission reduction calculations as interactions between the policies and their potential to achieve GHG reductions are analyzed.

Climate Action Plan Goals

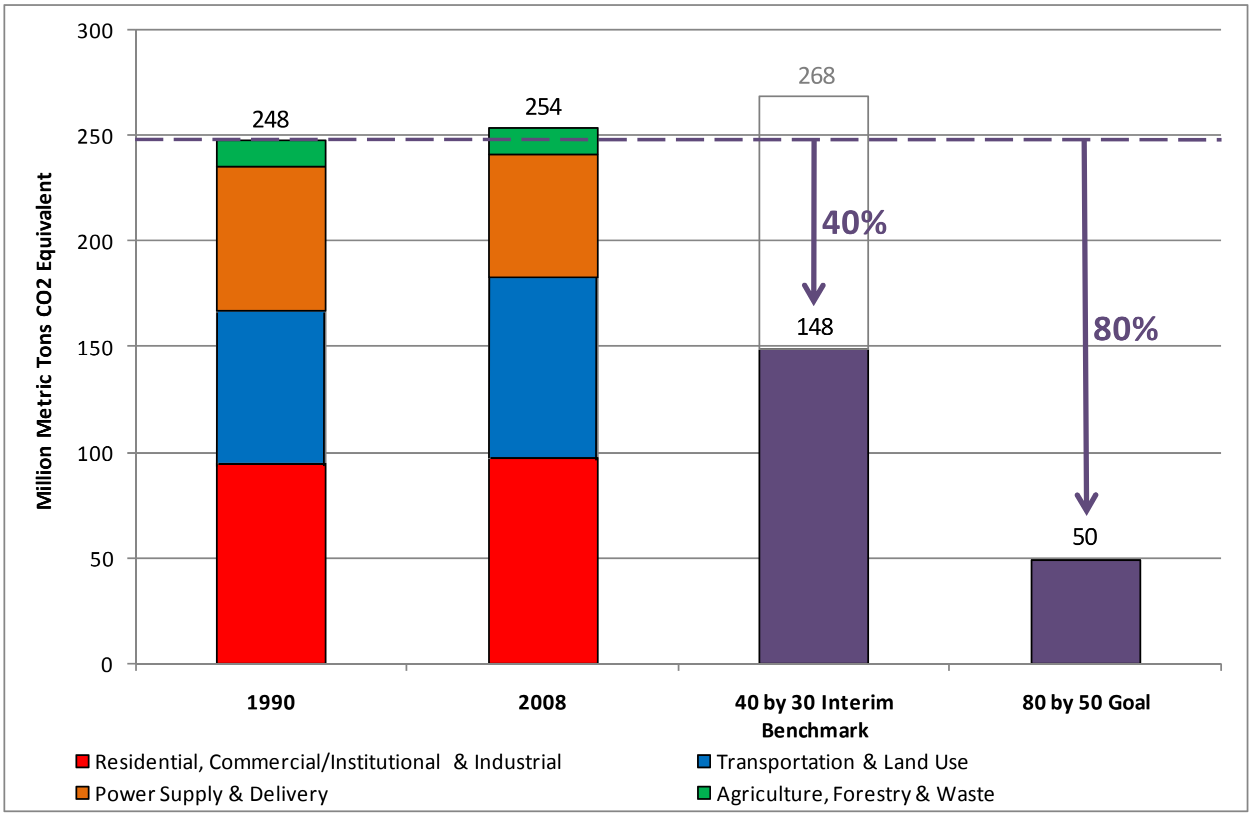
In August of 2009, Governor David A. Paterson signed Executive Order 2009-24 establishing the goal of reducing GHG emissions from all New York State sources to 80 percent below 1990 levels by 2050. To support development of a plan that will demonstrate New York's ability to meet this goal, the Council established an interim benchmark to reduce GHG emissions from all New York State sources to 40 percent below 1990 levels by 2030. This benchmark was provided to the Technical Work Groups so that the stakeholders would have a near-term target by which they could measure progress towards the 80 by 50 goal.

The 1990 reference emission levels, along with current levels, are presented in Figure 5-2. The forecasted GHG emission level for 2030, 268 million metric tons, is also presented along with

[1] Public-sector projects that result in durable, long-lasting effects, such as the expansion of transit and other infrastructure projects with long life-spans, may be evaluated with a lower discount rate than what is commonly used in the private sector. For example, the U.S. Department of Transportation allowed for the use of a 3% discount rate for its benefit-cost analyses under the Transportation Investment Generating Economic Recovery (TIGER) grant program, which is part of the federal government's $878 billion stimulus program.

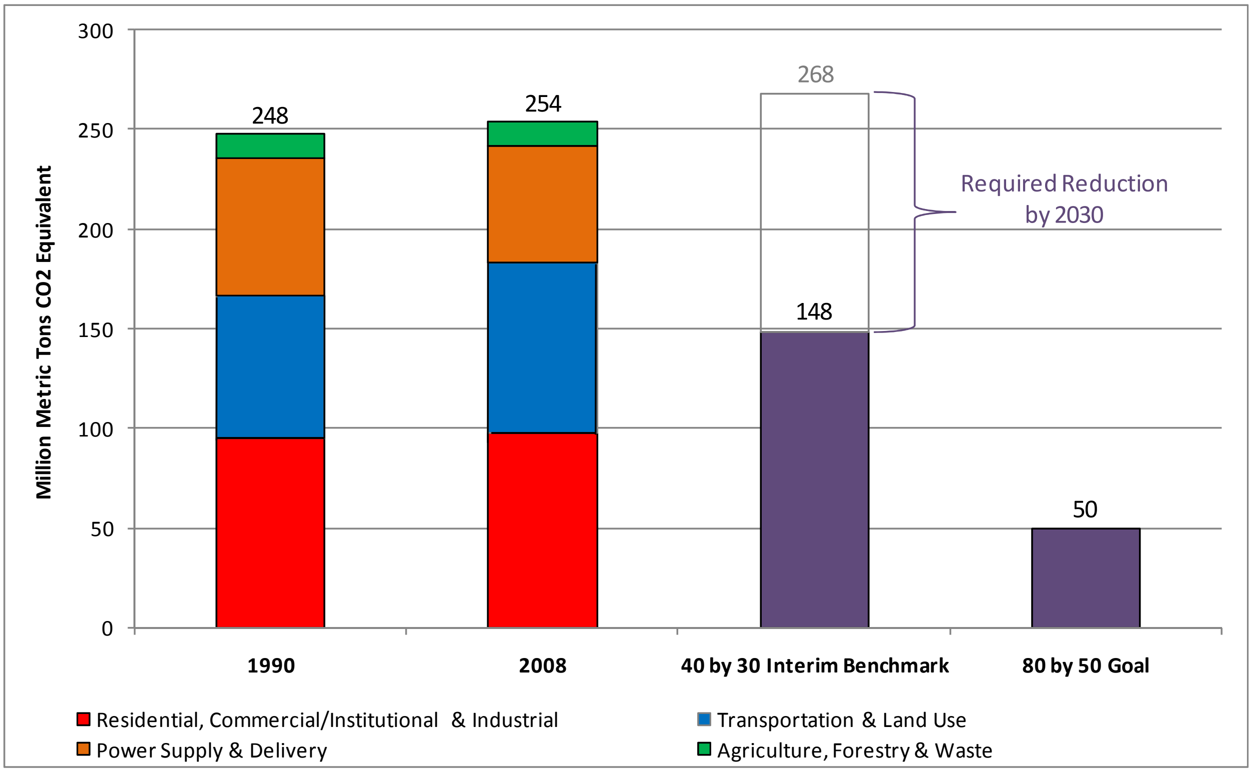
the emission limits implied by the 2030 benchmark (148 million metric tons) and the 2050 goal (50 million metric tons).

Figure 5-2. New York State GHG Emission Levels (1990 and 2008) and Forecast (2030) with Benchmark and Goal



The required emission reduction for 2030 is therefore 120 million metric tons, as shown in Figure 5-3. While the precise pathway to the 80 by 50 goal is not discernible at this time, the interim benchmark does provide a plausible mid-point target for the purpose of policy evaluation.

Figure 5-3. Required Emission Reduction by 2030 and 2050



Preliminary Results

Table 5-1 presents preliminary quantitative analysis of the mitigation policy options relative to the 2030 benchmark year. The preliminary analytical results presented here describe the potential effectiveness of the mitigation policy options on a stand-alone basis, without considering interactions among policies or overlapping emissions reductions. Table 5-1 presents an estimate of the total annual GHG emission reduction anticipated by 2030 as a result of the individual policy options (i.e., as measured by Millions Metric Tons CO_2e). In order to make this estimate, specific targets and goals were developed, where possible, for individual policy options. This is referred to as a “policy scenario”. Note, not all policy options are amenable to this type of quantification. The results also present an estimate of the total cost or savings of the policy option through 2030, as measured by net present value (NPV). This reflects the total capital costs, anticipated operation and maintenance costs/savings, and fuel costs/savings associated with the policy. As with any NPV analysis, a negative NPV reflects a savings and implies an economically desirable investment. Table 5-1 also presents an indicator of cost-effectiveness for the policy option, as measured by $/ton CO_2e avoided; this provides a metric to determine which policy options will deliver the most CO_2e on a dollar-for-dollar basis. As with NPV, a negative $/ton CO_2e implies that we save money as we reduce GHGs.

While further analysis is needed to better understand a more full range of economic impacts and to eliminate potential overlap, some general observations can be made from the analysis to date:

- No single policy can deliver the level of emission reduction needed to achieve a 40 by 30 target. A portfolio of policies will be needed to reduce emissions from the many different GHG sources throughout our economy.

- A linear path to achieving 80 by 50 may not be feasible. We may need to further ratchet up the stringency of the policies over time to increase the rate of emission reduction, as technologies and markets mature.

- There are a number of policies —particularly in the Buildings, Industry, and Transportation sectors —that represent cost-effective ways to take a meaningful step toward a low-carbon future. These "No Regrets" policies, which are primarily efficiency policies, could represent options for early action. Further analysis of benefits and costs, and strategies to finance and/or fund will be needed.

- Energy efficiency policies alone, however, will not deliver the level of emission reduction needed to achieve a 40 by 30 target (and ultimately the 80 by 50 goal). To make appreciable progress toward these aggressive goals and to break our dependence on finite fossil-fuel resources, the State will need to continue to strategically advance low-carbon energy supply-side policies and infrastructure investments, particularly focusing on policies that provide significant co-benefits to New Yorkers (e.g., improvements in local air quality, opportunities for economic development and job creation).

Table 5-1. Preliminary Results of Policy Scenario Analyses.

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value: Cost/Savings (Million $)	Net Cost/Savings per Avoided Emissions ($/tCO_2e$)
		2020	2030	Total 2011–2030		
RCI-2	Energy Efficiency Incentives	3.0	17	120	-$29	$0
	Combined Heat and Power (CHP) Incentives	0.2	1.1	7.1	$14	$2
RCI-3	Solar Electricity Incentives	0.7	3.3	22	$4,400	$200
	Solar Thermal Incentives	0.5	2.8	21	$2,600	$130
	Bioenergy Incentives	5.1	5.1	84	-$5,100	-$61
RCI-7	Enhanced Building Codes, Appliance Standards, and Enforcement	1.4	6.3	43	-$1,200	-$27
RCI-8	Building Commissioning, Benchmarking, and Upgrades	2.3	3.3	34	-$790	-$23
RCI-11	Industrial Process Incentives	1.2	2.6	26	-$2,500	-$95
TLU-1	Vehicle Efficiency Standards	5.3	17	130	$7,900	$62
TLU-2	Vehicle Incentives and Disincentives	0.9	2.0	20	-$2,300	-$120
TLU-3	Fleet Incentives and Disincentives	0.2	0.6	5.6	-$750	-$130
TLU-4	Alternative Fuel Related Measures and Infrastructure – Low Carbon Fuel Standard (LCFS)	3.9	8.5	84	$6,700	$79

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value: Cost/Savings (Million $)	Net Cost/Savings per Avoided Emissions ($/tCO_2e$)
		2020	2030	Total 2011–2030		
TLU-6	Commuter & Traveler Assistance	1.0	1.0	18	-$15,000	–$870
	Parking Pricing—					
	Upstate	0.3	0.3	0.5	$720	$1,400
	NYC Metro Region	0.4	0.4	0.8	-$480	-$610
	Telecommuting	1.0	1.0	18	-$15,000	-$870
	Congestion Pricing	0.2	0.2	2.4	-$1,100	-$460
TLU-7	Expand Transit	3.7	4.9	64	$25,000	$390
TLU-9	Priority Growth Centers	0.1	0.3	2.6	-$1,600	-$610
TLU-10	Transit-Oriented Development / Transit Supportive Development	0.3	0.5	5.7	-$5,000	-$870
TLU-11	Location Efficient Land Use	0.6	1.2	13	-$11,000	-$870
PSD-2	Renewable Portfolio Standard (RPS) and Incentives for Grid-Based Renewable Generation	2.8	7.9	64	$1,700	$27
PSD-4	Distribution System Upgrades	0.3	0.8	6.3	-$460	-$73
PSD-6	Low Carbon Portfolio Standard (LCPS): High Penetration of Renewables	7.3	29	220	$5,600	$26
AFW-3	Maximize Waste Reduction, Recycling, and Composting—In-State Only	0.5	0.7	8.0	$280	$35
AFW-4	Integrated Farm Management Planning and Application	0.3	0.6	6.5	-$201	-$31
AFW-5	Conserve Open Space, Agricultural Lands and Wetlands	4.5	5.5	95	$1,500	$16
AFW-6	Increase On-Farm Energy Efficiency and Renewable Energy	0.2	0.4	3.8	$3	$1
AFW-7	Forest Restoration	2.3	4.7	49	$290	$6
	Urban Forestry	1.0	2.0	22	$3,200	$140
	Reforestation	1.8	2.4	34	$1,200	$36

The data presented in Table 5-1 are also illustrated graphically in Figure 5-4. Figure 5-4 shows the potential annual emission reductions in 2030 and the net-savings or net-cost per ton CO_2e avoided for each policy. The 2030 benchmark goal has been drawn as a line in the figure to provide a basis for judging effectiveness of each policy. Some general observations can be made:

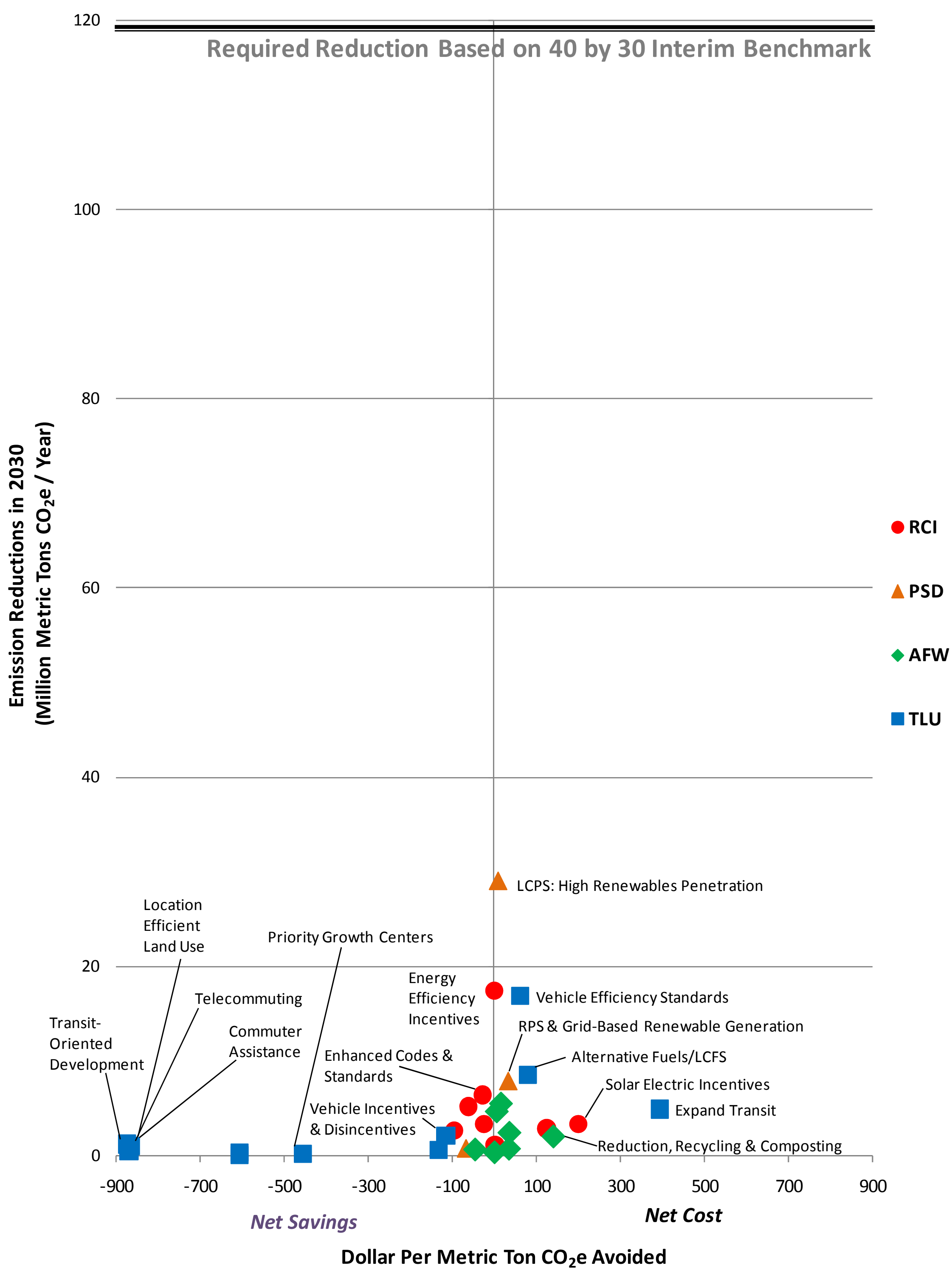
- Policies that provide the largest potential emission reductions in 2030 include the low-carbon portfolio standard (PSD-6), increased vehicle fuel efficiency standards (TLU-1), building energy efficiency incentives (RCI-2), and a low-carbon fuel standard (TLU-4).

- Polices that provide the largest savings per avoided metric ton of emissions include smart growth policies (TLU-9, -10, and -11), and commuter assistance (TLU-6).

- Policies that provide both significant emission reductions and net savings include building energy efficiency incentives (RCI-2), improved building codes and standard (RCI-7), and vehicle incentives (TLU-2).

The petroleum and non-petroleum fuel savings associated with these policies are presented in Table 5-2 and Table 5-3. Based on the estimated reductions in 2030 derived from the scenario analysis and on current consumption levels, RCI-2 would save enough electricity to power 4.6 million homes and enough home heating oil and natural gas to heat more than 1.9 million homes for a year. Similarly, based on the estimated reductions in 2030 derived from the scenario analysis and on current consumption levels, TLU-1 would save enough motor gasoline to power 7.3 million cars for a year.

Figure 5-4. Policy Scenario Analytic Results



NOTE: Scenario results are not additive as synergies and overlap have not been estimated.
Additional economic analyses need to be conducted to assess macroeconomic impacts and co-benefits.

Table 5-2. Preliminary Fuel Savings from Petroleum Products.

Policy No.	Policy Option	Annual Petroleum Products (Millions of Gallons of Gasoline Equivalent)	
		2020	2030
RCI-2	Energy Efficiency Incentives	58	360
RCI-3	Customer-Sited Renewable Energy Incentives	230	340
RCI-7	Enhanced Building Codes, Appliance Standards, and Enforcement	36	160
RCI-8	Building Commissioning, Benchmarking, and Upgrades	50	68
RCI-11	Industrial Process Incentives	54	120
TLU-1	Vehicle Efficiency Standards	1,000	3,500
TLU-2	Vehicle Incentives and Disincentives	100	220
TLU-3	Fleet Incentives and Disincentives	26	69
TLU-4	Alternative Fuel Related Measures and Infrastructure – Low Carbon Fuel Standard (LCFS)	870	2,000
TLU-6	Commuter & Traveler Assistance	110	120
	Parking Pricing		
	Upstate	3.0	3.0
	NYC Metro Region	5.0	5.0
	Telecommuting	110	120
	Congestion Pricing	18	18
TLU-7	Expand Transit	670	900
TLU-9	Priority Growth Centers	13	36
TLU-10	Transit-Oriented Development / Transit Supportive Development	49	100
TLU-11	Location Efficient Land Use	110	230

Table 5-3. Preliminary Fuel Savings from Non-Petroleum Fuels.

Policy No.	Policy Option	Annual Electric Energy (GWh)		Annual Natural Gas (BCF)		Annual Other Fuels (BBtu)	
		2020	2030	2020	2030	2020	2030
RCI-2	Energy Efficiency Incentives	5,300	32,000	22	130	2,700	8,900
RCI-3	Customer-Sited Renewable Energy Incentives*	2,300	11,000	60	83	0	0
RCI-7	Enhanced Building Codes, Appliance Standards, and Enforcement	2,000	9,500	11	51	1,100	5,100
RCI-8	Building Commissioning, Benchmarking, and Upgrades	3,200	4,900	16	23	630	860
RCI-11	Industrial Process Incentives	230	460	7	14	3,900	8,700

Other Fuels include non-petroleum fuels such as coal and wood.

*Other fuel savings do not include the increased consumption of biofuel associated with RCI-3. This consumption amounts to an increase of 90,000 BBtu.

Chapter 6
Residential, Commercial/Institutional, and Industrial Mitigation

Sector Vision for a Low-Carbon Future

In 2050, New Yorkers will enjoy safe, comfortable, well-functioning and sustainable buildings and communities whose construction and renovation activities, building operations, and Industrial Process Incentives are designed and operated to maximize energy and resource efficiency, to minimize fossil fuel inputs, and to meet remaining energy needs from a mix of local low-carbon resources and low-carbon imports. More specifically, buildings in New York will have the following characteristics:

Building design and renovation: Building design and renovation along with integrated site planning will optimize resource conservation opportunities from envelope, mechanical, lighting, site/landscaping, and other building systems. Building and site designs will emphasize passive solar energy, solar thermal systems, and onsite or local renewable electricity generation. Performance-based building codes will continue to save consumers substantial energy costs while avoiding unnecessary power generation and greenhouse gas (GHG) emissions. Design, renovation, and enforcement activities will be supported by a well-trained workforce.

Building operation: Supported by marketing, outreach, and education efforts, building owners, designers, operators, and users will implement building operations, upgrades, and Industrial Process Incentives that achieve high levels of energy efficiency, while improving occupant comfort and indoor air quality. Building upon RD&D efforts, equipment that meet advanced efficiency standards will minimize the energy demand of buildings and industrial processes.

Building energy supply: Instead of relying on combustion of fossil fuels for comfort control and daily operations, buildings will primarily use customer-sited renewable energy resources and import low-carbon resources as needed. Sources of waste heat, especially industrial process heat, will be used to the maximum extent possible; supplementary heating and cooling draws on carbon-neutral energy sources, such as wind, solar photovoltaic, or geothermal.

Land use planning and community development: Building developers and communities maximize location efficiency by integrating patterns of home, work, shopping, and entertainment, in accordance with Smart Growth principles and methods, maximize resource conservation, and minimize GHG emissions.

Adaptation: Through building codes and siting guidelines that place buildings and other facilities away from projected flood zones and favor designs and materials appropriate for future climate conditions, New York's communities will make themselves resilient to climate change.

Overview of GHG Emissions

The RCI sector is the largest source of gross greenhouse gas (GHG) emissions in New York, accounting for about 40 percent of gross GHG emissions in 2008. The residential, commercial/institutional, and industrial (RCI) sector includes onsite fuel combustion, industrial process, and manufacturing emissions, as well as fugitive[1] methane emissions from natural gas transmission and distribution. Energy-related RCI emissions result principally from the onsite combustion of oil and natural gas, with a smaller contribution by onsite combustion of coal.[2] The onsite combustion of these fuels in the RCI sector accounted for an estimated 75 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) gross GHG emissions in 2008. Industrial process emissions, primarily fluorinated gases and emissions from cement production, added another 9 percent of statewide emission in 2008. Fugitive emissions of methane from natural gas transmission and distribution contributed another 5.7 $MMtCO_2e$ (2 percent of total emissions) in 2008.

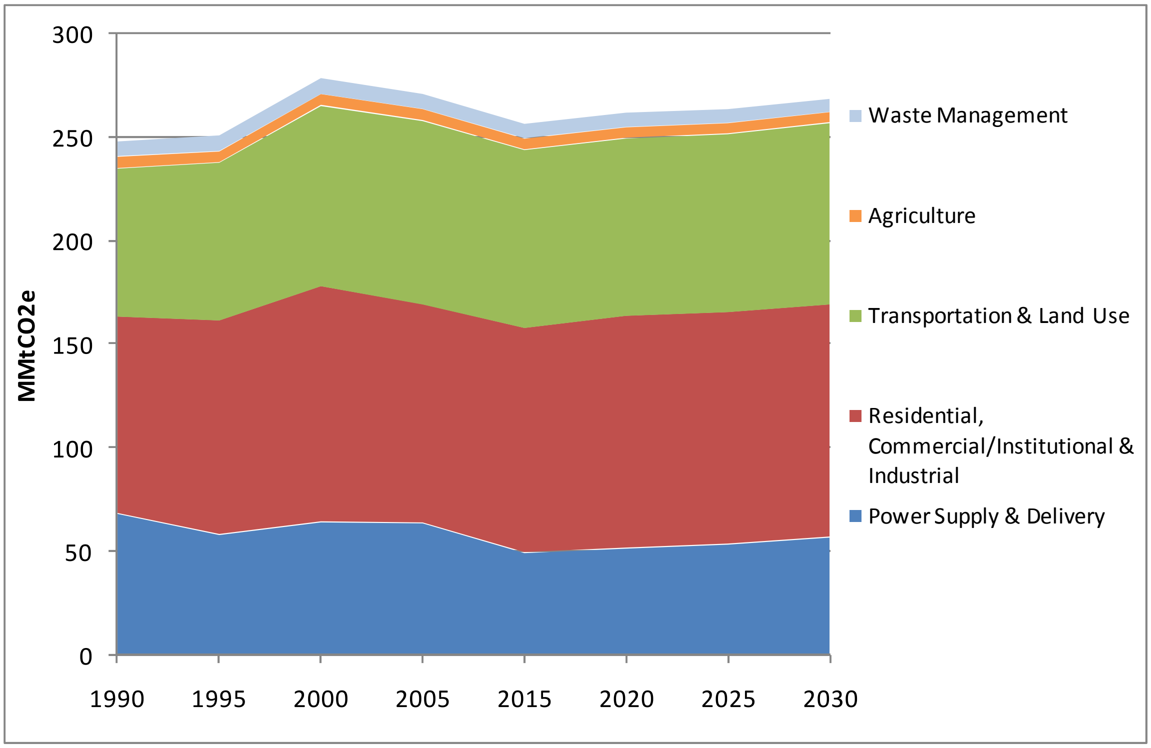
Considering only the onsite fuel combustion emissions that occur within buildings and industries, however, ignores the fact that nearly all electricity sold in the state is consumed as the result of RCI activities.[3] Emissions from the generation of electricity that RCI buildings consume contribute an additional 20 percent of emissions. Together with electricity generation, these sources of emissions that are all attributable to RCI sector activities are responsible for about 60 percent, or 151 $MMtCO_2e$, of total statewide GHG emissions in 2008. Figure 6-1 shows the relative contributions of the RCI, electricity, and industrial process sectors to New York State emissions from 1990 to 2030 under the reference scenario. New York's future GHG emissions will depend heavily on future developments in the consumption of electricity, industrial processes, and fuel use in these critical subsectors.

[1] The general definition of fugitive emissions given in the IPCC Guidelines is "an intentional or unintentional release of gases from anthropogenic activities excluding the combustion of fuels". http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_6_Fugitive_Emissions_from_Oil_and_Natural_Gas.pdf p.3

[2] The RCI inventory and forecast methodology accounts for only emissions from direct fuel and electricity usage. Thus, the GHG estimates presented here do not include GHG emissions associated with the extraction, processing, and transportation of RCI fuels, with the exception of natural gas leakage. Electricity sector emissions include GHG emissions from electricity imported from outside the state as well as from transmission and distribution losses.

[3] Emissions associated with the electricity sector (discussed in Chapter 8) have been allocated to each of the RCI subsectors for comparison of those emissions to the emissions associated with on-site fuel combustion. Note that this comparison is provided for informational purposes and that emissions are not double-counted in the total emissions for the state.

Figure 6-1. Historical and Forecasted New York GHG Emissions by Sector, 1990–2030



GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

RCI Sector Greenhouse Gas Emissions by Fuel

Figure 6-2 shows historical and forecasted RCI GHG emissions by fuel and source.[4] Emissions from the four relevant RCI subsectors including RCI onsite fuel combustion, RCI electricity consumption, industrial processes, as well as fugitive methane emissions are expected to increase from 152 to 166 MMtCO$_2$e between 2008 and 2030. Figure 6-2 also indicates that the vast majority of GHG emissions from the RCI sector come from electricity and natural gas (76 percent). RCI emissions associated with electricity use are expected to be largely unchanged between 2008 and 2030, at about 55 MMtCO$_2$e under the reference scenario. However, as discussed below, the unchanged overall emissions from electricity generation mask large forecasted declines in emissions from the residential and industrial subsectors and an increase in the commercial/institutional subsector's GHG emissions. While GHG emissions from the onsite combustion of petroleum remain flat or slightly decline, emissions from the onsite combustion of coal are forecasted to increase moderately by 15 percent from 2008 to 2030. Coal is expected to remain an important source of fuel for the industrial sector throughout the period in the reference case forecast. Natural gas is also expected to remain an important industrial fuel during this time, with a forecasted increase of 13 percent in emissions from onsite combustion.

[4] See Chapter 3 for reference case forecasts.

RCI Sector GHG Emissions and Trends

Figure 6-3 shows historical and forecasted GHG emissions by RCI subsector, including those associated with electricity consumption. Overall, Figure 6-3 shows that emissions from the RCI sector are forecasted to increase by 17 percent between 2008 and 2030 under the reference case scenario. Emissions associated within the RCI subsectors are forecasted to experience a wide variety of emissions growth and decline. Residential emissions are forecasted to decline by 6 percent between 2008 and 2030, while commercial/institutional and industrial sector emissions are expected to increase by 21 percent and 14 percent, respectively.

RCI Subsector GHG Emissions and Trends

Residential Subsector Emissions

Figure 6-4 shows that between 2008 and 2030, emissions for the residential subsector are expected to decrease by 6 percent to reach approximately 50 $MMtCO_2e$. The GHG emissions associated with the generation of electricity for this subsector are forecasted to decline by 17 percent from 2008 to 2030, while emissions associated with the onsite combustion of natural gas are forecasted to increase by 7 percent over this 22-year period. Figure 6-4 also shows that residential subsector emissions associated with the onsite combustion of petroleum are forecasted to decline by 14 percent from 2008 to 2030.

Commercial/Institutional Subsector Emissions

Figure 6-5 shows commercial/institutional subsector emissions are expected to increase by 21 percent from 2008 to 2030 to nearly 67 $MMtCO_2e$. Figure 6-5 also indicates that the increase in emissions from the subsector is due primarily to emissions from electricity used by commercial/institutional consumers, which are forecasted to increase by 24 percent. Emissions from the onsite combustion of natural gas are also forecasted to increase by 24 percent from 2008 to 2030. Commercial/institutional subsector emissions associated with the onsite combustion of petroleum are also expected to increase by 9 percent during the period.

Industrial Subsector Onsite Fuel Combustion and Process Emissions

Figure 6-6 indicates that industrial subsector emissions are expected to increase by 14 percent from 2008–2030 to almost 47 $MMtCO_2e$, although this aggregate forecast masks wide variation in emissions by fuel source. GHG emissions associated with the generation of electricity to meet industrial demand are forecasted to decrease by 84 percent from 2008 to 2030 due to less carbon-intensive electricity generation as well as decreased electricity demand from the subsector. However, emissions associated with the onsite combustion of coal, petroleum, natural gas, and wood are forecasted to increase by 17 percent, 8 percent, 1 percent, and 12 percent, respectively.

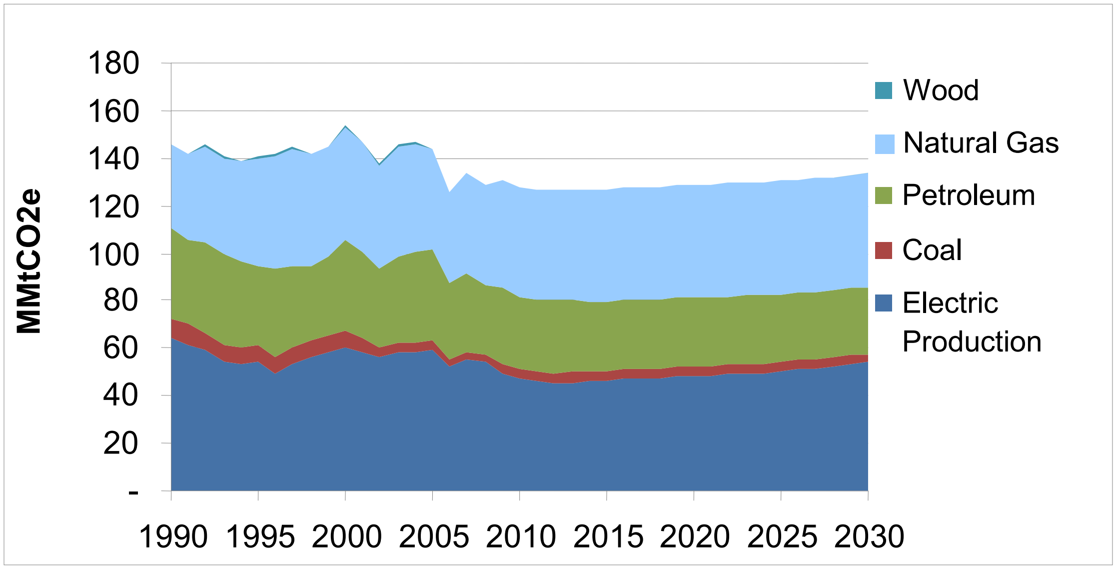
Figure 6-7 shows forecasted industrial process GHG emissions in New York State, which are dominated by emissions from cement production and substitutes for ozone-depleting substances.[5] Emissions from this source are expected to grow in line with national forecasts at

[5] New York emissions from substitutes for ozone-depleting substances (ODS) for 2010, 2015, and 2020 were scaled from EPA's estimates of total US emissions based on state and national population projections. New York's emissions for the missing years from 2008 through 2020 were estimated using linear interpolation. From 2021 through 2030, New York emissions were estimated by applying the New York projected population growth rate to the 2020 New York ODS emissions value.

over 5 percent a year, which equates to emissions more than doubling of GHG emissions between 2008 and 2030 from 7.5 to 16.4 $MMtCO_2e$.

Finally, Figure 6-8 shows methane emissions from the transmission and distribution of natural gas in New York State. The New York estimate is extrapolated from forecasted national fugitive methane emissions. The forecast shows an increase in methane emissions of 10 percent from 2008 to 2030 to approximately 6.2 $MMtCO_2e$.

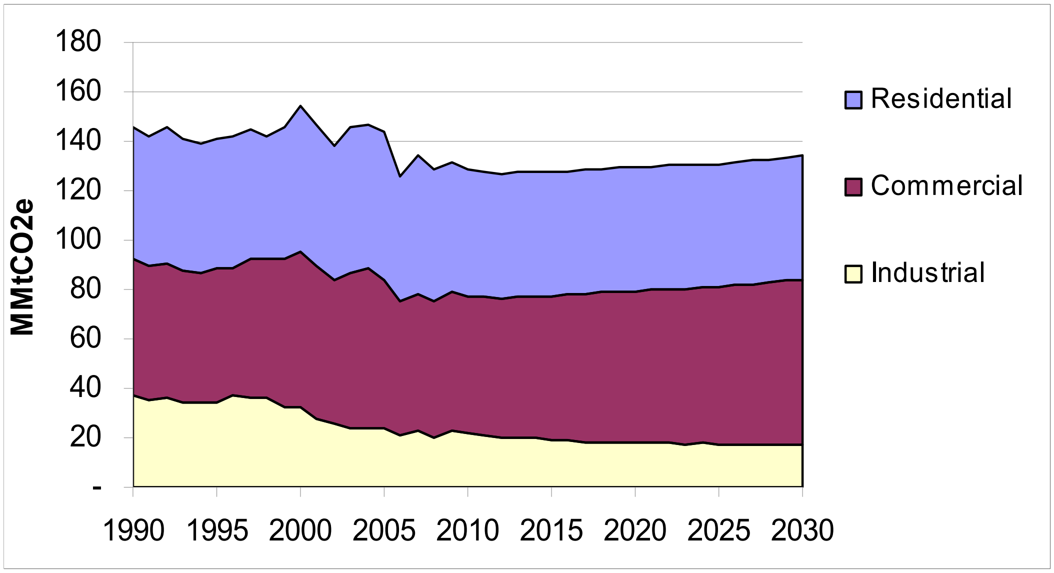
Figure 6-2. Historical and Forecasted Residential, Commercial/Institutional, and Industrial (RCI) GHG Emissions by Type of Fuel, 1990–2030



* Figure 6-2 does not include fugitive methane and industrial process emissions. GHG = greenhouse gas; MMtCO2e = million metric tons of carbon dioxide equivalent.

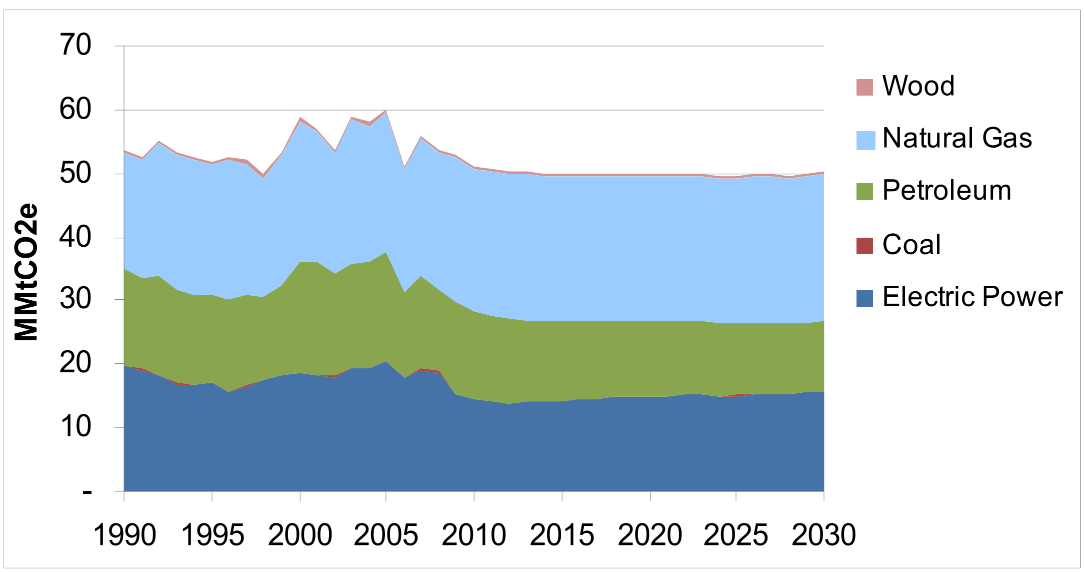
Substitutes for ozone-depleting substances, which include chlorofluorocarbons, halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HFCs), are used in a variety of industrial applications including refrigeration and air conditioning equipment, aerosols, solvent cleaning, fire extinguishing, foam blowing, and sterilization. Although their substitutes, HFCs, are not harmful to the stratospheric ozone layer, they are powerful GHGs. (EPA's *Draft User's Guide for Estimating Carbon Dioxide, Nitrous Oxide, HFC, PFC and SF_6 Emissions from Industrial Processes Using the State Inventory Tool*, February 2010)

Figure 6-3. Historical and Forecasted Residential, Commercial/Institutional, and Industrial (RCI) Greenhouse Gas Emissions by Subsector, 1990–2030



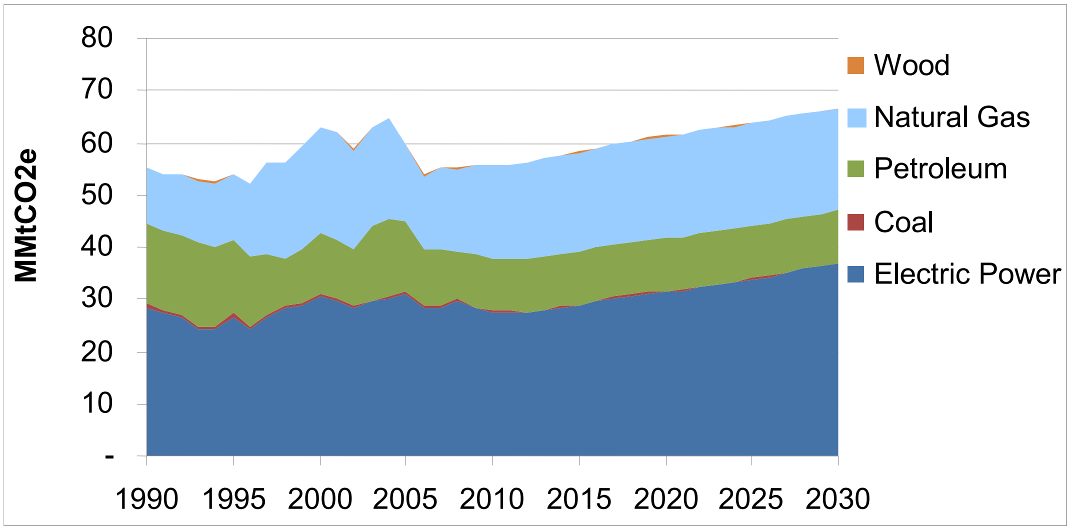
Emissions associated with the direct use of natural gas, petroleum, coal, and wood and the consumption of electricity. Figure 6-3 does not include fugitive methane and industrial process emissions. GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Figure 6-4. Historical and Forecasted Residential GHG Emissions by Fuel Type, 1990–2030



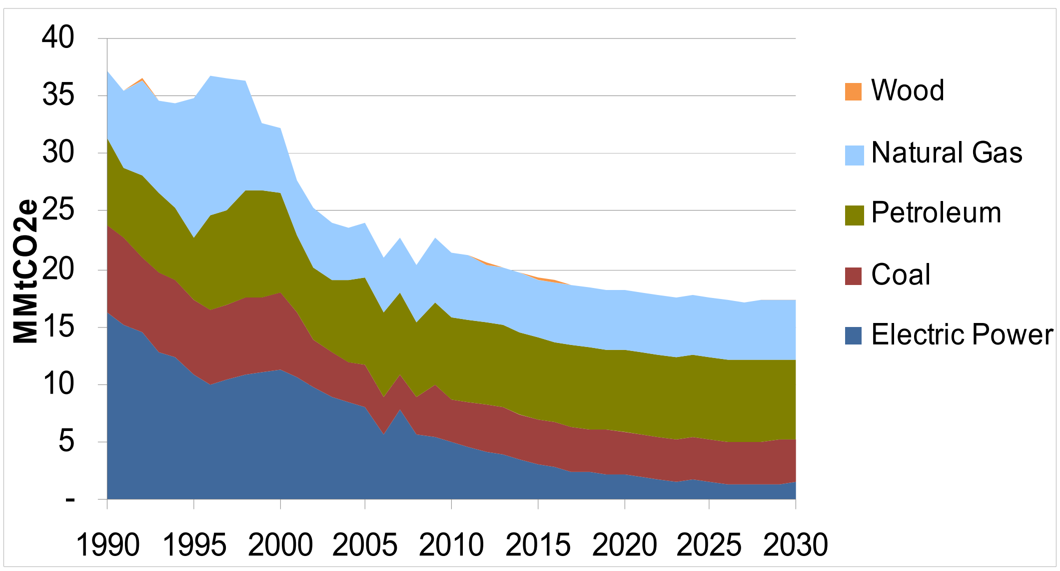
GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Figure 6-5. Historical and Forecasted Commercial/Institutional GHG Emissions by Fuel Type, 1990–2030



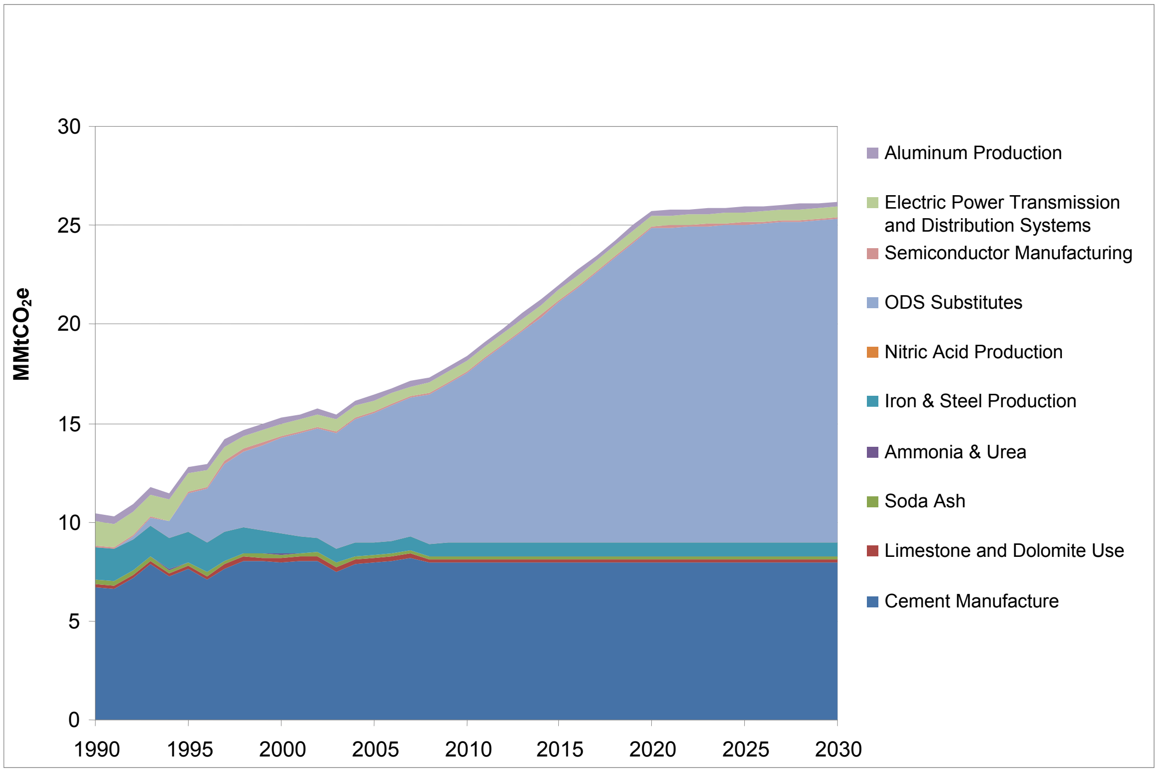
GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Figure 6-6. Historical and Forecasted Industrial Subsector GHG Emissions by Fuel Type, 1990–2030



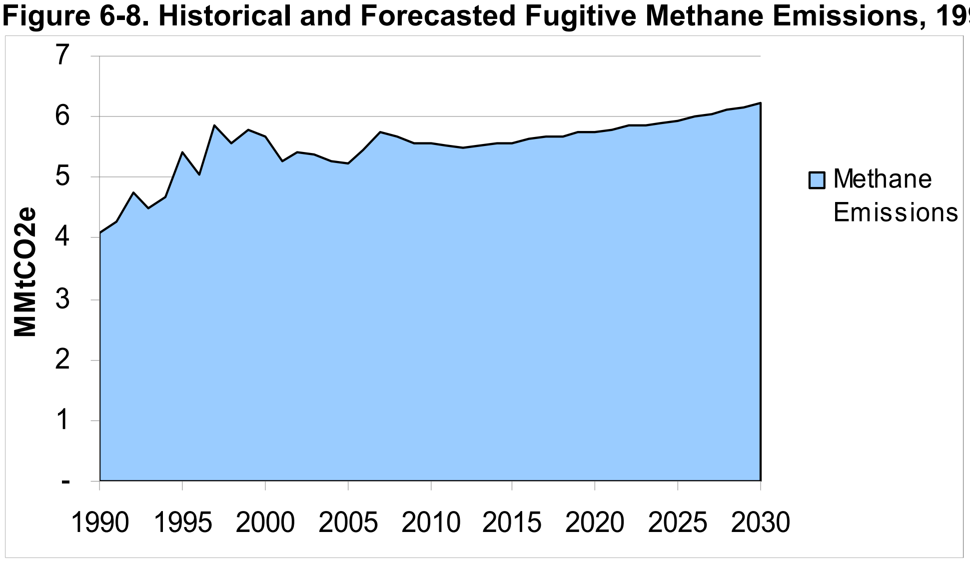
GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Figure 6-7. Historical and Forecasted Industrial Process GHG Emissions by Source, 1990 –2030



GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; ODS = substitutes for ozone-depleting substances.

Figure 6-8. Historical and Forecasted Fugitive Methane Emissions, 1990–2030



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Overview of Policy Options and Estimated Impacts

To achieve mid-century GHG reduction goals in its building stock, New York must implement an integrated, diverse set of policy options. Over the next 40 years, Residential, Commercial/Institutional, and Industrial buildings and processes will need to maximize energy and resource efficiency, minimize fossil fuel inputs, and provide remaining required energy inputs from local low-carbon sources and carbon-neutral imports.

New York has already put policies in place to begin this needed transformation. The 45 by 15 clean energy policy challenges the state to meet 45 percent of its electricity needs by 2015 through increased energy efficiency and renewable energy. The 45 by 15 policy proposes to reduce electricity end-use in 2015 by 15 percent below forecasted levels, while simultaneously meeting 30 percent of the state's electricity supply needs through renewable resources.

Building upon 45 by 15 policies, which focus on increased near-term statewide energy efficiency and renewable energy use, the RCI Technical Work Group has recommended a number of policies to further reduce the GHGs emitted by New York's existing homes, businesses, industries, and new construction. These policies can be organized into three categories: statutory and regulatory policies that reduce carbon emissions in new and existing buildings, voluntary incentive policies that promote energy efficiency and renewable energy improvements in buildings and industrial processes, and supporting policies.

At the core of the RCI policies, the Technical Work Group recommends that the State enact two statutory and regulatory policies: Building Codes, Appliance Standards, and Enforcement (RCI-7) and Building Commissioning, Benchmarking, and Upgrades (RCI-8). RCI-7 encourages New York to aggressively update and enforce the State Energy Code in the near-term, which will lead to long-term emission reductions in code-compliant new and renovated existing buildings. Providing municipalities with the choice of adopting a State-set stretch code, as recommended in the 2009 State Energy Plan, and establishing a flexible code compliance framework will further reduce GHG emissions at the local level. RCI-8 focuses on reducing existing buildings' operating costs and achieving energy savings through regular energy benchmarking, audits and commissioning activities and installing cost-effective energy efficiency measures. Together, these policies will ensure that an increasing percentage of New York's building stock will have significantly lowered GHG emissions and operating costs by 2050.

To encourage additional GHG emission reductions beyond those generated by the mandated policy options, the Technical Work Group recommends three additional voluntary policies to provide incentives for owners of existing buildings to undertake renovations that bring buildings above current code compliance and accelerate the rate of building renovation necessary to achieve the 80 by 50 goals. Energy Efficiency Incentives (RCI-2) uses a whole-building, integrated analysis approach to identify high-performance efficiency measures that could be installed in existing and new buildings. Onsite use of renewable energy would be incentivized through Customer-Sited Renewable Energy Incentives (RCI-3). Improving the state's industrial competitiveness, Industrial Process Incentives (RCI-11) enhances industrial activity and reduces carbon intensity through more efficient, productive and cost-effective operations. Given that most existing buildings will not be subject to code-mandated improvements, encouraging owners to voluntarily implement upgrades is vital to meeting New York's GHG emission reduction goals.

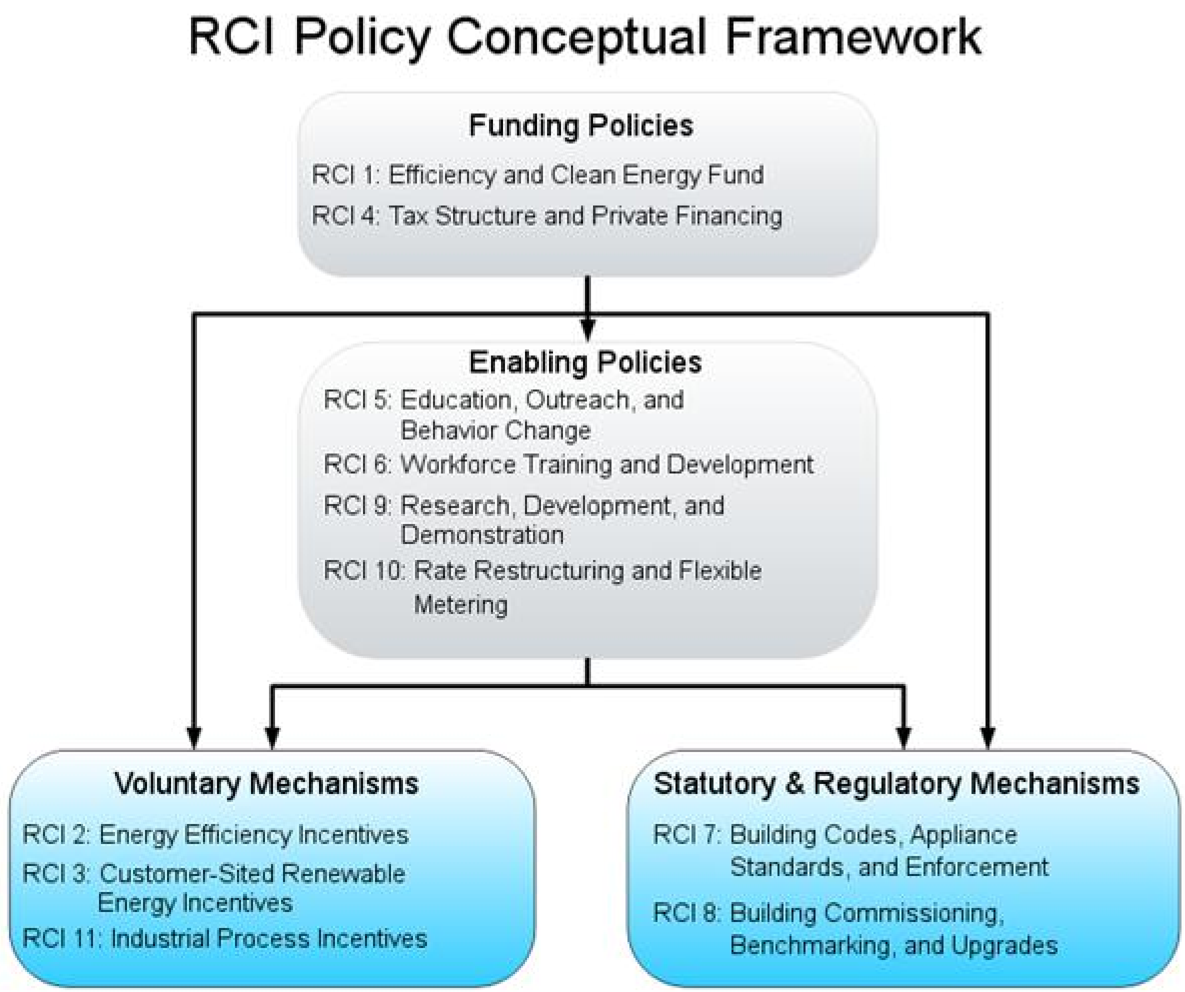
Six additional supporting policies are critical to the successful implementation of the RCI statutory and voluntary policies. Investment and deployment of a trained workforce is a core component of the clean energy economy and will significantly contribute toward achieving the State's climate policy objectives. Workforce Training and Development (RCI-6) recognizes the need for effective development of a skilled workforce equipped with the knowledge, skills, and ability to directly meet the energy service demands of RCI-2, 3, 7, 8 and 11. New technologies, along with a well-trained workforce to support the design, installation and maintenance of those technologies, are integral to successful reduction of GHG emissions in New York. Research, Development, and Demonstration (RCI-9) recommends continued investment—coordinated activity by federal, State and private-sector entities—in the research, development, demonstration, and deployment (RDD&D) of next-generation technologies that will help the State achieve its 80 by 50 goal. These initiatives would accelerate the development and commercialization of new products and technologies that will enhance the State's ability to achieve the 80 by 50 goal at lower cost, while also stimulating a clean energy economy.

Achievement of the State's climate action goals is dependent upon action by consumers to invest in energy efficiency and renewable energy equipment and infrastructure. Building upon the State's progress in this area, Education, Outreach, and Behavior Change (RCI-5) will increase consumer and State employee awareness of the benefits of clean energy, motivating immediate, and long-term action. Rate Restructuring and Flexible Metering (RCI-10) also recognizes the importance of providing real-time energy price signals to electricity customers and increasing the penetration of smart metering. Together, these policies enhance the energy savings information provided to consumers and State employees at the time of purchase or use. This would facilitate informed decisions that may have a long-term effect on energy consumption and bills, and provide a powerful incentive for retailers and manufacturers to provide products that satisfy consumer energy efficiency expectations. RCI-10 further explores electric rate structures that foster energy efficiency and renewable energy activities in RCI-2, 3, and 11, and encourage plug-in electric vehicle use, while promoting rate equity for vulnerable populations. Redesigning electric rates to vary by time of use for all electricity users and providing cost/use information to users on a "real-time" basis would enable customers to make informed decisions about when and how they can reduce their electricity use.

Last, Efficiency and Clean Energy Fund (RCI-1) and Tax Structure and Private Financing (RCI-4) work in unison to leverage public funding and private financing to fund the clean energy activities in RCI-2, 3, 5, 6, 7, 8, 9, and 11. Funds for incentives would be provided by RCI-1 and other sources, such as federal and foundation grants and private co-funding. RCI-4 recommends that the State undertake a comprehensive review of the current tax structure and financing programs and their impact on current and future carbon reduction activities and identify policy options for future shifts to support carbon reduction activities. RCI-1 and 4 recognize that dedicated and continuous funding is essential for the overall success of the RCI statutory, voluntary and supporting policy options and the attainment of long-term carbon reduction goals.

All of the RCI policy options have important co-benefits in terms of reduction of energy demand and the corresponding energy savings, bill reductions, improved occupant comfort, job creation, and clean air.

Figure 6-9. Residential, Commercial/Institutional, and Industrial Policy Options



Policy Scenario Quantification Summary Table

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value: Cost/Savings (Million 2005$)	Net Cost/Savings per Avoided Emissions ($/t$CO_2e$)
		2020	2030	Total 2011–2030		
RCI-2	Energy Efficiency Incentives	3.0	17	120	–$29	–$0.3
	Combined Heat and Power (CHP) Incentives	0.2	1.1	7.1	$14	$2.0
RCI-3	Solar Electric Incentives	0.7	3.3	22	$4,400	$200
	Solar Thermal Incentives	0.5	2.8	21	$2,600	$130
	Bioenergy Incentives	5.1	5.1	84	–$5,100	–$61
RCI-7	Enhanced Building Codes, Appliance Standards, and Enforcement	1.4	6.3	43	–$1,200	–$27
RCI-8	Building Commissioning, Benchmarking, and Upgrades	2.3	3.3	34	–$790	–$23
RCI-11	Industrial Process Incentives	1.2	2.6	26	–$2,500	–$95

$/t$CO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations. The policy numbers that appear in this table are not consecutive because they reflect only those policies for which quantification has been completed and not all policies are amenable to quantification.

Table 6-1. Summary of Electric and Fuel Savings

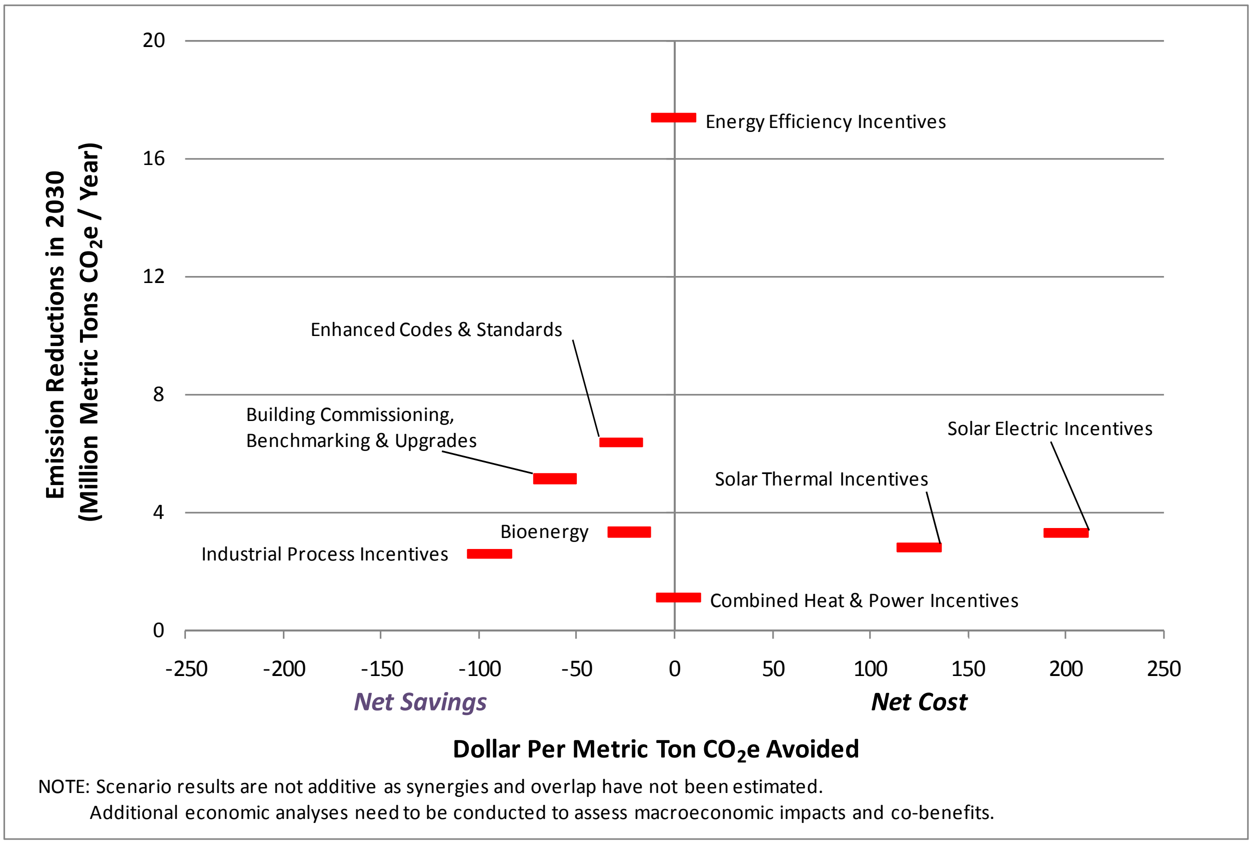
Policy No.	Policy Option	Annual Electric Energy (GWh)		Annual Natural Gas (BCF)		Annual Petroleum Products (Million GGE)		Annual Other Fuels (BBtu)	
		2020	2030	2020	2030	2020	2030	2020	2030
RCI-2	Energy Efficiency Incentives	5,300	32,000	22	130	58	360	2,700	8,900
RCI-3	Customer-Sited Renewable Energy Incentives (Scenario #2)	2,300	11,000	60	83	230	340	0	0
RCI-7	Enhanced Building Codes, Appliance Standards, and Enforcement	2,000	9,500	11	51	36	160	1,100	5,100
RCI-8	Building Commissioning, Benchmarking, and Upgrades	3,200	4,900	16	23	50	68	630	860

Policy No.	Policy Option	Annual Electric Energy (GWh)		Annual Natural Gas (BCF)		Annual Petroleum Products (Million GGE)		Annual Other Fuels (BBtu)	
		2020	2030	2020	2030	2020	2030	2020	2030
RCI-11	Industrial Process Incentives	230	460	7	14	54	120	3,900	8,700

BBtu = billion British thermal units; GWh = gigawatt-hour; BCF = billion cubic feet; GGE = gallons of gasoline equivalent.

Totals may not sum exactly due to rounding. "Other Fuels" estimates do not include increased use of bioenergy feedstock.

Figure 6-10. Estimate of Cost and GHG Emissions Reductions for RCI Policy Options



BUILDING CODES, APPLIANCE STANDARDS AND ENFORCEMENT (RCI-7)

Policy Summary

New York should aggressively update and consistently enforce the State Energy Conservation Construction Code (SECCC or State Energy Code), and provisions of the Uniform Fire Prevention and Building Code (such as water conservation) that have an energy impact. In addition to the State-mandated base code (SECCC), local municipalities should be given the choice to adopt a State-set stretch code,[6] as recommended in the 2009 State Energy Plan.

The prescriptive SECCC should increasingly become performance-based and include sustainable and whole building design provisions through the adoption of International Energy Conservation Code (IECC), the International Green Construction Code, and the National Green Building Standard (International Code Council [ICC] 700).[7]

To facilitate code compliance, the State should establish a flexible framework by 2015 that allows municipalities, which often lack the necessary resources or expertise, to enforce codes through inter-municipal and county-level agreement or through the services of privately operated, accredited or licensed third-party oversight entities. Third-party certification, training, and project-certification fees could help fund code compliance activities.

Currently, the State Energy Code applies to building renovations that involve replacement of 50 percent or more of a building subsystem (“Fifty Percent Rule”), and the ability to amend the State Energy Code is contingent on obtaining a study to confirm that the cost of compliance with the amended code will be paid back through energy savings in ten years or less (“Ten Year Payback”). Abolishing the Fifty Percent Rule and Ten Year Payback legislative mandates would help the State achieve American Recovery and Reinvestment Act (ARRA)-required rates of code compliance, ensure that each renovation activity that triggers a building permit also triggers an appropriate level of compliance, and enable the timely adoption of new energy conservation measures.

As specified under Article 16 of the Energy Law, the State should also continue to establish and update energy efficiency performance standards for appliances and products that are not federally preempted. For those appliances and products with federal preemption, the State should lobby the federal government to increase those performance standards.

This policy option should be re-evaluated and adjusted in 2020 and 2030 to take into account the future evolution of codes and appliance standards as well as economic development opportunities.

Quantification

The policy scenario quantified by the Technical Work Group includes the following:

Transition to performance-based codes: The State should work with model code development organizations, like the ICC, to develop a performance-based international model energy code by 2021, which New York could adopt by 2023.

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[6] Article 11 of the Energy Law allows municipalities to adopt and enforce a local energy conservation construction code more stringent than the Energy Code. Such programs are referred to as stretch codes.

[7] Performance-based codes provide architects and engineers with the flexibility to meet requirements while attaining higher efficiency.

New and existing buildings: The base and stretch codes are a specified percentage more efficient than current code, defined as the IECC 2009 with State Code Council approved modifications:

Table 6-2. Base and Stretch Codes for New and Existing Buildings

Year	Base Code	Stretch Code
2020	50%	60%
2030	60%	70%
2050	70%	80%

Given the available information on future code update trends, New York's base code scenario appears to lead or be on par with federal and other states' code efforts, e.g., Florida and Massachusetts, with the exception of California's goal for net-zero energy buildings by 2030. However, New York's proposed stretch code scenario represents a smaller increase between stretch and base code, compared to states that utilize stretch codes, like Massachusetts.

Existing buildings would be subject to energy efficiency upgrades, and the corresponding code compliance requirements, through the following:

- Building Commissioning, Benchmarking, and Upgrades (RCI-8) mandated benchmarking requirements, which may be triggered at the time of sale of a building or in conjunction with periodic energy audits
- Voluntary building renovation or alterations, which may be triggered when a building owner applies for a building permit

Code updates and compliance: The State would accelerate updating its codes to every three years. This would be coordinated with the latest edition of international codes, so that the SECCC and Uniform Fire Prevention and Building Code would be updated within 18 months of international code publication. Further, code compliance is assumed at 90 percent in 2017, as required by the ARRA, increasing to 95 percent in 2030.

Appliance standards: The State should review the energy efficiency performance standards for products that are not federally preempted every five years and update them as needed.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by dollars per metric ton of carbon dioxide equivalent [\$/t CO_2e]) for the policy scenario, which did not include Appliance Standards, are presented below.

GHG Reductions ($MMtCO_2e$)		Net Present Value: Savings (Million \$)	Savings per Avoided Emissions (\$/tCO_2e)
2030	Total 2011–2030		
6.3	43	–\$1,200	–\$27

\$/tCO_2e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- The State Energy Code should accommodate all building types and apply energy efficiency performance thresholds that are appropriate to an aggregated building classification framework, e.g., residential, commercial, institutional, versus industrial buildings, and new versus existing buildings. The State should also explore requiring government owned and operated buildings to meet this policy's scenario.

- To avoid discouraging building renovations, the State should consider establishing a regulatory "ability to pay" relief mechanism that adjusts the required level of "incremental" retrofit when owners of existing buildings and affordable housing have demonstrated that they would suffer extreme financial hardship through satisfaction of the required retrofit work.

- Building codes and siting guidelines should include adaptation considerations, such as placing buildings and other facilities away from projected flood zones and favoring designs and materials appropriate for future climate conditions, to help make New York's communities resilient to climate change.

- Workforce Training and Development (RCI-6) will be critical to the successful implementation of this policy. The continued development and demonstration of efficient and renewable energy technologies, as outlined in Research, Development, and Demonstration (RCI-9), will work to help building owners reduce costs to achieve code compliance and maximize co-benefits such as reductions in harmful air pollutants.

- This policy option could have a direct positive effect on jobs through the required code compliance activities and training. In addition, the flexible code compliance framework facilitates municipal compliance activities while reducing home rule concerns. Lastly, under the flexible code compliance framework, third-party certification, training, and project-certification fees should be considered as a potential revenue source for New York State.

BUILDING COMMISSIONING,[8] BENCHMARKING,[9] and UPGRADES (RCI-8)

Policy Summary

The State could mandate, through legislation, that all private buildings greater than 50,000 square feet or public buildings greater than 10,000 square feet publicly report their annual energy

[8] Commissioning is the systematic process of verifying that newly installed building systems perform interactively according to design intent, that they meet the operational needs of the owners and occupants, and that staff responsible for operation and maintenance are sufficiently trained. Retro-commissioning is defined as the same activities as commissioning, but applied to existing building systems.

[9] Benchmarking, which entails the public issuance of a building's energy consumption, indexed against buildings of comparable size and use, would provide information regarding a building's energy use to building owners and managers, prospective tenants and prospective purchasers, thereby increasing the incentive for building owners and managers to reduce energy consumption.

and water benchmarking scores using the ENERGY STAR internet-based benchmarking tool (Portfolio Manager). For the aforementioned-sized “covered” existing buildings, this policy recommends the following:

- Performing an energy audit every ten years by an energy auditor;
- Retro-commissioning and installing all energy efficiency measures identified in the energy audit that have less than a seven-year payback, within five years of completing the energy audit;
- Commissioning of new buildings of the aforementioned size during the design and construction process by a certified commissioning agent.

The State could also mandate, through legislation, the following:

- Every new one- to four-family home should receive a Home Energy Rating System (HERS) rating or an equivalent energy efficiency scoring methodology from a qualified rater. Each new home should obtain a legislatively-established rating to indicate that it meets minimum energy efficiency standards.
- Every existing one- to four-family home sold in the State should receive a HERS rating from a qualified rater and that the rating should be disclosed to all prospective buyers.

Quantification

The policy scenario quantified by the Technical Work Group includes the following:

- By 2020, 50 percent of all one- to four-family homes sold in the State will receive a HERS rating, increasing to 100 percent by 2030.
- By 2020, 100 percent of covered private buildings and 50 percent of covered public buildings will routinely file benchmarking reports, increasing to 100 percent of covered buildings by 2030.
- By 2020, 50 percent of covered private buildings and 25 percent of covered public buildings will have completed commissioning or retro-commissioning, energy auditing and installation of cost-effective retrofits resulting in an average of 20 percent reduction in total energy use for participating buildings, increasing to 75 percent of covered private buildings and 50 percent of covered public buildings by 2030.

The policy scenario does not include the costs and benefits of the HERS rating on one- to four-family homes.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by \$/t CO_2e) for the policy scenario are presented below.

GHG Reductions ($MMtCO_2e$)		Net Present Value: Savings (Million $)	Savings per Avoided Emissions ($/t$CO_2e$)
2030	Total 2011–2030		
3.3	34	–$790	–$23

$/t$CO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- There is uncertainty about whether the predicted energy, carbon, and cost savings of this policy will be achieved. Incorporating rigorous evaluation, monitoring, and verification into the policy design from the start would directly address this concern.

- A further uncertainty is the impact of the affected building owners. The policy creates the potential to significantly improve the energy efficiency of buildings occupied by businesses in New York, reduce their operating costs, improve health and safety of work environments, and increase property values. However, the new policy requirements could require capital commitments from building owners, and owners may have concerns with their energy usage information being made public. Coordinated with Education, Outreach, and Behavior Change (RCI-5), effective outreach to educate building owners on the programs and their benefits will be needed to effectively implement this program. Access to funding for studies and capital for the installation of energy efficiency measures are issues that should be coordinated with policies, such as Energy Efficiency Incentives (RCI-2) and Tax Structure and Private Financing (RCI-4).

- The State should consider establishing limited exceptions to the benchmarking requirements for specific building types not currently in Portfolio Manager or if business-sensitive information would be publicly disclosed.

- This policy option could have a direct positive impact on jobs through the required benchmarking and commissioning activities, energy audits, and installation of energy efficiency measures.

ENERGY EFFICIENCY INCENTIVES (RCI-2)

Policy Summary

This policy option would provide energy efficiency incentives that address building stock in New York, including existing homes, businesses, and industry, as well as all new construction. The policy and its scenario are both constrained and informed by the current economic potential[10] of energy efficiency. That potential will be re-evaluated every three years with a

[10] Technical potential for efficiency and renewable energy represents the theoretical outer bounds of the resources physically available for exploitation, without any regard for cost or market acceptability. Economic potential for

concomitant re-setting of efficiency scenario and re-examination of energy efficiency program offerings to achieve them.

The role of this policy is to provide incentives for owners of existing buildings to undertake renovations that bring buildings above current code compliance such that the rate of building renovation is accelerated above the norm, and for owners of existing buildings that meet the current State Energy Code to install efficiency measures that provide additional energy savings up to the economic potential. The presumption under this policy is that Building Codes, Appliance Standards, and Enforcement (RCI-7) aggressively ramps up code requirements so that new construction energy savings would be captured under RCI-7's quantified savings.

A whole-building, integrated analysis approach will be used to identify efficiency measures that could be installed in existing buildings to achieve the economic potential, including building envelope, lighting, HVAC (heating, ventilating and air conditioning), insulation, monitoring or control systems, plug-load, and CHP (combined heat and power). Onsite renewables providing a portion of the buildings' electricity load, industrial process efficiency and building commissioning would be incentivized through other RCI policy actions. R&D incentives would accelerate the development and commercialization of new, lower cost, higher performance products and technologies. Supporting policies include Education, Outreach, and Behavior Change (RCI-5), Workforce Training and Development (RCI-6), and Rate Restructuring and Flexible Metering (RCI-10).

The policy incentive structure is in the form of loans and direct payments to buy down the cost of installed efficiency measures. Funds for the incentives will be provided by Efficiency and Clean Energy Fund (RCI-1) and other sources, such as federal and foundation grants, and corporate contributions. Participants in the incentive programs would provide co-funding for their projects.

Quantification

The policy scenario quantified by the Technical Work Group includes full achievement of the economic potential for energy efficiency in New York's buildings. The following schedule of energy savings was assumed for this scenario; these reductions represent savings available after implementation of '15 by 15,' RCI-7 and RCI-8:

Electric efficiency savings: 5,300 gigawatt-hours (GWh) by 2020 and 32,000 GWh by 2030

Fuel efficiency savings: 32 trillion British thermal units (TBtu) by 2020 and 170 TBtu by 2030

The scenario also assumed that the policy would lead to additional Combined Heat and Power generation capable of producing 890 GWh/year in 2020 and 4,600 GWh/year in 2030.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e) for the policy scenario are presented below.

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efficiency and renewable energy is the amount of technical potential available at technology costs below the current projected costs of conventional energy that these resources would avoid.

Energy Efficiency

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings (Million $)	Savings per Avoided Emissions ($/tCO_2e$)
2030	Total 2011–2030		
17	120	–$29	–$0.3

$/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Combined Heat and Power

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost (Million $)	Cost per Avoided Emissions ($/tCO_2e$)
2030	Total 2011–2030		
1.1	7.1	$14	$2.0

$/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

Special Considerations

- The policy will define strategies to stimulate owners of existing buildings to make energy efficiency improvements that meet the current code at a minimum. Consistent with RCI-7, this action presumes new construction will meet code-mandated efficiency levels, but given voluntary code triggers for existing building stock, most existing buildings will not be subject to code-mandated improvements. In such an environment, building owners may be content to maintain the status quo unless significant energy savings and short-term paybacks from renovations are possible. In low-income, high-density communities, where problems with basic maintenance and upkeep of residential buildings are not uncommon, it will be even more challenging to ensure that building owners invest in code-mandated improvements. Targeted mechanisms for incentivizing action in these communities may be needed.

- The policy could consider a set of incentives for renovating existing buildings to exceed current code. The incentives for exceeding code are intended to help the State achieve a goal of obtaining all economic potential, which is the “gap” between the then current code (baseline) and the economic potential. Creative incentives are needed to reach the economic potential as some fraction of this potential is not achievable without them. This policy recognizes that as codes become increasingly aggressive, the difference between incentivized and code mandated efficiency levels will correspondingly shrink.

- Consistent with the “ability to pay” relief mechanism outlined in RCI-7, the State could explore establishing tandem scaled incentives for owners of existing buildings and affordable housing that face extreme financial hardship upgrading their buildings.

- As the State designs its incentive structure, it is encouraged to consider the savings to the end-user, the societal benefits of reduced GHG reductions as well as the co-benefits to New York, such as reduced energy demand, offsetting the need to site and build energy infrastructure, and reduced health care costs associated with improved air quality. This policy could have a direct positive co-benefit on jobs based on energy audits and increased installation and maintenance of energy efficiency measures. Properly installed energy efficiency measures, in accordance with a whole building approach, can also help building owners reduce their energy bills and increase occupant comfort.

CUSTOMER-SITED RENEWABLE ENERGY INCENTIVES (RCI-3)

Policy Summary

The use of renewable energy resources to meet energy service demands offers a number of benefits including the production of electricity without emissions of GHGs. As outlined in the 2009 State Energy Plan, New York State should continue to support the use of a diverse portfolio of customer-sited renewable energy technologies. However, given the magnitude of the 80 by 50 challenge and the required scale of low-carbon energy production, this policy design focuses on increasing the use of New York's solar and bioenergy resources to meet consumer energy needs.

There are a number of potential policy mechanisms that would further encourage the use of renewable energy systems in New York. These mechanisms can be organized into five broad categories (many of which are currently in use at the state and federal levels): (1) up-front payments, (2) performance payments, (3) tax policies, (4) financing policies, and (5) supporting policies. New York State could expand the use of the existing mix of policy mechanisms, which include up-front and performance payments coupled with tax and financing policies. For solar thermal applications, the existing programs could be expanded to include incentives for displacing fossil fuels currently used for heating space and water. As the installed price of solar technologies continue to decline, policy can transition away from up-front payments and focus on financing policies. While performance-based policies using solar renewable energy credits are not currently in use, New York could explore the potential use of these mechanisms given their wide-spread use in other states and the European Union.

Quantification

The Technical Work Group explored two scenarios that set different targets for solar energy use and also included use of bioenergy, as provided under AFW-2, to displace heating fuels. The scenarios assumed all bioenergy use would consist of direct combustion of solid biomass, e.g., wood pellets; however, liquid biofuels, e.g., biodiesel, could also provide meaningful carbon emission reductions.

The first policy scenario:

Solar Electric: 1,000 megawatts (MW) by 2020 and 3,000 MW of customer-sited solar electric by 2030. (Additional policy options to support solar electric investments at the utility scale are addressed in Chapter 5 Power Supply and Delivery).

Solar Thermal: 2,000 megawatts, thermal (MWth) by 2020 and 4,000 MWth by 2030

Bioenergy: By 2030 utilize 90 TBtu of sustainable bioenergy resource (See AFW-2 for further discussion).

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/tCO_2e$ reduced) for the first policy scenario quantified by the Technical Work Group are presented below.

Scenario 1: Solar Electric

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost (Million $)	Cost per Avoided Emissions ($/tCO_2e$)
2030	Total 2011–2030		
1.0	8.1	$1,800	$220

$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Scenario 1: Solar Thermal

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost (Million $)	Cost per Avoided Emissions ($/tCO_2e$)
2030	Total 2011–2030		
1.0	10	$1,500	$150

$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Scenario 1: Bioenergy

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings (Million $)	Savings per Avoided Emissions ($/tCO_2e$)
2030	Total 2011–2030		
5.1	84	–$5,100	–$61

$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

The second scenario:

Solar Electric: 2,100 MW by 2020 and 9,700 MW by 2030

Solar Thermal: 2,000 MWth by 2020 and 15,000 MWth by 2030

Bioenergy: Same as the first scenario.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e reduced) for the second policy scenario quantified by the Technical Work Group are presented below.

Scenario 2: Solar Electric

GHG Reductions (MMtCO_2e)		Net Present Value Cost (Million $)	Costs per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
3.3	22	$4,400	$200

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Scenario 2: Solar Thermal

GHG Reductions (MMtCO_2e)		Net Present Value Cost (Million $)	Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
2.8	21	$2,600	$130

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Scenario 2: Bioenergy

GHG Reductions (MMtCO_2e)		Net Present Value Cost (Million $)	Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
5.1	84	–$5,100	–$61

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- As compared to the generation of electricity and the provision of heat using fossil fuels, most renewable energy technologies avoid the production of harmful air pollutants (such as oxides of nitrogen, particulate matter, and hydrocarbons), increase system security of energy supplies by reducing energy imports, and reduce energy price volatility in the long-term. Customer-sited distributed generation increases reliability by lowering peak demand and relieving transmission and distribution bottlenecks in the electricity generation system, and use of in-state renewable resources also creates jobs, income, and economic development opportunities for New York State. Finally, early investment in emerging technologies will contribute to lowering the price of such technologies so that they can be more competitive in the future.

- Distributed renewable energy technologies are available in the marketplace and can be deployed without overcoming some of the significant siting barriers that slow the installation of large-scale low-carbon technologies such as wind turbine farms and nuclear power plants.

- The cost of solar energy technologies is forecasted to decrease over time. As this cost changes, incentive levels will need to be adjusted to maximize the use of public funds. Future analysis should be conducted to evaluate the cost and benefits of solar electricity generation under a real-time (time-of-use) pricing regime.

- There is considerable uncertainty surrounding carbon-accounting of bioenergy pathways given differing methods for modeling and measuring the release of carbon during land conversion processes and the rate of carbon uptake as new biomass is grown. As new methods and findings are published by organizations such as the U.S. EPA, the benefits associated with bioenergy use will need to be reevaluated.

- This policy depends on funding and financing policies as outlined in Efficiency and Clean Energy Fund (RCI-1) and Tax Structure and Private Financing (RCI-4). Eventually, codes may require the use of distributed renewable energy depending on the transition to a performance based system, as discussed in Building Codes, Appliance Standards, and Enforcement (RCI-7). Workforce Training and Development (RCI-6) and Education, Outreach, and Behavior Change (RCI-5) will be critical to the successful implementation of this policy. The continued development and demonstration of clean and efficient renewable energy technologies as outlined in Research, Development, and Demonstration (RCI-9) will work to both reduce costs and maximize co-benefits such as reductions in harmful air pollutants.

INDUSTRIAL PROCESS INCENTIVES (RCI-11)

Policy Summary

Voluntary incentive programs would be established to reduce the carbon intensity of industrial operations within the state, while fostering increased industrial activity through programs that result in more efficient, productive and cost effective operations. These programs would be available to both existing facilities and new facilities and processes, particularly those new industrial facilities involved in the clean energy economy. These programs would complement the Cap and Invest Program (PSD-6) if industrial sources are included in that program.

The policy option would establish a voluntary program, similar to existing energy efficiency programs, which provides technical assistance and financial incentives. Similar to Leadership in Energy and Environmental Design (LEED), the voluntary program would also provide recognition to industrial facilities that have met defined targets for reduction of their carbon intensity on a per-facility basis. The programs would include, but are not limited, to:

- Efficiency measures, including building energy efficiency, process optimization, water usage minimization, minimization of waste generation, e.g., solid wastes and wastewater;

- Adoption of advanced process technologies, including electro-technologies, which result in an immediate net reduction in carbon intensity;
- Installation of CHP systems;
- Waste heat capture and reuse, either onsite, including the production of electricity from waste heat (bottoming cycles), or shared with neighbors through district energy systems;
- Application of renewable energy systems, including the use of renewable fuels.

Quantification

The policy scenario quantified by the Technical Work Group includes a reduction in statewide carbon intensity, defined as carbon dioxide-equivalent (CO_2e) per industrial Gross State Product, of 15 percent by 2020 and 30 percent by 2030.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e) for the policy scenario are presented below. This is one of the more cost-effective policy options considered for this sector.

GHG Reductions (MMtCO_2e)		Net Present Value Savings (Million $)	Savings per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011-2030		
2.6	26	-$2,500	-$95

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent; N/A =not applicable; R&D = research and development.

Negative values represent savings.

Special Considerations

- If not properly designed and absent other economic development programs, state-level GHG reduction mandates applied to energy-intensive industries that are subject to interstate or international competition, could be a factor in industry decisions to relocate to other locations, which could lead to the loss of employment in the state with no reduction in global GHG emissions. If well-designed cap-and-invest and other mandatory programs are implemented, complementary incentive programs can provide an effective stimulus for plant improvements that increase efficiency and reduce emissions. Similarly, if national policies are put in place that limit industrial GHG emissions either through emission controls or cap and trade mechanisms, state-level incentive programs will still be needed to ensure that investments in new and upgraded facilities are made in New York instead of other locations.
- Improved efficiency of an industrial facility tends to result in improved economic viability and job growth/retention. The incentives offered by the programs will only cover a portion of the total cost of the GHG reduction measures. The industrial facilities will need to provide the remaining capital requirements.
- Commencing in 2011, federal new source review requirements will apply to GHG emissions from new or modified industrial sources. Those requirements are likely to

require new or modified sources to utilize highly efficient processes and incorporate energy efficiency measures into their design.

- The make-up and size of industry in New York State in the future are difficult to predict, as are the products that those industrial facilities will produce, and the processes that will be employed.

WORKFORCE TRAINING AND DEVELOPMENT (RCI-6)

Policy Summary

The effective development of a skilled workforce equipped with the knowledge, skills, and ability to directly meet energy service demands is an enabling policy effort. Workforce training and development is primarily intended to improve productivity (quality of production output) by improving the knowledge, skills, and abilities of the workforce.

Workforce training and development is primarily intended to improve productivity (quality of production output) by improving the knowledge, skills and abilities of the workforce. This bundle will examine the following current workforce development strategies and programs: energy efficiency; customer-based clean and renewable energy resources; power supply and demand; smart grid; codes and standards; agriculture, forestry, and waste; transportation; manufacturing; and other related areas. Opportunities to prepare and expand upon current workforce training, continuing education, credentialing, licensing, on-the-job training, recruitment, and job placement efforts will be identified. The following initiatives will be the focus: midstream decision makers and building professionals in the residential, multifamily, and commercial/institutional building sectors; industrial, power systems, and manufacturing engineers and skilled technicians; bio-refinery, upstream, or feedstock production training related to biomass energy, as well as downstream training for conversion facility personnel; integrated farm management processes and systems; forest management focusing on upstream workers and; waste reduction, recycling, and composting.

Workforce training and development implementation mechanisms require a coordinated effort across State agencies, such as the work of the State Energy Technology Partnership to define the characteristics of the future workforce based on demographics (languages spoken, age, educational level, location), expectations for displaced workforce due to shrinking job sectors, and expectations regarding communities in need. New York State Department of Labor (NYSDOL) actions include identifying those industries critical to meeting the 80 by 50 goal, determining the areas that currently lack or will soon lack sufficient numbers of adequately skilled workers, and defining the training needs to move that workforce into green energy career pathways.

The Technical Work Group has established a policy scenario to further encourage a stronger workforce responsive to needs of the clean energy economy: (1) quantify the training needs in terms of the number of individuals to be trained and dollars to be spent on workforce development activities; (2) establish a process for early identification of these new needs, defining the training and education needs, developing training curriculum and certifications, and delivery of the same; (3) define the characteristics of the future workforce based on demographics, expectations for displaced and underemployed workers as well as others who have faced barriers to equal employment opportunities due to shrinking job sectors, and expectations regarding communities in need, and define the training needs to move that workforce into the green energy career pathway; (4) better define the career ladders and training needed to advance the clean energy economy; (5) identify the education and training needs for green professionals; (6) ensure the educational system supports the development of green career training; (7) make workforce training and development investments to address skill shortages in the energy efficiency labor market that will significantly contribute toward achieving the 80 by 50 goals and maximize the use of public resources; and (8) commit to train building professionals involved in the clean energy field to reach 35 percent of these participants by 2020, and 70 percent by 2030.

Quantification

This policy was not quantified; however, studies have shown quantifiable energy and emissions reductions benefits from training participants directly involved in efficiency work.

Special Considerations

- An unskilled workforce poses a significant potential risk of compromising the State's ability to achieve carbon reduction goals. If one assumes that about 20 percent of the performance of measures is attributable to the ability of the workforce to properly analyze, design, install, and maintain systems, then the absence of a trained workforce could reduce the potential environmental benefits by a similar amount. This policy, along with policy mechanisms outlined in Education, Outreach, and Behavior Change (RCI-5) will be critical to the successful implementation of most policy initiatives under the New York State Climate Action Plan.

Environmental justice (EJ) stakeholders have strongly endorsed the following principles with respect to "green jobs" workforce development initiatives:

They should include strong Minority and Women-owned Business Enterprise contracting and hiring standards.

Whenever possible and feasible, they should incorporate 1) a community-based delivery system that establishes and funds local groups as hubs for the program to generate homeowner interest and develop training-to-jobs networks, and 2) local environmental and community-development goals whenever feasible.

- o The future workforce will be different from today's workforce in many ways. Data from the U.S. Department of Labor's Bureau of Labor Statistics (BLS) and the U.S. Census implies that the workforce will suffer a shortage in well-educated, highly skilled workers due to the retirement of the baby boomers; the projections from this data extend to the year 2018. However, many factors, such as potential changes in immigration and education policy, make it difficult to confidently predict the demographics and training needs of the workforce in the long term. In the short term, NYSDOL receives continuous updates on the state of the workforce through projections from BLS and the Census, unemployment insurance data, layoff notices, and services through the One-Stop Career Centers. These projections and updates can inform future initiatives.

- A skilled workforce will have a positive impact on the State's industrial competitiveness and promote economic development activities.

EDUCATION, OUTREACH AND BEHAVIOR CHANGE (RCI-5)

Policy Summary

The State would conduct a thorough review and evaluation of existing academic and market research and engage the academic community to better understand New Yorkers' attitudes and behaviors as they relate to energy decision making. Building on this research, which will drive program design and implementation both at the onset and duration of this policy, the State would create market-based and educational approaches that inform end-users and encourage reduction of energy use, energy efficiency, and renewable energy. The State would also ensure that the outreach, education, and marketing efforts reflect best practices in terms of design and delivery, and are properly integrated, coordinated, and evaluated. Incorporating state-of-the art behavioral change tools and principles, the State would pilot test these market-based and educational approaches and establish evaluation methods to analyze the success of these pilots before programs are rolled out on a regional or statewide basis. Regular evaluation would also occur through the program's duration to gauge the policy's effectiveness.

This policy option would develop methods and incentives to increase consumer awareness and understanding of the benefits of reduced energy use, and to 1) motivate people to take immediate energy efficiency action, and 2) bring about fundamental change in attitudes that will result in long-term behavior change related to energy efficiency and renewable energy. This policy recommends focusing efforts on several key areas:

- Changes in retail sales and stocking preferences in New York State through a statewide training program to educate and train all retailers on how to effectively sell energy-efficient and renewable energy products and plug-in electric vehicles. The training could include introduction to new product standards and specifications; understanding product life cycle costs and efficiency measurements; and other topics related to selling energy-efficient and renewable energy products and plug-in electric vehicles.
- Changes in education and testing through 1) a New York school district educational initiative that would facilitate the full integration of energy efficiency and GHG emission information into current curriculum and testing at all levels, and 2) a State employee Lead-by-Example educational initiative that would require all State employees to complete energy efficiency and sustainability training as a condition of employment.
- Expansion of education of energy consumers with outreach programs and provision of tools that provide more detailed and frequent information and feedback on energy use to help consumers make more efficient and effective use of energy resources, and encouraging plug-in electric vehicles. New York could explore expanding the scope and

funding for statewide consumer education programs and electronically accessible energy efficiency tools and resources for all fuels.

A multimedia approach could include TV, print, radio, web, and collateral materials as well as community-based outreach to reach diverse audiences across the state, including low-income, senior, and environmental justice communities.

The Technical Work Group identified the following targets as appropriate given the magnitude of the 80 by 50 challenge:

Retail

Retail workforce training: The percentage of New York retail stores where management will have implemented employee training: 80 percent by 2020; 100 percent by 2030.

Sales and stocking: The percentage of energy-efficient products sold and stocked by New York retailers above national baseline: 7 percent by 2020; 12 percent by 2030.

Education

School district: The percentage of New York school districts (K–12) reached with integrated education programs about energy efficiency and broader sustainability issues: 70 percent of public school districts by 2020; 100 percent of public school districts by 2030; 100 percent of private and at-home school systems by 2030.

State employee training (lead-by-example): The percentage of New York employees receiving energy efficiency and sustainability training with a refresher course every two years: 50 percent by 2012; 100 percent by 2015.

Behavior

Implement clearinghouse of tools by 2012, expanding upon existing clearinghouses. Update and revise statewide education programs to reflect state-of-the art best practices, including behavioral changes approaches, every three years.

Quantification

This policy option has not been quantified.

Special Considerations

- Several key uncertainties include measuring the impacts of behavior change programs and tools motivating end-users to change their procurement habits, particularly in unreached communities; fully integrating climate and energy information into evolving school curriculums; temporal changes in energy consumption and use patterns; and the duration and magnitude of the current fiscal crisis and its impact in program budgets, retail establishments, and end-user finances.
- In EJ communities, in particular, stakeholders maintain that lasting behavior change emerges from sustained local dialogue and assistance provided by respected opinion leaders. Setting standards and programmatic guidelines that promote or integrate community-led capacity-building may be critical to the success of the proposed behavior change programs. These kinds of approaches could help ensure that the proposed energy

efficiency programming reaches the scale needed to address climate impacts while simultaneously promoting community centered job development.

- This policy option could help end-users save on energy bills, and, correspondingly, New York employees reduce state operational costs, which, in turn, may facilitate economic growth.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS FOR THE RESIDENTIAL, COMMERCIAL/INSTITUTIONAL, AND INDUSTRIAL SECTOR (RCI-9)

See Chapter 10 for a complete presentation of Research, Development and Demonstration needs for this sector.

RATE RESTRUCTURING AND FLEXIBLE METERING (RCI-10)

Policy Summary

Building upon current initiatives, this policy option would focus on expanding use of more effective, dynamic price signals and providing in-home displays that show detailed electricity usage information to electricity customers as well as home automation, increasing customer engagement and intelligent vehicle charging. The desired result is an overall reduction in monthly electrical usage, shifting electrical usage to off peak periods, and encourage demand response activities.

The policy option recognizes that rate structures must evolve as conditions change. For example, alternative metering and pricing regimes may be needed in the near term to provide a clear regulatory and pricing environment to encourage the widespread market penetration of electric vehicles. This policy would be implemented through the following mechanisms:

Legislation and Regulations
Time-of-use pricing: After full implementation of the current policy of mandatory day-ahead hourly pricing for large commercial customers, explore expansion to small commercial and enact legislation that permits the Public Service Commission to implement mandatory time-of-use pricing for residential customers upon finding that it is beneficial and in the public interest to do so. Absent legislation, the State could explore voluntary residential real-time pricing options.

Net metering: Improve and evolve net metering regulations to facilitate installation of renewable distributed generation and CHP resources that provide carbon reduction benefits.

Smart Meters
Consumption information: Install smart meters and feedback tools; e.g., in-home displays, to convey price and consumption data, and implement rate structures, potentially including critical peak pricing or peak-time rebate programs, that encourage reductions in peak usage and shifting of usage to off-peak hours, along with public education and outreach programs in RCI-5 and energy efficiency activities in RCI-2.

Assessments and Surveys
Smart grid, smart metering, and plug-in electric vehicles pilot program design: Conduct a survey and assessment of smart grid and smart metering pilot programs, including rates and metering for plug-in electric vehicles, to determine the need for further in-state pilots, and to determine best practices and programs suitable for adoption in New York. Based on findings and analysis, the State could develop and implement New York-specific pilots or targeted programs.

Smart meter cost-benefit analysis: Perform a sector-based benefit-cost analysis of implementing smart meters and initiate an assessment of available consumption and feedback options; e.g., commercial and industrial meter data dashboards and in-home displays. Based on findings and assessment, the State will determine the extent to which smart meters could be deployed within New York.

Submetering best practice: Conduct a sector-based survey of regional and national best practices for submetering to assess applicability and opportunities for the State. Investigate extent to which such best practices can help support other subgroup policies, such as Energy Efficiency Incentives (RCI-2), which address barriers to energy efficiency, e.g., landlord-tenant split incentives, benchmarking, and monitoring based commissioning.

Carbon impacts and demand response: Conduct a survey and assessment of carbon impacts associated with various rate options and demand response that encourage reductions in peak usage and shifting of usage to off-peak hours.

Quantification

This policy was not quantified.

Special Considerations

- Some key uncertainties that could significantly affect the implementation of this policy include: (1) the timing and likelihood of mechanisms to incorporate the price of GHG emissions into energy prices and the energy sources to which such mechanisms will apply; (2) the timing of broad market adoption of electric vehicles and electric building heating systems; (3) the development of new low- or zero-carbon sources of electricity production and the associated costs; (4) whether the recommended legislation and regulations would be enacted; and (5) uncertainty with regard to the degree to which consumers will alter their consumption in response to prices. The State could study the relationship of carbon impacts on consumption patterns; e.g., reduced on-peak and increased off-peak demand.

- Increased use of time-of-use pricing, and other rate and demand response options, could lower critical peak usage in New York City, which is expected to reduce the hours that higher emitting, electric peaking generating units run.
- The State could explore residential rate designs and rate mechanisms that foster energy efficiency, promote rate equity for vulnerable residential populations, such as low-income households, and encourage plug-in electric vehicle use.

EFFICIENCY AND CLEAN ENERGY FUND (RCI-1)

Policy Summary

This policy option would create a Efficiency and Clean Energy Fund to further the State's long-term efforts toward its 80 by 50 goal, building upon the State's current near-term efforts to implement 45 by 15. The purpose of the Fund is to facilitate investment in electricity, natural gas, propane, fuel oil, thermal energy, and district heating energy efficiency and onsite renewable energy options using a "whole-building" approach. A whole-building approach involves implementing fuel-neutral, integrated steps to meet energy requirements. In addition, adaptation of building energy capabilities for new technologies and uses, such as electric transportation, may also be considered in developing the fund.

Through legislation, the State could possibly establish a Efficiency and Clean Energy Fund by 2015 that consolidates current funding streams (e.g., the Systems Benefit Charge [SBC], Energy Efficiency Portfolio Standard [EEPS], Renewable Portfolio Standard [RPS], Regional Greenhouse Gas Initiative [RGGI], weatherization) and be combined with new revenue sources such as oil and propane public-benefit surcharges and code-based user charges. The legislation would recognize that dedicated and continuous funding is essential for the overall success of the individual programs and the attainment of long-term carbon mitigation strategies. The Fund could be designed to support the entire spectrum of energy efficiency and clean energy product and service development: from research and analysis through technology development and demonstration through business and market development through market commercialization and adoption to standardized practice.

A governing structure, headed by a Coordinating Council, would be established to provide common administration and funding distribution of the State's energy efficiency, renewable energy, and low-carbon programs. Comprised of State agencies and authorities, this Coordinating Council would have the flexibility to modify funding distributions, as needed, to take advantage of evolving technological advances or programmatic needs. As revenue streams are identified and implementation mechanisms developed, broad criteria for program participation will be considered, including those that would apply for public and private participation. An advisory group, including private advisers, would also be established to advise the Coordinating Council during its decision making processes.

The outflow of the funding can be guided by proportional distribution based on the inflow of revenue streams per source (fuel or, in the case of RGGI or another emission cap-and-invest program, pollutant), but would not be wholly constricted by such revenue inflow, and may consider the existent needs and opportunities as recognized by the Climate Action Plan, State Energy Plan, or other State activities or studies and as deemed appropriate by the Coordinating Council. Continuing the practices of current funding streams, private recipients will be eligible to receive incentives.

Until the Efficiency and Clean Energy Fund is established, the current collection methods of the existing 45 by 15 funding streams would continue as currently designed. The State should draft a transition plan from 2011 to 2015 outlining how the current funding streams would be transitioned to the Efficiency and Clean Energy Fund. The Fund will also recognize any restrictions on non-state funding streams, such as federal weatherization funding, and will accordingly continue to dedicate funding to the desired end-users; e.g., low income recipients of weatherization funding.

Quantification

This policy was not quantified. However, it provides funding for Energy Efficiency Incentives (RCI-2); Customer-Sited Renewable Energy Incentives (RCI-3); Building Codes, Appliance Standards, and Enforcement (RCI-7); Building Commissioning, Benchmarking, and Upgrades (RCI-8); and Industrial Process Incentives (RCI-11), which are quantified.

Special Considerations

A legislative mandate establishing this Fund will be necessary given the various regulatory jurisdictions that apply to energy supplies. Such legislation can best identify the appropriate revenue resource opportunities to support the Fund's various program activities, including whether to assess new user charges.

TAX STRUCTURE AND PRIVATE FINANCING (RCI-4)

Policy Summary

This policy option recommends that the State undertake a comprehensive review of the current tax structure and financing programs and their impact on current and future carbon reduction activities. As part of its review, the State would also identify gaps in the current tax structure and financing programs and identify policy options for future shifts to support carbon reduction activities.

Based on this analysis, New York could establish a two-phase comprehensive financing and tax policy that supports the reduction of GHG emissions and encourages investment into clean energy options. The first phase, to be implemented incrementally annually from 2011 to 2015, includes suggested near-term modifications to existing programs that New York could evaluate as part of its comprehensive financial and tax policy framework, implementing those options that it deems viable. During this phase, the State is encouraged to advance PACE and on-bill financing by 2011, and advocate for any necessary policy changes at the federal level as needed. Given the complexity of the State's tax policy, the modifications and new policies would be incrementally rolled out in the second phase: modifications to existing programs to be completed by 2015 and new policies to be fully rolled out by 2020, with pilot programs as appropriate from 2015 to 2020.

Quantification

This policy option was not quantified. However, it provides funding for Energy Efficiency Incentives (RCI-2); Customer-Sited Renewable Energy Incentives (RCI-3); Building Codes, Appliance Standards, and Enforcement (RCI-7); Building Commissioning, Benchmarking, and Upgrades (RCI-8); and Industrial Process Incentives (RCI-11), which are quantified.

Special Considerations

- Access to capital and favorable economic considerations underpin the success and rate of implementation of this policy. Complementary or competing programs, policies, and laws on the federal level, such as PACE, will impact the success of the implementation and/or need for modification of State proposals. Tolerance for modification of existing financial mechanisms and creation of new such mechanisms will provide additional venues to fund energy efficiency and renewables.
- Financing mechanisms are demand-driven. The pace that the other RCI policies are implemented will affect the timing and demand of the financial and tax recommendations contained in this policy.
- As the State evaluates the viability of the financing policy options, it will need to take into account the limitations on State entities' ability to provide financing, including their statutory authorization, their covenants with bondholders, the overall capacity of their balance sheet to provide large capital investments, and their ability to collaborate with other agencies.

Chapter 7
Transportation and Land Use Mitigation

Sector Vision for a Low-Carbon Future

The Transportation and Land Use (TLU) Technical Work Group—comprised of stakeholders from government agencies, industry, academia, and nonprofit organizations—developed a vision statement for the transportation and land use sector. Under that vision, New York's transportation system will have the following characteristics:

Vehicle types and fuels: Trips that are not made using mass transportation will be made in vehicles fueled by electricity, hydrogen and/or sustainably derived biofuels.[1] Aviation, the goods movement system, and the construction industry will be powered by a similar mix of low-carbon fuels. Vehicles across the entire fleet population will approach carbon neutrality.

Mass transportation and vehicle miles of travel (VMT): Extensive mass transit systems will be powered by very low- and/or zero-carbon fuels. Because so many attractive mass transportation options will be available, per-capita personal vehicle miles of travel will be low.

Freight transportation: Goods will be moved over a variety of low-carbon modes—an emphasis on non-highway systems will reduce overall VMT. The share of goods transported by each mode (ship, rail, barge, truck, aviation) will be optimized to minimize greenhouse gas (GHG) emissions while accommodating a growing and thriving economy. Maintaining the public and freight transportation system in a state of good repair will be an important baseline GHG reduction strategy.

Land use planning: New York communities will be compact, mixed-use and interconnected, keeping per capita VMT low. Residents, employees and visitors will rely primarily on public transit, walking, biking, telecommuting, and limited, short distance car trips to reach central locations with concentrations of commercial, residential, cultural, recreational, social, civic, and educational activities. Neighborhoods will be designed to encourage non-motorized travel including walking and biking. Centers for goods distribution and consolidation will be located near consumer centers to minimize "last mile" transit; these centers will use advanced technology to minimize emissions, light pollution, and noise pollution.

Adaptation: Transportation infrastructure decisions will take into account and adjust for the effects and impacts of climate change. In particular, transportation infrastructure location, elevation, and constituent materials will be appropriate for existing and projected climate

[1] All three fuels of the future (electricity, hydrogen, and biofuels) can be produced using carbon intensive fuels such as coal. For this reason, reliance on these fuels must only occur when they are produced in low-carbon ways, as measured in terms of the total fuel cycle.

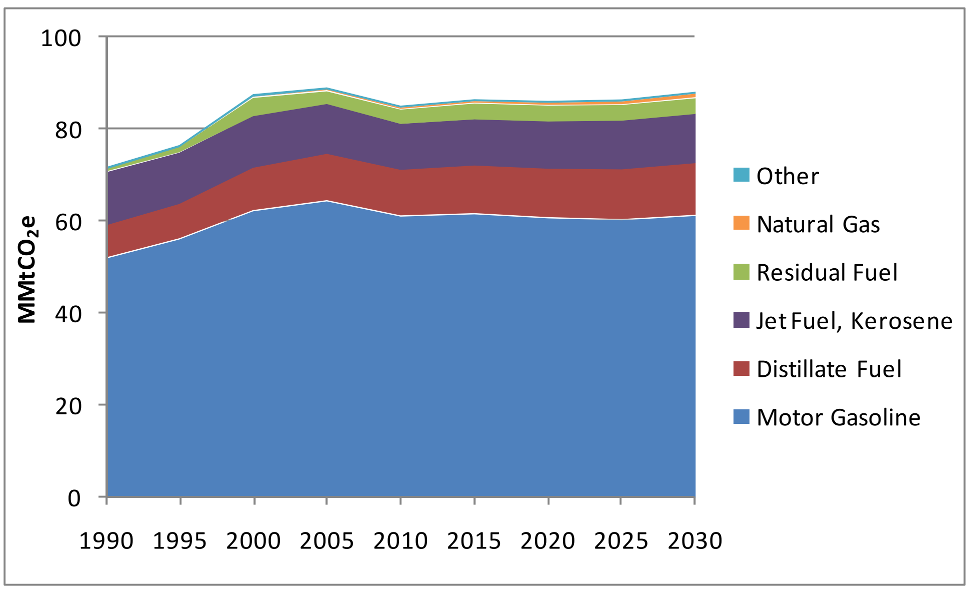
conditions: transportation infrastructure will be located above and inland from rising water levels, and will employ heat resistant materials for optimal functioning in warmer temperatures.

Investment: Investment in mass transit will be serious and sustained, in and between cities and towns, and in most regions of the state. Public incentives will favor smart growth planning, transit-oriented development and revitalization of downtowns, main streets, and other central business districts. Public investments in transit and alternative vehicles and fuels will increase significantly. Investments will avoid subsidizing sprawl development. Existing infrastructure will be maintained in a state-of-good-repair.

Overview of GHG Emissions

The transportation sector accounts for 34% of New York's gross GHG emissions in 2008. Total transportation sector emissions are forecasted to increase to 99 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2030 under the reference scenario, compared to 86 $MMtCO_2e$ in 2008. The increase in transportation sector emissions from 2008 to 2030 can be attributed in part to the increase in VMT, which is partly offset by the increased fuel economy values for on-road vehicles over this same period.

Figure 7-1. Transportation Gross GHG Emissions by Fuel, 1990–2030



GHG = greenhouse gas; MMtCO2e = million metric tons of carbon dioxide equivalent.

As shown in Table 7-1 and Figure 7-1, emissions from this sector rose at an average annual growth rate of 1.4% from 1990 to 2005. Emissions from the transportation sector are forecasted to increase slightly in the forecast years, with an average annual growth rate of 0.12% from 2015 to 2030. The mix of transportation fuels responsible for GHG emissions is expected to remain relatively similar between 2005 and 2030, with motor gasoline, jet fuel, and diesel fuel forecasted to account for 64%, 21%, and 12% of gross 2030 transportation emissions, respectively.

Table 7-1. Historic and Forecasted New York State Gross GHG Emissions from Transportation, 1990–2030 ($MMtCO_2e$)

Fuel Types	1990	1995	2000	2005	2015	2020	2025	2030
Motor Gasoline	52.0	56.2	62.3	64.5	61.6	60.8	60.3	61.3
Distillate Fuel	7.20	7.66	9.32	10.2	10.5	10.6	10.9	11.3
Jet Fuel, Kerosene	11.4	11.0	11.2\	10.9	10.0	10.2	10.5	10.7
Residual Fuel	0.67	1.15	4.02	2.81	3.52	3.49	3.46	3.46
Natural Gas	<0.01	0.02	0.05	0.15	0.31	0.44	0.59	0.75
Other	0.49	0.47	0.55	0.44	0.43	0.43	0.43	0.43
Totals	**71.8**	**76.5**	**87.4**	**88.9**	**86.4**	**86.0**	**86.3**	**88.0**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Overview of Policy Options and Estimated Impacts

An effective suite of transportation GHG reduction policies must address three determinants of transportation emissions: vehicle efficiency, fuels emissions intensity, travel activity/system efficiency. New York will not achieve its 2050 vision and goals simply by attaining only a low-GHG fleet, or only low carbon fuels, or only less driving in single occupancy vehicles. The range of policy options presented herein recognizes this imperative that all dimensions be addressed. Further, these GHG reduction strategies recognize that the existence of a safe, efficient, balanced and environmentally-sound transportation infrastructure is critical.

The policy options identified by the Technical Work Group seek to:

- Influence the future mix of technologies in New York's fleet of vehicles (low-carbon vehicles, or vehicle efficiency);
- Influence the fuels used (low-carbon fuels or fuel emissions intensity);
- Influence travel activity by reducing the need for individual trips, increasing public transit options, reducing total VMT, and increasing overall transportation efficiency.

Some of the policy options address more than one of these dimensions. Figure 7-2 portrays graphically how the transportation and land use policy options can be expected to interact with one another across these different dimensions.

Policy options TLU-1, TLU-2, and TLU-3 seek to influence the future mix of technologies in New York's fleet of vehicles, while TLU-4 addresses fuels. These policies aim to shift the vehicle market away from conventional internal combustion engine, petroleum fuel-dependent vehicles towards a mix of alternative fuel vehicles including plug-in electric, hydrogen fuel cell, and biofuel powered vehicles and toward more fuel-efficient vehicles in general. The more this shift occurs, the more GHG emissions reductions will be realized. While the success of these technology-focused options depends on technology development and commercialization, there is an important role for the public policy that can provide certainty to the private sector and help technology evolve.

TLU-6 and TLU-7 attempt to reduce VMT by increasing the efficiency of the transportation system and reducing the share of trips that occur in single occupancy vehicles. Investment in transit—both for maintenance and expansion—and investment in high speed rail are central to this goal. These policies recognize the need to give most New Yorkers access to low-carbon mass transit, and to create high speed rail corridors to serve the Empire State, the Northeast Corridor, and the nearby provinces of Canada. Improved mass transit will provide efficient ways to travel between cities and, if well connected, allow for complementary transit options within those cities.

TLU-8 is a group of strategies to reduce emissions from freight transportation, which can occur by shifting freight from trucks to rail or water transport and by having more efficient and alternatively-fueled trucks.

TLU-9, TLU-10, and TLU-11 are designed to influence future land use patterns in order to minimize VMT and to offer New York residents more choice in places to live and work using three policies: priority growth centers, transit-oriented development and location efficient land use. These policies integrate much greater access to transit and shared modes with planning and land use decision-making aimed at minimizing the need for motorized transportation by increasing mixed use, density, and efficient design. Because both population and VMT are projected to rise in New York, these smart growth measures are key strategies to reduce emissions over the long term.

Many of the recommended policy options could be applied at the state level or in partnership with other states. There are certain options that are especially appropriate for coordinated, multi-state and regional cooperative actions. These have been grouped and described under TLU-12 as ‘intergovernmental/regional proposals.”

The TLU policy options have important co-benefits in terms of public health, quality of life, clean air, reduction of demand for imported petroleum-based fuels, and conservation of open space. Many of these TLU policies will also spur economic development. For example, investment in transit and rail could revitalize construction and manufacturing in the state. Economic benefits could accrue from using high speed rail to link cities that enjoy robust economies with cities working to develop stronger economies. Investment in rail will also increase freight capacity, increasing efficiency and reliability in freight movement. Finally, by reducing dependence on petroleum and minimizing the need for single occupancy vehicle travel, New York could reduce the vehicle costs and fuel expenditures for residents and businesses. This would keep more energy-related spending within the state economy.

While many of these recommendations are expected to have low associated costs or net savings to the State of New York, there are notable exceptions:

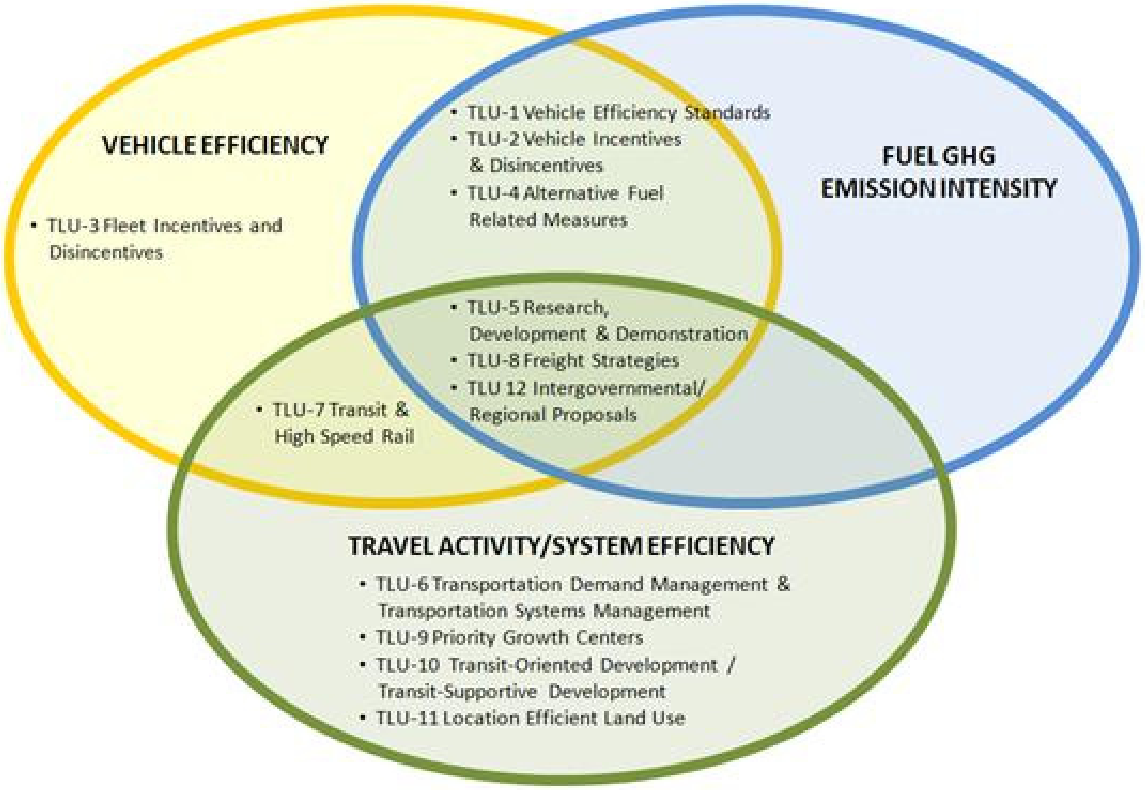
- Maintaining, expanding, and improving public transportation systems;
- Creating high speed rail for key corridors within New York State and the Northeast Corridor;

- Enhancing New York's rail infrastructure, especially eliminating freight rail bottlenecks;
- Investing in the research, development, and deployment necessary to grow the next generation of vehicle technologies and fuels.

Even programs that have a low State cost or result in net savings—like a revenue-neutral fee and rebate system of vehicle purchasing incentives ("feebate") or a new public low-interest loan program for vehicle replacements—still require seed funding and program administrative support to be successful. Further, revenue from current fuel-based taxes that currently fund the transportation system will decrease if programs that encourage drivers to switch to more fuel-efficient vehicles and reduce the number of miles they drive are successful. As a result, New York will need policies that generate State revenue to support some of the GHG reduction policy options, and to continue to support the state's existing transportation system. New York will also need policies specifically designed to leverage investment by the private sector and draw on capital held by regional or national infrastructure banks.

For the transportation sector, the same pricing policies that are needed to generate revenue can also be policies to directly reduce emissions. Financial incentives to reduce transportation emissions can both influence choices and generate revenue that can be dedicated to programs to reduce emissions. Examples include: VMT fees, fuel fees, emission-based road tolls, emission-based vehicle registration fees, sales tax surcharges for high GHG vehicles, congestion pricing, or fees on vehicle related expenses. Other important pricing mechanisms, such as pay-as-you-drive (PAYD) insurance or a feebate system, are planned to be revenue-neutral but will reduce significant amounts of emissions. Both the amount of emissions reductions and the amount of revenue that will result from these types of policies will depend on the size and scope of the pricing mechanism and the elasticity of demand for the type of vehicle, fuel, or travel mode.

Figure 7-2. Transportation and Land Use Policy Options



Policy Scenario Summary Table Estimates

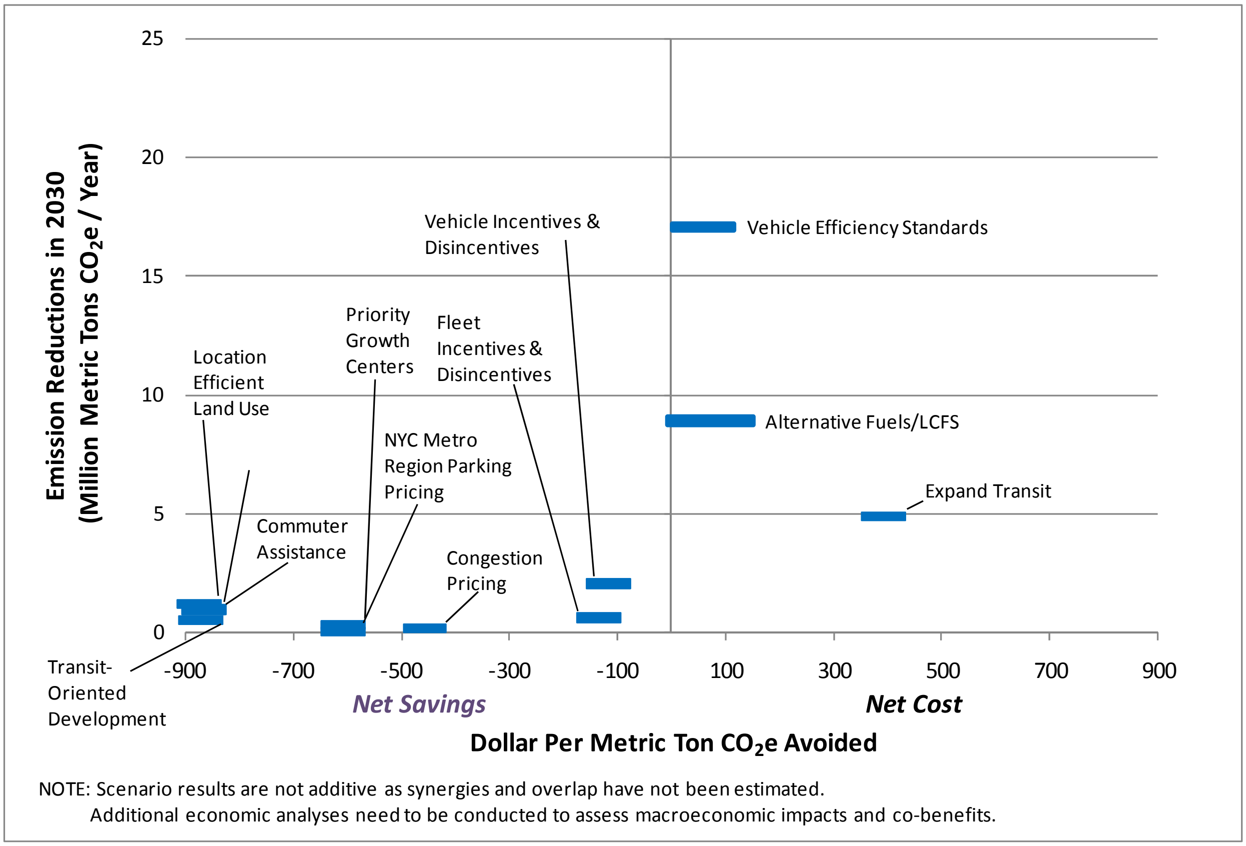
Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value: Cost/Savings (Million $2005 (2011–2030)	Net Cost/Savings per Avoided Emissions ($\$/tCO_2e$) (2011–2030)	Energy Savings (million gallons fuel saved in 2030)
		2020	2030	Total (2011–2030)			
TLU-1	Vehicle Efficiency Standards	5.3	17	130	$7,900	$62	3,600
TLU-2	Vehicle Incentives and Disincentives	0.9	2.0	20	-$2,300	-$120	220
TLU-3	Fleet Incentives and Disincentives	0.2	0.6	5.6	-$750	-$130	69
TLU-4	Alternative Fuel Related Measures and Infrastructure—Low Carbon Fuel Standard (LCFS)	3.9	8.5	84	$6,700	$79	2,000
TLU-6	Commuter & Traveler Assistance	1.0	1.0	18	-$15,000	–$870	120
	Parking Pricing— Upstate NYC Metro Region	 0.3 0.4	 0.3 0.4	 0.5 0.8	 $720 -$480	 $1,400 -$610	 3 5
	Telecommuting	1.0	1.0	18	-$15,000	-$870	120
	Congestion Pricing	0.2	0.2	2.4	-$1,100	-$460	18
TLU-7	Expand Transit	3.7	4.9	64	$25,000	$390	910
TLU-9	Priority Growth Centers	0.1	0.3	2.6	-$1,600	-$610	36
TLU-10	Transit-Oriented Development / Transit Supportive Development	0.3	0.5	5.7	-$5,000	-$870	100
TLU-11	Location Efficient Land Use	0.6	1.2	13	-$11,000	-$870	230

$\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; TDM = transportation demand management; TSM = transportation system management.

Negative values represent savings.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations. The policy numbers that appear in this table are not consecutive because they reflect only those policies for which quantitative analysis has been completed and not all policies are amenable to quantification.

Figure 7-3. Estimates of Cost and GHG Emissions Reduction for TLU Policy Options



Note that for the Vehicle Efficiency Standards and Alternative Fuel Related Measures and Infrastructure—LCFS policies, the elongated data points represent the range of potential costs of carbon based on differing petroleum price forecasts.

VEHICLE EFFICIENCY STANDARDS (TLU-1)

Policy Summary

New York State could advocate for a stronger federal or California carbon dioxide emission program[2] for light-duty vehicles (LDVs). Under current federal law (the Clean Air Act), New York State cannot adopt its own CO_2 emission standards for LDVs independently. If stricter standards are adopted in California, New York has the option of adopting California's program through a rulemaking process. In the past, New York has always exercised this option and adopted California's clean car standards. New standards would be technology-neutral but could be expected to significantly increase market penetration of zero-GHG vehicles as well as increase fleet-wide fuel economy.

[2] Current standards apply to vehicles up to model year 2016.

This policy could also include the implementation of an Eco-Driving Program to raise drivers' awareness via an outreach and education component and an enforcement component (e.g., for speeding).

Quantitative Analysis

To approach the 80 by 2050 vision and goal for the whole transportation sector, 100 percent of new LDVs sold in 2035 would have to be near-zero-GHG. There would need to be a mix of plug-in electric vehicles (PEVs), hydrogen fuel-cell vehicles, and bio-fueled vehicles. Toward this vision, the GHG emission standards for LDV would strengthen over time, with a 50 percent reduction in LDV GHG emissions by 2025 (for new fleet, from 2016 levels = 125 grams per mile [g/mi]); and 90 percent reduction in LDV GHG emissions by 2035 (for new fleet, from 2016 levels =25 g/mi). The TLU vision requires a near 100 percent reduction of GHG emissions for LDV, assuming that other transportation types (aviation, heavy-duty trucks, marine, railroads) will not be able to achieve as aggressive reductions.

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by dollars per metric ton of carbon dioxide equivalent [\$/tCO_2e] reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that New York will successfully advocate for a fleet wide LDV standard of 75 g/mile by 2030.

GHG Reductions (MMtCO_2e)		Net Present Value Cost (\$Million)	Net Cost per Avoided Emissions (\$/tCO_2e)
2030	Total 2011–2030		
17	130	\$7,900	\$62

\$/tCO_2e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

A price sensitivity analysis was performed to show how different fossil fuel price forecasts affect estimated net present value and cost per metric ton. Using fuel price forecasts from the most recent *U.S. Department of Energy Annual Energy Outlook* (AEO 2009), the net present value and net cost per avoided emissions were respectively reduced to \$770 million and 6 \$/tCO2e. The use of higher price forecasts transforms this policy scenario from a net-cost to approximately cost-neutral, showing the sensitivity of this analysis to price forecasts. .

For purposes of illustration, the following vehicle mix would approximately achieve this standard:

- 69 percent of all new LDVs sold in 2030 are PEVs, and the remainder is conventional vehicles.
- Of the new PEV fleet, about half (49 percent) are all battery electric vehicles, 17 percent are plug-in hybrid electric vehicles (PHEVs) with a 10-mile range (PHEV-10), and 34 percent are plug-in electric with a 40-mile range.
- Also in this scenario, cellulosic ethanol comprises 21 percent of fuel used in conventional and plug-in hybrid vehicles.

Special Considerations

- In contrast to most other policy options, implementation of this policy is not fully within the discretion of New York State and instead depends on federal or California action.[3]
- As defined here, this policy option results in the largest GHG reduction estimates, as a result of the fact that the emission standards goals identified by the technical work group were extremely aggressive. This represents a result-oriented, top-down approach, which starts with the 80 by 50 vision and identifies an emission standard that would nearly achieve that goal. In contrast, TLU-4 is a more constrained scenario that also results in substantially lower-carbon mix of vehicles, but not to the same level as TLU-1.
- The most significant co-benefit is a reduction in the emissions of other air pollutants, including particulates, toxics, and oxides of nitrogen, which contribute to ozone formation (smog). These pollution reductions would be noticeable and significant in terms of attaining federal health-based air quality standards and improving public health and quality of life, especially in urban areas and areas of high traffic volume.
- While the indirect emissions from electric vehicles are not counted in the vehicle standards, these emissions are taken into account in the Quantitative Analysis of GHG reductions presented above.

VEHICLE INCENTIVES AND DISINCENTIVES (TLU-2)

Policy Summary

The State of New York could create financial incentives for the purchase of low-GHG vehicles. These incentives can take the form of feebates, tax credits, sales tax exemptions, registration fees (or fee waiver), emission based tolls, or other mechanisms as appropriate.

To influence vehicle purchasing decisions, New York State could implement a revenue-neutral feebate system for all new LDVs starting in 2015. There are a variety of ways to design a feebate program. Under one approach, the program would establish a baseline GHG emission level for two to four classes of vehicles based on their passenger capacity. Consumers who purchase vehicles that emit fewer GHG emissions per mile than the baseline for their class could receive a proportional rebate. Those that purchase vehicles that emit more GHGs per mile than the baseline could pay a similarly proportional fee. The program could be designed to simply favor vehicles with a higher fuel economy to affect purchasing decisions across the market, or to target the fees or rebates only at the highest and lowest GHG-emitting vehicles on the market to influence purchasing just at these margins.

New York State could also implement emissions-based registration fees and tolling based on a vehicle's GHG emissions per mile, providing further incentives to buy and operate low GHG vehicles and potentially raising revenue for other transportation GHG reduction programs.

[3] New York's current State Energy Plan also directs New York to advocate for a stricter federal standard.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by \$/tCO_2e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that New York implemented a feebate program that successfully reduced average GHG emissions from newly purchased vehicles on average by 5% beyond the existing standards.

GHG Reductions (MMtCO_2e)		Net Present Value Savings (\$Million)	Net Savings per Avoided Emissions (\$/tCO_2e)
2030	Total 2011–2030		
0.9	20	-\$2,300	-\$120

\$/tCO_2e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- In contrast to emission standards (TLU-1), incentive programs are fully in the control of New York State.
- The level of program success would depend on the level of fee or rebate put into place. Because economic modeling of feebate programs at the national level suggests that most of the GHG reductions would result from vehicle manufacturers reducing the GHG emissions of their cars, a feebate program's effectiveness increases if implemented over a larger market, such as the northeastern states region or at a national level, similar to the options described in TLU-12. However, it could also be effective if implemented exclusively in New York State.
- By designing a revenue-neutral feebate system, where the total amount offered as incentives is equal to the total amount charged as disincentives, New York could implement a program without any General Fund expense. The rebates disbursed could be slightly smaller than the fees collected, with a small amount of fees reserved each year to cover administrative costs and in case of an unexpectedly large need to pay for rebates in future years. But a vehicle purchase incentive program could also be designed to be revenue generating (e.g., gas-guzzler sales tax surcharge), or to be revenue-negative (e.g., tax credit for purchase of electric cars or a cash for clunkers program).
- This policy option was developed independent of New York's ability to achieve TLU-1. Even if TLU-1 standards were put in place, an incentive program would still be necessary to achieve the 2030 vision for LDVs.
- Co-benefits for this policy would be in the form of 1) reduced gasoline expenditures by New Yorkers as the fleet becomes more fuel efficient, and 2) reduced vehicle pollution and the accompanying improvement in air quality.
- Low-income communities tend to have a much higher percentage of older vehicles, which has implications for air quality. Programs that facilitate the retirement of such vehicles help to address this problem.

HEAVY-DUTY FLEET INCENTIVES AND DISINCENTIVES (TLU-3)

Policy Summary

This policy could establish a State revolving loan fund for replacing fleet vehicles with lower GHG-emitting vehicles, or other financial incentives for both public and private fleet replacement. The 2050 vision for the transportation sector includes a zero emission light-duty fleet and a heavy-duty vehicle (HDV) fleet with GHG emissions as low as possible using available technology and low-carbon biofuels. New soon-to-be-released federal standards mandating greater HDV efficiency mean that normal vehicle turnover will reduce GHG emissions. However, accelerating this HDV turnover will be necessary to achieve the 2050 vision. A low-interest revolving loan program could be used to provide the necessary incentive to achieve fleet turnover in the required timeframe. New York State could offer below market interest rates and extended loan terms based on the useful life of the vehicle, reducing annual loan or lease payments. The state could also enhance the financing incentive by offering lower interest rates to incentivize fleets to purchase alternative vehicles; i.e. hydrogen fuel-cell or electric.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost-effectiveness (as measured by \$/tCO_2e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that New York put in place a State revolving loan program that is successful in replacing 3% of the HDV fleet per year. (Although LDVs could also be included in a loan program, the quantitative analysis focused on HDVs.)

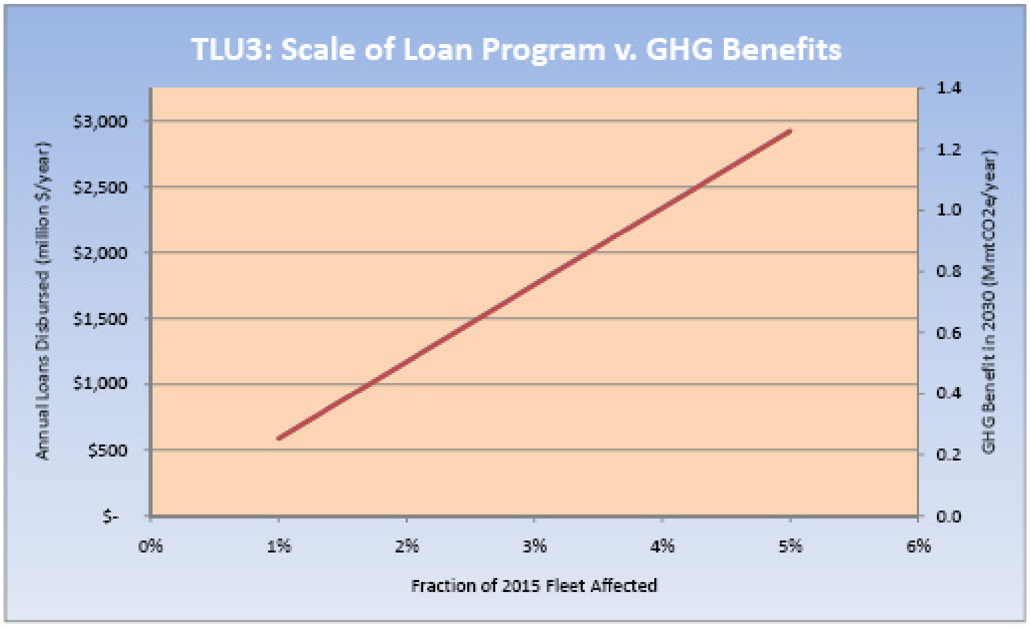
GHG Reductions (MMtCO_2e)		Net Present Value Savings (\$Million)	Net Savings per Avoided Emissions (\$/tCO_2e)
2030	Total 2011–2030		
0.6	5.6	-\$750	-\$130

\$/tCO_2e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Figure 7-4 provides an indication of the level of capitalization required to accelerate HDV turnover and emission benefits achieved depending on the fraction of the fleet to be turned over:

Figure 7-4. Level of Capitalization Required to Accelerate HDV Turnover



Special Considerations

- Due to its experience implementing loan programs with lower-than-market interest rates, the New York State Environmental Facilities Corporation would be well positioned to take on the role of administering this type of program. New statutory authority would need to be provided by the Legislature.
- Accelerated turnover in the HDV fleet would bring significant co-benefits in terms of air quality, because diesel vehicles are a major source of particle pollution, toxics, black carbon, and oxides of nitrogen. Although on-road diesel HDVs are considerably cleaner since 2007 due to new federal standards, the longevity of vehicles slows fleet-wide emissions improvements. Diesel emissions contribute to New York State's non-attainment of air quality standards, and urban environmental justice (EJ) neighborhoods often bear a disproportionate burden from truck traffic due to their proximity to industrial areas, freight routes, or transit depots. A cleaner HDV fleet will help New York State attain air quality standards and improve health and quality of life in EJ neighborhoods.
- Another important co-benefit is the provision of access to credit for small and large businesses, non-profit organizations (e.g., paratransit agencies), and local governments that could use this loan fund to replace and upgrade their fleet vehicles.
- The environmental impacts associated with truck traffic, including emissions, noise, dust, and congestion often represent one of the primary concerns of EJ communities, particularly those burdened with solid waste management facilities. By incorporating an explicit focus on overburdened communities and encouraging a shift to newer vehicles with lower emissions, this policy could provide significant EJ benefits, while helping to meet New York State's GHG reduction goals.

ALTERNATIVE FUEL RELATED MEASURES AND INFRASTRUCTURE (TLU-4)

Policy Summary

In December 2009, the governors of New York and 10 other states in the Northeast and Mid-Atlantic region signed a Memorandum of Understanding (MOU), affirming each state's commitment to developing a low-carbon fuel standard (LCFS) program framework by 2011. This policy supports this LCFS program: a market-based program to decrease the carbon intensity (the amount of average GHGs released per unit of energy produced or g CO2e/megajoule) of all on-road transportation fuels sold in New York by some amount from current levels by 2020. The LCFS would provide an incentive to commercialize new fuel technologies and encourage the development of infrastructure to produce and distribute low-carbon fuels including biodiesel (B20 and B100), cellulosic ethanol (E10 and E85), and electricity.4

In addition, to help develop and expand alternative, low-carbon fuels New York State could establish financial incentives for low-carbon fueling investment: sales tax exemption for low carbon fuels, investment tax credits for retail fueling infrastructure, and production tax credits. As part of the 11-state Transportation and Climate Initiative, New York State has proposed a planning process to develop guidelines and a master plan for implementing a regional electric vehicle (EV) network of charging stations that enable local and regional EV travel. New York State could potentially invest in and construct charging/battery-exchange stations in the context of this regional framework.

To support near-zero carbon vehicle deployment, New York could invest in research and modeling to assess the in-state infrastructure needs for fueling for electrification and hydrogen, including the standardization of electrical connections and voltages necessary for electric charging infrastructure. New York could also develop policies and regulations that support the development of business models that allow the sale of electricity by non-utilities (through both direct charging and battery swapping), aggregation of loads for business transactions, private and public investment in publicly accessible vehicle charging, and the development and deployment of standardized quick charge technology. (See paper by the electric vehicle sub-group in Appendix G.)

For this group of policy options, an important consideration will be the sequencing of implementing a LCFS and investing in fueling infrastructure, so as to achieve the standard's carbon intensity reductions and to prevent stranding of significant investment.

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[4] B20 is a fuel blend of 20 percent biodiesel and 80 percent gasoline, and B100 is 100percent biodiesel fuel. E10 is a fuel blend of 10 percent ethanol and 90 percent gasoline, and E85 is a fuel blend of 85 percent ethanol and 15 percent gasoline.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed implementation of a LCFS that achieves a 10 percent decrease in average carbon intensity by 2020 and a 12 percent improvement by 2030.

GHG Reductions (MMtCO_2e)		Net Present Value Cost ($Million)	Net Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
8.5	84	$6,700	$79

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

A price sensitivity analysis was performed to show how different fossil fuel price forecasts affect estimated net present value and cost per metric ton. Using fuel price forecasts from the most recent *U.S. Department of Energy Annual Energy Outlook* (AEO 2009), the net present value and net cost per avoided emissions were respectively reduced to -$180 million and -1 $/tCO2e. The use of higher price forecasts transforms this policy scenario from a net-cost to approximately cost-neutral, showing the sensitivity of this analysis to price forecasts.

An LCFS program would be fuel technology-neutral—in other words, it would set a performance standard but would not prescribe how fuel providers meet the standard. The LCFS would be expected to lead to an increased market penetration of alternatively fueled vehicles. For purposes of illustration, one mix of vehicles that would achieve this LCFS (10 percent improvement in carbon intensity by 2020 and 12 percent by 2030) is: 50 percent of all new LDVs sold in 2030 are PEVs, and the remainder of the LDV fleet uses a combination of conventional fuels, conventional biomass, and advanced biomass.

Although the quantitative analysis did not propose specific goals for the complementary policies (financial incentives, infrastructure installation) these policies are an important part of a comprehensive fuel strategy, and would facilitate achieving an LCFS.

Special Considerations

- Additional analyses will be conducted in the next phase of the Climate Action Plan process to separately quantify the potential benefits and costs of utilization of biomass for application in the TLU sector.
- Assuming that the policy promotes the use of zero-emission electric or hydrogen vehicles, a significant co-benefit is a reduction of pollutants, including particulates, toxics, and oxides of nitrogen, which contribute to ozone formation (smog). These pollution reductions would be noticeable and significant in terms of attaining federal health-based air quality standards and improving public health, quality of life, especially in urban areas and areas of high traffic volume.

- Only a portion of the sustainable level of biofuels production, as described in New York's Biofuels Roadmap, would be available to the transportation sector, and this Quantitative Analysis takes this into consideration. The GHG emissions reductions presented above did not take into account indirect land use changes.
- For PEVs, quick charging technology is not currently commercially available and battery swapping systems must be standardized to be widely used. If multiple technologies and business models continue to develop, EV charging and long-range travel will become more convenient for consumers.
- Note that the scenario quantified for this policy option does not achieve the fleet-wide emissions standards put forward in TLU-1, which was 75 grams of CO_2/mile by 2030.

RESEARCH, DEVELOPMENT AND DEMONSTRATION NEEDS FOR THE TRANSPORTATION AND LAND USE SECTOR (TLU-5)

See Chapter 10 for a complete presentation of Research, Development and Demonstration needs for this sector.

TRAVEL DEMAND MANAGEMENT AND TRANSPORTATION SYSTEM MANAGEMENT (TLU-6)

Policy Summary

An essential strategy in reducing GHG emissions from transportation sources is improving the energy efficiency of the road and highway network. This may include reducing the growth rate in VMT, providing alternatives to single-occupant vehicle travel, and reducing delay and eliminating bottlenecks on the highway system. Providing these elements may reduce GHG emissions by reducing the number of trips on the highway system and VMT per person, and by generating a significant mode shift to carbon-efficient and zero carbon modes of travel.

An important aspect of this is transportation system management (TSM). Effective TSM (such as high-occupancy vehicle lanes, improved traffic flow) utilizes a variety of strategies including advanced technologies, policies, and design standards. TSM strategies attempt to make travel more efficient by shortening trip lengths, reducing vehicle delay, increasing the reliability of the transportation network, and reducing idling and other transportation actions. System design complements technology actions, and includes access management and intersection improvements. An efficient system minimizes GHG emissions.

Another important component is the integrated implementation and delivery of travel demand management (TDM) strategies and services (such as carpooling, van pooling, telecommuting) in New York's urban, suburban, and rural locations, built on market-based incentives and education and outreach programs to reduce, eliminate, or shorten vehicle trips. When these strategies are applied in concert, substantial gains can be achieved.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e reduced) for the policy scenario analyzed by the Technical Work Group are presented below.[5] The implementation in New York State of the following programs was quantified:

- Implement a Commuter and Traveler Assistance Program in upstate New York starting in 2011. This program aims to change commuter and traveler behavior by providing easily accessible information that prompts the choice to use other commute modes or carpooling, and includes other actions to maximize commuter and traveler mobility.
- Implement parking pricing practices in New York urban areas using smart parking meters in central business districts starting in 2011.
- Implement a New York State Telecommuting Project, primarily in the New York metropolitan area and secondarily on a statewide level.
- Implement congestion pricing in the New York City metro area as previously proposed by New York City starting in 2015. Implementing a congestion pricing program in the New York metro area could reduce VMT and provide revenue for TSM and TDM activities by requiring a fee for vehicles to enter designated parts of the New York metropolitan area. Legislation would be needed to permit this strategy but is estimated to reduce VMT within the cordon area in New York City by approximately 6%, with additional VMT reduction in the greater metropolitan area due to reduction in trips to and from the City.

Commuter & Traveler Assistance

GHG Reductions (MMtCO_2e)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
1.0	18	-$15,000	-$870

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

[5] Note that quantitative analysis was not undertaken for the TSM measures.

Parking Pricing: New York City Metropolitan Region

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/$tCO_2e$)
2030	Total 2011–2030		
0.4	0.8	-$480	-$610

$/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Telecommuting

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/$tCO_2e$)
2030	Total 2011–2030		
1.0	18	-$15,000	-$870

$/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Congestion Pricing

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/$tCO_2e$)
2030	Total 2011–2030		
0.2	2.4	-$1,100	-$460

$/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- State legislation would be needed to allow a congestion-pricing program to be developed and implemented in New York City.
- TDM measures should be designed to reduce single-occupant vehicle commuting and overall VMT; i.e., addressing both commute and non-commute trips. TDM measures should be integrated with other related strategies that promote transit options.
- Successful programs must use innovative, and non-traditional measures that consider and reflect best practices; a customer-needs focus in delivery; enhanced marketing, communications, outreach, and public relations including leveraging existing resources such as 511-NY and Clean Air NY; advanced, state-of-the-art information and communication; and

education, training, and development activities. Further, successful programs should monitor for performance and effectiveness that track commuter and traveler behavior, response, and change. There needs to be multi-agency coordination and collaboration to maximize effectiveness.

- Availability of information through the Internet must be maximized to provide travelers with a full range of real-time travel options through on-line trip brokerages, travel planners, and service databases. As trip brokerages and travel planners mature, new forms of demand-responsive taxi, transit, and paratransit services can be developed to operate more efficiently and effectively in lower density areas as well as higher density, urbanized settings.
- In developing parking pricing programs, particular care should be given to implement the program so that it is not counter-productive to the State's smart growth efforts; i.e., that it does not discourage use and enjoyment of downtown areas. For existing employer-provided parking, the State could implement a parking cash-out program with a tax credit for employers as an incentive for their participation; and for new parking in developing areas, the true cost of parking should be reflected in municipal development policies and zoning ordinances.
- Co-benefits include improved travel mobility, flexibility, and choice, as well as a reduction in congestion and travel time, and a reduction in other air pollutants from transportation.

TRANSIT and HIGH-SPEED RAIL (TLU-7)

Policy Summary

New York State could reduce GHG emissions from the transportation sector by encouraging a major shift in mode share from predominantly single-occupant vehicle travel to public transportation. This would occur through investment in the improvement and expansion of transit systems to existing communities and the development of high speed rail with competitive trip times along the Empire and Adirondack Corridors. In cooperation with other Northeast states, New York State could also promote the development of high speed rail in the Northeast Corridor. Sustained financial investment in public transportation, particularly transit infrastructure, could provide affordable, convenient, and comprehensive travel options that would connect communities, jobs, and long-distance travel centers. Construction of expanded subway, light rail, bus rapid transit, and high speed rail networks would promote job growth and economic development in the state in two ways. The expansion of transit systems in New York State could spur a growth in the transit- and rail-related manufacturing sectors. High speed rail that offers competitive trip times could boost economic output and prosperity by linking metro areas with robust economies to metro areas trying to create strong economies, a strategy that would expand the options of job seekers and employers. Dedicated high speed rail tracks would also free up existing rail tracks for improved freight deliveries and efficiencies by reducing congestion and competition for track availability. The strategies, investments, and high speed rail trip times suggested in this policy are aggressive, but are suggestive of what would be needed to reach the 80 percent GHG reduction goals established for 2050. Achieving these goals would require funding well above what is available today. It would require increased federal resources, including a dedicated ongoing funding source for rail investments at the federal level, as well as ongoing operating subsidies to support continued service and operations. Achieving these transit goals would require a sustained long-term commitment to system planning and funding. Accomplishing these high speed rail goals would require right-of-way acquisition, legislation to allow new corridor construction in the Adirondack State Park, and interstate and international agreements.

The state could also promote the use of shared modes of transportation, such as transit, carpooling, and ride sharing, by expanding available information about these services through improved communications technology. The appropriate mix of technology and real-time information could provide the kind of comparative data on costs or saving that would enable workers, residents, and visitors to make more informed choices when they select a particular mode or combinations of modes for work trips and discretionary trips. Expanded use of wireless technology could enable new demand-responsive transit services to be developed that can operate more efficiently and effectively both in lower-density areas and in higher-density and urbanized settings. Improvements and expansions to inter-city train travel could also reduce GHG emissions by developing additional shared modes of transportation in cities once a traveler reaches their destination city.

One short-term discrete action for New York is to invest in a multi-state high speed rail feasibility and planning study that also examines the multitude of economic and environmental benefits.

Quantitative Analysis

Investment in transit and high speed rail would be pursued to bring about a major expansion of mobility options for New Yorkers, such that the annual rate of VMT growth would decrease to 0.4 percent until 2020, stabilize at 0 percent by 2030 and reduce VMT 10 percent below 2030 levels by 2050. (The current rate of VMT growth is greater than 1 percent per year.)

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/tCO2e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that the percentage of trips made in single occupancy vehicles would decrease from the current 50 percent downstate and 80 percent upstate to 35 percent by 2030 downstate and 65 percent by 2030 upstate.

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost ($Million)	Net Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
4.9	64	$25,000	$390

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Although not included in the quantitative analysis, another key goal of these policy measures is to make high speed rail more competitive with aviation in the Empire State and Northeast corridors, which would decrease emissions from the aviation sector and well as shift travelers from automobiles to trains. Please see TLU-12 for additional information.

Special Considerations

- This policy option is closely linked with TLU-6, which consists of TSM and TDM policies, including those that encourage using shared modes. It is also linked to TLU-9, TLU-10, and TLU-11, which consists of policies to promote the land use patterns that are particularly supportive of increased use of public transportation and high speed rail. The Regional recommendations are also linked to TLU-12.
- Increased use of public transportation, with its accompanying reduction in VMT, would greatly improve air quality, especially in the state's urban centers, because public transportation and shared modes of transportation generally emit less pollution per passenger mile traveled than single occupancy vehicles. These measures could also drastically improve mobility and reduce congestion in these same areas by taking vehicles off the road as drivers migrate toward shared modes. Other important co-benefits include the expansion of travel mobility, flexibility, and choice, which can be especially important to middle- and lower-income New Yorkers. Integration of an expanded transit network with high speed rail on Empire Corridor lines and the Northeast Corridor could have several other broad macroeconomic benefits, including freeing up airport capacity and airspace, freeing up rail capacity for rail freight movements, and better linking cities throughout the State.
- VMT reductions in more rural areas could be very difficult to achieve, as these trips may not lend themselves easily to shared mode travel.
- Recognizing the significant climate benefits and co-benefits, expanding public transportation options across the state to the extent described above would be very expensive. High speed rail, subways, and even light rail or bus rapid transit systems require significant infrastructure expenditures. Achieving large increases in transit ridership across the state will require major expansions of transit infrastructure, which is largely absent in many communities. New rail lines may require New York State to exercise its power of eminent domain, possibly over large areas. The GHG impact of induced demand from development opportunities created by high speed rail access should also be considered, as this would likely lead to both economic activity and population increases in New York compared to business as usual.
- Development of high speed rail would require ongoing, sustained funding and support to plan and develop the corridors. A separate and sustained source of federal funding for rail would be required.
- To attain the reliability and higher speeds suggested along the Adirondack Corridor, significant cross-border negotiations to reduce or eliminate border inspection delays (e.g., moving passenger inspections to Montreal) would be required. Further, development of high speed rail along the Adirondack Corridor would require a constitutional amendment to pursue new alignments.
- Moreover, providing transit services in diffuse communities, especially upstate, would likely require significant operating support to keep fares at publicly acceptable levels. If the land use policies in TLU-9, TLU-10, and TLU-11 are successful, a larger portion of the New York State population will live in areas that are easier to service with transit options.

FREIGHT STRATEGIES THAT PROMOTE GHG REDUCTIONS (TLU-8)

Policy Summary

New York State, in conjunction with a broad-based stakeholder group including State agencies and municipalities, adjoining states, the goods movement industry, and local community groups, could establish a comprehensive Goods Movement GHG Policy, with the dual goals of increasing freight efficiency while reducing GHG emissions.

The comprehensive policy should identify and prioritize key freight projects such as consolidation and distribution centers (including important highway and non-highway modal connections), new intermodal yards, rail system improvements, the development and expansion of non-highway system capacity, and the operational enhancement of existing highway systems to support local, regional, and transcontinental freight service into and out of New York State. Such projects would provide alternative off-road clean transport systems to improve goods movement, reduce congestion, and reduce emissions.

Once identified, key freight projects could also be subject to an efficient permit process that considers the needs of the local community. The policy could establish state requirements for system-wide GHG analyses and green technology advancement through the State Environmental Quality Review (SEQR) and other permitting requirements; set specific performance standards to incentivize low to zero emissions truck, rail, ship, and support equipment technology; and establish freight fees dedicated to transportation system and infrastructure upgrades. The policy could draw on existing efforts and partnerships, such as the New York State Rail Plan, the Port Authority of New York and New Jersey Comprehensive Long-Term Regional Goods Movement Plan, and the Regional Greenhouse Gas Initiative, while acknowledging New York State specific issues.

Further, the plan should identify key freight corridors and connectors and establish land-use guidelines for local and regional municipalities in those corridors that are specific to freight. It should also consider rail clearance and track improvements to allow heavier loads, thereby supporting a more viable rail system and should look for other investments and incentives to support low GHG options. The Technical Work Group explored several policy options that warrant further consideration:

- Develop comprehensive Goods Movement GHG Policy, prioritizing increasing efficiency and reducing GHG and congestion as main design metrics;
- Increase non-highway mode shift;
- Establish a network of freight villages/consolidation centers/urban distribution centers serving the upstate and downstate regions;
- Provide incentives to establish progressive performance standards and develop low-GHG rail and truck technology, terminal equipment, and ships/tugs/barges acknowledging full life-cycle emissions.

Quantitative Analysis

The estimated GHG reduction potential for the policy scenario analyzed by the Technical Work Group was not fully analyzed in quantitative terms, since it was difficult to estimate reliable costs of implementation for the multi-faceted program developed and described during the Technical Work Group process.

Special Considerations

- A Goods Movement Policy would first have to involve a baseline assessment of bottlenecks and network capacity issues, to act as a benchmark. Following this baseline assessment, and building from existing work, key freight corridors, connectors, and eventual projects throughout the state and northeast region could be identified. An efficient permitting process could be available to these resulting freight projects, with local and regional agencies able to apply for direct federal and state funding.
- Coordination both within and outside of New York State would be needed to ensure that freight moves by the most efficient combination of modes and the most efficient route, and utilizes a combination of VMT/unit of freight and total GHG per transit mode as metrics. Such coordination will prioritize consistency in policies and permitting requirements to alleviate administrative congestion such as differences in oversize/overweight rules between cities, counties, states, and Canada. Coordination must also recognize that freight decisions are largely under private sector control and that decisions are interstate, national, international, and global in nature. Freight decisions in New York must be made in ways that do not disadvantage the state's economy.
- Freight fees or congestion pricing could be established to promote efficient movement and reduce both VMT and total GHG emissions. Ideally developed in partnership with the freight industry, fees could be based on elasticity studies and consider existing tolls and taxes. Fees could be collected by and administered through a regional partnership entity and go into a fund dedicated solely to freight infrastructure improvements. Note: If a non-gas tax results from federal transportation law in 2011, this fee may supplement freight fee efforts. Decisions must be balanced in consideration of impacts on the state's economy.
- Progressive performance standards for trucks, rail, terminal equipment, ocean-going vessels, and harbor craft will need to be developed. The U.S. Environmental Protection Agency could be lobbied to adopt national standards modeled after California. Standards for freight consolidation/distribution centers will be needed to ensure minimal community impacts.
- The 2009 New York State Rail Plan cites a study conducted by the American Association of Railroads that reports that significant investment in the existing railroad freight infrastructure will be required to account for the projected growth in rail freight through 2035. This investment will be needed to maintain the current rail freight capacity. To allow for mode shift of freight to rail, additional investment will be required.

PRIORITY GROWTH CENTERS (TLU-9)

Policy Summary

The State of New York could assist and incentivize municipalities in designating, planning, zoning, and developing/re-developing priority growth centers. This could happen through a combination of State assistance and State incentives, such as shifting State resource allocations towards identified priority growth centers, which could be in urban, suburban, or rural areas. The priority growth centers would be encouraged to have compact, mixed-use, walkable/bikeable development in existing centers of activity, whether urban centers or hamlets and village centers. New York State could accomplish this through incentive programs such as:

- Assisting localities and regions in designating priority growth centers;
- Accelerating and prioritizing permit and SEQRA review for smart growth projects, without compromising outreach to, and input from, underserved populations or EJ areas;
- Ensuring affordable housing options within priority growth centers;
- Providing priority infrastructure funding (transportation, water, economic development, schools, housing) for Smart Growth;
- Incorporating principles of strategic land conservation and green infrastructure into open space preservation funding, plans, and documents;
- Providing public accessibility to parks and green spaces, both within and outside priority growth centers;
- Assisting with alternative local funding mechanisms, such as Tax Increment Financing;
- Further rewarding such smart growth development as described above if it comports with a regional land use and/or transportation plan; and
- Using regional transportation and land use planning to encourage development patterns that achieve prescribed transport-based GHG emission reductions.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that the actions described above, if aggressively pursued at the State level, would result in 50 percent of new construction taking place in identified priority growth centers by 2030.

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/tCO_2e$)
2030	Total 2011–2030		
0.3	2.6	-$1,600	-$610

$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Implementation costs were estimated by applying assumptions similar to those used for the *Moving Cooler*[6] study's Land Use and Smart Growth Strategies under the Maximum Deployment scenario. These include costs for policy, planning, and visioning. Since these planning costs are assumed to include all measures in TLU-9, TLU-10, and TLU-11, the cost was distributed between the three policy options, weighted by the emissions reduction.

Special Considerations

- Current and projected shifts in demographics and home/community preferences will in many ways support the policy recommendations and GHG reduction goals in this policy option. Population projections see an increase in more than 1 million residents in the urban areas downstate by 2030, but a decrease of almost 300,000 residents upstate, which should contribute to increasing access to smart growth land uses. Based on market and real estate trends and projections, the increase in the over-65 population (projected to be over 20% by 2030) will concomitantly increase the demand for smaller dwelling units (including more attached housing) in walkable/bikeable, transit-friendly, mixed-use communities, particularly in municipal centers. The rise in the number of childless households, single parent households and young, single professionals is projected to increase the market for compact, vibrant, diverse, mixed-use, walkable/bikeable, transit-friendly communities, particularly in urban areas. Furthermore, a larger nationwide trend toward urbanization could manifest itself in supportive, climate-friendly real estate and home-buying trends in New York.
- Implementation of this policy is especially relevant in those areas of the state that expect population growth between now and 2030, and could be targeted to those areas in the short term.
- Considering the limitations of State incentives and assistance (vs. mandates for example, which this policy doesn't include), the scenario of having 50 percent of all new construction occur in priority growth areas is very aggressive, but potentially feasible, given the long timeframe. Achieving these results would require a sustained long-term State commitment to promoting priority growth centers with assistance and incentives.
- TLU-9 is closely linked with TLU-10 and TLU-11, which consist of related land use policies, and TLU-6 and TLU-7, which consist of policies supporting transit and transportation demand management that enable and thrive in partnership with compact, mixed land use.

[6] "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions," http://www.movingcooler.info/.

- Compact, mixed use developments, which could be encouraged through Priority Growth Centers, offer significant co-benefits from improved public health and air quality; better mobility through access to additional travel options such as public transportation, walking, or biking; and reduction in building energy use (compact land use is generally associated with lower building energy use per square foot).
- Without significant changes in land use and development patterns in New York State, the level of VMT reductions and mode share changes contemplated in the entire suite of TLU policies will be difficult to achieve. However, land use changes are particularly difficult to prescribe in New York State. New York State can offer incentives to municipalities and regional planning organizations to incorporate priority growth centers, but the State ultimately does not have the authority to create them itself, due to home rule. Incentives will have to be designed carefully to attract local authorities to update and alter their land use plans. Land use patterns are difficult to change once established, and changing incentives and local regulations could lead to significant property value shifts, raising values in denser areas and reducing values in sprawling neighborhoods. This could have significant economic and equity impacts.

TRANSIT- ORIENTED DEVELOPMENT (TOD)/ TRANSIT-SUPPORTIVE DEVELOPMENT (TSD) (TLU-10)

Policy Summary

This policy is a suite of measures to encourage and incentivize transit-oriented development (TOD). The State could provide favorable tax incentives, priority infrastructure funding, and technical assistance/planning grants for the planning, zoning, and development/re-development of: transit villages in close proximity (one-half mile, as a general rule) to transit stations (rail, bus, ferry); targeted compact, mixed-use development within walking, biking and short-car-ride distance of a transit station; and pedestrian-/bicycle-friendly access to transit. New York State could also develop parking policies and alternative funding mechanisms for parking that support TOD/transit-supportive development (TSD). New York State could offer:

- Continued development and expansion of existing technical assistance and public education around TOD;
- Sales tax exemptions and/or income tax credits for retail within one-half mile of a transit hub in an area appropriately planned and zoned for TOD;
- Priority state and local assistance for projects within a TOD;
- Additional location efficiency incentives if TODs reduce transportation and/or parking costs due to location efficiency;
- Assistance and incentives for Transfer of Development Rights initiatives that transfer development away from open space that serves maximum carbon sink and sequestration benefits and toward TOD;

- Agreements established by the state housing agencies to maintain the long-term affordability of affordable housing within TOD/TSD as a condition of receiving state affordable housing assistance;
- Rewards/incentives for communities with adequate TOD/TSD ordinances.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/tCO₂e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that the suite of programs outlined above were successful in having 65 percent of all new development in the MTA service area within close proximity and accessible to transit; and in establishing bus rapid transit lines throughout all major metropolitan areas of the state, with TOD located on each route.

GHG Reductions ($MMtCO_2e$)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/$tCO_2e$)
2030	Total 2011–2030		
0.5	5.7	-$5,000	-$870

$/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Implementation costs were estimated by applying assumptions similar to those used for the *Moving Cooler*[7] study's Land Use and Smart Growth Strategies under the Maximum Deployment scenario. These include costs for policy, planning, and visioning. Since these planning costs are assumed to include all measures in TLU-9, TLU-10, and TLU-11, the cost was distributed between the three policy options, weighted by the emissions reduction.

Special Considerations

- Population levels in New York are expected to increase and development and building is expected to occur. This policy option aims to steer that development to locations accessible by transit. This policy suite is closely linked with TLU-9 and TLU-11, which consist of related land use policies, and TLU-6 and TLU-7, which consist of policies supporting transit and transportation demand management that enable and thrive in partnership with compact, mixed land use. It is also linked to TLU-12 through policies to promote these policies at a Regional level
- The scenario of 65 percent of development in Metropolitan Transportation Authority (MTA) area occurring near transit is taken from the report of the Blue Ribbon Commission on Sustainability and the MTA.
- Compact, mixed use developments, which could be encouraged through TOD/TSD, offer significant co-benefits from improved air quality and public health; better mobility through

[7] "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions," http://www.movingcooler.info/.

access to additional travel options such as public transportation, walking, or biking; reduction in building energy use (compact land use is generally associated with lower building energy use per square foot); and enhanced quality of life.

- Without significant changes in land use patterns in New York State, the level of TOD and TSD in this policy option and those related to transit, HSR, and freight will be difficult to achieve. As mentioned in TLU-9, land use changes are difficult to prescribe in New York State.
- Traffic congestion and heavy traffic areas are significant environmental burdens on EJ communities across the state. Efforts to increase efficiencies and strategically promote the use of mass transit can help to ameliorate these impacts.
- As described in more detail in TLU-9, demographic changes will support the recommendations and goals in this TLU. Population projections for New York foresee an increase in urban areas downstate by 2030, but a decrease of almost 300,000 residents upstate. The increase in the over-65 population will increase the demand for smaller dwelling units in walkable/bikeable, transit-friendly, mixed-use communities. Demographic trends support projections of a strong market for compact, vibrant, diverse, mixed-use, walkable/bikeable, transit-friendly communities.

LOCATION-EFFICIENT LAND USE (TLU-11)

Policy Summary

The State of New York could incentivize and promote local planning, zoning and development/re-development that minimizes the distance between locations of daily destinations through targeted density and mixed land uses; infill development/adaptive reuse (commercial, retail, residential); retrofitting sprawl development to achieve greater density, mix of land uses, inter-connectivity and walkability; affordable housing opportunities; close proximity between jobs and transit; and close proximity between affordable housing and low-/moderate-income jobs. As distinguished from TLU 9—Priority Growth Centers, this policy could occur by taking a micro-planning approach by creating specific, people-friendly/oriented network/land use connections. New York State could accomplish this through programs such as:

- Recognizing and incentivizing projects that comport with location efficiency with state economic development assistance;
- Developing a Location-Efficient Mortgage program, modeled on the Housing Finance Agency/State of New York Mortgage Agency Mortgage Insurance Fund agreement with the MTA to provide additional incentive for affordable housing near transit;
- Requiring that to the extent practicable and within the context of the setting, road and network design would adhere to the Complete Streets approach, offering equal access and use to all users including automobiles, transit vehicles, pedestrians, bicyclers, seniors, and children regardless of age or ability;
- Catalyzing university and college resources to create greater town land use synergies with surrounding neighborhoods and municipal centers;

- Developing policies that promote local food production and distribution;
- Building location efficiency into state housing program eligibility and policies to mitigate any negative aspects of gentrification and increased housing prices resulting from revitalization and redevelopment; and
- Investing State funds in brownfields cleanup and redevelopment, including improving the existing brownfields tax credit program for privately owned brownfields, and re-establishing the grants and technical assistance to localities for municipally-owned brownfields.

Quantitative Analysis

The estimated GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/tCO$_2$e reduced) for the policy scenario analyzed by the Technical Work Group are presented below. The scenario assumed that the measures above would measurably reduce the distance/VMT required to access work and other daily destinations, as well as the household costs devoted to transportation.

GHG Reductions (MMtCO$_2$e)		Net Present Value Savings ($Million)	Net Savings per Avoided Emissions ($/tCO$_2$e)
2030	Total 2011–2030		
1.2	13	-$11,000	-$870

$/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Implementation costs were estimated by applying assumptions similar to those used for the *Moving Cooler*[8] study's Land Use and Smart Growth Strategies under the Maximum Deployment scenario. These include costs for policy, planning, and visioning. Since these planning costs are assumed to include all measures in TLU-9, TLU-10, and TLU-11, the cost was distributed between the three policy options, weighted by the emissions reduction.

Special Considerations

- TLU-11 is closely linked with TLU-9 and TLU-10, which consist of related land use policies, and TLU-6 and TLU-7, which consist of policies supporting transit and transportation demand management that enable and thrive in partnership with compact, mixed land use. It is also linked to the TLU-12 related to RGGI for land use.
- Compact, mixed use developments, which could be encouraged through Location-Efficient Land Use, offer significant co-benefits from improved air quality, better mobility through access to additional travel options such as public transportation, walking, or biking, reduction in building energy use (compact land use is generally associated with lower building energy use per square foot), and enhanced quality of life.

[8] *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*, http://www.movingcooler.info/.

- The significant changes in land use patterns in New York State required by this policy will be complicated to achieve because land use changes are particularly difficult to prescribe in New York State. There is, for example, no guarantee that the list of State-level incentives enumerated above would result in a significant shift in land use patterns.
- As described in more detail in TLU-9, demographic changes will support the recommendations and goals in this TLU. Population projections for New York foresee an increase in urban areas downstate by 2030, but a decrease of almost 300,000 residents upstate. The increase in the over-65 population will increase the demand for smaller dwelling units in walkable/bikeable, transit-friendly, mixed-use communities. Demographic trends support projections of a strong market for compact, vibrant, diverse, mixed-use, walkable/bikeable, transit-friendly communities.

INTERGOVERNMENTAL/REGIONAL PROPOSALS (TLU-12)

Policy Summary

New York could pursue a range of regional (i.e., multi-state) strategies to reduce GHG emissions from the transportation sector. This policy description is separated into four parts, although they are clearly interdependent: (1) a regional initiative for land use and GHG emissions, (2) a regional initiative for transportation and GHG emissions, (3) a regional initiative for high speed rail lines inside New York State (Empire Corridors) and on the Northeast Corridor, and (4) a federal advocacy program. The regional transportation initiative would include a carbon pricing mechanism that would generate revenue, and the regional land use initiative would reinvest that revenue in economic development projects that lead to reduced per capita GHG emissions from transportation.

Certain regional transportation initiatives have already begun. For example, on June 15, 2010, a Northeast and Mid-Atlantic Regional Transportation and Climate Initiative summit brought together transportation, energy, and environmental agency heads from 11 states plus Washington, DC to work collaboratively to reduce GHG emissions from the transportation sector. In another example, in December 2009 the governors of New York and 10 other states signed an MOU affirming each state’s commitment to developing a low carbon fuel standard framework. The programs described here also suggest policies that could be developed with existing entities, such as the Coalition of Northeastern Governors, the Northeast Association of State Transportation Officials, or the I-95 Corridor Coalition.

Regional initiative for Land Use and GHG Emissions

This program could encourage states to prioritize the provision of their own state funds to those municipalities that take specific actions to encourage low GHG land use. Municipalities that commit to certain land use planning actions (e.g. sustainable planning, zoning, transit-oriented development) could get priority for a range of state and federal funding. Funds (potentially from a GHG auction resulting from a regional initiative for transportation and GHG emissions, described below) would be reinvested in smart growth economic development projects in communities, and communities would be eligible for funding based on their commitments to climate change mitigation and adaptation actions. In the short term, states could work together to identify and publicize best practices; offer joint municipal training/information sessions; or share results.

Regional Initiative for Transportation and GHG Emissions

Under this policy, a price for carbon emissions from the transport sector would be established via an auction of credits. Entities that provide fossil fuel for transportation would be required to hold credits to cover their sales. Revenue from the auction would be reinvested in: (1) shared modes, including high speed rail and intra-city transit; (2) smart growth land use actions that would reduce VMT, e.g. transit oriented development; and (3) transportation system efficiency. Providers of transportation fuels could, instead of purchasing credits, invest in projects to offset their emissions. Instead of the cap-and-invest framework, states could implement other pricing strategies, including VMT fees, PAYD auto insurance, and an increased fuel tax, which each should be further studied.

Also in this policy, the Technical Work Group suggests a range of potential joint research and development (R&D) projects. Examples include developing a methodology for quantifying transit projects for offsets, piloting a pay-as-you-go insurance project, piloting emission-based tolls in interstate transportation corridors, and developing an electric-vehicle corridor through joint planning and investment in electric fueling infrastructure.

The freight sector offers another opportunity for collaboration on GHG reduction strategies from the transportation sector. A multi-regional approach to freight transportation creates the potential for far greater GHG emission reductions than a New York-only approach. Regional cooperation could include incentives to municipalities that commit to freight planning actions (e.g., intermodal rail yards, distribution centers, freight villages, and consolidation centers). A price for freight carbon emissions could also be established via credit auctions. Shippers, freight forwarders, and retailers would be required to hold credits to cover shipping, based on total freight VMT. Auction revenues would be reinvested in low-carbon freight system infrastructure and smart growth land use actions reducing freight VMT. States could pursue R&D projects, for example, to develop low and zero-emission short and long-haul freight rail systems or use advanced technology such as linear induction or emission-based truck tolls in interstate transportation corridors.

Regional High-Speed Rail for the Empire Corridors and the Northeast Corridor

New York should continue to engage and collaborate with Northeast states to undertake a major investment study on high speed rail in the Northeast Corridor and within New York State (Empire Corridor lines) and the nearby provinces of Canada. By far America's busiest rail corridor, the Northeast Corridor moves more than 259 million passengers annually. Amtrak's share of these riders in 2009 was 13 million. Preliminary estimates are that intercity passenger rail ridership along the Northeast Corridor is forecast to increase by 59 percent to a total of 412 million by 2030, with 23 million of these riders using Amtrak.[9]

Development of a high speed rail system that offers competitive trip times could shift travel demand from single-occupant vehicles and air travel to rail. Short-haul air travel would not be eliminated, as the need for connecting flights will likely persist but it could be dramatically

[9] The NEC Master Plan Working Group. Northeast Corridor Infrastructure Master Plan. May 2010.

reduced, freeing up congested airspace in the region. World class high speed rail in the Northeast could also create economic synergies between cities on the Eastern Seaboard. Linking cities that enjoy strong economies with cities trying to develop stronger economies will transform the economic geography and output of the Northeast. New York State should continue all efforts to develop high speed rail along the Empire Corridor. Dedicated high speed rail tracks would also reduce congestion on existing rail lines, leading to improved and more efficient freight movement.

The Northeast Mega-region is projected to grow from a population of 49.5 million in 2000 to 58 million by 2025 and 70 million by 2050.[10] The ability of the Northeast Mega-region to capture and sustain this population growth will depend largely on the quality of its transportation infrastructure. To continue its economic growth, the Northeast Mega-region will need to provide expanded capacity for intercity travel. Highways and airports cannot provide this capacity in a manner that meets the goals of the New York State Climate Action Plan. Dramatically increasing intercity rail capacity in the Northeast Mega-region, and reducing trip times in the process, could achieve increased mobility, economic growth, energy security, and GHG emissions reductions.

Preliminary data and analysis conducted by the Regional Plan Association suggests that a "California-style high speed rail" in the Northeast and Empire Corridors could shift 24 percent and 17 percent of passengers from air travel to rail, respectively.

New York State should continue to aggressively work with other Northeast States to undertake a major investment study of the impact of high speed rail on the Northeast and Empire Corridors. This study would forecast the economic development benefits of high speed rail on city pairs within the Northeast, changes in regional air space, GHG benefits, and mode shift toward rail.

A Federal Advocacy Program

Many actions to reduce emissions would best occur at the federal level. New York State advocacy for these changes will be most effective in concert with other states. New York State should advocate for a stronger federal program for LDV standards to significantly increase market penetration of zero-GHG vehicles (*see* TLU-1). As enumerated in the 2009 New York State Energy Plan, a new federal funding formula is needed within the next surface transportation funding bill to provide the correct incentives to states. There also needs to be significant federal investment in new low-GHG transportation modes, and an increase in federal funds for transit, rail and other modes that reduce GHG emissions. New York State should advocate for a diversification of the portfolio of revenue supporting the federal surface transportation program for a healthy transition to a low-carbon system. A federal advocacy partnership with other states could also address the need for streamlining the process to secure federal approval to expand transit systems, and linking the award of federal funds for major transportation system expansion to land use plans that support GHG emissions reduction.

Quantitative Analysis

Quantitative analysis of this suite of policy options was not undertaken.

[10] Ibid, page 8.

Special Considerations

- These are policies believed to be best designed and implemented on a multi-state basis. In some cases, the interconnected nature of the regional system (e.g., highways, trucking, and fuel markets) is the main impetus for a regional approach. For other policies, implementation on a regional basis could minimize any competitive disadvantages for New York. A regional approach may be necessary to reduce leakage. Also, a policy may need more research and analysis of likely outcomes, and this research would be most informative if it occurs for several states.
- Successful implementation of the policies described here would bring a range of co-benefits including reduction of other pollutant emissions, the provision of additional transportation choices, the reduction of traffic congestion, and more sustainable land use patterns.
- The policy options presented here are linked to many of the other options presented, especially TLU-7 (transit), TLU-8 (freight), and TLU-4 (fueling infrastructure).

Chapter 8
Power Supply and Delivery Mitigation

Sector Vision for a Low-Carbon Future

New York will have a safe, reliable, diverse, and extremely low-emitting electric power system that meets the needs of all its citizens and accommodates the widespread conversion of buildings and transportation from fossil fuel to electricity. The state will meet its energy needs in a manner that maximizes societal benefits, minimizes societal costs and avoids imposing an undue burden on any community.

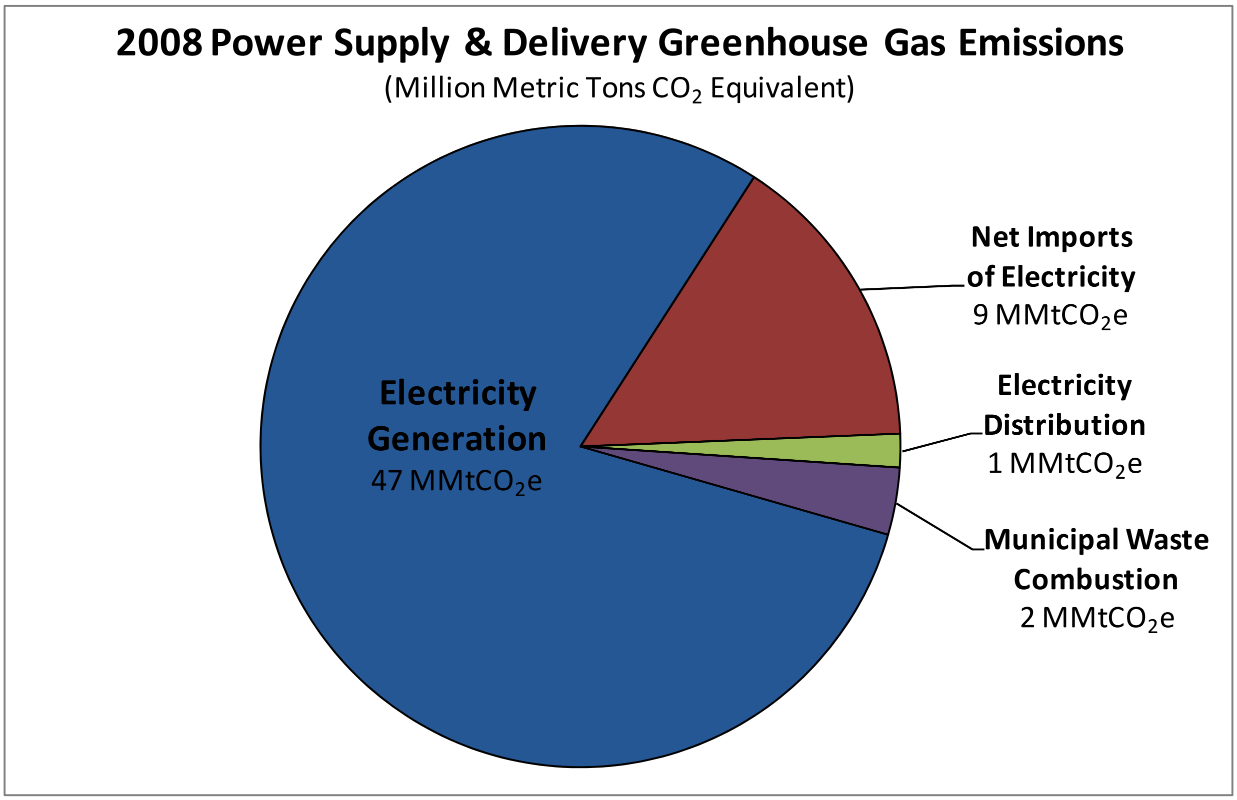
More specifically, New York's electric power system will have the following characteristics:

- **Electric generation mix:** New York's electricity will be generated by an optimal mix of renewable generation—both central station and distributed—complemented by safe nuclear power and fossil fuel-fired power plants that safely and permanently capture and sequester carbon dioxide (CO_2). Fossil-fired units existing today will have been retired, replaced with renewables or nuclear power, or repowered using carbon capture and sequestration (CCS) technologies.
- **Power transmission and distribution:** Transmission and distribution facilities will have been upgraded to reduce line losses and expanded to move electricity from new clean generation sources to the areas where demand exists.
- **Energy storage:** Centrally located energy storage systems (such as pumped storage, compressed air and flywheel), as well as batteries and other distributed storage technologies, will make it possible for variable renewable energy resources to meet system needs around the clock and will promote system reliability by helping to meet load-following, reserve capacity and frequency response needs.
- **Demand management:** Renewable distributed generation, energy storage, and smart grid technologies will enable New York's utilities to reduce or manage demand for grid-based electricity. In particular, smart grid technology allows sophisticated management of energy demand: it enables consumers to function as energy storage facilities and generators, helps minimize the disparity between base load and peak demand on the grid, and facilitates use of renewable resources whose energy output varies with weather conditions or by season.
- **Adapting to climate change:** The electric power system will be reliable in part because utilities have anticipated and counteracted the impacts of climate change on electric generation, transmission, and consumption. (Examples of such impacts are higher peak electricity loads and accelerated degradation of critical system components from warmer temperatures, or changes in availability and predictability of renewable energy resources due to changes in hydrology, wind patterns and solar incidence.)

Overview of GHG Emissions

The Power Supply and Delivery (PSD) sector includes greenhouse gas (GHG) emissions from the combustion of fossil fuels for the generation of electricity, the transmission and distribution of electricity, and the combustion of municipal waste at waste-to-energy facilities in New York. This includes both imported and New York-based generation. Electricity generation accounts for the vast majority of these emissions, representing 95 percent of New York's total PSD sector emissions in 2008. Total GHG emissions from the PSD sector are expected to represent 23 percent of New York's total consumption-based emissions in 2008 (Figure 8-1).

Figure 8-1. New York State Power Supply and Delivery Emissions, 2008



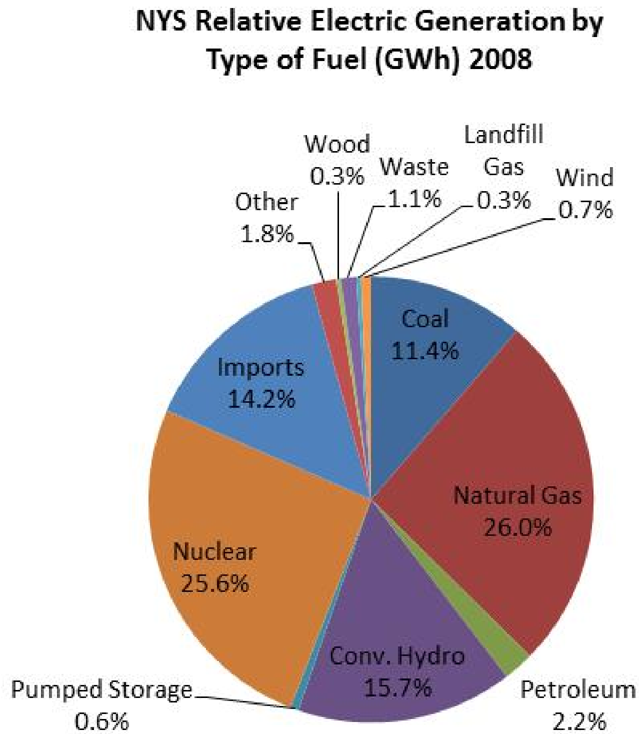
$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Note: 'Electricity Distribution' refers to emissions of sulfur hexafluoride.

Electricity Generation Fuel Mix

Electricity is generated using a variety of fuels in New York. The relative generation by fuel source in 2008 is shown in Figure 8-2. This mix of generation types has changed over time. In 1990, petroleum and coal represented 42 percent of the total generation by gigawatt-hours (GWh). By 2008, this had dropped to 14 percent, with natural gas (up 10 percent), hydro (up 4 percent), nuclear (up 9 percent) and imports (up 11 percent) making up most of the difference.

Figure 8-2. New York State Electric Generation by Type of Fuel, 2008[1]

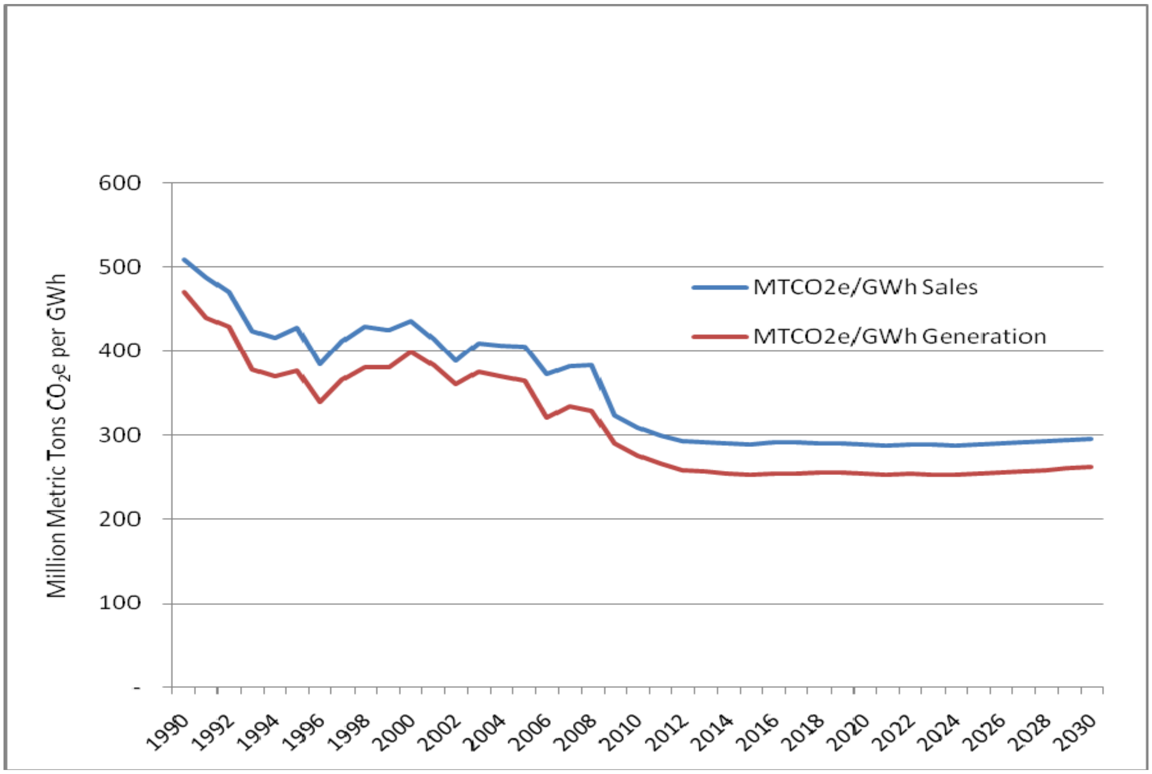


GWh = gigawatt-hour; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

This shifting of the fuel mix away from high-GHG fossil fuels to low-GHG fuels has resulted in an overall decline in emissions from this sector, even though total generation has increased. It is illustrated in Figure 8-3, showing the carbon intensity of electricity generated and sold (including imports) between 1990 and 2008, and expected using the reference case forecast through 2030. Over the 18-year period between 1990 and 2008 generation increased 17.5 percent, while GHG emissions associated with generation, including imports, declined by 16.2 percent.

[1] In New York State, the accounting convention for pumped storage works as follows: Generation required for pumping is included in the net energy for load total. More specifically, the electricity required for pumping water to a higher elevation is not deducted from the net energy for load value for hydroelectric plants, while the generation produced by pumped storage is reported separately as a positive value. In terms of tracking total amount of generation for load, the approach is fully equivalent to the approach where net generation for pumped storage is negative.

Figure 8-3. Historical and Forecasted Carbon Intensity for New York State Power Supply and Delivery, 1990–2030



GWh = gigawatt-hour; CO2e = carbon dioxide equivalent.

Roles of Imports and Emissions Accounting

New York has historically been a net importer of electricity. Electricity imports have been relatively small compared to total consumption but have increased from about 4,519 GWh in 1990 to about 23,900 GWh in 2008. Absent the implementation of new policies, imports are expected to increase to about 11 percent of total consumption in 2022 and remain at that level through 2030. In 2008, the emissions per GWh for imports were about 12 percent higher than the emissions per GWh for in-state generation.

There are two generally accepted methods to account for emissions associated with electricity generation from imports and exports. The consumption method includes emissions associated with all electricity consumed within the state regardless of where it is generated. The production method includes all emissions from electricity generated within the state regardless of where it is consumed. The development of the inventory and forecast of historical and forecasted GHG emissions in New York includes both methods but the consumption accounting method is used for the purpose of attributing both emissions and emissions reductions to New Yorkers.

Another accounting question has to do with direct emissions versus full fuel cycle emissions. In the case of electricity generation, direct emissions are those associated with the end use or combustion of the fuel. Full fuel cycle emissions include the direct emissions but also include the emissions associated with the extraction, processing, and transportation of the fuel. Both methods have been used in this study and analysis in the Appendices compares the two results.

Recent Actions to Promote Energy Independence

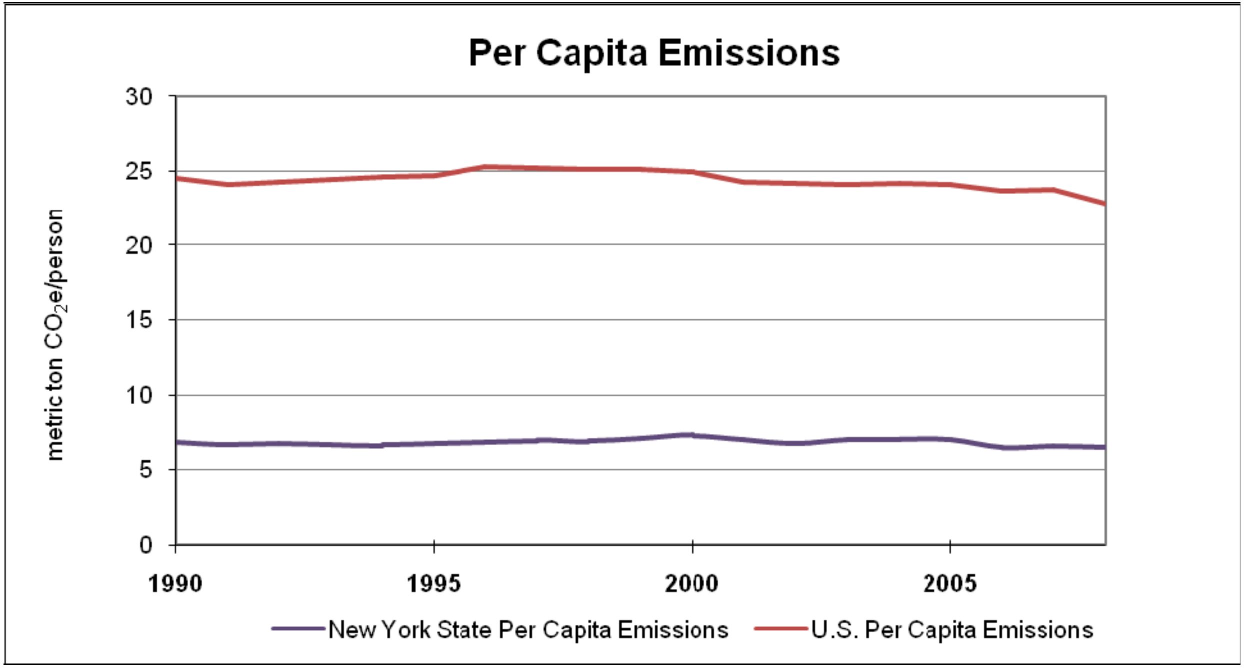
New York's innovation and leadership in the field of clean energy production and use goes back decades and includes the renewable portfolio standard, programs funded by the systems benefit charge, the net metering law, decoupled tariffs, a host of energy efficiency programs, and the creation of the New York State Energy Research and Development Authority, which remains a model for other states. The precedent-setting Regional Greenhouse Gas Initiative (RGGI), the only GHG cap-and-trade program currently operating in North America, was the result of a New York State initiative.

In his State of the State Address on January 7, 2009, Governor David A. Paterson announced his proposal for a "45 by 15" plan to reduce electricity consumption by 15 percent and provide 30 percent of the remaining electricity demand through renewable energy resources by 2015. This standard requires 30 percent of the state's electricity to be supplied from renewable energy sources by 2015 and provides financial incentives to support development of renewable energy sources. The renewable portfolio standard has supported 34 large-scale renewable projects (mostly wind) and approximately 330 customer-sited projects. New York is one of 27 states to use a renewable portfolio standard to drive a transition to renewable sources of electricity.

The state program to reduce energy consumption has a goal of reducing power demand 15 percent from forecasted levels by 2015 through energy efficiency. It includes eliminating a key conservation disincentive by decoupling utility profits from the amount of energy being consumed (this step is already underway), strengthening efficiency standards for appliances and buildings, and addressing New York's largest energy consumer—State government. When fully funded, this program is expected to provide more than $4 billion in benefits to customers, along with thousands of jobs to support energy efficiency programs, such as retrofitting outdated and inefficient residential, commercial, and industrial properties and installing new energy-efficient equipment.

As described in detail in Chapter 3, Inventory and Forecast, New York's long-standing leadership has contributed to New Yorkers having a dramatically lower carbon "footprint" than the average American. Figure 8-4 shows a comparison between the historical U.S. and New York GHG emissions per capita.

Figure 8-4. U.S. and New York Emissions per Capita



GHG = greenhouse gas; tCO_2e = metric tons of carbon dioxide equivalent.

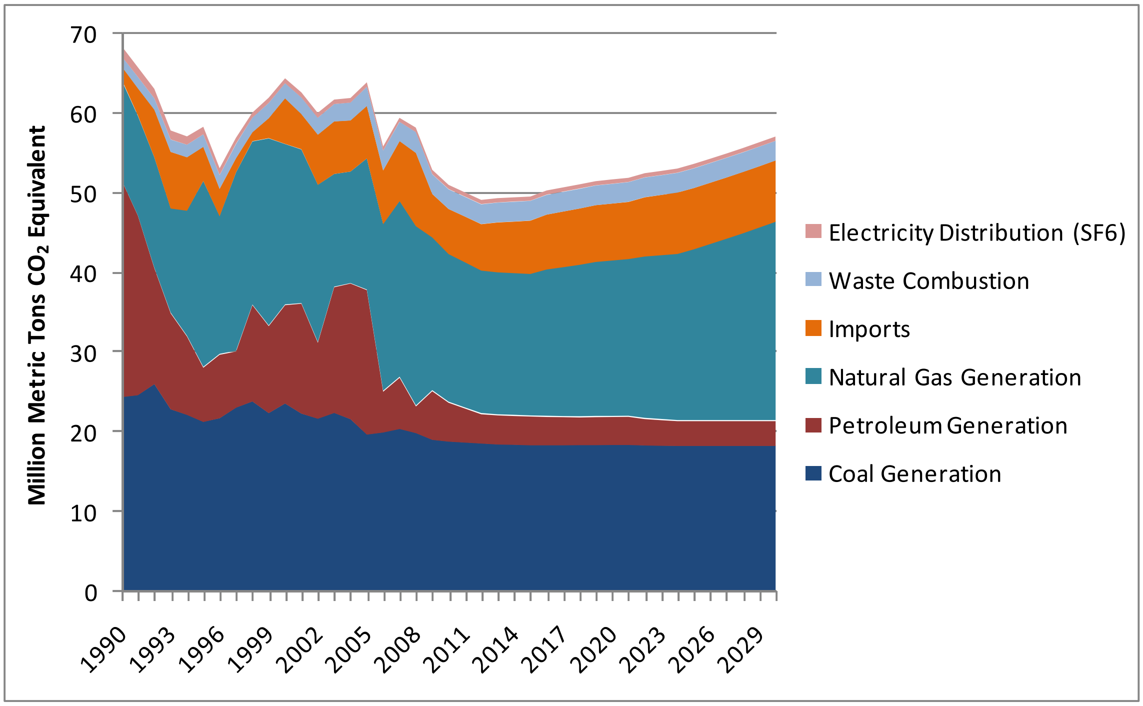
This progress is reflected in the reference case forecast of future emissions, which assumes past efforts will remain in place but no further actions are taken to reduce emissions. The reference case does not, however, assume that New York will achieve the full 15 percent reduction in electricity use established in the 45 by 15 goal. To be conservative, the reference case adopts the Reliability Needs Assessment 2008 forecast of a 27 percent achievement toward the 15 by 15 demand reduction portion of the goal. The policy scenarios developed by the technical work group assumed that new policies would build from the full 45 by 15 goal, so that proposed new policies initiatives do not take credit for the impacts of recent actions.

Power Supply and Delivery Emission Trends

In the absence of any additional mitigation efforts in the future, GHG emissions from New York's PSD sector are expected to decline and then return to roughly 2008 levels of 58 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) by 2030.

Figure 8-5 shows the historical and forecasted emissions from power supply and delivery in New York from 1990 through 2030. Note that since this is direct emissions, nuclear, hydro, and renewables are not included. The figure shows that although there has been a decline in electric sector emissions since 1990, assuming no new GHG reduction measures are enacted in the future it is expected that beginning around 2012 total emissions will rise, largely through the increased use of natural gas.

Figure 8-5. New York, State Historical and Forecasted Electricity Supply Sector Emissions by Source Type, 1990–2030 (2009–2030 forecasted)

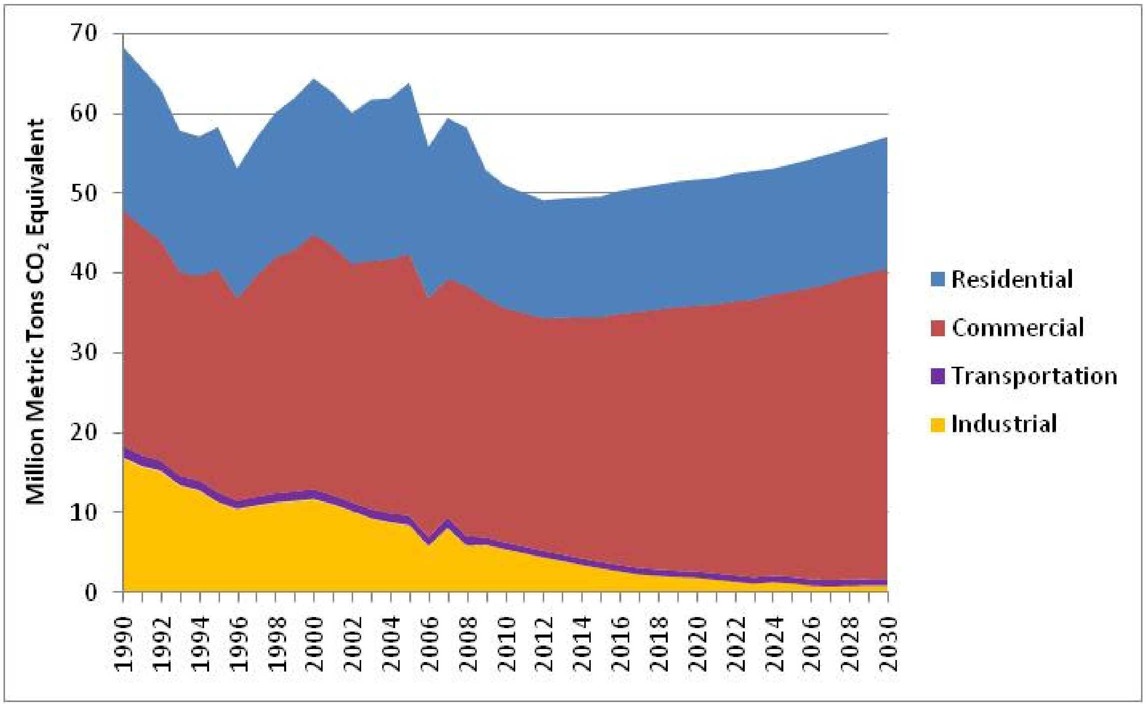


$MMtCO_2e$ = million metric tons of carbon dioxide equivalent. SF_6 = sulfur hexafluoride.

Relative to total forecasted emissions from all sectors, emissions from the PSD sector are expected to remain about the same, going from 23 percent of total emissions in 2008 to 21 percent of total emissions forecasted in 2030.

Also of interest is the demand for electricity. Figure 8-6 translates Figure 8-5 into the demand sectors in New York. All sectors in New York are assumed to generate emissions based upon the GWh each consumes, so this graph assumes that the mix of sources of generation are identical for each demand sector.

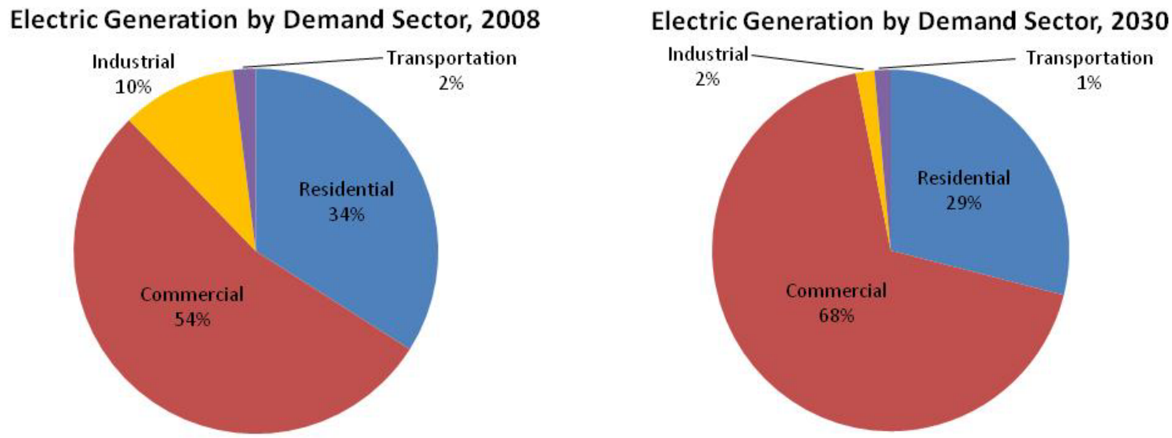
Figure 8-6. New York, State Historical and Forecasted Power Supply and Delivery Sector Emissions by Demand Sector, 1990–2030 (2009–2030 forecasted)



MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

The forecasts indicate that industrial sector emissions in the reference case are expected to continue a slow decline while commercial sector emissions are expected to grow by 24 percent between 2008 and 2030. Over the same period residential electricity consumption-related emissions are expected to decline 17 percent. Demand sector contributions to total electricity demand emissions would therefore shift between sectors as indicated in Figure 8-7.

Figure 8-7. Electricity Generation Emissions Demand by Sector, 2008 and 2030



Overview of Policy Options and Estimated Impacts

Building a near-zero carbon electricity sector is the foundation of New York's transition to a low-carbon economy. New York already obtains more than 50 percent of its electricity from essentially carbon-free sources, including nuclear and hydroelectric and other renewable power. But for New York to achieve its goal of reducing GHG emissions 80 percent by 2050, close to 100 percent of New York's electricity will need to come from low-carbon sources—sources with near zero-carbon emissions—by 2050. Furthermore, as the use of carbon-intensive fossil fuels in the transportation and buildings sectors is phased out or reduced substantially, New York will need an adequate supply of low-carbon electricity to power those sectors. Therefore, over the next 40 years, New York will need to replace most of the existing fossil fuel-fired sources of electricity—coal, gas and oil-fired power plants—with low-carbon sources of power, including renewable, nuclear and possibly fossil fuel-fired plants equipped with CCS.

Fortunately, New York has a number of policies in place that begin this needed transformation. The Public Service Commission (PSC) recently approved expanding the State's renewable portfolio standard (RPS) to 30 percent by 2015. If coupled with the 30 percent of power currently provided by nuclear power plants, New York would have an electricity grid that is powered 60 percent by renewable or other low-carbon sources of electricity by 2015. New York is also a member of RGGI, a regional program to cap and reduce power plant emissions 10 percent below historic levels by 2018. While these existing programs provide a good start on building the low-carbon power sector, they are insufficient by themselves.

Therefore, a number of policy options should be considered to achieve this transition to a low-carbon electricity sector while maintaining the reliability of the electricity supply. In general, these policies fit into three categories: (1) policies that promote renewable energy and other low carbon energy sources, (2) policies to reduce carbon emissions from new and existing fossil fuel-fired power facilities, and (3) complementary policies that maintain the viability of an electric grid that relies increasingly on renewable sources of energy and supports electrification of the transportation system. These options will be evaluated further through integrated analysis.

Three policies will be responsible for most of the emission reductions from the electricity sector:

- The primary policy for achieving emission reductions in the relatively short term is the extension and expansion of the State's existing RPS. One option would be to substantially expand (more than double) the amount of electricity that is provided by new renewable energy by 2030, including deploying off-shore wind energy and solar energy. In addition to an expanded RPS, this policy would include complementary measures providing the early support needed to bring low-carbon renewable sources on line. (PSD-2)
- Another policy to consider is the implementation of a low-carbon portfolio standard (LCPS) that will build on the RPS, requiring regulated utilities and other load-serving entities to procure an increasing amount of low-carbon energy—renewables, appropriately sited nuclear, and fossil energy with CCS. This policy will initially supplement the RPS, requiring load-serving entities (LSEs) to provide an increment of low-carbon power beyond the renewable power attributable to the RPS. Eventually, after 2030, when CCS and new nuclear power may be more commercially viable, the LCPS can potentially supplant the RPS. (PSD-6a)
- National and regional action is needed to fully address climate change. Therefore, the State should work with its regional partners to build upon and strengthen the RGGI program. These joint efforts may result in expanding RGGI into a multi-sector cap-and-invest program that caps and reduces carbon emissions region wide, sets a price on carbon emissions, and invests proceeds from allowance auctions in building the clean energy economy in New York. Ultimately, New York would benefit by a national cap on GHG emissions but, until Congress acts, a stronger RGGI can serve as the model or foundation for a strong national carbon reduction program in addition to helping to achieve New York's climate goals. (PSD-6b)

It is worth noting that there is considerable interaction and policy overlap among the policy options identified. State policymakers would need to design and implement the policies that are selected in an efficient manner that takes account of the potential interactions between the policies.

In addition to the policies described above, other policies intended to reduce emissions from all new and existing power plants are proposed for further consideration. PSD-1 and PSD-10 work in unison to facilitate the siting of new lower-carbon power-generating facilities in New York. PSD-1 would require the enactment of a new, fuel neutral siting process for new plants, while PSD-10 includes a provision that all new plants sited in New York meet a GHG emission standard that is based on the emissions level of modern, efficient natural gas-fired plants. Together, these two policies would provide for siting new generating facilities in New York in a manner that is consistent with achieving the State's GHG reduction goals. Regarding existing plants, PSD-8 seeks to reduce emissions by requiring all existing plants to meet comparable emission standards after 2030 and providing incentives to encourage the repowering or replacement of such plants with more efficient, lower-emitting technology earlier than 2030.

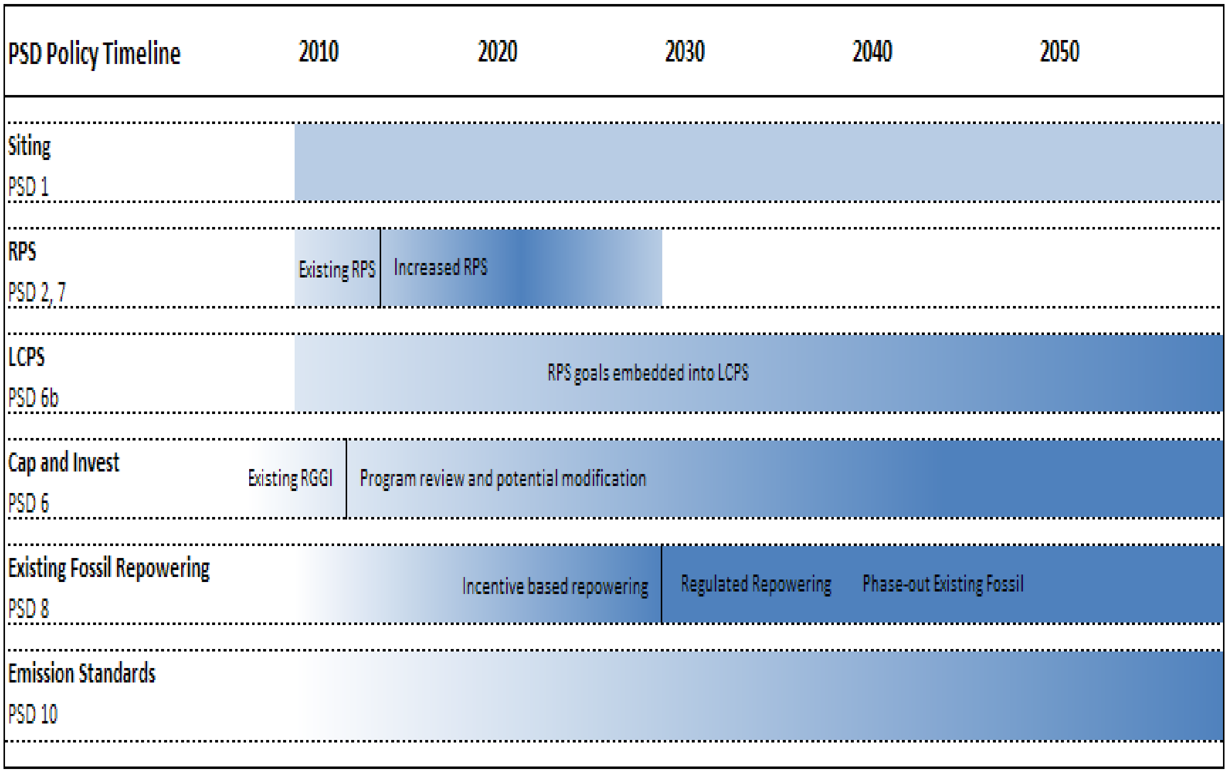
Collectively, these policies would ensure that all fossil-fired plants—existing now or built in the future—would have relatively low emissions by 2030.

Other policies are necessary to ensure that an electricity grid that relies increasingly on renewable and other low-carbon power sources continues to provide electricity in a reliable manner. PSD-4 recommends upgrades to the electricity distribution system to enable more reliance on distributed renewable energy sources and increased use of electric vehicles; a key recommendation of this policy is the continued development and deployment of smart grid technologies. PSD-5 recommends modernization of the electricity transmission network to enable the efficient transmission of renewable and other low-carbon energy from the point of generation to where the demand for electricity exists. PSD-3 recognizes the importance of energy storage in maintaining the reliability of an electricity grid that relies increasingly on variable, renewable sources of electricity.

Finally, PSD-9 recommends that continued investment in research, development, demonstration and deployment is needed to achieve the transition to a low-carbon power sector. Although many of the technologies needed to achieve the transition to a low-carbon electricity sector have been identified, continued research and development—at the federal, tate and commercial levels—will lead to technological advances that will enhance New York's ability to meet the challenge of building a clean energy economy in a cost-effective manner.

These policy options will help to achieve the transformation of New York's electricity sector in a manner that is consistent with the vision of a low carbon New York, in which electricity will be supplied by low carbon renewables, appropriately-sited nuclear power, and fossil-fired plants with CCS. In the near term, the deployment of renewables will be facilitated by the RPS and other renewables policies described in PSD-2, as well as the LCPS and cap-and-invest policies. In the longer run, as existing baseload fossil-fired plants are retired, new nuclear plants are expected to play an important role in New York's electricity sector, in addition to fossil-fired plants equipped with CCS. Figure 8-8 presents the proposed sequencing of policies in time, showing that a number of policies could be implemented immediately and that some could be phased-out based on successful implementation of new policy mechanisms.

Figure 8-8. Power Supply and Delivery Policy Options Timeline

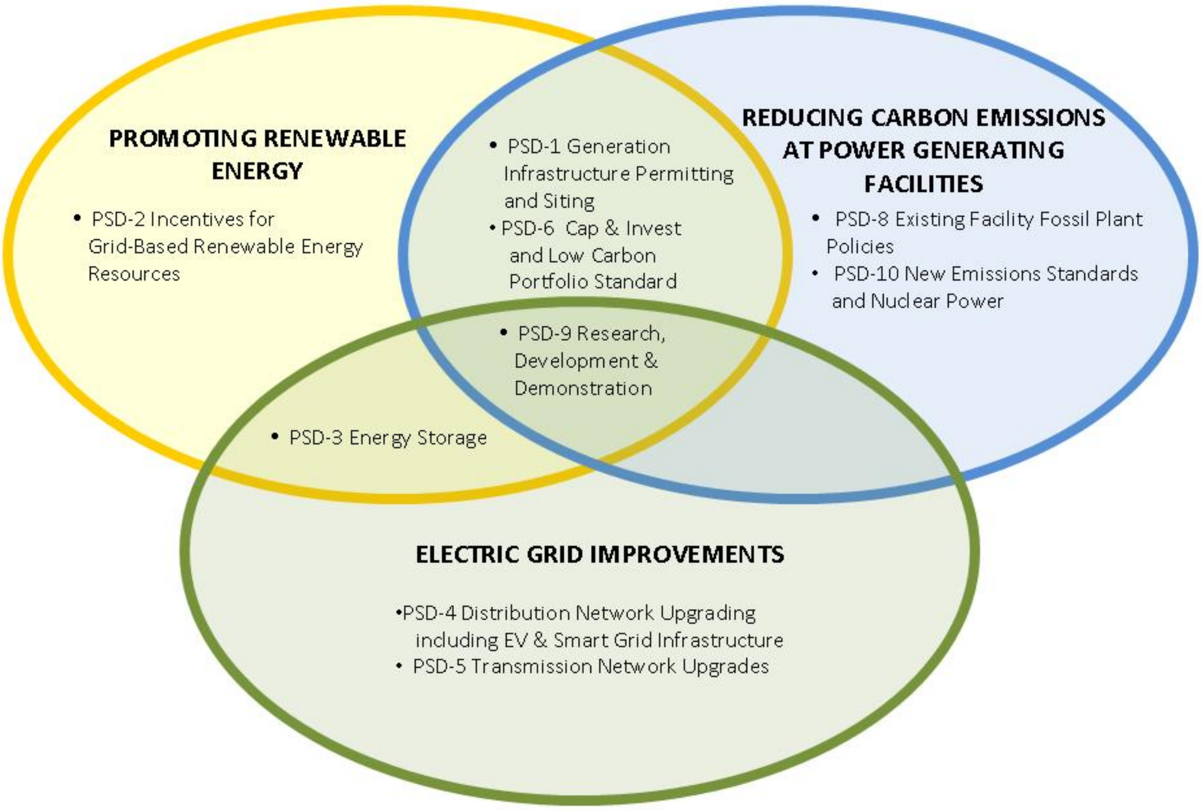


LCPS = low-carbon portfolio standard; PSD = power supply and delivery; RPS = renewable portfolio standard.

Although New York will rely on the federal government to provide most of the substantial financial support and loan guaranties that new nuclear plants currently require, it should be prepared to facilitate the siting of nuclear plants that receive such financial support. Likewise, when substantial federal investment in CCS research and development yields commercial-scale CCS projects, New York should be prepared to site such projects in New York. A number of policies support these goals, including the siting processes of PSD-1 and the emission standards of PSD-10. Most importantly, the LCPS will create a fertile market for nuclear power and CCS (as well as renewables) and will lead utilities and other LSEs to enter into long term contracts for low carbon power.

In further developing, designing, and implementing the policies that are selected, the State will need to continue to preserve the reliability of the electricity system and strive to minimize costs while maximizing benefits. In the context of planning for a New York energy future with greatly constrained emissions of GHGs, it is important that the State review carefully the current design of the structure of the electricity markets (energy, capacity, and ancillary service markets) to see if there are ways to improve their overall efficiency and effectiveness. In addition, the State should continue to assess the reliability of the electricity system as it designs and implements the policies selected, many of which will constitute transformative changes in the way in which electricity is generated and used. To support that process, the State should urge the New York Independent System Operator to include 20-year sensitivity analyses in its Comprehensive Reliability Planning Process/Reliability Needs Assessment that incorporate supply strategies recommended herein as well as load-altering policies in the transportation and land use (TLU) and residential, commercial/institutional, and industrial (RCI) sectors.

Figure 8.9 Power Supply and Delivery Policy Options



Policy Scenario Quantification Summary Table

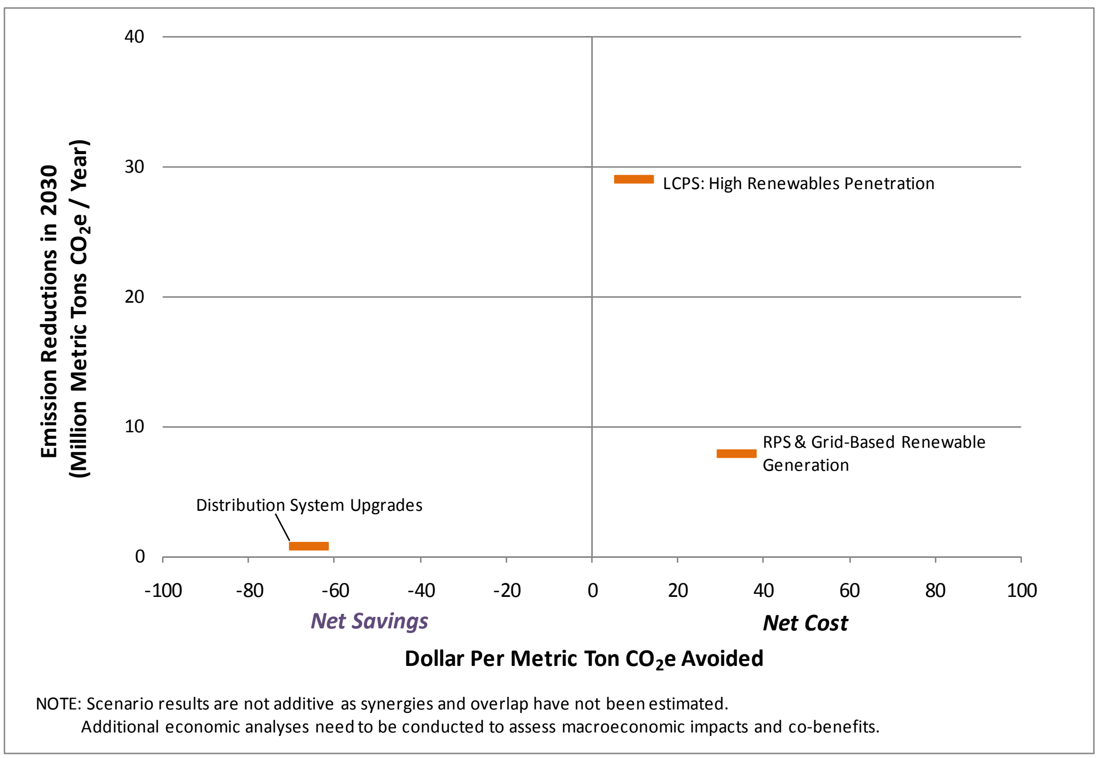
Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value: Cost/Savings (Million 2005$)	Net Cost/Savings per Avoided Emissions (2005$/$tCO_2e$)
		2020	2030	Total 2011–2030		
PSD-2	Renewable Portfolio Standard (RPS) and Incentives for Grid-Based Renewable Generation	2.8	7.9	65	$2,200	$34
PSD-4	Distribution System Upgrades	0.3	0.8	6.3	-$420	-$66
PSD-6	Low-Carbon Portfolio Standard (LCPS): High Penetration of Renewables	7.3	29	220	$2,100	$10

$/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; EV = electric vehicle; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; N/A = not applicable.

Negative values represent savings.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations. The policy numbers that appear in this table are not consecutive because they reflect only those policies for which quantification has been completed, and not all policies are amenable to quantification.

Figure 8-10. Estimates of Cost and GHG Emissions Reductions for PSD Policy Options.



INCENTIVES for GRID-BASED RENEWABLE GENERATION (PSD-2)

Policy Summary

This policy promotes the development of low-carbon renewable energy resources in New York over the period from 2015–2030 by increasing incentives and removing existing barriers for grid-connected renewable energy resources. This policy is intended particularly to increase investment in and development of in-state renewable energy resources such as wind (both onshore and offshore), solar photovoltaic (PV), low-carbon sustainable biomass/biofuels, and others.

This policy option would increase the amount of new renewable power from approximately 10 million MWh in 2015 (when the current RPS of 30 percent by 2015 is fully implemented) to 23–24 million MWh by 2030. Assuming that the energy efficiency policies developed by the RCI Technical Work Group keep electricity demand from growing in New York, this policy could increase the renewable portion of New York's electricity supply to approximately 40 percent by 2030. Specified targets would be identified for both offshore wind and grid-based solar power. The State could achieve these goals through a variety of policy mechanisms, starting with the continuation and expansion of an RPS program using funds raised through charges on utility bills. Achieving the goals outlined above, including the diversity in renewable resources, may benefit from supplementing existing funding mechanisms with other incentives, such as power purchase agreements, whereby the New York Power Authority and Long Island Power Authority purchase power or renewable attributes from renewable energy providers, and renewable energy payments (also known as feed-in tariffs) for specific categories of smaller renewable energy projects. These incentives can be designed to assist in the implementation of developing and emerging technologies. The State should continue to monitor changes in the price differential between grid-based solar power, offshore wind, and other renewable sources so that incentives can be adjusted in accordance with their economic and technical viability.

Additionally, in order to further encourage these clean energy resources, New York State should examine any remaining barriers that prevent market-based development of utility-scale renewable energy generation projects. Possible policy approaches include: (1) specific standards and fees for interconnecting renewable energy resources into the grid, (2) establishment of renewable energy development zones that allow for concentration of transmission grid upgrades to efficiently deliver renewable power to end-user consumers, and (3) specific regional siting policies for technologies such as offshore wind. Coordinated studies could identify additional barriers to development and design strategies to alleviate them.

Quantification

The Technical Work Group explored two scenarios[2] with different renewable penetration levels (13,000 GWh and 14,000 GWh), above and beyond the approximately 10,000 GWh goal

[2] Additional scenarios were studied. These results are in the summary table on page 8-14.

established under the current 30 percent RPS program to be achieved by 2015. To promote diversity, the 13,000–14,000 GWh of new grid-based renewable resources could be required to include at least 3,000 GWh of offshore wind projects and at least 1,000–2,000 GWh of grid-based solar power.

The order of magnitude impacts of the Net Present Value and Cost-Effectiveness metrics for both scenarios were essentially the same. Therefore, the higher renewable penetration scenario is included here, which assumes the addition of the following renewable generation by 2030: 2,000 GWh of biomass co-firing, 2,000 GWh of solar PV, 7,000 GWh of onshore wind, and 3,000 GWh of offshore wind. The other scenario may be found in the full Technical Work Group policy option document.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by net cost per avoided emissions – 2005\$/tCO_2e) for the policy scenario quantified by the Technical Work Group are presented below.

GHG Reductions (MMtCO_2e)		Net Present Value Cost (Million 2005$)	Net Cost per Avoided Emissions (2005\$/tCO_2e)
2030	Total 2011–2030		
7.9	65	$2,200	$34

\$/tCO_2e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Special Considerations

- In the next two decades, this renewables incentive policy will be the primary mechanism to facilitate the development of the renewable resources needed to move New York to a lower carbon power sector. Over time, this policy could be phased out in favor of programs such as the low-carbon portfolio standard and an expanded regional cap-and-invest program.
- The implementation of some GHG reduction programs at the federal level (e.g., RPS, cap-and-invest) may require that New York modify its RPS implementation and administration strategies.
- The Federal Energy Regulatory Commission (FERC) has exclusive jurisdiction under the Federal Power Act to regulate rates and conditions of sales for resale of electric energy in interstate commerce. The States are pre-empted from setting wholesale power rates that exceed utility avoided costs. New York's utility-based incentive programs for supply from renewable sources will need to be developed in compliance with this federal requirement. (Source: FERC, Order on Petitions for Declaratory Order, issued July 15, 2010).
- A substantial amount of pre-development work (e.g., engineering studies and surveys) is necessary to foster market introduction of a broad range of promising renewable energy technologies in New York, including advanced biomass, tidal, and off-shore wind technologies. Meeting electric demand in a manner that satisfies climate protection goals will also require continued advances in the performance of current and emerging renewable

generation technologies. PSD-9 (Research and Development) includes policy initiatives focused on ways in which New York can help address these needs.

- Consistent with other PSD policies, a thorough assessment should be conducted to evaluate the energy storage, transmission, and distribution requirements that will support the expanded use of renewable power generation technologies in a reliable manner.
- The investment of funds in support of this goal is likely to create large numbers of jobs installing and maintaining renewable energy systems. Early investment in emerging technologies will contribute to lowering the price of such technologies so that they can be more competitive in the future.
- Additional analyses will be conducted in the next phase of the Climate Action Plan process to separately quantify the potential benefits and costs of utilization of biomass for application in the PSD sector.

GHG REDUCTION MARKET MECHANISMS: CAP-AND-INVEST AND LOW-CARBON PORTFOLIO STANDARD (PSD-6)

Policy Summary

This policy option identifies two market-based policy mechanisms that could provide strong economic incentives for private sector investment in low-carbon emitting sources of energy and other low-carbon technologies: (1) a low-carbon portfolio standard, which would require all providers of electricity to obtain a portion of the electricity they sell from low-carbon energy sources; and (2) a cap-and-invest program, which would be implemented on a regional basis and could include the power sector and other sectors within its coverage.

Low-Carbon Portfolio Standard (PSD-6a)

Under this policy, utilities and other LSEs would be required to provide a specified portion of their electricity sold from low-carbon sources (renewable, nuclear, fossil with carbon capture and sequestration). Currently, approximately 50 percent of the electricity generated in New York would qualify as low-carbon. That portion would have to grow to close to 100 percent by 2050. The policy would likely be implemented through low-carbon electricity credits that would be sold to LSEs by developers of low-carbon electricity. Imports could be treated the same as power generated within New York. Implementation of this policy would provide strong market signals for the development of renewable energy and other low-carbon sources of electricity.

Cap-and–Invest (PSD-6b)

New York should support the establishment of a strong federal cap-and-trade program that places a national price on carbon emissions. In the absence of a federal policy, New York should build on the successful RGGI effort and work with its regional partners in RGGI to construct a cap-and-trade, or cap-and-invest, program that would cover large stationary emission sources in addition to the electricity-generating sources included in RGGI. The program would be designed to reduce emissions from the covered sectors by approximately 2.2 percent per year so that the 2050 cap is 80 percent below today's levels. It would also provide a source of revenues for clean energy investments that contribute to economic development and job growth in New York by providing that all proceeds from the auction of allowances are reinvested in complementary programs to deploy energy efficiency, renewable energy and other low-carbon technologies or policies. Steps would have to be taken to address leakage/imports of electricity from sources in uncapped jurisdictions.

At this time, RGGI covers only the power sector but this policy recommends that consideration be given to including industrial sources in the program as well as fuels used in the transportation and building sectors. The program would be designed to mitigate impacts on energy-intensive industries that are subject to interstate or international competition.[3] As an alternative to including the emissions associated with transportation and building fuels in the cap, a carbon fee could be applied to the use of those fuels at a per ton carbon level that is comparable to, or based on, the clearing price for allowances used in the cap-and-invest program. Placing a carbon price on building and transportation fuels would provide an incentive for energy efficiency and low-carbon renewable sources of energy and a source of revenues to fund some of the policy initiatives discussed in the RCI and TLU sections of this report. In addition, if the scope of the cap-and-invest program is expanded beyond RGGI, offsets should be expanded beyond those available under the current RGGI program if the offsets meet the fundamental requirements of RGGI and other credible emission reduction programs (the offsets must be real, additional, verifiable, enforceable, and permanent).

Quantification

Cap and Invest

The cap-and-invest policy will be quantified after integrated cost curves are completed in the next stage of the planning process.

Low-Carbon Portfolio Standard

The Technical Work Group explored several scenarios for achieving a possible LCPS goal where 75% of the electricity generated in New York would come from low-carbon sources in 2030. Three scenarios that bound the analysis are described below. The other scenarios may be found in the full Technical Work Group policy options document.[4]

The first scenario focused on achieving the goal with a high penetration of new renewable generation. It assumed the addition of 9,000 GWh of lower-carbon sustainable wood and other biomass, 10,000 GWh of solar PV, 16,287 GWh of onshore wind, and 9,198 GWh of offshore wind generation by 2030. The GHG reduction potential, total cost, or savings (as measured by

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[3] The recommendation to include industry sources in the cap-and-invest program would not conflict with the RCI Technical Work Group's recommendation of voluntary efforts only if measures are included in the cap-and-invest program to protect energy-intensive industries, such as free allocation of allowances.

[4] Additional scenarios were studied. These results are in the summary table on page 8-14.

net present value), and cost-effectiveness (as measured by 2005$/t$CO_2$e) for the first policy scenario quantified by the Technical Work Group are presented below.

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost (Million 2005$)	Net Cost per Avoided Emissions (2005$/t$CO_2$e)
2030	Total 2011–2030		
29	220	$2,100	$10

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

A variation of this scenario, which supplements renewables with energy efficiency as a low-carbon supply-side resource, results in similar reductions at a lower cost per ton avoided of $4.

The second scenario assumed that the 2030 goal would be met with a mix of renewable generation and new coal with CCS. It assumed the addition of 7,274 GWh of coal integrated gasification combined-cycle technology with CCS, 9,000 GWh of wood and other biomass, 3,333 GWh of solar PV, 16,287 GWh of onshore wind, and 8,590 GWh of offshore wind generation by 2030. The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e) for the third policy scenario quantified by the Technical Work Group are presented below.

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost (Million 2005$)	Net Cost per Avoided Emissions (2005$/t$CO_2$e)
2030	Total 2011–2030		
28	200	$2,200	$11

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

A third scenario assumed that the 2030 goal would be met with renewable generation and a greater use of new nuclear energy. It assumed the addition of 30,748 GWh of nuclear (i.e., generation associated with 3 units of 1,300 MW each), 3,442 GWh of wood and other biomass, 3,333 GWh of solar PV, 5,429 GWh of onshore wind, and 1,533 GWh of offshore wind generation by 2030. The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by 2005$/t$CO_2$e) for this policy scenario are presented below.

GHG Reductions ($MMtCO_2e$)		Net Present Value Cost (Million 2005$)	Net Cost per Avoided Emissions (2005$/t$CO_2$e)
2030	Total 2011–2030		
27	120	$3,000	$24

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Special Considerations

- The LCPS would build upon and could eventually supplant the RPS by 2030. The LCPS would require LSEs to procure only the additional low-carbon power that is needed to achieve the specified targets after consideration of existing renewable and other low-carbon (nuclear) resources as well as renewables being developed by the RPS. After 2030, State support in the form of the Main Tier RPS for central power could be discontinued, allowing additional low-carbon power procurements by LSEs under the LCPS to drive the continued development of the low-carbon electricity sector in New York.
- The proposal for the State's LSEs to provide a percentage of electricity to consumers from low-carbon sources of generation will require further analyses, including impacts on the State's deregulated wholesale generation market and dispatch, potential increases in retail electric prices for consumers, forecasts of available low-carbon electric supply sources (including imports), and costs and requirements to maintain the reliability of the state's electric transmission and distribution system.
- Design of the cap-and-invest program will need to address leakage of emissions. Among the mechanisms to be used would be implementation of complementary measures to reduce electricity demand and deploy renewable energy (including the RPS and LCPS), allocating a portion of the allowances for free to sources in energy-intensive, competitive industries, and including imported energy within the scope of the program. Regulating the carbon intensity of electricity imported into the state would have to be implemented in a manner that complies with the constitutional principles governing state regulation of interstate commerce.
- In designing these programs, State policymakers will need to be mindful of the interactions between the programs and their applicability to state power programs and customer classes. Although further evaluation of the interactions will be needed, some preliminary conclusions can be drawn. For example, implementing strong complementary measures directed at the power sector, such as the LCPS and RPS, will have a tendency to reduce the cost of emission allowances under the cap-and-invest program, thereby reducing the cost to New York ratepayers. However, if other states participating in a regional cap-and-invest program do not make similar investments, this benefit will be diluted, thereby raising the cost of the cap-and-invest program to New York. Therefore, New York would need to work with its partners in the RGGI to seek deployment of similar programs in the other RGGI states and explore the possibility of regional implementation of an LCPS. Another possible way of ensuring that New York reaps the benefits of its other policies is to base the percentage allocation of allowances that New York receives in a regional program on state emissions baselines that do not consider the emission reductions that will result from other policies, such as implementation of the LCPS, expanded RPS and other complementary measures.
- Ideally, in the long term, the regional cap-and-invest program would transition into, or form a part of, a national program that is enacted through legislation or regulation. In deliberations over the design of a federal cap-and-trade program, New York should advocate for measures to ensure that emission reductions achieved under an LCPS or other similar measures have value when a federal cap is in place.
- Achieving the goals of these two policies will require the implementation of other measures recommended in the PSD chapter of this report, including energy storage (to enhance

reliability of a grid that relies increasingly on renewables), a siting process for new low-carbon energy facilities and upgrade of electricity transmission and distribution systems. The cap-and-invest program could provide a revenue stream to enable the funding of many of the other policies recommended in this report.

- Additional analyses will be conducted in the next phase of the Climate Action Plan process to separately quantify the potential benefits and costs of utilization of biomass for application in the PSD sector.

GENERATION INFRASTRUCTURE PERMITTING and SITING (PSD-1)

Policy Summary

The current siting process for power plant facilities is left to a patchwork of local and State regulatory processes. An opportunity exists to re-create a more streamlined process for the siting of power plants.

There are many components to consider in an authorization statute for power plant siting, including:

- A siting process that combines and coordinates numerous regulatory authorizations and procedures into a single fuel- and technology-neutral approval process that provides greater market certainty to developers and investors;
- A time-certain framework for rendering a decision on an application;
- A provision for the override of the application of local substantive legal requirements that are unreasonably restrictive in view of factors specified in the statute;
- An analysis of alternative sites similar to that required by State Environmental Quality Review Act;
- A finding and determination that the authorized generating facility minimizes and mitigates predictable, significant, and adverse disproportionate environmental impacts, considering the cumulative effect of emissions from other major facilities and the goal of reducing net emissions or, at a minimum, avoiding increased pollution in communities that bear a disproportionate burden of emissions;
- Opportunities for extensive public involvement, including improved notice provisions, so as to address environmental justice and other public concerns associated with the construction and operation of the proposed electric generating facility;
- Availability of intervenor funding, starting at the pre-application phase, for technical and legal services.

Regarding carbon capture and sequestration, a regulatory and statutory framework should be considered for the development and use of CCS technology. One aspect of such framework is to amend the existing major transmission facility siting process (reflected in Article VII of the

Public Service Law) to establish a mechanism for the review and siting of a captured carbon transmission pipeline. In addition to this PSC-led activity, legislation could provide the New York State Department of Environmental Conservation with responsibility for CCS oversight, including a review process for obtaining a carbon sequestration permit, the injection of captured carbon into a reservoir, and the observation and monitoring of the carbon sequestration reservoir and its buffer zone boundaries.

Quantification

This policy option has not been quantified.

Special Considerations

- It will be challenging to balance the need for efficient and predictable permitting with expanded opportunities for extensive public involvement, including improved notice provisions, to address environmental justice and other public concerns associated with the construction and operation of proposed electric generating facilities. This policy proposes a revised process that serves both goals because unless progress is made in both areas it is doubtful that sufficient support can be mustered to accomplish either.
- A coordinated project review under the power plant siting law could result in greater efficiency and lower costs for state agencies and municipalities from not having to conduct individual and possibly duplicative review processes. Also, permitting costs should be reduced with the use of a shorter and more certain regulatory process. This should result in lower costs to the developer. In addition, a more predictable permitting process might encourage a larger number of projects to be proposed, affording the state a wider range of future generation options.
- The concern expressed by certain stakeholders that a siting bill could be used to site high-emitting facilities contrary to the 80 by 50 goal will be addressed by the implementation of PSD-10, which will require that all new or rebuilt power plants meet stringent emission standards for GHG emissions. Consideration could also be given to providing expedited treatment in the siting process to low-carbon and environmentally beneficial repowering proposals.

NEW FACILITY EMISSIONS STANDARDS and NUCLEAR POWER (PSD-10)

Policy Summary

In the next 20 years, New York should integrate new baseload fossil fuel-fired generation into the generation mix in a manner that is consistent with maintaining reliability and reducing system-wide GHG emissions. To reach the goal, this policy option supports the development of a low-carbon emission standard aimed at ensuring that the development of new power generating units contributes to the reduction of the State's GHG emissions. This standard would require that new or reconstructed fossil fuel-fired electric generating units that produce power for sale in New York and new power purchase agreements for delivery of electricity into the New York

Independent System Operator (NYISO) control area would achieve CO_2 emission rates (pounds of CO_2/MWh gross) that are based on the best available operating technology. For baseload units, the standard would be set at a level that can be achieved by combined cycle natural gas-fired technology. Gas turbines that are used for peaking purposes would be subject to a higher rate. In either case, the rates would allow for use of oil as a back-up fuel, consistent with reliability guidelines. In accordance with this proposed standard, new coal-fired power plants should not be built until CCS is available. For future decades, the emission standards could be revised based on the best available operating technology that arises in those periods.

Nuclear power plants currently play an important role of providing necessary baseload power in New York's electricity system. New York could strive to maintain the net installed capacity of power from nuclear plants that can continue to operate in an appropriate location and safe manner consistent with all environmental requirements and eventually replace the capacity of the units that are not relicensed with new nuclear or other low-carbon baseload plants. In all cases, the relicensing, replacement with new units at the same facilities, or the development of new nuclear energy (or other zero GHG emitting base-load generation) facilities needs to be done in a safe and environmentally sound manner. In addition to the traditional large-scale reactors, opportunities may arise to site newer smaller scale units.

Quantification

This policy option has not been quantified.

Special Considerations

- The goal of promoting the development and operation of power generation facilities that will have zero- or very-low-carbon emissions is also promoted by the policy of developing an LCPS for power plant emissions (PSD-6). In addition to promoting statewide emission reductions, the instant policy—along with the siting policy (PSD-1)—will reduce the adverse environmental impact of new facilities on particular communities.
- The evolving role of the federal government is critical in the expansion of the nuclear industry and creating the policies and mechanism(s) for long-term storage, reprocessing, or neutralization of used nuclear fuel.
- Currently, the two units at Indian Point are in the re-licensing process as their licenses expire in 2013 and 2015. If these (or other) facilities are not relicensed, then plans for the siting or expansion of new nuclear units (or other zero-GHG-emitting baseload generation) at new or existing facilities would be needed eventually to attain the same level of power currently provided by nuclear energy in the state.

EXISTING FOSSIL PLANTS (PSD-8)

Policy Summary

New York's current fleet of fossil-fired plants includes plants—fired by coal or other fuels—with relatively high rates of carbon emissions. The purpose of this policy is to reduce emissions from these facilities by repowering and replacing existing fossil-fired facilities with more efficient, lower-emitting and less carbon intense generators. This goal would be achieved through a combination of incentives and emission standards.

Initially, the State would rely on market-based solutions to promote repowering, including: (1) Request for Proposals open to repowered resources, regardless of technology; (2) market-based credits (similar to the REC market); or (3) long-term contracts. The PSC could work with the NYISO, the New York State Reliability Council, and market participants to identify fair and cost-effective incentives for the repowering of facilities to modern, state-of-the-art generation. Repowering would also be supported by the cap-and-invest program, as well as other market-based and regulatory efforts.

Eventually, however, existing sources would have to meet emission standards that would be applicable in 2030 after the above policies have been given a chance to work. These standards could be based on the standards applicable to new sources in PSD-10 (based on the emissions of natural gas-fired plants). Depending on the level of their emissions, existing sources would have a number of options available to meet specified emission standards, including efficiency upgrades, repowering with lower carbon fuels, co-firing of lower-carbon, sustainable biofuels, and the use of CCS (when it becomes commercially available). Flexibility may be provided by allowing the grouping or system-averaging of unit emissions to demonstrate compliance with applicable emission limits.

Quantification

This policy option has not been fully quantified.

Special Considerations

- The State should consider postponing the applicability of any performance standard to any source that is, at the time of rule or regulation effectiveness, in contract for power sale until the expiration of that existing contract.
- Consideration could be given to incorporating incentives for repowering proposals that reduce emissions of all relevant pollutants in the new facility siting process recommended by PSD-1.
- In developing and implementing the policy, the State should ensure that any incentives are cost-effective and it should avoid providing incentives to plants that are not expected to operate many years into the future.
- Implementation of this policy is important to environmental justice communities that are burdened inequitably by existing fossil fuel-fired plants.

DISTRIBUTION NETWORK UPGRADING INCLUDING EV and SMART GRID INFRASTRUCTURE (PSD-4)

Policy Summary

The electric power distribution system represents the critical linkage between the high-voltage transmission system and a wide variety of end-use consumer loads and functions as the injection point for distributed generation. An effective and reliable interface must be maintained between both systems as New York transitions to a low-carbon economy. The distribution system serves as an enabling technology to allow for greater market penetration of customer-sited low-carbon technologies (rooftop PV, electric vehicles [EVs]). Improved distribution monitoring, diagnostics, and interactive communication systems would be necessary to realize carbon reduction targets and concurrently maintain system integrity. Accurate monitoring of upstream transmission system status and downstream end-use conditions in real-time represents an essential component of the smart distribution network, and secure data exchange protocols would need to be simultaneously implemented at both ends of the system. Smart distribution also improves system reliability and can improve the efficient operation of distribution circuits with voltage conservation and improved reactive power control. To accommodate high-penetration EV charging, some upgrades to the distribution system at the local level involving distribution transformers and customer service will be required. Stationary electrical storage may be necessary to deploy fast charging of EVs without negative grid impacts.

The PSC has instituted a proceeding aimed at establishing a strategic vision and plan for investing in smart grid technology for New York that will guide future research, development, and demonstration in New York in support of the policy objectives stated herein. In addition, the following initiatives should be pursued to support these policy goals:

- Pilot projects should be undertaken to both quantify energy efficiencies from various approaches to smart distribution and to establish best practices.
- PSC rate cases could require regulated utilities to consider the use of smart grid distribution technologies that would support the achievement of lower GHG emissions.
- The New York State Smart Grid Consortium’s strategic roadmap should be used to guide smart grid roll out.
- Utilities regulated by the PSC could have load factor targets and incentives to implement appropriate technologies to achieve them.
- Develop and implement improved distribution circuit performance indices that better incorporate distribution automation and/or smart grid operations.
- New rate tariffs could be established that provide incentives to customers to improve their power factor.
- A workshop could be held annually with industry experts and stakeholders to conduct a smart grid technology assessment.

Quantification

Three policy areas were identified for quantification: (1) expanded use of smart meters, (2) reduction of distribution system losses, and (3) smart charging of electric vehicles. The benefits related to smart charging are being evaluated under TLU-4, Alternative Fuel Related Measures and Infrastructure.

The literature suggests that smart grid deployment can result in very cost-effective emission reductions under some circumstances. However, because costs and savings are both highly site-specific, a reliable quantification of emission reductions and costs associated with extensive deployment of smart grid technology in New York cannot be made at this time. The cost-effectiveness of smart grid technology is being evaluated in an ongoing PSC proceeding that may provide the basis for more precise quantification in the future.

The Technical Work Group also investigated the potential for distribution loss savings. These savings can be accomplished in a number of ways, for instance, by upgrading transformers and by reducing reactive power losses (installation of capacitors). The table below contains the results of a quantification built upon a study conducted by the NYISO that estimates that it is possible to improve distribution system losses by up to 30% (this would reduce current losses from approximately 6 percent to 4 percent).[5] The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by 2005$/t$CO_2$e) for this policy scenario are presented below.

GHG Reductions (MMtCO_2e)		Net Present Value Cost (Million 2005$)	Net Cost per Avoided Emissions (2005$/t$CO_2$e)
2030	Total 2011–2030		
0.8	6.3	-$420	-$66

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- Substantial additions of electric vehicles and other technologies will require upgrades to the distribution network. The geographical distribution of these technologies will have a large influence on this matter. For instance, local concentrations of EVs may seriously strain the distribution system, especially if they require fast charging. Many of these issues and potential solutions were summarized by a cross-sector task force.[6]
- The policy will consider any/all unique circumstances associated with individual electric service territories throughout New York including, but not limited to, geographic topology

[5] Chao, H. and J. Adams (NYISO), *Benefits of Reducing Electric System Losses*, April 9, 2009, p. 17.

[6] *Report of the Cross-Sector Electric-Grid-Powered Vehicle Sub-group.*

that may impact communications infrastructure, expected market adoption rates for electric vehicles and market penetration of demand side resources.

- The use of smart grid technologies provides customers with greater flexibility and resources to manage energy demand and costs. Electricity system reliability is also enhanced with smart grid technologies.

TRANSMISSION NETWORK UPGRADES (PSD-5)

Policy Summary

This policy option encourages and supports cost-effective transmission system improvements that reduce GHG emissions while improving efficiency, satisfying electricity demand, and maintaining reliable and secure system operations. It is expected that this policy would facilitate the development of generation that would be influenced by other policies (PSD-2, PSD-6, PSD-10, RCI policies, etc.)

The Technical Work Group focused on ways to encourage cost-effective transmission system upgrades, expand transmission capacity, and reduce sulfur hexafluoride (SF_6) emissions from transmission-related equipment. It recommended that renewable energy and GHG emissions policy goals be incorporated into existing and ongoing centralized system planning studies. Through this, system planners may identify cost-effective upgrades to existing infrastructure (including opportunities to incorporate smart grid technology) that reduce system losses and new transmission that interconnects remotely-located clean energy resources to the power grid. Utilizing existing rights-of-way should be encouraged to the extent practicable. The policy also recommends that system planning studies identify areas or zones within the New York Control Area that have high potential to provide clean energy, and then target these zones for transmission expansion to accommodate clean resources.

The NYISO and PSC will need to develop regulatory mechanisms, market signals, and/or incentives to encourage upgrades and interconnections that facilitate the State's climate and energy goals. This includes regulatory mechanisms that expedite decisions on cost recovery and cost allocation for New York Transmission Owners (NYTO) that invest in loss-reducing equipment and upgrades. In the Article VII process, PSC could give greater weight to a proposed project's contribution to state climate and energy policy goals in the determination of project need.

To reduce the emissions of SF_6 from transmission operations, the policy calls for all NYTOs to sign on to the U.S. Environmental Protection Agency's SF_6 Emission Reduction Partnership for Electric Power Systems and set goals for reducing SF_6 emissions, and to establish a New York State working group including the NYTO and other stakeholders, to share best practices and develop strategies to meet the Partnership's goals. The State could also support the development of environmental regulations, manufacturer incentives, and federal SF_6 emissions performance standards to encourage the use of environmentally-friendly equipment that limits emissions of

SF_6, and encourage research and development programs to find ways to limit and/or replace SF_6 technologies.

Quantification

This policy option has not been quantified.

Special Considerations

- Siting of transmission projects can be complex and contentious due to regulatory issues at the State and federal level, differing perspectives on the benefits and cost burdens, opposition at the local level, and potential environmental and visual impacts.
- There are transmission technologies—forecasting software for solar and wind resources, energy storage technologies, etc.—that are in early stages of development. These technologies, when technically and commercially viable, will be needed to facilitate large-scale integration of variable renewable resources while maintaining high levels of reliability. Technological developments will happen, but may not break through at the pace and/or scale needed to meet the renewable energy goals of the Climate Action Plan. PSD-9, Research and Development for Electric Energy Supply and Delivery, focuses on developing new sources of renewable generation and developing mechanisms to enable the efficient and cost effective delivery of electric energy.
- Transmission expansion and interconnection intended to satisfy energy and climate policy goals will be evaluated by developers and regulators on an economic basis before getting approval. For example, the NYISO Congestion Assessment and Resource Integration Study process requires a benefit-cost ratio higher than 1.0 before considering a project for cost recovery through the tariff. Incorporating the benefits of meeting climate goals into a tariff, like other changes to the NYISO tariff, will require stakeholder acceptance and FERC approval. New projects must also be evaluated and approved by the PSC through the Article VII process.

ENERGY STORAGE (PSD-3)

Policy Summary

To achieve the 80 by 50 goal and the benchmark interim goal of 40 by 30, while maintaining electric system reliability, the State will need to move toward an extremely low-carbon electricity sector. Achieving an extremely low-carbon electricity sector will, at a minimum, require the successful implementation of two distinct sets of strategies: (1) a very substantial increase in the use of mostly intermittent renewable sources of generation, as proposed in PSD-2, Renewable Portfolio Standard and Incentives for Grid-Based Renewable Generation, and in RCI-3, Renewable Energy Incentives; coupled with (2) a steady reduction in the use of fossil fuel generation, as proposed in PSD-6, GHG Reduction Market Mechanisms, PSD-8, Existing Fossil Plants Policies, and PSD-10, New Facility Emissions Standards and Nuclear Power.

One of the most important challenges that the state's electric system faces is the need to assure that system reliability is maintained. At present, balancing system load and supply conditions, and addressing short and long term system disruptions, are addressed by calling on various load-following fossil fuel generation plants and/or demand response for reduced load. One challenge the State will face in meeting the 80 by 50 GHG reduction goal will be the need to find clean energy substitutes for the set of fossil fuel generation facilities that are called upon to address those circumstances. For example, the prospect of minute-to-minute rapid changes in the output of the state's generation mix remains likely while, at the same time, the types of fossil fuel generation historically relied on to address fluctuations in demand may no longer be operating.

Energy storage—in its many forms—can be used to help ensure that the State will be in a position to implement these strategies in ways that maximize the potential contribution of intermittent renewable generation, maintain reliability at every level of the electric system, and make full use of market efficiencies.[7] Energy storage facilities of sufficient capacity as measured in megawatts and total energy as measured in MWh, whose output may need to be called upon for hours, days, weeks, or even months, as well as facilities that could respond to system changes almost instantaneously but only briefly (labeled Limited Energy Storage Resources by the NYISO), will likely be critical to support routinely reliable operation of the electric system and to respond to system contingencies when and where they occur.

A thorough assessment should be conducted to evaluate the energy storage, transmission, and distribution requirements that will support the expanded use of renewable power generation and electric vehicle technologies in a reliable manner, for the 40 by 30 benchmark and the 80 by 50 goal. This should include an engineering and economic analysis, identification of institutional barriers and financing strategies, and identification of New York-specific needs for technology improvements. The expertise resident in both the New York Smart Grid Consortium and the New York Battery and Energy Smart Technology Consortium will be valuable in this assessment. In addition, given the significant need for fundamental improvement in Energy Smart cost and performance, New York State should advocate for substantial and increased federal investment in research and technology development.

Quantification

This policy option has not been quantified.

Special Considerations

- At the transmission system level, increased use of pumped-storage hydro and the introduction of compressed-air energy storage facilities (CAES), flywheels, and batteries could be developed as an alternative to curtailing renewable generation for system stability and to avoid choosing among renewable generation sources that would otherwise face

[7] Energy storage will not be the only tool available. Shifting electricity usage to hours where excess generation supply is available and demand curtailment, for example, are more efficient and cost effective than any currently available means to store and later retrieve such energy and helps avoid the use of inefficient peaking generation sources. Transmission and distribution system enhancements, as proposed in PSD-4 and PSD-5, will also support this effort.

transmission constraints. As renewable energy supplants larger quantities of fossil energy, the role of storage may transition to providing capacity and energy to compensate for sudden changes in the output of wind and solar generation caused by short term weather changes. While the state already has two large pumped storage facilities, studies will need to be undertaken to identify other potentially feasible sites for additional large pumped-storage facilities including options outside of New York's borders. CAES facilities are an option, but also require appropriate underground geologic structures (e.g., salt domes) and proximity to both natural gas supply and transmission capacity.[8]

- At the distribution system level, storage facilities—primarily batteries—could provide ancillary services and provide clean energy alternatives to generation facilities in load pockets. Installation of local storage systems could also avoid the need to make potentially more costly distribution system enhancements. Storage of delivered electricity in the forms of ice systems for cooling and thermal storage for heating may also be effective technologies to reduce peak demand while accommodating the cross-sector migration of building heating and cooling loads.
- There are institutional, regulatory, and financial barriers that must be overcome to facilitate the expanded use of energy storage. For instance, an efficient regulatory mechanism needs to be created to support the siting of facilities that use energy storage.
- Although a number of energy storage technologies are currently available, additional advanced energy storage systems will need to be developed to support the achievement of the State's GHG reduction goals. PSD-9 elaborates further on the research and development activities that should be pursued to support these objectives.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS FOR THE POWER SUPPLY AND DELIVERY SECTOR (PSD-9)

See Chapter 10 for a complete presentation of Research, Development, and Demonstration needs for this sector.

[8] As currently conceived, CAES facilities would utilize nighttime generation to inject air into an appropriate storage structure and then during the day release the heated compressed air into a combustion turbine, burning natural gas, to dramatically increase the combustion efficiency of the turbine. Thus, use of natural gas in CAES facilities would need to be accounted for in the future emissions of the electricity sector. As a future possible alternative, it would be appropriate to also consider the use of compressed air energy storage without the use of fossil fuels.

Chapter 9
Agriculture, Forestry, and Waste Management Mitigation

Sector Vision for a Low-Carbon Future

The Agriculture, Forestry, and Waste Management (AFW) Technical Work Group, comprised of stakeholders from government agencies, industry, academia, and nonprofit organizations, developed visioning statements for the agriculture, forestry, and waste management sectors.

A Vision for New York State's Agriculture Sector in 2050

A carbon-negative New York agricultural sector will help to meet the state's food and fiber needs, while also making a significant contribution to the energy supply mix. Farms will be profitable, valued by society, and highly adapted to a changing climate. Farmers will be unable to recall the time when managing single-resource concerns was the norm, or when the number and the area of farms declined each year because single-product farms could not compete in a fossil-fuel dependent world undergoing major climate shifts.

More specifically, New York's agriculture sector will have the following characteristics:

Energy: New York farms will be net exporters of energy, including market-ready electricity and biogas; farms will serve as a direct source of heat and electricity for surrounding communities, providing consistent, baseload power to the grid from on-farm anaerobic digestion of organic wastes and waste heat for onsite and offsite use. Farms will supply feedstocks for transportation fuels, as advances in bio-technology will have dramatically increased yields of dedicated bio-energy crops.

Agricultural practices and technology: Farming practices and technology will capitalize on the inherent strengths of natural systems, will effectively re-couple animal and crop production, and will manage carbon flows using system-oriented approaches like those developed for nutrient management, soil conservation, and water quality protection. The public will recognize working landscapes, including farms, as ecosystem service providers.

Land use: Smart growth policies have arrested and reversed the erosion of the agricultural land base. Farms will make selective use of land suited for intensive cultivation for crop production and for carbon storage, incorporating into the soil millions of tons of compost and biochar each year. Production of closed-loop energy crops, soil carbon capture, and low-carbon food production methods will be fulfilling their promise as the largest available land-based greenhouse gas (GHG) reduction opportunity. An improving market will have encouraged the return of as many as two million acres of high quality, well-drained, formerly agricultural land into the farm economy.

Adaptation: The agricultural sector will have adopted management strategies and technologies that support adaptation to unavoidable changes in climate and enable agricultural and economic success in a carbon-constrained environment. Farm management practices will deal successfully with the greater intensity of rain events and longer dry periods.

Production of food, fiber, and feedstocks: New York farms will supply food and fiber for in-state consumption, along with feedstocks for chemicals and bioplastics. Advanced bio-technology will have made it possible to breed crops for specific end uses (e.g., fiber crops destined for the green-building industry).

Economy and quality of life: Reshaping of the agricultural industry will have substantially increased rural employment in job categories that cannot be readily outsourced, resulting in a sustained resurgence of the rural economy. The abundance of local food, energy, jobs, and scenic landscapes will make New York a vibrant, sought-after place to live and a global model for a sustainable society.

A Vision for New York State's Forestry Sector in 2050

Rural forest land conversion will be rare and long-term storage of carbon at its maximum. Urban green space and trees will reduce building heating and cooling loads. Working together, land owners, government officials, and the public will maximize the long-term carbon sequestration and bio-energy potential of the state's forests. Forests will deliver co-benefits that are vital to the economy and to New Yorkers' quality of life, maximizing the value of forest lands to private forest owners and to the public.

More specifically, New York's forests will have the following characteristics:

Management in accordance with a stewardship ethic: New York's forest lands will be managed for sustainable biomass production and carbon sequestration or will be conserved in perpetuity under state law. With support by landowners and the public, policies and regulations will motivate retention, expansion, and beneficial management of forest lands, while discouraging deforestation. Land-use policies will maximize ecosystem services, especially carbon benefits.

Carbon sequestration: Forest carbon sequestration will be promoted and monitored, with the aim of achieving optimal carbon storage on all forest lands. Wood will be used sustainably and efficiently for durable wood products. An effective monitoring system will track forest carbon pools.

Fuel substitution: New York's million-plus acres of formerly idle agricultural land will have been brought back into tillage or are producing woody biomass crops for energy. Woody biomass species substitute as needed for fossil fuels in high-performance, low-emission bio-energy systems and other industrial applications. State-of-the-art biofuel production and combustion technologies achieve net neutral (or even net negative) GHG emissions and play an important role in producing low-carbon liquid fuels for the aviation and shipping industries. Life-cycle costs and benefits are taken into account in decisions to derive energy from woody biomass.

Climate change adaptation: The capacity of the state's forest lands to both mitigate and adapt to climate change will be fully developed. Forest pest invasions will be anticipated and controlled.

A Vision for New York State's Waste Management Sector in 2050

New York will have a sustainable and energy-efficient materials economy in which environmental stewardship is pursued as a common societal value and environmental considerations inform purchasing, production, and materials management, minimizing waste and reducing risks to human health and the environment. Materials management systems and infrastructure will maximize the recovery and re-use of water, wastewater, and other materials in ways that capture their economic value, conserve embedded energy, and minimize net life-cycle emissions of GHGs and other pollutants.

More specifically, New York will have a materials management system with the following characteristics:

GHG reduction: Waste disposal technologies will efficiently capture the material and energy value of different types of waste and incorporate carbon-neutral or carbon-negative methods for disposing of residual wastes. Any landfills still in use will employ every available technology and method to reduce emissions of methane and other GHGs, and the GHG footprint of wastewater treatment plants will have been reduced as far as possible.

Co-benefits: Residual materials will be composted or otherwise beneficially used. Water treatment systems will yield waste heat and waste gas for productive uses. Wastewater treatment plants and similar facilities will host solar, wind, and hydraulic turbine power generation.

Materials management: Products and packages will be designed for maximum incorporation of recycled materials, and for full recycling or reuse after useful life. Infrastructure will be in place to distribute, recover, and reverse-distribute goods.

Response to an evolving market: Comprehensive planning for materials management, stormwater and wastewater management will ensure that GHGs, energy use, and other harmful by-products of waste management are minimized as the marketplace for both materials and energy evolves. Comprehensive planning for materials management will ensure that energy and natural resources are conserved and GHG emissions are minimized as the marketplace for both materials and energy evolves.

Overview of GHG Emissions

The AFW sectors are responsible for a relatively small portion of New York's current GHG emissions. The total AFW contribution to carbon dioxide equivalent (CO_2e) gross emissions in 2008 was 12 million metric tons (MMt), or about 5 percent of the state's total. The reader should understand three important concepts related to the AFW inventory and forecast (I&F) and the forecasted GHG reductions from AFW mitigation options:

- The AFW I&F only covers non-combustion-related GHG emissions.

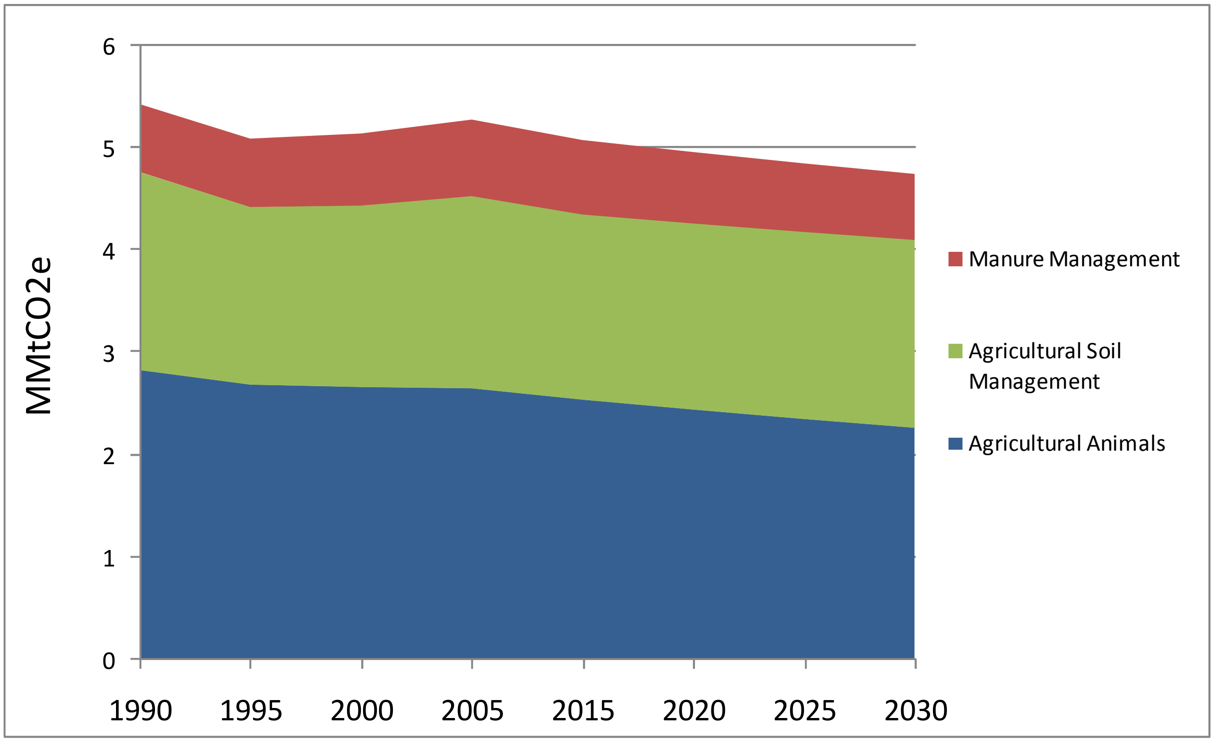
- The embedded emissions within the AFW sectors are significant, especially within waste disposed at landfills, but are not counted in the I&F.
- The AFW policy recommendations will impact GHG emissions within and outside the AFW sector and both in-state and out-of-state.

It is important to note that the AFW sector I&F emissions exclude fossil fuel combustion-related GHGs, such as diesel fuel consumption in the agriculture sector and waste management sector fuel use. These fuel combustion emissions are included as part of the industrial fuel combustion sector (and covered in the Residential, Commercial/Institutional, and Industrial [RCI] Mitigation chapter). The emissions that result from the generation of electricity consumed within the AFW sectors are included in the Power Supply and Delivery (PSD) sector I&F.

Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation (referred to as Agricultural Animals in Chapter 3), manure management, and agriculture soils. As shown in Figure 9-1, emissions from livestock (primarily dairy cows) make significant contributions to the sector totals in both manure management and enteric fermentation. Sector emissions also include N_2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic and livestock manure) application and production of nitrogen-fixing crops (legumes).

Overall, the agriculture sector accounted for about 2 percent of New York's total gross emissions in 2008, with the same approximate contribution estimated in 2030. The CH_4 emissions occurring from enteric fermentation are a large contributor to the state's total agricultural GHG emissions by 2030, the contribution from this source is estimated to be about 48 percent of the total agriculture emissions. The next-highest contributor in 2030 is forecasted to be agricultural soil management, at about 39 percent. Methane emissions from manure management are declining slightly due to lower animal populations; however, they are forecasted to contribute around 13 percent in 2030.

Figure 9-1. Historical and Forecasted Gross GHG Emissions from the Agriculture Sector, New York, 1990–2030



Notes: The Agricultural Soil Management category includes incorporation of crop residues and nitrogen fixing crops (no cultivation of histosols estimated in New York). Soil carbon sequestration is not shown.

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Note that, in keeping with U.S. Environmental Protection Agency (EPA) methods and international reporting conventions, the New York inventory and forecast covers sources of GHGs from human activities. There could be some natural sources of GHGs that are not represented in the inventory and forecast; however, these are not addressed in the New York Climate Action Plan process.

The forestry and land-use sector can include both emissions sources and carbon sinks, which are calculated from estimates of the net CO_2 flux[1] from forested lands, urban trees, and landfilled yard trimmings in New York .The inventory is divided into two primary subsectors: the forested landscape and urban trees/land use. Both subsectors capture net carbon sequestered in forest biomass, urban trees, landfills, and harvested wood products.

As shown in Table 9-1, USFS data suggest that New York's forests sequestered about 19.5 $MMtCO_2e$ per year in 2005 (this excludes estimates of carbon flux from forest soils based on recommendations from the USFS). The negative numbers in Table 9-1 indicate a CO_2 sink rather than a source. Hence, throughout the policy option period, forest carbon losses due to forest conversion, wildfire, and disease were estimated to be smaller than the CO_2 sequestered in forest

[1] Flux refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere stored in plant tissue or soils.

carbon pools, such as live trees, debris on the forest floor, and forest soils, as well as in harvested wood products (e.g., furniture and lumber) and the disposal into landfills of forest products. Emissions of CH_4 and N_2O during forest wildfires and prescribed burns were not estimated due to a lack of data; however, it is not expected that these emissions will contribute substantially to Forestry sector totals. This expectation is based on work in other states, as well as wildfire activity in New York. The forecast for the sector to 2030 remains a net sequestration of 19.5 $MMtCO_2e$.

Table 9-1. Forestry and Land-use Flux and Reference Case Forecasts ($MMtCO_2e$)

Subsector	1990	1995	2000	2005	2015	2025	2030
Forested Landscape (excluding soil carbon)	–23.9	–22.6	–22.6	–22.6	–22.6	–22.6	–22.6
Urban Forestry and Land Use	–3.6	–3.0	–2.9	–2.9	–2.9	–2.9	–2.9
Sector Total	**–27.5**	**–25.6**	**–25.5**	**–25.5**	**–25.5**	**–25.5**	**–25.5**

CH_4 = methane; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; N/A = not available; N_2O = nitrous oxide. Note: Positive numbers indicate net emission. Based on USFS input, emissions from soil organic carbon are left out of the forestry sector summary due to a high level of uncertainty.

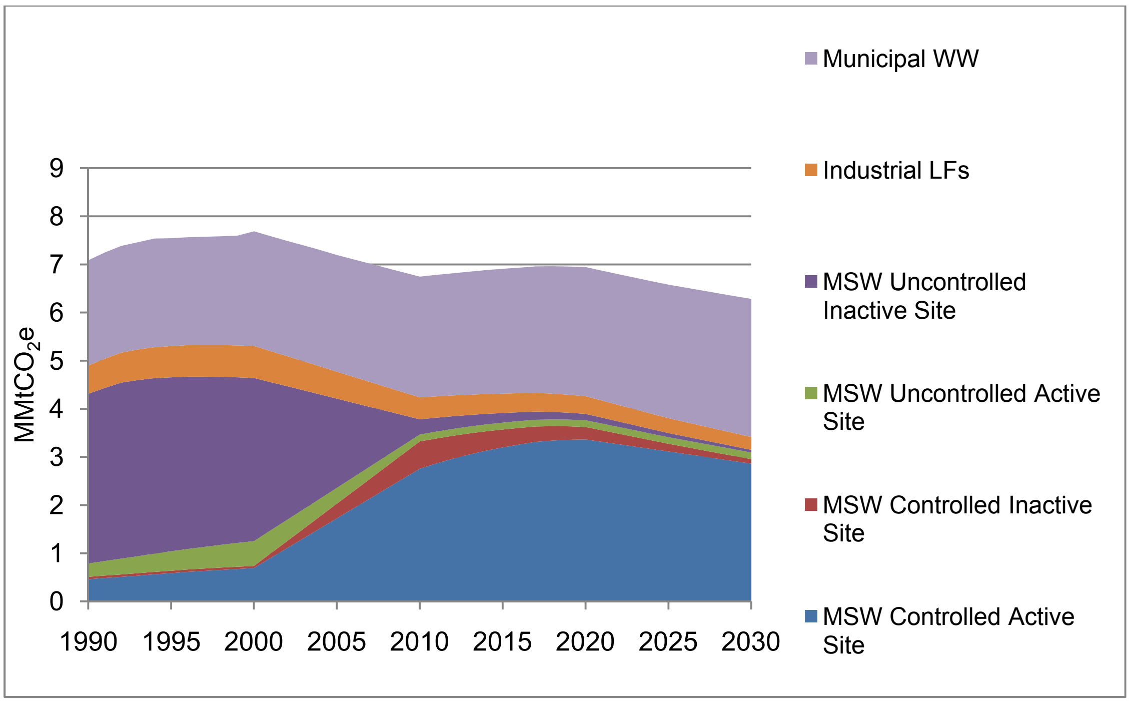
Figure 9-2 shows estimated historical and forecasted emissions from the management and treatment of solid waste and wastewater. Emissions from waste management consist largely of CH_4 emitted from municipal solid waste (MSW) and industrial landfills, while emissions from wastewater treatment include both CH_4 and N_2O. Emissions are not included for MSW combustion, as all waste combustion facilities in New York recover the energy. Therefore, waste combustion emissions are counted in the PSD sector I&F. Available data were insufficient to include emissions from industrial wastewater treatment. Composting in New York results in a sink (not included in Figure 9-2) of 0.11 $MMtCO_2e$ per year. This is the result of accumulated stable carbon in compost, which is eventually applied as a soil amendment. CH_4 and N_2O emissions at composting facilities are not included but are expected to be minimal.

MSW landfill sites were grouped into four categories according to available control equipment and operational status at the site: (1) controlled active, (2) controlled inactive, (3) uncontrolled active, and (4) uncontrolled inactive. As seen in Figure 9-2, between 2000 and 2010, emissions from active controlled landfills increased, while emissions from controlled inactive sites decreased. This is likely a result of three changes: disposal of more MSW at landfills with landfill gas controls in place, implementation of landfill gas control at more landfills, and decrease of landfill gas emissions from inactive landfills as MSW is no longer disposed at these landfills. Industrial landfill emissions are estimated to be 7 percent of the potential emissions (before methane destruction at controlled landfills) at MSW landfills, per EPA default methodology.

Municipal wastewater emissions estimates are estimated based on population and are relatively stable through the inventory and forecast period. The level of composting has also remained relatively stable since 1990, and estimates of emissions from composting are based on 2006 composting data.[2]

Overall, the waste management sector accounted for about 3 percent of New York's total gross emissions in 2008. Emissions from this sector are expected to decline slightly to only 2 percent of the state's total by 2030. As mentioned above, the estimates for solid waste management do not include the embedded emissions in generated waste, which could increase the total fuel-cycle emissions of waste disposal by an order of magnitude, nor do the emissions include those from waste exported from the state.[3] Inclusion of these emissions would make the waste sector a much larger contributor to New York's totals.

Figure 9-2. Estimated Historical and Forecasted Gross GHG Emissions from Solid Waste and Wastewater Management in New York, 1990–2030[4]



MMtCO₂e = million metric tons of carbon dioxide equivalent; MSW = municipal solid waste; LFs = landfills; WW = wastewater.

The embedded GHG emissions of waste generated in New York are significant. These embedded emissions occur during the extraction of raw material, manufacturing of material into goods and packaging, and transportation of the material. Climate action plans developed in other states, such as Michigan, show that embedded emissions can exceed direct landfill emissions by a factor

[2] L. Lim. 2009. New York State Department of Environmental Conservation, personal communication with R. Anderson.

[3] According to 2008 data submitted by DEC, more than 50 percent of MSW disposed at landfills (about 6 million tons) is exported for disposal outside New York State.

[4] Composting is not included in the graph, as composting is a net carbon sink.

of 10.[5] These emissions largely take place outside New York State, except for the emissions that are counted within the PSD, RCI, and Transportation and Land Use (TLU) sectors. In addition, a sizable fraction of solid waste is exported from New York for disposal in other states. The emissions associated with the management of exported waste are not included within the direct emission estimates shown in Figure 9-2. If the emissions associated with waste exports and the full fuel cycle were to be included in the state's inventory and forecast, contributions to total statewide AFW emissions would likely exceed 25 percent, instead of the 5 percent cited above.

Overview of Policy Options and Estimated Impacts

The combined agriculture, forestry, and waste sectors contribute a small portion of total state GHG emissions (4.8 percent), but many of the mitigation and sequestration options offered by these sectors are relatively low-cost and low-tech approaches, making these viable options.

The proposed policies are fundamentally resource management options ranging from energy production and use to natural resources and materials management and waste. The suite of proposed policies adds reduction of CO_2 and other GHGs as a resource management objective. If implemented properly, these approaches offer significant environmental, economic, and social benefits beyond GHG reductions, including the provision of improved water and air quality, increased agricultural and forest products, and green job creation.

The proposed policy options seek to accomplish the following:

- Reduce energy-related emissions through the deployment of renewable energy technologies, including bio-based energy solutions, and energy efficiency policies and measures that address direct and embedded energy usage;
- Conserve the embedded energy in materials through maximized reuse and recycling;
- Reduce methane (global warming potential (GWP) =21-25) and nitrous oxide (GWP=296-310), the predominant agriculturally generated and waste-related GHGs, through the deployment of a combination of systems;
- Capitalize on agriculture and forestry's ability to store carbon in natural systems;
- Incorporate adaptation strategies wherever possible.

Energy from biomass represents an opportunity to reduce GHGs through the displacement of higher-carbon fossil-based energy sources while at the same time increasing in-state circulation of energy dollars and providing significant economic opportunities. However, the use of biomass for energy carries inherent risks. Each step of the process from field or forest to conversion to end-use has environmental, economic, and social benefits and costs. Properly managed biomass

[5] Michigan Climate Action Council. 2009. *MCAC Final Report*. Appendix J: Agriculture, Forestry and Waste Management Sectors – Policy Options. Available at Hhttp://www.miclimatechange.us/ewebeditpro/items/O46F21205.pdfH

production systems offer an opportunity to realize net carbon benefits. The proposed policies seek to capitalize on the state's ability to achieve GHG reductions through sustainable production and wise use of this renewable resource.

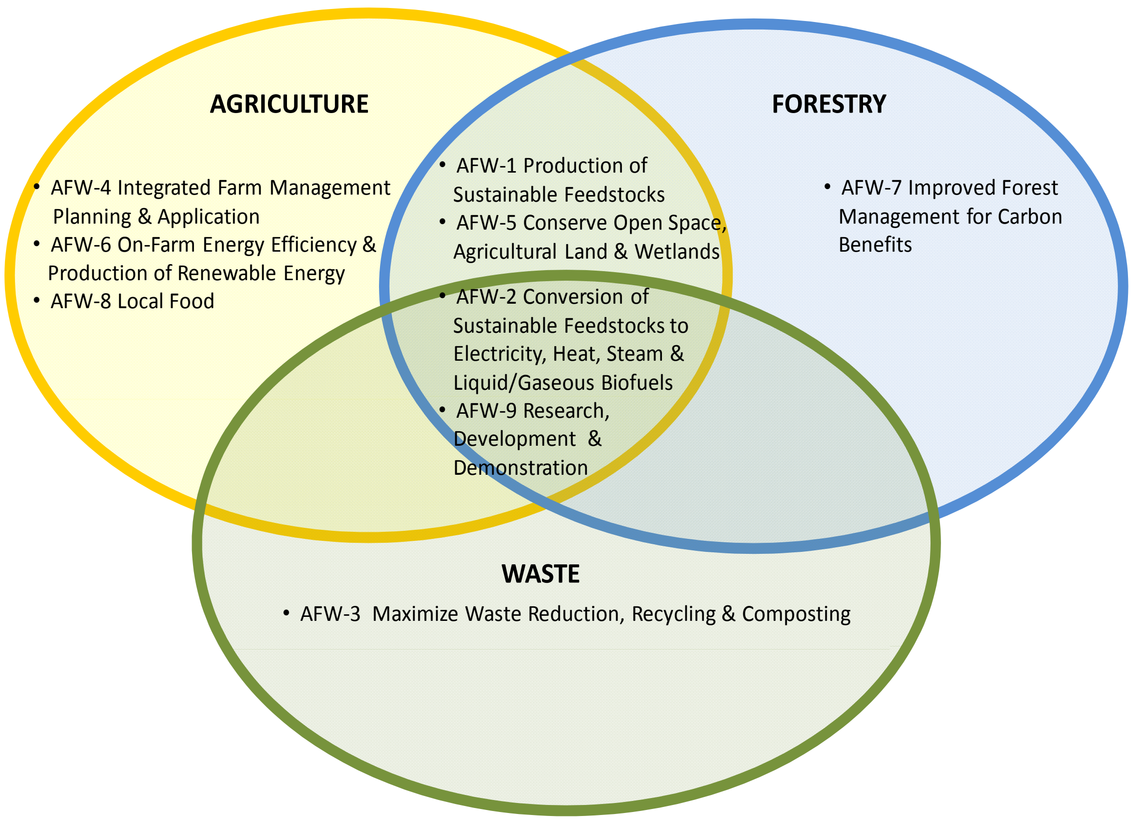
Waste disposal currently makes up a significant portion of GHG emissions in the AFW sectors. In the coming decades the current method of waste disposal—relying primarily on landfills—will become increasingly unsustainable. The solution to achieving long-term meaningful reductions from this sector is through a dramatic reduction in the amount of waste destined for disposal. Redirecting the materials currently in the waste stream to higher-value uses not only reduces methane generation at landfills but also captures the embedded energy in the products and materials currently going to waste and reduces energy and emissions related to their extraction, processing, and manufacturing. Therefore, from a lifecycle perspective, increasing reuse and recycling will have significant energy conservation and GHG benefits. The proposed policy is aggressive and uses a combination of tools to achieve the necessary reductions.

While energy is a focus of many of the policies, it is not the exclusive focus. Since carbon dioxide is not the primary GHG emitted by the agricultural sector, the policy options take an integrated, site-specific approach to managing farm emissions.

Our existing landscape is a critical component of the carbon cycle. Several of the policy options seek to enhance the state's existing carbon sinks through a combination of improved land management and land-use protection measures.

All of the policy options presented rely on management system changes at the most basic level on the farm, in the forest, at businesses, and at home. Incorporating GHG reduction and sequestration strategies into existing management systems and stewardship principles will require a high degree of behavioral change. Developing the education, outreach, job training and decision-making tools necessary to engender this level of behavioral change is an immediate challenge.

Figure 9-3. Agriculture, Forestry and Waste Policy Options



Policy Scenario Quantification Summary Table

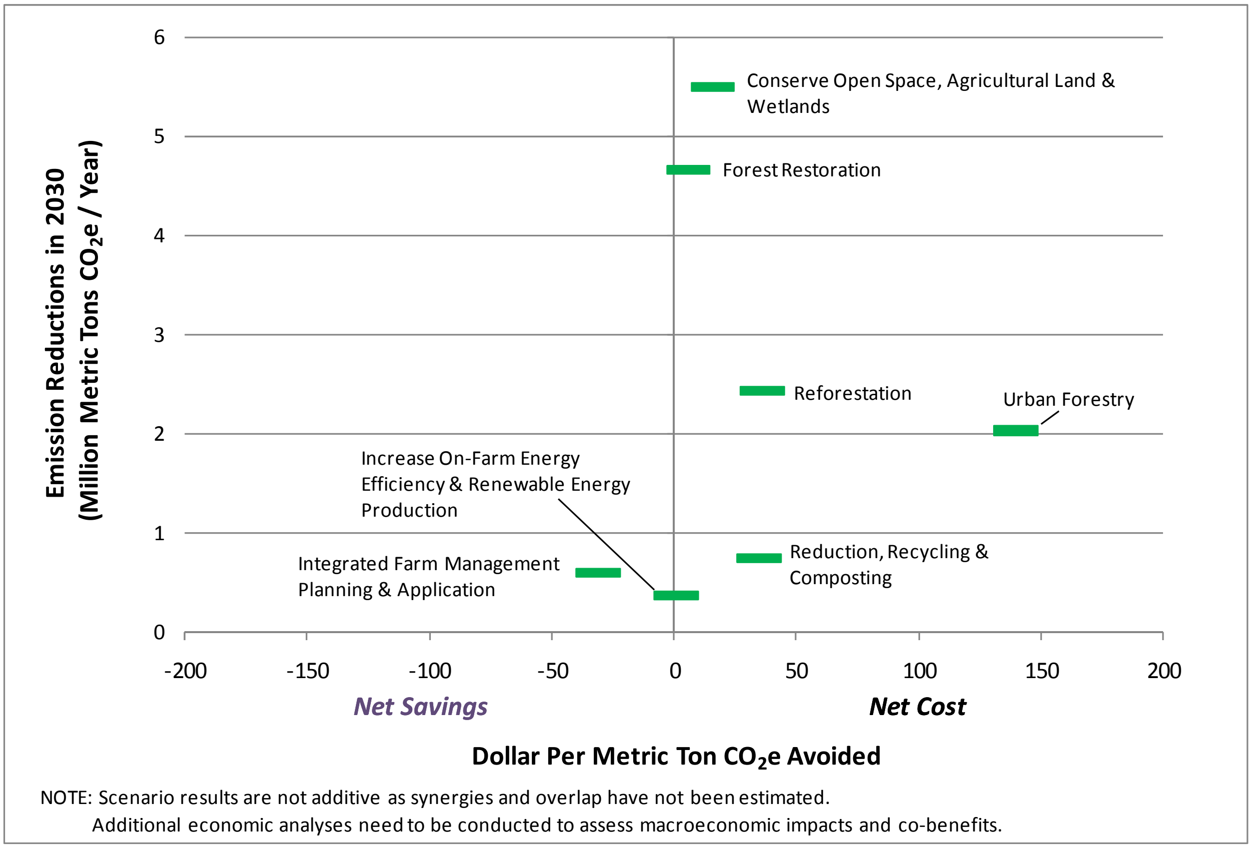
Policy No.	Policy Option	In-State GHG Reductions ($MMtCO_2e$)			Net Present Value: Cost/Savings 2011–2030 (Million 2008$)	Net Cost/Savings per Avoided Emissions ($\$/tCO_2e$)
		2020	2030	Total 2011–2030		
AFW-1	Production of Sustainable Feedstock for Electricity, Heat, Steam Production, and Liquid/Gaseous Biofuels	*GHG reductions and costs included in fuel-cycle analysis of PSD-2, PSD-6, RCI-3, and TLU-4.*				
AFW-2	Conversion of Sustainable Feedstock to Electricity, Heat, Steam Production, and Liquid/Gaseous Biofuels	*GHG reductions and costs quantified under PSD-2, PSD-6, RCI-3, and TLU-4.*				
AFW-3	Maximize Waste Reduction, Recycling, and Composting—In-State Only	0.5	0.7	8.0	$280	$35
AFW-4	Integrated Farm Management Planning and Application	0.3	0.6	6.5	-$201	-$31
AFW-5	Conserve Open Space, Agricultural Land and Wetlands	4.5	5.5	95	$1,500	$16
AFW-6	Increase On-Farm Energy Efficiency and Production of Renewable Energy	0.2	0.4	3.8	$3.0	$1
AFW-7	Forest Restoration	2.3	4.7	49	$290	$6
	Urban Forestry	1.0	2.0	22	$3,200	$140
	Reforestation	1.8	2.4	34	$1,200	$36

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Negative values represent savings.

The numbering used to denote the above policy recommendations is for reference purposes only; it does not reflect prioritization among these important policy recommendations. The policy numbers that appear in this table are not consecutive because they reflect only those policies for which quantification has been completed and not all policies are amenable for quantification.

Figure 9-4. Estimates of Cost and GHG Emissions Reductions for AFW Policy Options



PRODUCTION of SUSTAINABLE FEEDSTOCKS for ELECTRICITY, HEAT, STEAM PRODUCTION, and LIQUID/GASEOUS BIOFUELS (AFW-1)

Policy Summary

This policy option seeks to increase the amount of agricultural and forest biomass available on a sustainable basis to support low-carbon energy development while accounting for the environmental, economic, and social impacts of expanded biomass feedstock production.

Objectives include the following: (1) Defining sustainability criteria that address the social, economic, and environmental dimensions of biomass-derived energy, including the ability for a production system or technology to survive without public subsidies, and the development of full life-cycle carbon analysis that can support objective comparisons with other renewable and non-renewable energy sources; and (2) Developing and encouraging the use of best management systems for the establishment and harvest of feedstocks. These systems should be designed to ameliorate local impacts of storage, pre-processing, and distribution of feedstocks at conversion facilities.

The primary implementation mechanism is the creation of a state-level Biomass Energy Program. The program would provide overall coordination to encourage regional consistency in sustainability criteria, track and maintain a biomass inventory employing appropriate sustainability indicators to monitor changes in the flow of biomass, provide for the coordination of research to ensure that the development of a sustainable bio-based economy proceeds in an orderly fashion, and facilitate the development and leveraging of public/private partnerships.

Quantification

The GHG reductions and costs for this policy are quantified in the fuel-cycle analyses of PSD-2, PSD-6, RCI-3, and TLU-4. The baseline assumptions for AFW-1 and AFW-2 state that all GHG reductions from the AFW-1 and AFW-2 targets are accounted for in the analyses of the policies from the other Technical Work Groups (PSD-2, PSD-6, RCI-3, and TLU-4). Each of the other Technical Work Groups (PSD, RCI, and TLU) have been allocated one-third of the total potential sustainable biomass supply as provided by the Biomass Resource Assessment.

Although the in-state biomass feedstock scenarios included in the New York State Renewable Fuels Roadmap analyses were selected to minimize the likelihood of significant indirect land use change (iLUC) impacts, the quantification described for PSD-2, PSD-6, RCI-3, and TLU-4 related to biomass feedstocks does not include iLUC factors and effects on GHG reductions. The science behind assessing GHG emissions from iLUC is evolving, and both EPA and the California Air Resources Board are refining models and improving key input variables to reduce the uncertainty associated with quantifying land-use change and indirect effects analyses. The Roadmap will continue to follow iLUC issues and update its findings as appropriate during its annual updates. Furthermore, New York State along with the 10 other states in the Northeast and Mid-Atlantic regions have committed to including non-*de minimis* direct and indirect emissions, such as those attributed to land-use changes from fuel production, as part of their Low-Carbon Fuel Standard Memorandum of Understanding and framework development.

Special Considerations

- GHG reductions will be realized through the end use of biomass feedstock to displace higher carbon forms of energy and reductions will vary accordingly.
- The availability of in-state produced sustainable biomass feedstock must parallel, and often times precede, the development and growth of biomass conversion facilities if New York State is to maximize GHG reductions and economic benefits.
- Development of sustainability criteria related to the production and harvest of biomass should be pursued on a regional basis.
- Continued research focused on improving cradle-to-grave efficiencies (increasing yields, improving conversion technologies, understanding and improving sustainability criteria) will impact the rate at which biomass production occurs.
- This policy option provides significant rural revitalization potential. The Renewable Fuels Roadmap estimates feedstock supply jobs account for over 80 percent of the job growth potential associated with the increased production of sustainable feedstocks.
- State and federal policies related to renewable portfolio standard (RPS) and renewable fuel standard (RFS) will impact the rate at which biomass production occurs.

- The on-farm production of biomass feedstocks on idle and marginal land represents a crop diversification strategy for the purposes of adapting to climate change.
- While biomass production potential will increase with longer, warmer growing seasons, this could be limited by nutrients and drier, midsummer and fall soils.
- This is a cross-cutting policy with overlap in AFW-2, AFW-5, AFW-6, AFW-7, Adaptation, TLU, PSD, and RCI.

CONVERSION of SUSTAINABLE FEEDSTOCKS to ELECTRICITY, HEAT, STEAM PRODUCTION, and LIQUID/GASEOUS BIOFUELS (AFW-2)

Policy Summary

Sustainable feedstocks can be converted to liquid, gaseous, and solid fuels. These biofuels can offer important solutions to carbon management needs. This policy option would advance the development and commercialization of low-carbon biomass conversion processes, which for some pathways can be an area with considerable technical and financial risk. Feedstock supply and the consumption of the fuels are addressed elsewhere in this Interim Report.

The policy option acknowledges the need to support the biomass conversion industry along the development and commercialization continuum. The nature of the public support can transform from grant support at the research stage to market or production-based tax incentive programs to encourage market transformation following commercial introduction. From a GHG perspective, it is critical that production-based incentives focus on low-carbon pathways, and not all biomass conversion process are low-carbon pathways (e.g., corn to ethanol is not necessarily a low-carbon pathway).

A long-term commitment of public (primarily federal) sector funding will be necessary to partner with industrial funding to support the development of new biomass conversion technologies and the realization of the lessons learned from market experience. Research will be needed in both academic and private laboratories. Publicly funded programs should be implemented in a manner that promotes the commercial use of new intellectual property.

After the initial research stage, new products must move through a demonstration and market assessment stage of development. The relative level of investment to move a new product or process toward commercialization will increase substantially at this stage. Public funding is critical to help demonstrate the market potential and value of new technology. If New York wants to stimulate creation of this industry in the state, support for demonstration should be considered.

When the technology is ready to be developed at a commercial scale, public support could be in the form of low-cost financing or other innovative mechanisms to reduce the technical uncertainty of the new technology to the private investment community. Innovative risk-sharing programs can be implemented to share the technical and market uncertainty and promote private investment. The U.S. Department of Energy and the U.S. Department of Agriculture have advanced several types of loan guarantees that play a very important role in these markets; these federal efforts should be continued.

Beyond the point of commercial-scale manufacturing, public support is critical to ensure that all actors along the supply chain are positioned to move the product to the consumer. Public incentives, either grants or tax incentives, can be critical at this stage. While federal incentives can be important, at this stage of market transformation state initiatives could be significant in helping to develop the industry base in New York State.

Quantification

This policy option was not quantified. Quantification was captured in the end-use application, assuming that the feedstock supply will be allocated equally to the three primary end uses for power (PSD-2), transportation fuel (TLU-4), and buildings and industry (RCI-3).

Special Considerations

- Additional analyses will be conducted in the next phase of the Climate Action Plan process to separately quantify the potential benefits and costs of utilization of biomass for application in the AFW sector.
- There will be competition among the liquid, bioheat, and gaseous fuels markets for the limited sustainable feedstock resource. It is likely that the feedstocks will move where the highest profit can be realized. Realizing the carbon reduction benefits from the conversion to fuels will require a consistent and major commitment to developing the sustainable resource base (AFW-1).
- Sustainable feedstocks can also serve as the building block for more than biofuels. Conversion processes already on the verge of being commercially viable and technologies that will be developed in the future will allow for the development of bio-based products that may also have an impact on carbon reduction. These products may serve as substitutes or alternatives to products that are inherently carbon-intensive.
- Federal policies (e.g., the RFS) will drive the majority of market activity in this sector. The ability of New York to capitalize on advanced conversion technologies will be, in large part, determined by regional policies and programs. New York markets do not operate in a vacuum.
- Indirect land-use change was a topic of discussion in the Technical Work Group. Since the feedstock estimates used in AFW1 and AFW2 were based on the assessments found in the Roadmap and would not impact current agricultural or forestry production, the discussion focused on the need for additional global-scale research as a short-term need.
- Co-benefits include economic revitalization, primarily in rural areas but also statewide, by keeping energy dollars in-state, and improved ecosystem benefits, if done properly.

MAXIMIZE WASTE REDUCTION, RECYCLING, and COMPOSTING (AFW-3)

Policy Summary

This policy option includes a combination of programmatic, regulatory, and legislative actions that aim to reduce or eliminate waste, including diversion of materials for reuse, recycling (including organics recycling), and composting. The actions include updating, strengthening, and expanding the state's regulatory and statutory authority; dedicating resources to build the infrastructure for reuse, recycling (including organics recycling), and composting; expanding existing, and launching new programs at the state and local levels; and coordinating cooperation from all levels of government, the private sector, and individual New Yorkers.

This policy is related to the new draft statewide solid waste management plan, *Beyond Waste: A Sustainable Materials Management Strategy for New York* State.[6] This policy also works in concert with two other AFW policies. AFW-2 includes the conversion of municipal solid waste to electricity, heat, steam or liquid fuels; and AFW-4 aims to develop on-farm sources of renewable energy that will likely involve the recycling of organic materials from other, off-farm sources through anaerobic digestion.

Quantification

Two scenarios were quantified for this policy. Each scenario assumed that the amount of MSW going to disposal (landfills and waste to energy) is reduced from 4.1 lb/person/day to 0.6 lb/person per day and that all other materials are reduced, reused, recycled, or composted.

The first scenario presented below captures maximized waste reduction, recycling, and composting only within New York State. Quantification does not include potential increases in recycling and reduction in the disposal of construction and demolition debris, industrial waste, or biosolids.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by dollars per metric ton of carbon dioxide equivalent [$/tCO$_2$e]) for the policy scenarios quantified by the Technical Work Group are presented below.

GHG Reductions (MMtCO$_2$e)		Net Present Value: Cost (Million $)	Net Cost per Avoided Emissions ($/tCO$_2$e)
2030	Total 2011–2030		
0.7	8.0	$280	$35

$/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

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[6] This report is available at http://www.dec.ny.gov/chemical/41831.html.

A second scenario, presented below, quantifies the full energy cycle for maximized waste reduction, recycling, and composting.

GHG Reductions ($MMtCO_2e$)		Net Present Value: Cost (Million $)	Net Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
32	248	$280	$1.0

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Special Considerations

- The potential obstacles to achieving the objectives of this policy include the following:
  - **Political will:** This policy calls for a significant change in how materials are managed in New York. This change will require the engagement of all New Yorkers, including residents, businesses, municipalities, state legislators, and policy makers.
  - **Financial resources:** Significant resources will be needed in the short- to medium-term to achieve the objectives of this plan. Resources include public and private investment capital, as well as operating resources for municipalities and the state. Efforts to expand the resources dedicated to waste reduction, recycling, and composting at the federal, State, and local levels should continue.
  - **Technical constraints:** Achieving these objectives will require the efficient deployment of new and additional recycling technologies, particularly those related to organics recycling and composting.
- The global GHG reduction impacts of achieving these waste and recycling reductions are significant; however, much of that reduction may happen out of state. Most of the GHG emissions that can be reduced through aggressive waste prevention and recycling are achieved through the life cycle of products and packaging; i.e., when a recycled material is substituted for a virgin material, or when a material is not manufactured at all, thereby avoiding the mining, extraction, and much of the production impact. While many of the reductions related to organics recycling and composting would occur in-state, the export of the waste generated by half the state's population (in New York City, and Nassau and Suffolk counties) further complicates the analysis of reductions within the state's boundaries.
- This policy has several additional benefits. This policy could result in substantial opportunities for the creation and expansion of businesses in New York State. DEC estimates that this policy could create more than 70,000 jobs. The jobs and businesses would generate much needed tax revenue for the state. In addition, reducing the amount of waste going to disposal reduces the environmental and public health impacts of waste handling, transfer, transport, and disposal. While such a reduction benefits all New York State communities, it is of particular relevance to environmental justice communities, which often bear a disproportionate burden with respect to the solid waste management facilities and

infrastructure.

INTEGRATED FARM MANAGEMENT PLANNING and APPLICATION (AFW-4)

Policy Summary

This policy option introduces a farm-level system-based integrated approach to reducing agricultural GHG emissions and proactively positions New York State agriculture for a carbon-constrained future. Integrated Farm Management Planning and Application will provide the resources necessary for farms: (1) to develop comprehensive, farm-specific plans to reduce GHG emissions, increase carbon sequestration, and address agricultural adaptation challenges resulting from a changing climate; and (2) to implement the necessary suite of practices to achieve those objectives. This policy adds managing GHGs as an on-farm resource management objective.

The existing New York State Agricultural Environmental Management program, outfitted with technical standards and practices for GHG mitigation and carbon management, could be employed to develop farm-specific, GHG conservation plans to coordinate implementation of the best suite of GHG practices for the farm.

Providing producers with a suite of possible practices to improve on-farm environmental performance ensures that the diversity inherent in New York State agriculture is recognized and that the potential synergies among climate, air quality, and water quality benefits of individual practices and technologies are captured and capitalized upon.

Quantification

The policy scenario includes: (1) by 2013, develop a comprehensive catalog and process for planning and implementing GHG management practices and systems; and (2) by 2015, complete training and certification of conservation professionals to develop site-specific GHG management plans. The scenario for 2030 is 100 percent of mid-sized to large livestock farms have developed and fully implemented comprehensive GHG management plans (835,000 dairy cows and 1,670,000 acres); 30 percent of small livestock farms, 80 percent of grain and vegetable farms, 90 percent of orchards and vineyards, and 100 percent of greenhouses have developed GHG management plans; and 10 percent of small livestock farms, 33 percent of grain and vegetable farms, 10 percent of orchards and vineyards, and 10 percent of greenhouses have fully implemented GHG plans.

This policy option bundles a number of behind-the-farm-gate mitigation practices under the umbrella of a comprehensive GHG management plan. These practices include feed management, manure management, nutrient management, soil management, composting, grazing, pest managemen,t and water efficiency. Metrics and timelines that recognize the size and type of farm have been established for each component practice.

Anaerobic digestion of livestock waste is included under this policy option as it is an integral component of manure management systems.

Soil carbon management practices related to changes in tillage practices were not quantified due to uncertainty of net carbon benefits presented in recent research.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e) for the policy scenario quantified by the Technical Work Group are presented below.

GHG Reductions ($MMtCO_2e$)		Net Present Value: Savings (Million $)	Net Savings per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
0.6	6.5	-$201	-$31

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Negative values represent savings.

Special Considerations

- Quantification of an integrated comprehensive approach on a practice-by-practice basis may not capture the cumulative GHG reductions that may occur.
- Improved soil carbon practices could increase carbon-sequestration gains in the future, but additional research is required.
- These practices have significant water and air quality benefits; therefore, there is an opportunity to leverage additional resources to implement practices.
- There may be an opportunity to use current and future carbon market mechanisms to increase implementation rates.
- As with several of the other AFW policy options, the level of technical capacity and behavior change required to achieve these changes is significant.
- Since this policy is based on development of a Comprehensive Farm-Level GHG Management Plan, this policy works in concert with AFW-1: Production of Sustainable Feedstocks, AFW-6: On-Farm Energy Efficiency and Production of Renewable Energy, AFW-5 Conservation of Open Space, AFW-7 Improved Forest Management, and AFW-3: Waste Reduction. Through these linkages, AFW-4 is secondarily related to components of PSD, RCI, TLU (biomass supply, energy efficiency, and renewable energy, respectively).
- As the primary means of delivering outreach, education, and technical assistance to the agricultural community, this policy is designed to incorporate significant components of adaptation to climate change within individual farm GHG management plans.

ON-FARM ENERGY EFFICIENCY and PRODUCTION of RENEWABLE ENERGY (AFW-6)

Policy Summary

This policy option seeks to achieve meaningful GHG reductions through energy efficiency by employing a coordinated approach that addresses all forms of on-farm energy consumption including embedded energy. These efficiency gains can be realized through a comprehensive energy audit, which is a multi-disciplinary approach to energy-use analysis including equipment, structural, and management related energy use, as well as identification of renewable energy opportunities. Deployment of these energy efficiency measures will require shifts in farm-level management practices.

The agricultural sector's natural capacity (sun, wind, land area, available biomass) to generate energy exceeds its energy demand. This policy also seeks to capitalize on agriculture's ability to produce energy using multiple sources and renewable energy technologies. Included in this policy is recognition that multiple technologies at varying scales can be co-located at individual operations.

As an implementation mechanism it is recommended that a State-level Agricultural Energy Program be established to facilitate energy efficiency and renewable energy efforts at the distributed generation level to achieve this aggressive policy. A sector-specific approach is necessary due to the unique nature of the agricultural sector. One of the challenges in meeting these changes is the diversity of the agricultural sector. The numerous types of operations (the dairy segment alone has multiple production systems each having very different infrastructure requirements) have very specific energy needs and present specific energy efficiency opportunities. The diversity within any given segment of the sector is due to a number of variables including age, location, and size of operation. This is very different from other sectors in which standardization of production and retail sales is the norm. The age of the agricultural building stock and infrastructure alone presents a significant opportunity for energy efficiency improvements.

The second challenge is financing on-farm energy efficiency and renewable energy measures. Farmers operate in very volatile markets with high risk and relatively small returns. Dairy, the primary segment of our agricultural economy, operates in a controlled market (i.e., price of milk is set at the federal level). The ability to invest significant amounts of planning time and capital in energy efficiency and renewable energy measures with rates of return that span multiple years predicated on unknown climatic (e.g., weather, disease, pest) and market forces (e.g., commodity recall unrelated to individual farm) completely outside of the control of individual farms is severely limited. An Agricultural Energy Program would begin to address these challenges. The program would be responsible for coordinating and administering comprehensive energy audits, coordinating efforts to streamline federal and state funding opportunities to maximize energy efficiency and renewable energy implementation as identified in the comprehensive energy audit, coordinating with utilities to facilitate interconnection, offering grant application assistance to interested farmers, tracking implementation and documenting results, supporting and coordinating research efforts related to energy efficiency and renewable energy, and technology improvements required to achieve farm-level carbon efficiency.

Quantification

The policy scenario is a 40 percent fossil-based energy reduction, and quantification assumes 26,778 farms deploying energy efficiency measures. Quantification is based on a limited number of currently available energy efficiency measures for which cost data exist. To achieve the renewable energy deployment for 65 percent of farms (23,660), quantification assumes the mix of generation will be 25 percent wind technology, 30 percent solar thermal technology, and 45 percent solar photovoltaics (PV). Quantification is based on currently available renewable energy technologies for which cost data exist (PV, wind, solar thermal). Quantification is based on the extrapolation of current renewable energy deployment rates for PV and wind. Quantification is sensitive to cost of energy efficiency and renewable energy implementation and the type of technology ultimately deployed.

The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/tCO$_2$e) for the policy scenario quantified by the Technical Work Group are presented below.

GHG Reductions (MMtCO$_2$e)		Net Present Value: Cost (Million $)	Net Cost per Avoided Emissions ($/tCO$_2$e)
2030	Total 2011–2030		
0.4	3.8	$3	$1

$/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

Special Considerations

- This policy builds on existing RPS-Customer-Sited Tier program goals by significantly increasing renewable energy deployment rates after 2015.
- Since anaerobic digestion (AD) is an on-farm management system that influences many other farm management systems, quantification of AD is included under AFW-4.
- There may be significant interconnection and reliability concerns related to the scale of distributed generation in rural areas.
- This policy represents an adaptation strategy regarding heat stress in livestock, which results in decreased milk yields and reproduction rates. Increasing the cooling capacity in livestock housing will increase energy usage. Energy efficiency and renewable energy technologies can mitigate negative impacts resulting from increased energy uses.
- Renewable energy technology requires significant upfront capital investment. It is possible that without coordinated and/or increased state and federal assistance that New York farms will be unable to purchase renewable energy technology on the scale outlined in this policy.
- This policy is cross-cutting with overlap in several areas, including AFW-4, PSD, and RCI. This policy also impacts existing state policies, including RPS, the energy efficiency portfolio standard, and the Regional Greenhouse Gas Initiative.

- This policy provides significant workforce development and community-scale energy opportunities in rural areas.

CONSERVE OPEN SPACE, AGRICULTURAL LAND, and WETLANDS (AFW-5)

Policy Summary

This policy option reduces the rate at which open space, including agricultural lands, forests, and wetlands are converted to developed uses and increases the acreage in open space. Conversion may be prevented through conservation land grants, landowner incentives, regulation, fee acquisition, and purchase of conservation easements by State and local governments, or nonprofit land preservation organizations. Support for agriculture and forest products may reduce the risk of conversion to an undesirable land use.

Quantification

The policy scenario is described as follows:

- Increase New York State agricultural land, as defined by the National Agricultural Statistics Service, 25 percent by 2050 without converting mature forest. Restore 475,000 acres of agricultural land (25 percent of the acreage lost since 1984) by 2020 and restore a total of 950,000 acres of agricultural by 2030. Permanently protect, through the State's Farmland Protection Program, 200,000 acres by 2020 and 400,000 additional acres by 2030 of agricultural land with the highest risk of conversion to higher-carbon intensive uses.
- Maintain or increase forestland acreage, without converting agricultural land to forest, unless the agricultural land would have higher carbon sequestration potential. Extend protections to an additional 700,000 acres of forestland under threat of conversion by 2030 through a number of tools, including private land stewardship programs, working forest conservation easements, and tax incentives. Work to maintain or increase the parcel size of private forestland.
- Protect and restore freshwater and tidal wetlands through acquisition of fee or easement and regulation to prevent releases of GHGs which will allow existing freshwater and tidal wetlands to continue to sequester carbon and mitigate the effects of more intense storm events caused by climate change.

  The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e) for the policy scenario quantified by the Technical Work Group are presented below.

GHG Reductions (MMtCO_2e)		Net Present Value: Savings (Million $)	Net Savings per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011-2030		
5.5	95	$1,500	$16

Special Considerations

Uncertainties

- Price of fee and easements can vary greatly with location of the parcel and the terms of an easement.
- Viability of farm operations is vitally linked to the health of available markets for farm products.
- Ability of agricultural land and forestland to produce current crop species is climate dependant. Shifts in climate may alter the species that can be grown. The flux of sequestered carbon in a shift of plant species is an uncertainty.
- Leakage in the case of forest land protection is a concern because development could still happen on unprotected acres within the state, or could be shifted out-of-state. Connecting this policy with smart growth strategies is of upmost importance to avoid leakage issues.
- Existence of wetlands is dependent on climate and rainfall patterns. If these patterns shift, existing wetlands may disappear and new wetlands may form. The balance of this flux remains uncertain.

Feasibility Issues

- Increasing agricultural land and forest land are not mutually exclusive strategies. Shifts between agricultural and forest land must be evaluated on a case by case basis.
- Funding: Consistent funding is needed to ensure the protection of valuable open space, and agricultural and wetland resources to mitigate and adapt to climate change. A diversity of funding and capacity is needed at all levels of government, federal, State and local, as well as private investment through non-governmental organizations, landowners, and private citizens.
- Local government capacity: New York is a home rule state, and the vast majority of land-use decisions are made at the local level. Capacity building at the local level is necessary to help local governments make good decisions. Many land conservation projects are dependent on local government capacity to fund and complete projects.

Adaptation

- The change in climate will have an impact on some plant species' ability to grow and thrive. Longer growing seasons potentially increase biomass productivity if not limited by drought or nutrients.
- Increased winter rain and increased total runoff could expand some wetlands. Increased summer evaporation will decrease the hydroperiod of some wetlands.
- There is a need for additional riparian corridor protection and restoration to mitigate effects of predicted increase of intensity and duration of storm events, and possible extended periods of drought.
- Connectivity between wildlife habitats will be needed to facilitate climate related migrations.

- The balance among carbon sequestration, adaptation, and other ecosystem services must be examined.

Co-benefits

- Co-benefits include water quality protection, flood mitigation through riparian buffers, wetlands and storm water retention, clean air and reduced pollutants, improved quality of life, wildlife habitat protection and connectivity for migration and adaptation, and avoided additional costs of sprawling development.

Environmental Justice

- Lack of open space, waterfront access, stormwater management, and the destruction of wetlands are significant environmental justice concerns for many overburdened and low-income communities. Many of the specific proposed actions in this policy area could help to address one or more of these concerns in such communities.

IMPROVED FOREST MANAGEMENT for CARBON BENEFITS (AFW-7)

Policy Summary

This policy option seeks to develop a renewed and improved stewardship ethic among decision makers that control rural forest lands and existing and potential urban planting spaces. Through a wide variety of incentives, education, and technical assistance and support, both proven and innovative practices could be applied to New York's forests and urban areas to sequester additional carbon, save energy, and, at the same time, supply New Yorkers with additional and improved co-benefits supplied by improved forest management and green infrastructure related practices.

Policy actions will be led by developing and implementing a system for identifying recently unmanaged or neglected and degraded forest lands that are not stocked with trees to full potential. A similar system will be developed for identifying vacant rural land that is unsuitable for agriculture but suitable for reforestation with native trees.

Subsequent actions include the following:

- Using various methods for forest management, site preparation, and wildlife management allow for natural regeneration of trees at appropriate levels for optimum stocking levels;
- Developing forest management plans and applying methods and technologies that increase overall forest productivity, heath, and benefits while increasing the rate and levels of carbon sequestration in trees, soil, and durable wood products;
- Increasing forest cover and associated carbon stocks by planting native tree species on vacant lands that are unsuitable for agricultural use; after establishment, employing forestry practices that maintain and enhance the ability of the forest to sequester carbon and provide forest related benefits;

- Maintaining and improving the health and longevity of existing trees in urban settings and increasing tree cover area by planting new trees;
- Developing and supporting prevention, early detection, and rapid response programs that prevent invasive and destructive forest pests and mitigate or eradicate the impacts of current or future introductions that threaten forest carbon stores.

Quantification

Three scenarios were quantified under this policy option. The GHG reduction potential, total cost or savings (as measured by net present value), and cost effectiveness (as measured by $/t$CO_2$e) for the policy scenarios quantified by the Technical Work Group are presented below.

1. Identify and treat 25 percent of all under-stocked forest stands on timberland by 2025 in order to achieve full stocking level.

GHG Reductions (MMtCO_2e)		Net Present Value: Cost (Million $)	Net Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
4.7	49	$290	$6.0

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

2. Increase tree canopy cover in cities, villages, or hamlets by 50 percent by 2030.

GHG Reductions (MMtCO_2e)		Net Present Value: Cost (Million $)	Net Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
2.0	22	$3,200	$140

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

3. Identify and reforest 50 percent of all suitable vacant idle land in the state by 2025.

GHG Reductions (MMtCO_2e)		Net Present Value: Cost (Million $)	Net Cost per Avoided Emissions ($/t$CO_2$e)
2030	Total 2011–2030		
2.4	34	$1,200	$36

$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Special Considerations

- The establishment of new forests by planting native trees on vacant land conflicts with the establishment of dedicated energy crops on vacant land proposed in AFW-1. In addition, overlap exists with the AFW-1 proposal to identify vacant lands suitable for tree planting.

- Improving forest management practices in rural forests for carbon sequestration and other benefits is a challenging proposition for a number of reasons. For example, goals and objectives of owners for their forests may require management that does not take into account societal benefits that accrue from improved carbon management. In addition, the long-term nature of forest growth and the extended timeframe of revenues from timber harvesting provide challenges such as investment of capital or willingness to accept opportunity costs needed to improve forest growth and benefits.

INCREASE THE AVAILABILITY OF LOCALLY PRODUCED FOOD (AFW-8)

Policy Summary

Increasing the availability of locally produced foods to New York State residents can reduce the energy required for transportation, packaging, and marketing; enhance rural economic development; improve health and nutrition; and increase food security and food safety. However, for this small but growing share of U.S. agricultural production there remains a lack of empirical evidence to definitively support the claims of GHG reductions associated with local foods. Recently the U.S. Department of Agriculture Economic Research Service (ERS) released a comprehensive literature review of the current understanding of local food systems.[7] The study had the following key findings:

- Local food markets account for a small but growing share of total U.S. agricultural sales.
- Production of locally marketed food is more likely to occur on small farms located in or near metropolitan counties.
- Consumers who value high-quality foods produced with low environmental impact are willing to pay more for locally produced food
- Empirical research has found that expanding local food systems in a community can increase employment and income in that community.

Although much research remains to be completed on the direct reduction of GHGs resulting from local foods, this policy option promoting increasing the availability of local foods is complementary to several other GHG mitigation policy options, including AFW-5 and TLU-11 by encouraging an alternative land use to development in those areas experiencing the greatest land-use conversion pressure; TLU-10 by enhancing local open space conservation efforts; and AFW-3 by encouraging minimal processing and packaging of locally produced food. Direct to consumer sales also provide producers with a higher rate of return, which further reduces the rate

[7] Martinez, Steve, et al. *Local Food Systems: Concepts, Impacts, and Issues,* ERR 97, U.S. Department of Agriculture, Economic Research Service, May 2010.

of land conversion to developed uses and better positions producers to cope with potentially costly adaptation strategies.

Building on the work of the New York State Council on Food Policy this policy option seeks to employ a multi-faceted approach to increase the availability of locally produced food to New York State consumers.

Quantification

This policy option is currently not quantifiable.

Since this is an emerging field of research it is fully expected that in the future, as additional empirical studies are completed, it will be possible to quantify GHG reductions for this policy.

Special Considerations

- Several of the proposed policy initiatives involve significant levels of federal funding and subsidies including food assistance programs and school meal programs. State policies that encourage or incentivize local foods within these programs must be consistent with federal policies.
- Technical: Currently New York-specific data quantifying food miles traveled and the resulting benefits have not been thoroughly studied. Additionally, it must be recognized that food-mile reductions must be assessed on a product-by-product basis that includes life-cycle analyses of the numerous crop specific inputs and concomitant production methods.
- Financial: In the short term, increased public funds will be needed to expand existing direct marketing programs; this may be somewhat problematic during austere budget times regardless of the benefits.
- Political support: According to a recent Cornell University survey "Imported food is a concern for 72.6 percent of shoppers surveyed and "Local" is sought by almost 70 percent of shoppers."

RESEARCH, DEVELOPMENT, AND DEMONSTRATION NEEDS FOR THE AGRICULTURE, FORESTRY, AND WASTE SECTOR (AFW-9)

See Chapter 10 for a complete presentation of Research, Development, and Demonstration needs for this sector.

Chapter 10
Research and Development Needs for a Low-Carbon Future

Introduction

The New York State goal to reduce greenhouse gas (GHG) emissions to 80 percent below 1990 levels by 2050 (80 by 50) may not be achievable in a politically and socially acceptable manner with the suite of energy technologies commercially available today. New York's Climate Action Plan must include a commitment to support research, development, and demonstration (RD&D) in partnership with the federal government and the private sector, to ensure that cost-effective technologies and practices are developed to mitigate climate change impacts and promote the economic strength of local businesses. Statewide RD&D investments, across all economic sectors, must be targeted to provide direct benefits for New York companies.

A long-term RD&D investment strategy is needed to begin the process of improving the local economy and reduce New York's GHG emissions. The two issues are linked and complementary. The subsequent development of this investment strategy represents a critical follow-on task that will build upon the high-level recommendations presented in this chapter and include broad stakeholder input across all economic sectors in New York State. The investment strategy will further define New York's technological strengths, establish multi-disciplinary collaborative teams between universities and industry, and identify all opportunities to further leverage limited in-state resources with federal and private sector funds.

A recent quote from Jeffrey Sachs, director of the Earth Institute at Columbia University, emphasizes the importance of innovation in the energy sector and the need for additional RD&D investment:

> "If we try to restrain greenhouse gas emissions without a fundamentally new set of technologies, we will end up stifling economic growth. We need to develop radically advanced low carbon technologies, which can only come about with greatly increased spending by determined governments on what has so far been an anemic commitment to RD&D."[1]

This Interim Report provides a high-level overview of the RD&D needs within the mitigation sectors, identifies technology areas where New York can best leverage its investments and capabilities to benefit local businesses, and presents "order-of-magnitude" funding estimates necessary to support the innovation ecosystem to advance low-carbon technologies. It is expected that any future state-funded RD&D program established to support the implementation of New York's 80 by 50 goal would be managed by a broad array of public stakeholders throughout the State—with active private sector involvement.

It is important to note that New York State cannot support the entire technology development process (basic research, technology development, large-scale demonstration, commercial adoption) on its own. A clear role must be established for the federal government and the private

[1] New York Times. April 6, 2008

sector that efficiently optimizes limited resources, appropriately assigns technical and business risk, and ensures a consistent and stable flow of investment capital to finance advanced energy technologies. Any State-level investment strategy must function as an advocacy tool to drive national RD&D energy policy and leverage private-sector RD&D investments.

Overarching Principles

Developing a comprehensive RD&D strategy that cost-effectively reduces GHG emissions across all sectors of the economy is a complex task that requires a coordinated effort among all stakeholders. It is essential to recognize that a technology solution implemented in one sector may impact another. For example, if plug-in hybrid electric vehicles (TLU sector) outfitted with vehicle-to-grid capability achieve widespread market penetration, then these mobile electric energy storage systems may obviate the need for larger stationary storage systems (PSD sector) such as flow batteries and flywheels. A systems approach will be necessary that includes technical/business experts across all disciplines and sectors in order to ensure that RD&D investments yield optimized results. A set of seven overarching principles will be used to guide the RD&D program to maximize effectiveness[2]:

- There must be ample and sustained support for early-stage research and exploratory development.
- The research program must be managed to ensure that it encompasses the full range of energy challenges from supply to production to distribution to end-use.
- The research program must span the spectrum from early-stage research to later-stage demonstration, and therefore, there should be an intimate relationship between setting policy and designing programs to stimulate innovation.
- The decision-making process must be integrated so that factors of cost, technical performance, and environmental impact are factored in at every stage of development.
- A multi-year plan must establish a role for governments, industry, universities, and laboratories.
- All later-stage demonstration projects must be carried out on as close to commercial terms as possible in order to provide the private sector with the information it needs to make large investments in new energy technologies.
- There is an opportunity for substantial international participation in selected energy R&D projects, and all energy initiatives must develop technologies that are attractive not only to U.S. companies but to foreign countries and investors as well.

State-level RD&D investments will help New York businesses institute technology development processes consistent with these principles in order to increase the pace of innovation and improve the success rate of commercially viable low-carbon products and services.

[2] The Center for American Progress. *A New Strategy to Spur Energy Innovation*. January 2008. Peter Ogden, John Podesta, and John Duetch.

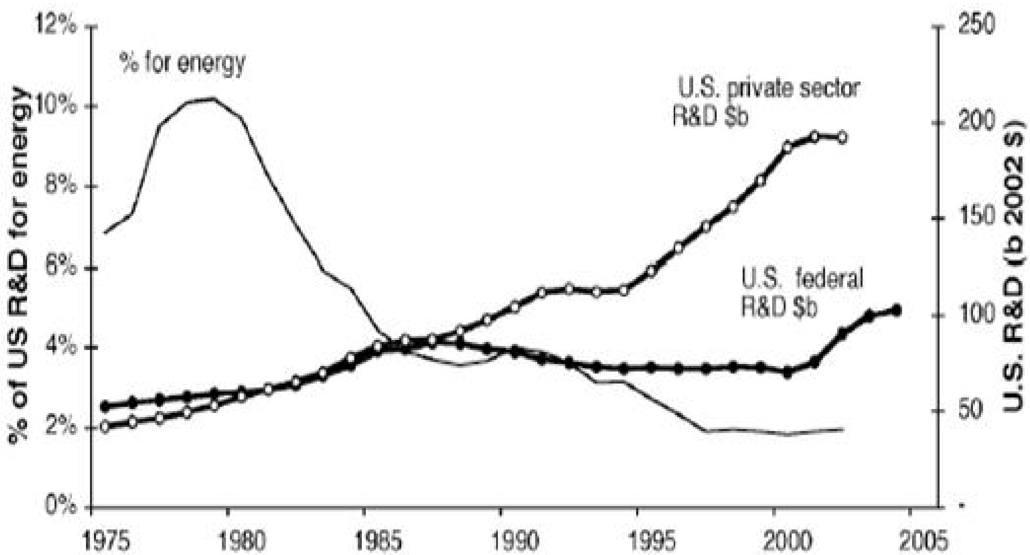
National Energy RD&D Perspective

Past

Energy RD&D funding peaked in 1980 at 10 percent of total U.S. RD&D spending (both private and public) across all sectors of the economy (Figure 10-1). The precipitous reduction in energy RD&D spending after 1980 correlates with the decline in global oil prices following the Iran/Iraq War. Energy RD&D spending leveled off in 1985 to approximately 4 percent of total U.S. RD&D expenditures until the electric power industry was de-regulated in many parts of the country in the mid/late 1990s and oil prices plummeted further to new historic lows. Energy RD&D funding has remained fairly level over the past decade and currently represents less than 2 percent of all U.S. RD&D funding.

It is worth noting that since the establishment of the U.S. Department of Energy (DOE) in 1977, private sector energy RD&D (including large corporations and venture capital) investment has never exceeded public funding levels. This is symptomatic of a fundamental problem and reinforces the notion that 1) existing markets do not provide a sufficient return on investment to warrant adequate private investment in energy RD&D, and 2) substantial benefits accrue to society in general rather than to any specific industry segment or individual corporation.

Figure 10-1. Historical U.S. RD&D Expenditures[3]



Present

Current (fiscal year 2010) annual federal energy RD&D spending is approximately $5 billion, excluding recent one-shot initiatives funded under the American Recovery and Reinvestment Act (ARRA). Corresponding private sector investment in the U.S. is $3 billion annually. This ratio (0.6:1) of private to public energy RD&D expenditures is significantly lower than other

[3] Elsevier: Energy Policy. *U.S. Energy R&D: Declining Investment, Increasing Need, and the Feasibility of Expansion*. February 2006. Greg Nemet and Daniel Kammen

sectors—specifically in comparison to the healthcare and defense industries, which maintain an equivalent ratio of 2:1 and account for the vast majority of public RD&D funding. A comprehensive national energy policy must be established that adequately encourages greater private sector participation. A tangible metric for gauging the success of any given federal policy may be to measure over time whether the private-to-public energy RD&D investment ratio steadily climbs from 0.6:1 to 2:1. Although not a sole diagnostic, monitoring this ratio may yield valuable insights.

U.S. energy companies, on average, spend 0.23% of total revenues on RD&D. This is in stark contrast to other industries that invest on average 2.6% of revenues back into RD&D.[4] Some more innovative industries such as IT and pharmaceutical companies invest closer to 15 percent of their revenues in RD&D. Over the long-term this lack of revenue re-investment undermines the competitive position and innovative rigor of the U.S. energy industry.

What is the appropriate level of federal energy RD&D investment to effectively address climate change? Many research studies have focused on this question over the past decade. A report by Robert Schock[5] presents a unique methodology for determining appropriate energy RD&D levels by calculating its insurance value to mitigate four significant risk factors—oil price shocks, electricity supply disruptions, local air quality, and climate change. Each issue is independently analyzed to reveal separate price points or premiums for the four risk factors. The results suggest that a three to seven-fold increase in federal energy RD&D spending is warranted to insure against the potential impacts of climate change alone. Taking the average (five-fold increase in RD&D funding) of this range translates to an annual federal energy RD&D budget of $25 billion (5 X $5 billion). This level of funding is commensurate with commitments to other grand challenges that the U.S has supported over the years (Apollo Mission, Manhattan Project). New York's portion of these federal funds could be as high as $1.5 to $2.0 billion annually (New York represents 6.5% of U.S. total population).

Federal energy RD&D funds should be directed toward low-carbon initiatives that cannot be adequately addressed by state governments and the private sector. These include high-risk/high-cost areas focused on the development and deployment of nuclear energy systems and carbon capture and sequestration technologies as two primary examples. Additionally, the federal government must continue to support basic scientific research and first-of-a-kind large-scale commercial demonstration projects, which require significant capital investment.

State Energy RD&D Perspective

New York State's annual energy RD&D expenditure is approximately $50 million and this supports a broad array of initiatives across all sectors. These energy RD&D funds are managed by a number of state entities including the investor-owned utilities and have traditionally leveraged an additional $150 million in cost sharing. By comparison, California invests roughly $100 million annually in energy RD&D, also with substantial leveraging.

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[4] Institute of Electrical and Electronics Engineers (IEEE). IEEE Spectrum Top 100 R&D Spenders. S&P Data2006.

[5] Annual Review: Energy and Environment. *How Much is Energy R&D Worth as Insurance*? Robert Schock 1999.

New York State recognizes the need to continue support for long-term energy RD&D to create our clean energy economy. The first step in formalizing this commitment occurred when New York established the Regional Greenhouse Gas Initiative (RGGI) and successfully encouraged neighboring states in the northeast to adopt GHG emissions targets for large-scale electric power plants. New York further developed an Operating Plan, which detailed how auction proceeds resulting from the RGGI cap and trade program were to be used to reduce carbon emissions across all economic sectors.

The Operating Plan included a total annual budget of $100 million. Funds were allocated to support both short-term mitigative initiatives and longer-term R,D&D initiatives that reduce carbon dioxide emissions. Total annual long-term RD&D investments amount to $28.5 million and reinforce the fact that a significant portion of the funds must support the continued development of advanced technologies. The RGGI RD&D program targeted the four mitigation sectors (RCI, PSD, TLU, and AFW) plus cross-cutting research.

The targets established under the RGGI program require the electric power sector (PSD) to reduce aggregate GHG emissions by 10 percent by 2018. This pales in comparison to challenges associated with attaining the economy-wide 80 by 50 goal. An order-of-magnitude increase in RD&D funding, beyond that outlined in the RGGI Operating Plan; i.e., closer to $250 million per year, may be necessary in order to achieve New York's more stringent 2050 GHG reduction goal. This level is consistent with preliminary estimates of specific research needs in New York within the four sectors identified below. This estimate will be developed further in the Final Climate Action Plan.

New York RD&D funds would be specifically targeted towards helping local businesses develop low carbon technologies. This level of State funding must be integrated with a comprehensive long-term economic development strategy to diversify New York's economy. Total current annual energy expenditures (across all sectors and all fuels) in New York sum to approximately $80 billion. A $250 million energy RD&D cost therefore represents 0.3% of total statewide energy expenditures. Relevant State agencies and the electric utilities would be responsible for administering these funds in a coordinated manner that specifically builds on the technical capabilities of New York businesses and optimizes all local economic development opportunities.

It is assumed that continued environmental research (including climate change adaptation planning) and business develop initiatives (technology incubators, proof of concept centers, etc.) would be an integral component of each sector's overall RD&D implementation plan. Specific and tangible benchmarks for technological, business, and environmental performance must be considered throughout the entire innovation process—from basic research through commercial adoption.

RD&D Program Implementation

The formation of a statewide RD&D Advisory Council (Council) will be necessary in order to effectively manage expenditures across all sectors in a manner that optimizes collective value. Representatives from each mitigation sector (RCI, TLU, PSD, and AFW) will serve on the Council. The first task will be to define a technology development framework consistent with New York's carbon mitigation abatement curve (the development of this abatement curve is currently underway). Specific RD&D initiatives will be prioritized and sequenced in an effort to systematically build on previous investments and carbon reductions in the most cost-effective manner.

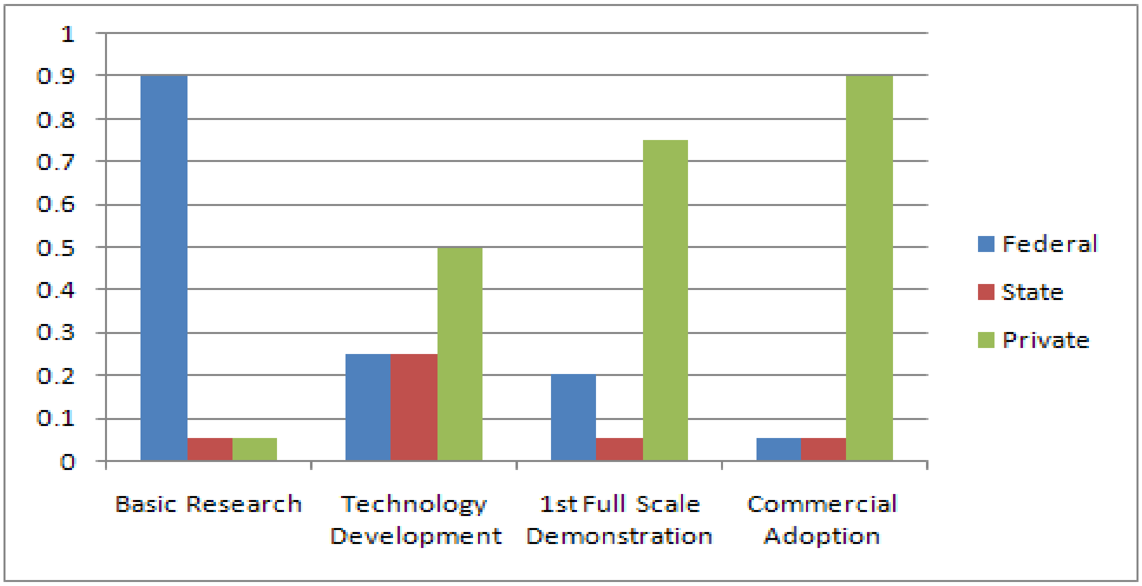
Although the Council will map out a high-level coordinated statewide strategy, the individual sectors will be responsible for establishing multidisciplinary teams (including representatives from industry, academia, government and the investment community) to execute specific carbon reduction projects. Technology, environmental, and business milestones will be established before a project is started in order to provide tangible benchmarks for gauging performance along the way. Projects failing to meet pre-determined targets will be quickly abandoned and RD&D funds will be allocated to other more promising areas within the sector. Federal and private sector financial commitments to support a project throughout the entire innovation process—assuming successful completion of all milestones—will be required before State funds are assigned to the project.

The specific roles of the federal/State governments and the private sector may vary depending on the type of project pursued. However, Figure 10-2 illustrates a reasonable template as to the level of commitment necessary from all three parties (federal, State, and private sector) for the vast majority of initiatives. The technology innovation process is broken down into four steps: basic research, technology development, technology demonstration at scale, and commercial adoption. A more granular breakdown is certainly possible, but these categories are used to simply illustrate a common pattern.

The chart clearly illustrates a waning level of federal funds coupled with a concurrent waxing of private sector investment as the technology moves closer towards commercial adoption. This result is to be expected and is governed by the reduced level of technical and business risk as a given technology matures.

What is less clear from Figure 10-2 is the underlying nature of the State's role within this continuum. This deserves more detailed scrutiny because the role varies substantially from one step to the next. The main objective, however, is to spend the minimum amount necessary in order exploit any/all opportunities for New York businesses that reveal themselves along the way.

Figure 10-2. Apportionment of Funding Levels throughout the Innovation Chain



A brief description of New York State's role in each step follows.

Step 1—Basic Research

State funds are predominantly used to increase the competitive performance of proposals submitted by New York universities and companies to federal agencies seeking very high leveraging, typically more than 10:1. State support can provide significant value and has recently demonstrated successful results yielding five Energy Frontier Research Centers (EFRCs) and a variety of Advanced Research Projects Administration—Energy (ARPA-E) grants in New York through DOE.

Step 2—Technology Development

States can play a critical and potentially game changing role at this point in the innovation process where the so called Valley of Death often presents a virtually insurmountable obstacle. This area requires significant State investment to assist New York companies with a wide array of risk-sharing and technology and business development support. This can then position the company for subsequent private sector investment.

Step 3—Technology Demonstration (Full Scale)

This is a very expensive step (often referred to as the Mountain of Death) and limited State resources cannot be expected to carry the high capital costs associated with large-scale technology demonstrations. The State should participate at a minimum level to gain access to important technical information that may be useful for New York businesses in a strategic position to supply value-added parts/components/services associated with the technology. The State should also begin the development of innovative policies that reinforce, streamline, and accelerate ultimate commercial adoption.

Step 4—Commercial Adoption

The commercial adoption step provides an opportunity for states to exploit potential work force development and training opportunities resulting from widespread technology market penetration. This may at first blush seem outside the realm of RD&D activities, but the initial mobilization of qualified engineers, scientists, technicians, and service personnel can require innovative training methods and catered instruction techniques developed in partnership with a variety of New York academic institutions.

The RD&D program needed to achieve the 80 by 50 GHG reduction goal only works when federal, State, and private-sector organizations collaborate. Risk profiles need to be fully understood and costs equitably allocated to promote innovation. In the long-term, a private to public energy RD&D funding ratio exceeding 2:1 will be necessary to ensure continued development and market introductions of innovative low-carbon technologies. This will take some time to achieve. The adoption of a national climate and energy policy is critical to promoting long-term and sustainable levels of private sector RD&D investment within the energy sector.

Descriptions of the RD&D strategy for each of the four mitigation sectors are provided in the following sections. Adaptation related RD&D needs are presented in Chapter 11.

Residential, Commercial/Institutional, and Industrial (RCI) Sector RD&D Needs

Overview

Buildings account for 40 percent of the state's energy use and a similar percentage of GHG emissions. Emissions associated with buildings and appliances are projected to grow significantly yet according to the Brookhaven National Laboratory[6] net carbon emission from this sector needs to approach zero by mid-century to achieve New York's 80 by 50 target. The industrial sector is a heavy consumer of fossil fuels for process heating in manufacturing, and while this sector can improve its efficiency substantially, this sector will likely account for a sizable portion of the total economy-wide GHG emissions in New York under 80 by 50.

RD&D funds are needed to advance low- and zero-carbon energy technologies in buildings and industry. Research for all building types should focus on more energy-efficient designs for new construction and retrofit technologies for existing facilities, elimination of fossil fuel use, increased use of on-site renewable energy, and human factors that influence operating modes. For the industrial manufacturing sectors, RD&D should focus on new products and processes that reduce the carbon intensity of the industrial sector.

Cost effective and easily implementable advances in energy technologies are needed to raise building performance levels far beyond today's best practices and available technologies. Present best practices and commercially available technologies for residential and non-residential new

[6] BNL; *Envisioning a Low-Carbon 2050 for New York State*; A White Paper submitted to the Climate Action Council. Stokes and Looney. March 2010.

construction energy efficiency programs typically only attempt to achieve 20—30 percent energy savings. Nearly all buildings are subject to financial decisions that favor property market values over reductions in energy costs therefore technologies need to be exceptionally robust in terms of return on investment. Building design, production, and warranty are performed by different entities, as compared to other mass-produced goods, and require substantial external impetus and coordination of RD&D activities to cost effectively achieve the performance necessary for a low carbon economy.

Equally challenging are the efforts to reduce energy use by improving the fabrication methods used by New York manufacturers. Typically manufacturers are reluctant to change their established fabrication methods without clear and significant financial benefits, or without government regulations. It is true that manufacturers are often very interested in reducing the energy content of their product, which will reduce GHG emissions. However, as manufacturers' financial resources are currently stretched so thin that they struggle to remain viable, few manufacturers have the capital to invest in the engineering and equipment resources to research, adopt, and implement emerging processes and products that would reduce GHG emissions.

Additionally, energy-efficiency technology developed in a laboratory may require innovative fabrication methods for its mass production. Such new fabrication methods can require significant financial capital to develop. Without sufficient financial capital, a proven technology's entry into the market may be delayed or prevented because it cannot be produced.

Program Design

The State should support RD&D activities that result in the advancement and commercialization of clean energy and energy efficient products, services, and production methods for buildings and industry. The State should strategically bridge gaps between federally supported basic research and market-driven private interests, avoiding redundancy and inadequacies. The RD&D strategy must be inclusive of near, middle, and long term elements and recognize those aspects of RD&D that are best accomplished at the national, regional, or State level. State RD&D investments in RCI should seek to achieve the following objectives:

- Develop technologies that have the potential to increase energy efficiency and/or reduce GHG emissions of the magnitudes necessary for accomplishment of 80 by 50 goals;
- Prioritize technology goals to increase efficiency, eliminate use of fossil fuels, and promote use of on-site renewable energy sources;
- Prioritize technology development that is relevant to new and existing building stock and industrial capacity in New York State;
- Prioritize high-performance incremental and new technology in the context of near, medium and long term implementation;
- Prioritize technology development according to market-based value propositions;
- Establish concurrent requirements to enable path-to-market; provide support for manufacturing capacity development; increase consumer acceptance and education; and coordinate government policy (codes, standards, regulation, deployment);
- Utilize public, university; and private partnerships where appropriate.

Federal Role

The primary research role of the federal government in RCI is to support basic energy research to advance net zero-energy-use buildings, including development of new materials, new heating and cooling processes, and low-density energy scavenging devices. For the industrial sector, necessary federal efforts should include research for advanced materials, materials processing, and electro-technologies that replace traditional thermal processes. The federal government should also continue to co-fund some near-term research activities (e.g., demonstrations) and medium-term activities located at regional building science and industry application centers.

State Role

Demonstrating advanced building and industry technologies at New York locations to accelerate local adoption and help New York companies gain a strategic advantage is an important role for State government. This research can best be accomplished at a regional level to address the unique building stock, climate conditions, construction practices, and industrial activities at the local level. Demonstration and evaluation of whole building systems will be critical to advancing net zero-energy buildings. As we attempt to ramp up building performance, understanding the human interface will also be critical. The State should also continue to support various building science and industry application consortia in New York and facilitate university and industry collaborations. Examples of successful research collaborations include lighting technologies with the Lighting Research Center at Rensselaer Polytechnic Institute, Building and Energy Systems at Syracuse University, and materials work with the Center for Advanced Material Processing at Clarkson University. Funding research in precision measurement and controls, robotics, and sensors could help New York's industrial sector to reduce its energy footprint.

Private Role

Many smaller and mid-sized corporations will need to participate as partners in demonstration projects for innovative building and industrial technologies to advance. Large corporations, which have the resources and talent pool to make major advances in technology, will need to continue to make substantial investments in energy research (e.g., GE Global Research, IBM, Corning, and Kodak). Utilities will likely need to be more involved in demonstrations of advanced buildings systems, which will increasingly need to have two-way communications and smart-grid interfaces.

Target Areas

The development period to commercialize a new technology and apply an existing one can be long. This delay is often the result of start-up companies lacking the business skills to advance a technology from the R&D phase to the commercialization phase, or of mature companies unaware of potential partnering opportunities. Mechanisms need to be developed to provide start-up companies with executive level mentoring and management advice to help them make the jump between these stages. For buildings, RD&D target areas could include improved building envelopes to reduce heating and cooling loads, down sized mechanical systems that are more efficient, advanced controls for building optimization, and increased plug load efficiency. Projects might also include the use of dual function elements, which provide either power generation or increased energy efficiency in additional to a conventional purpose. Examples include windows with embedded photovoltaic (PV) elements or thin films that generate electricity when sunlight strikes them, or membrane roofing materials with PV films incorporated in the layers. In both of these cases the PV systems replace conventional building products, reducing the additional overall cost to the developer or owner. Additionally, projects can include innovative design and construction processes that contribute to a carbon-neutral or negative building.

Additional examples of possibly supported building technologies and systems include the following:

- Innovative energy storage systems,
- Building-scale renewables,
- MicroCHP,
- Active power management,
- Smart grid,
- Energy-efficient building envelope technologies,
- Breakthrough light emitting diode lighting products,
- Consumer behavior modification,
- Whole building system design.

Industrial sector RD&D investments could include advanced heating processes, methods that reduce fossil fuel usage for thermal destruction of byproducts, new heat recovery approaches, and novel cost-effective applications of combined heat and power technologies. Additional examples of possibly supported industrial technologies include the following as examples:

- Microwave sintering of ceramics,
- UV curing that eliminates the need for VOCs and energy intensive thermal oxidizers used to destroy them,
- Electron-beam curing of coatings,
- RF and induction heating.

For industry, examples of product improvement projects include:

- Lower energy content of products,
- Reduced scrap and emissions,
- Use of green and organic materials ,
- Increase use of life-cycle assessment based concepts in product designs.

Other Considerations

The time frame to develop a new technology from an initial concept to its final design is frequently five to ten years. Compounding this factor is that the construction industry is very risk adverse, and therefore slow to adopt new technologies. An additional 5 to 10 years frequently passes from when a new technology enters the market to it becoming standard practice in this industry. Similarly, consulting engineering practices that offer process design services to industrial clients are very risk averse, and therefore slow to recommend new fabrication methods. To have new technology ready to assist in achieving 80 by 50 goals during the 2020 to 2030 timeframe, their development must start now.

The RD&D activities required to achieve the climate change goals need to start as soon as possible so that their benefits can be accrued quickly and avoid unnecessary GHG emissions in the mid- and long-term horizons.

Transportation and Land Use (TLU) Sector RD&D Needs

Overview

Twenty years ago the transportation options such as lithium–ion batteries and fuel cells, which we now believe will play a key role in our ability to meeting our GHG reduction targets, did not exist. These technologies supported by public RD&D investment are just now showing the potential performance needed to achieve the performance and cost targets necessary meet 2030 goals. RD&D in yet additional transportation options over the next several decades will be needed to achieve our 2050 goals. Public policy must provide increased support for research, development and demonstration of technologies, products, and business models that create these new options and accelerate their adoption. RD&D investments within the State and region provide both immediate and long term economic benefits enabling the level of prosperity necessary to fund continued improvements. Public RD&D investment will be needed in: vehicle technology, low carbon fuels and infrastructure, public transit, transportation systems, and demand management technologies and innovations.

It took 15 years from the time of initial development and demonstration for hybrid–electric vehicles to achieve a 4 percent market penetration rate. The products and technologies we have in the market today are not capable of delivering the level of efficiency improvements needed to achieve our GHG reduction goals. Technology development, demonstration, and validation cycles must be accelerated to deliver market introduction of new options that will play pivotal roles in achieving GHG reduction goals.

Creating the clean energy economy will require a multi-faceted approach, including increased use of alternative fuels, significant improvements in the energy efficiency of the vehicle fleet, improving the performance and efficiency of public transit, and reducing trips and vehicle miles traveled (VMT) through changes in travel habits and land management. RD&D investments that support accelerated, validation, and utilization of GHG reduction technologies and approaches are called for in all of these areas.

Program Design

The goal of public investment in transportation RD&D is to develop, demonstrate, and validate new innovative transportation options, stocking the shelves with better products accelerating progress towards meeting GHG reduction targets at lower overall cost. The investment must promote new discoveries that will allow us to achieve our long term goals, demonstration of emerging technologies to validate practicality and benefits, and pilot programs that seed the market and accelerate the introduction of new options. Advancements are needed in all areas, from basic research into new battery chemistries, innovations in public transit technology and performance, new products, and business models that enable electric vehicle charging or on-demand public transit. As noted above, the RD&D investment strategy must be inclusive of near, mid, and long term elements and recognize those aspects of RD&D that are best accomplished at a national, regional, or State level.

Federal Role

Light-duty vehicles (LDV) are produced on a global scale and it is primarily through influencing vehicle standards that states influence LDV research efforts. In the United States, only the federal government and California are allowed to set vehicle emission standards. New York has elected to adopt California standards. State-funded research can support vehicle components manufactured locally and result in a significant positive contribution to state gross domestic product.

Similarly, Federal support of long-term and high-risk basic research such as fuel cell and new battery chemistries is critical to the technology advancements and cost reduction necessary to achieve 2050 goals. This Federally funded research will generally be done at competitively selected research, academic, and industrial centers. States have an opportunity to influence the choices through their own research investments and support of clusters of organizational expertise in these clean tech growth areas.

The U.S. Department of Transportation (DOT), U.S. Environmental Protection agency (EPA), and DOE all support transportation research through the Transportation Research Board (TRB), as well as programs run through Federal Highway Administration, Federal Transit Administration, Federal Rail Administration, Federal Maritime Administration, and the Federal Aviation Administration. In general the federal programs address issues based on national priorities. New York's transportation system components are unlike the rest of the country. No other state approaches our commuter rail and subway system in terms of passenger trips or physical size, or New York's public transit bus operations, taxi fleets, or commercial delivery truck fleets. Federal research programs often do not fund the research needed to improve components these transportation system components.

Federal parties include: DOE, DOT, National Institute of Standards and Technology (NIST), National Labs, ARPA-E, and TRB.

State, Regional, and Local Roles

State, regional, and locally supported research plays a key role in addressing specific needs not adequately addressed by federal programs. Examples of high-impact State-supported RD&D include the development of heavy-duty hybrid–electric drives for transit busses, and energy storage products designed to capture train braking energy in electrified rail and subway applications. Stat- supported RD&D in these areas has and is developing products that are providing huge energy efficiency benefits to New York and creating jobs for New Yorker's manufacturing products that are being sold to the rest of the country.

State, regional, and local RD&D is also validating the benefits of new technologies and approaches prior to transportation agencies making major commitments. Newly emerged and unproven products and approaches involve risk both technical and financial. Few transportation operations can allocate resources to unproven endeavors. State and local RD&D funding helps minimize the risk associated with testing, demonstrating, and validating new products and ideas and in disseminating information on the cost and performance of the demonstration to other potential beneficiaries.

Examples of State, regional, and local RD&D efforts that have helped inform public policy decisions include: anti-diesel idling technologies such as fuel fired heaters and hybrid refrigeration systems, traffic light signal controls, high speed commercial vehicle inspection technology, car sharing, and van pool pilot program demonstration. Current projects in short sea shipping, aviation departure optimization, off-peak utilization of subway assets, and commercial goods movement show potential for significant GHG reductions. To achieve our clean economy goals, the rate at which new options such are developed and validated must be accelerated through RD&D programs that select sponsored efforts based on merit, mitigate risk, provide creditable third party evaluation of performance, and disseminate the results via technology transfer programs.

State, regional, local parties include: state DOTs, Metropolitan Transportation Authority, Port Authority of New York and New Jersey (PANYNJ), New York State Energy Research and Development Authority (NYSERDA), regional transit properties, metropolitan planning organizations, New York City Department of Transportation (NYCDOT), municipal governments, academic institutions, private-sector service and product suppliers.

Private Sector Role

State RD&D should promote clusters of technical expertise that develop innovative products and services, create jobs, and produce innovative solutions to New York problems. Helping private firms minimize the technical and financial risk inherent to research activities provides public benefits. Once technical risk or profitability risk is reduced, it is the role of the private sector to complete development and commercialize the advancement.

Public funding alone is not always adequate to entice private investment and sometimes public and private funding must be combined to reduce risk and accelerate development. Examples of such cooperative successes in New York include: support of applied research in fuel cell technology, batteries, and materials research with programs, such as the New York Battery and Energy Storage Consortium (NY-BEST), which has catalyzed a cluster of expertise and attracted outside investment developing next generation energy storage technology; programs supporting developing products for heavy duty vehicle original equipment manufacturers, as well as aftermarket and repower suppliers; improving the efficiency of electrified rail and subway systems; support of intelligent transportation systems, transportation system management, and transportation demand management technology development; and the creation of service providers offering hardware, software, and operation that enable VMT reduction and system level efficiency improvements.

Demonstration and assessment of newly emerged products, services, and approaches is an important role for State and local RD&D and frequently the final step in verifying to the private sector that their continued investment is warranted. In well designed research programs, cost to benefit ratios, and best practices can be determined even in areas where cause and effect can be difficult to assess and benefits difficult to quantify such as eco-driving education programs, some DSM measures and ITS technology. This is what differentiates a research program from financial assistance and deployment incentives.

Implementation

A robustly funded RD&D program would be most effective if it is consistent with a State Transportation Research Master Plan. The RD&D investment strategy should define individual research programs, each focused on a specific segment of the Transportation and Land Use sector. Each program area should be staffed and administered by representatives from governmental units having responsibly in that segment and advised by representatives from universities, industry, government, and private sector stakeholders.

To address New York's pressing transportation challenges, a multi-dimensional program involving NYSERDA, State agencies (New York State Department of Transportation, NYC DOT, and New York State Department of Environmental Conservation), universities, and the private sector is necessary. The program should not supplant the responsibilities of State agencies, but should provide coordination of energy efficiency-sustainability measures, sponsor research and pilot projects that validate benefits, and accelerate the utilization of products, processes and alternative measures. In addition, funds should be utilized to educate, subsidize, and accelerate the early adoption of solutions in both the public and private sectors. Extensive use of the private sector will foster in-state economic and intellectual property development.

As indicated in Table 10-1, the program should support four types of activities in seven focus areas. All program areas would involve analysis/policy studies and education/outreach activities. Several of the program areas would additionally address needed RD&D, transitional strategies, or deployment mechanisms aimed at developing, demonstrating and implementing innovative solutions for the transportation sector.

Table 10-1. TLU RD&D Program Activities

Program Area	Program Activity			
	Policy Studies/ Analysis	Technology Development	Demonstration Verification	Education Outreach
Government Agency Practices	X			X
Public Transit	X	X	X	X
Freight/Commercial	X	X	X	X
Vehicle Efficiency		X	X	X
Transportation Infrastructure	X	X	X	X
Alternative Fuels	X			X
Smart Growth	X		X	X

X= areas of proposed funded activities.

Other Considerations

Each of the Transportation and Land Use policy working groups has established target reductions goals for 2030. These goals will universally require the wide-scale utilization of options that are today unproven or not currently cost effective. Most of these goals such as: 30 percent of vehicle-miles-traveled by zero-carbon vehicles, or 50 percent of all up-state (80 percent downstate) travel by public or shared ride leave open the pathway used to achieve the goal. However, achieving the goal will require a major pathway decision in the near term (electric vehicle charging infrastructure or fuel cell hydrogen) and significant public investments in infrastructure if these targets are to be achieved. The first goal of public transportation RD&D policy is to invest in research activities in the near term that allow accelerated exploration of emerging options together with field test, demonstrations, and pilot programs for a wide variety of the most promising options thereby allowing the best possible and most timely public policy and investment decisions.

These public RD&D investment decisions should be driven by assessments of risk and benefit. Benefits should consider economic development, mobility, environmental justice, and cost effectiveness as well as potential to meet carbon reduction targets.

In a period of constrained resources it is important that RD&D investments are prioritized and made in the most effective way. Modest investments must be made in long-term higher-risk research into options that will be needed to achieve long term 2050 goals. Accelerated investments must be made in optimizing and evaluating approaches that could meet mid-term goals. Options showing the greatest potential must be demonstrated, piloted, and validated prior to making major investments in approaches that prove to be dead ends or non-competitive.

It generally takes 10 to 15 years after initial introduction for a new technology (microwave oven, cell phone, hybrid vehicle) to have significant market penetration. If we are to achieve 2030 goals the technologies and approaches that will get us there must at a minimum be at a point of initial introduction with public policy commitment by 2015.

Power Supply and Delivery (PSD) Sector RD&D Needs

Overview

Substantial RD&D investments are needed to develop new sources of renewable generation, improve the efficiency/performance of existing renewable and traditional generating options, and develop technology that will enable the efficient and cost-effective delivery of electric energy.

Meeting electric demand in a manner that satisfies climate protection goals will require continued advances in the performance of current renewable and traditional generating resource technologies, the development of new sources of renewable generation including generation utilizing fuels derived from sustainable chemical conversions and the fuels they will require, new technologies associated with the efficient management (storage and regulation) of increased intermittent renewable energy upstream from customers (e.g., large wind) and downstream, at the end use level (e.g., distributed solar), the development of technologies and operating practices for the transmission and distribution system (delivery system) that enable the penetration of these new renewable resources while maintaining system reliability and increasing the efficiency of the delivery system. Finally, electric supply and delivery systems must evolve to accommodate the expectation for electrification of transportation and the resulting impacts on electric use and peak demand.

New York is fortunate to have RD&D assets already in place that can be leveraged with federal and non-New York interests to build an economy upon climate and environmental preservation. These assets are listed below in the section: State Role.

Program Design

This policy would support RD&D and early deployment activities that result in a material increase in the proportion of electric energy used in New York generated by renewable, non-carbon emitting resources and increased capacity of the delivery system to enable their integration and be more efficient at doing so. Such activities include:

- Development of short, medium, and long term technologies;
- Use of private-public partnerships where appropriate;
- Supporting the development and deployment of technologies by facilitating end-use customer engagement in the RD&D and early deployment process and encouragement of early adopters, to mitigate the risk of high cost technology development;
- Supporting the development, testing and verification of control and communication technologies that increase efficiency of the delivery system and enable the integration of renewable, intermittent resources;
- Supporting a continuum of activities from early-stage, scientific assessment through technology demonstration and business development in support of new renewable energy resources;
- Supporting significant improvements in the environmental and efficiency of existing electric generating technologies.

State and federal commitments to early-stage research, technology validation, and demonstration will be critical to enticing increased infusion of private sector capital that will become necessary over the longer-term to take new products to market and to finance the scale of renewable generating projects that are expected to be necessary to achieve ambitious climate preservation goals. Such a commitment will validate the significance and vitality of climate change policies and reduce risks to levels where private capital will become vested in amounts sufficient to meet policy goals. To be effective over the long term, RD&D and early deployment programs must include consideration of the business and environmental case that must be made for adoption and development of technologies, projects, and implementing mechanisms and provide complimentary programs to ensure that businesses that will develop, manufacture, and deploy preferred technologies can be created and operated profitably. Concerns about the impacts of RD&D efforts that rely on expanding existing infrastructure or that involve the deployment of new technologies with uncertain or unknown impacts on public health should also be accounted for.

Federal Role

Marine-based Resources

Offshore marine hydrokinetic energy technology comprises only a few prototype systems today. If New York is to exploit its vast offshore marine-based resources, and wave and ocean current technologies are considered necessary, their development would require a research and development program similar in scale to that enjoyed by onshore wind technology over the last 20 years, and involvement of the DOE and its national laboratories, industry, federal, and State authorities, and academia. The research agenda for such early-stage resource development would include proof-of-concept assessments for conversion devices; lab scale modeling/design;

development of enabling technologies (e.g., moorings, materials); met/ocean characterization and modeling; and full scale in-ocean testing. This would be long-term and involve high risk research so a strong federal commitment would be necessary. The use of such resources for the period of interest (2025–2050) will also require the building of new supplier chains and infrastructure (port facilities/service capabilities) and this must be considered when developing a research agenda. If an ambitious research agenda supported at the federal level for wave and current technology commenced immediately, New York would not likely benefit from this resource until 2030–2035.

Energy production from offshore wind turbines could occur more rapidly (2015-2020) than that from other marine technologies. The American Wind Energy Association Offshore Wind RD&D working group set forth a RD&D agenda that should provide a basis for developing a long-term offshore wind development program for the US and guide decisions on focus and funding that would be of interest in New York. Current industry estimates place the cost for this research agenda at about $600 million over the next 5–7 years. Pending federal legislation would authorize the appropriation of $200 million a year over the 2010–2014 period for research, development, and demonstration activities related to wind energy systems and would direct DOE to establish a research and development program to improve the efficiency of wind turbines, reduce the cost of wind energy systems, and conduct a demonstration program to measure the performance of wind energy systems at locations across the United States. It is assumed that this funding, if authorized, would be administered by DOE and allocated across land and offshore based wind technology and require cost sharing between federal and state governments and the private sector.

Nuclear Energy

The State will have limited influence on research into advancements in nuclear energy generation. The federal government and selected, highly capitalized industries will dominate in terms of any research agenda and investment. The federal government will be responsible for managing the matter of long-term storage, reprocessing, and neutralization of spent fuel.

Fossil Generation

Compared to many other states, fossil generating resources in New York represent a smaller fraction of the electric generation mix. New York should continue supporting a research agenda that focuses on technologies that can be demonstrated to increase efficiency and environmental performance of power plants. New York can partner with the federal government to support the development of carbon capture and sequestration demonstration projects in New York. Investment in this research can be funded through an appropriate mix of State, federal, and other funding sources, while avoiding duplication of effort.

Power Supply Transmission and Distribution Systems

The federal government should be tasked with coordinating the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems including advanced networking and cyber-security.

Participation on DOE ARPA-E and other research, development, and demonstration initiatives should continue to be evaluated and pursued if such activities can be shown to present opportunities for learning, customer savings, and business growth that are unique to New York and unlikely to occur through the actions of others.

Examples of federal organizations that would be key stakeholders with the states in any research and development agenda include, but are not limited to DOE (including ARPA-E) and affiliated laboratories, NIST, and the Electric Power Research Institute.

State Role

Marine-Based Resources

The coastal states and federal authorities have initiated processes to collaborate on various aspects of offshore wind project development and to a limited degree, technology development. Affected organizations include the US Offshore Wind Collaborative, Atlantic Offshore Wind Energy Consortium lead by the U.S. Department of the Interior, the Mid-Atlantic Regional Council on the Ocean; and specific to New York, New York State Department of State, NYSERDA, Con Edison Company, Long Island Power Authority, and the New York Power Authority. These organized efforts to address pressing technology and project development is expected to drive the agenda for applied research and development activities for the ocean and off shore environment. New York's share could represent an investment of upwards of $60 million should the costs be shared by coastal states. The research agenda encompasses the following areas: scale up of turbine size and evolution of gearbox and blade designs and materials, development of alternative/deep water/floating foundations, development of facilities for component testing/validation, comprehensive resource characterization/measurement campaigns, aerodynamic flow modeling, codes and standards, deployment and servicing strategy formulation and infrastructure development, avian and marine ecological evaluation, and grid integration.

These same entities could play a role in field testing/demonstration of other marine-based energy production technologies (wave, current, hydrokinetic) that emerge from federally supported efforts. New York's contribution to the evolution of technology, resource characterization, and demonstration/validation could be measured in the tens of millions of dollars—staged over 20 years.

Land-Based Wind

State-funded research with respect to on-shore wind technology should be limited to advanced wind resource forecasting/mapping and turbine condition monitoring and diagnostics, and such efforts in these areas should continue in support of State policy objectives. Increased performance of the existing fleet of turbines should be expected to occur during the next decade (2010–2020) and improvements on the order of 1–2 percent in terms of energy capture are realistic. Such an effort would require a modest investment of several million dollars over the next five years.

Carbon Sequestration

New York may have the geology appropriate for sequestration of carbon, and characterizing and testing this potential for the purposes of sequestering carbon from fossil-fired power plants is an avenue of research that New York can undertake at reasonable cost. New York can partner with the federal government to support the development of carbon capture and sequestration demonstration projects in New York. A template for a state-specific research initiative would be activities outlined in NYSERDA's initial operating plan under the RGGI program[7].

Solar

Additional research is needed to prepare utilities and other stakeholders for the eventual integration of larger amounts of PV at the distribution voltage level. Analytical tools and models must be developed that establish the value proposition for PV at this voltage level including estimation of the benefits and costs to grid operations associated with deeper penetrations of this technology coupled perhaps with local storage devices. Any research agenda should also include the development of assessment tools and guidance for the integration of PV systems with building energy management systems and infrastructure. In addition, since the large scale deployment of solar has largely been a southwest exercise, the New York/Northeast performance expectations and optimizations will require investigation. Investment for this research could approach several million dollars over the next five years.

Biomass and Sustainable Fuels

Advances in biomass conversion processes (e.g., gasification, direct combustion, pyrolysis) as well as advances in sustainable fuel generation (e.g. water splitting, carbon dioxide reduction, fuel generation catalysis) should continue to be pursued. Equally important are the application of life-cycle assessments of project attributes and fuel/feed stock (e.g., minimization of environmental impact, i.e., carbon neutrality) and feed stock depletion. The question of what will constitute low carbon or carbon neutral application of biomass and other sustainable chemical conversions to create fuels is critical in terms of determining the contribution that biomass and sustainable chemical conversions may make to long-term renewable energy production goals. For biomass to be a material contributor to renewable energy goals, the definition of sustainability with specific regard to carbon must be answered. The question of feed stock availability for power generation (bio-power) was the subject of extensive review/analysis.[8] Any research agenda for biomass should take into consideration the findings contained therein. Investment in this research agenda could approach several million dollars over the next five years.

Power Supply Transmission and Distribution Systems

With respect to improvements in the delivery system to increase its efficiency, enable greater penetration, delivery, and value of renewable energy, New York stakeholders will have a more influential role in research, development, and demonstration. The New York Independent System Operator and utilities (transmission owners) will need to consider how best to deliver energy associated with increasing penetration of intermittent, wind generation (land-based in the coming years; off-shore by the last years of this decade) at both ends of the system. They will do this as they consider making the delivery system more efficient and reliable and as they consider

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[7] *Operating Plan for Investments in New York under the CO_2 Budget Trading Program and the CO_2 Allowance Auction Program*, April 16, 2009, pages 41 – 42, http://www.nyserda.org/RGGI/Files/Final%202009-2011%20RGGI%20Operating%20Plan.pdf.

[8] Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply for New York. NYSERDA Report 10-05. April, 2010.

transforming the grid from an electromechanical to digitally controlled system and making the delivery system more intelligent (smart grid). Energy storage will play a key role in enabling smart grid functionality. NY-BEST will serve as a key stakeholder in the development and demonstration of a wide variety of energy storage technologies for stationary power applications.

The New York Public Service Commission (PSC) has instituted a proceeding aimed at establishing a strategic vision and plan for investing in smart grid technology for New York that will guide future research, development, demonstration, and deployment (RDD&D) in New York in support of the policy objectives stated herein. Some potential avenues of RDD&D for consideration are described below.

Research should continue the development of technologies, practices, and programs that promise to improve the efficiency and operation of transmission and distribution systems. Such activities could include the automation of communication and control processes (e.g., deployment and testing of advanced sensors and communication devices) to reduce energy losses and extend equipment life, and would involve demonstrations, testing, and validation to aid in making determinations as to the scale, phasing, and the expected costs of implementation. As the power supply system in New York grows less-carbon intensive over time, the value of electric system efficiency improvements will decline and the research focus shift toward evolving end-use technologies such as electric-vehicle charging and distributed storage that offer the potential for improved grid load shape, asset utilization, and reliability. Research of electric vehicles and batteries, consumer and vehicle load profiling, smart charging and storage technologies at the distribution voltage level, and related consumer metering and billing are expected to be a key components of the RDD&D program over the next 10 years.

State investment in research in support of the Power Supply Transmission and Distribution Systems RDD&D agenda could approach $75 million over the next 5–10 years, excluding investment by electric utilities.

Investor-owned utility systems in New York will become a laboratory for testing/demonstrating various smart grid technologies including distributed resources, grid power vehicles, smart appliances, and storage. Utilities could also invest in research and demonstration of advanced power conditioning and cabling related to the interconnection of off-shore renewable resources. Such RDD&D investment could easily approach $250 million over the next 10 years

Examples of State organizations that would be stakeholders in any research and development agenda include, but are not limited to, Smart Grid Consortium members,[9] the PSC, NYSERDA, New York State Foundation for Science, Technology and Innovation (NYSTAR) Centers of Excellence and Centers of Advanced Technology, New York Academy of Sciences, PANYNJ, State University of New York (SUNY) colleges and universities, and Pace Energy and Climate Center.

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[9] Advanced Energy Research and Technology Center, Brookhaven National Laboratory, Central Hudson G&E, City of New York, Clarkson University, Computer Associates, Consolidated Edison (Con Ed), General Electric, IBM, Long Island Power Authority, National Grid, New York Department of Public Service, New York Independent System Operator, New York Power Authority, New York State Business Council, New York State Electric & Gas, New York State Energy Research and Development Authority, New York State Foundation for Science, Technology and Innovation (NYSTAR).

Private-Sector Role

While government is expected to set the agenda for long term societal imperatives, private sector organizations/companies with the involvement of institutions of higher learning, are expected to yield the ideas and innovation that government will look to enable with its funding. Companies will provide valuable engineering and equipment/facilities to test and validate concepts that they and academia collaborate on. State and federal government will partner with these types of entities to buy down or cover risks that these and other private sector participants (e.g., venture capital and infrastructure capital investors) are unable or unwilling to fund. As the menu of options necessary to meet ambitious climate protection goals expands, existing institutions for business incubation will grow in significance and number. Such institutions will continue to provide essential support for business planning and product commercialization.

Private sector organizations located in New York State that would be stakeholders include Smart Grid Consortium members, private universities and colleges, General Electric (e.g., solar, wind, bio-fuels, batteries), IBM (e.g., thin film PV devices, consumer smart appliance controls), AWSTruepower (e.g., meteorological modeling, wind/PV energy modeling and engineering), technology incubators (e.g., Syracuse, SUNY Buffalo and Stony Brook, Rochester Institute of Technology, Polytechnic Institute of New York University), and investors (e.g., Hudson Clean Energy Partners, Environmental Capital Partners, GE Finance).

Agriculture, Forestry, and Waste Management (AFW) Sector RD&D Needs Overview

The agriculture, forestry, and waste management sectors are critical drivers in the economy of New York State. With a long-term investment in research, development, and demonstration, these sectors can also serve as a primary sustainable resource for the production of fuels, chemicals, and products. An integrated portfolio of strategies can be implemented to achieve key carbon reduction initiatives and prepare the state to adapt to changing climates. It is important to acknowledge from the outset that many of the approaches and goals in these sectors are related to each other. Progress in any one area requires concomitant commitments in the other areas.

The research agenda can be categorized into the following broad areas: Reduce the carbon intensity of agricultural and forest management activities and optimize the ability of agriculture and forestry lands to sequester carbon. Develop, demonstrate, and commercialize technologies and processes to convert sustainable resources into fuels, chemicals, and products that will result in an overall reduction in carbon. Support and optimize market participants along the relevant supply chains to ensure that products can efficiently reach the customer. Invest in research activities to continuously develop new crops and cultivation techniques that will supply the conventional customer base and the renewable feedstock customer base as efficiently as possible. Develop and implement adaptation strategies to allow for the continuation of resource supply as environmental conditions change. Maximize urban green space, avoid forest land conversion, and improve the long-term storage of carbon in New York’s rural forests. Maximize waste prevention and recovery and utilization of recyclable materials.

Achieving the carbon goals outlined for this sector will require coordination at all levels of government and an alliance among public and private stakeholders, including landowners and research universities to identify strategic research needs, develop partnerships to move the research forward, and financial mechanisms to provide long-term funding for the research to achieve the state's carbon reduction goals. The federal and State governments have a long history in the agriculture and forestry areas. Academic research institutions (land-grant universities) serve as the foundation of research and training for these sectors. Private landowners will need to make commitments to the goals of the program and commercial businesses will have the primary responsibility to convert sustainable feedstock into fuels, chemicals, and products and establish the supply chain.

Program Design

The recommended program involves the long-term commitment and investment of financial support on the part of all participants. Early in the program, supported activities provide a baseline of information and tools to define, for example, sustainable and best management practices, and appropriate methods to verify performance, for agriculture and forestry; provide insight into biomass resource competition to develop a sustainable feedstock/materials management strategy that first aims to reduce or eliminate waste and divert materials for re-use, recycling and composting; and analyze the waste stream to determine the amount, availability and characteristics of waste biomass and trends in industrial and municipal solid waste generation among rural, suburban, and urban areas. These are core activities that can bring research and market participants up to a common level of knowledge. As outlined below, there are some activities that with both federal and state roles. Also identified below is an activity that is likely to be primarily a state effort.

Federal Role

Federal support is important to finance and facilitate the research programs that address key problems of national, regional, and multi-state importance and to provide the financial support and risk management for large-scale investments prior to private sector commercialization. Research and development topics warranting federal support include:

Sustainable Feedstock Supply

- Research focused on crop breeding and optimization of new and existing bioenergy feedstocks to increase yields and improve the economic viability of these systems;
- Development and improvement the crop management for perennial energy crops;
- Research on the long-term system-wide sustainability of specific existing and emerging bio-energy pathways.;
- Developing models to predict responses of soil and biomass productivity to climate change;
- Examining the balance between carbon sequestration, adaptation, and other ecosystem services such as carbon sequestration, wildlife habitat conservation, or water quality protection.

GHG Management

- Improving quantitative models of carbon, nitrogen, and water cycles in bioenergy feedstock production systems to predict productivity and environmental outcomes from field to landscape scales;

- Investigating landscape ecology at regional scales to understand the relationships among diverse processes;
- Determining approaches that will cost-effectively allow private landowners with relatively small parcels of forest land to harvest biomass in a way that is conducive to carbon sequestration and the long-term productivity and health of their woodlots;
- Continued research focused on improving cradle to grave efficiencies (increasing yields, improving conversion technologies, understanding and improving sustainability criteria) will impact the rate at which biomass production occurs.

Feedstock Conversion and Business Risk Management

- A long-term commitment of public (primarily federal) sector funding will be necessary to partner with industrial funding to support the development of new technologies and the realization of the lessons learned from market experience. Research will be conducted in both academic and private laboratories. The importance of a long-term commitment to research cannot be overemphasized. After the initial research stage, new products will need to move through a demonstration and market assessment stage of development. The relative level of investment to move a new product or process towards commercialization will tend to increase at this stage.
- When the technology is ready to be developed at a commercial-scale, public support could be in the form of low-cost financing or other innovative mechanisms to reduce the technical uncertainty of the new technology to the private investment community. Building commercial-scale manufacturing/conversion process systems for new technologies is a risky venture. Innovative risk-sharing programs can be implemented to share the technical and market uncertainty and promote private-sector investment.

State Role

States will take the lead in areas where the benefits are easier to define at the state or local level and the majority of the program participants are in the state. For projects along the research – commercialization continuum, State support will primarily focus on supply chain and market transformation issues. The State should also lead the effort to design and implement tools to manage integrated programs, evaluate, and assess progress towards goals and to provide overall program integration and coordination.

Baseline Date/Resource Inventory and Tools

- Ongoing assessment of measurements of state-wide, sustainable resource availability;
- Support the development of a comprehensive inter-agency database to store baseline and monitoring data on land and forest management and the condition of the state's agricultural and forest land resources.;
- Develop and implement a system for identifying recently unmanaged or neglected/degraded forest stands that are under stocked by 2015. By 2025, identify and treat, using necessary and appropriate methods, 25 percent of all appropriate (i.e., poletimber and sawtimber size classes) timberland acres.

- Develop and implement critical survey, monitoring, and mitigation methods for potential and existing forest pests;
- Develop and implement programs that alter traditional cultural and commercial conventions that have proved to spread destructive pests;
- Develop and implement a system for identifying owners of vacant idle land that is unsuitable for agriculture but suitable for reforestation by 2015. By 2025, identify and reforest 50 percent of all suitable vacant idle land.
- Currently New York-specific data quantifying Food Miles Traveled and the resulting benefits has not been thoroughly studied. Additionally, it needs to be recognized that food mile reductions must be assessed on a product-by-product basis that includes life-cycle analyses of the numerous crop specific inputs and concomitant production methods.
- Establish benchmark sites, suitable for measurement of soil carbon and other parameters; integration of remote sensing data and application of new technologies for more rapid less expensive measurement of carbon stocks and GHG fluxes; and improvements in forecasting future agricultural GHG emissions and sinks;
- State-level monitoring to document trends and predict forest composition changes; research to focus on identifying tree species that will be suitable for the anticipated changes in climate.

Business Risk Management

- Develop targeted programs to share the risk of new business development. This includes business models for biomass feedstock production, infrastructure requirements, employment options, and possible public awareness concerns in order to overcome misperceptions and barriers to the use of biomass.
- Conduct research on strategies to connect consumers with farmers who direct market their products (i.e. farmers' markets) that will work in rural, suburban, and urban communities and with a broad base of consumers within each community. Such strategies may include various means of transportation, outreach, and incentive programs.
- Support initiatives that add both economic and nutritional value to New York State agricultural products through the development of new products (such as sauces, jams, juices, etc.). This includes processing and packaging initiatives that help make fresh foods more accessible and convenient. Recognize that minimally processed products often preserve optimal nutritional benefit.

Stakeholder Coordination

- Support the development of a system for State agencies and State-owned facilities that purchase food and food products to identify the percentage of locally produced agricultural products purchased throughout the fiscal year; and track and report locally produced agricultural products purchased on an annual basis.

Sustainable Feedstock Supply

- Support sustainable production strategies and research that help farmers remain competitive and viable such as organic, integrated pest management; season extension technologies, and nutrient management programs. Sustainable production strategies are consistent with adaptation strategies.
- Develop and support prevention, early detection, and rapid response programs that seek to prevent the introduction of exotic and invasive forest pests and mitigate/eradicate the impacts of current or future introductions. In addition, develop and support programs that reduce the potential for and severity of wildfire.
- Develop forest management plans, methods, and technologies that increase overall forest productivity and benefits on all forests identified as timberland, and that increase the rate of carbon sequestration in forest biomass and soils and in harvested wood products.
- Data on key management practices (e.g., tillage, fertilization, and grazing) could assist in the design of policies to maximize the role of agricultural in mitigating climate change.

Private-Sector Role

As a land-based policy, the private landowner community is an integral partner in the success of strategies in the agriculture, forestry, and waste management sectors. Landowners will need to be involved in every component of the program. In the case of product development, beyond the point of commercial-scale manufacturing, private-sector support will be the primary mechanism to build and operate conversion facilities and to move products along the supply chain. Public (both federal and State) support will be necessary to reduce risk and uncertainty to a level that private-sector investment can take over.

Other Considerations

Achieving the research, development, and commercialization goals outlined in the section will require the commitment of a diverse set of stakeholders and the application of a portfolio of financial strategies. It will be incumbent upon the State sector to facility the coordination of the stakeholders.

Chapter 11
Adapting to Climate Change

The Earth is experiencing changes in climate that appear to be accelerating and permanent. Climate change is already affecting New York State's communities, economy,, and natural ecosystems, and these effects are expected to increase. Historical climate conditions are no longer a reliable guide to the future for planning within natural, social, or economic systems.

Adaptation refers to actions taken to prepare for climate change, to reduce adverse impacts, or to take advantage of new opportunities. Adaptation can take place at many levels—individual, community, organizational, and institutional. In many respects adaptation is simply better planning, incorporating the most current information about future climate change into routine decision making. Adaptive *capacity is* the ability of a system to adjust to climate stresses or to cope with their consequences. New York State already has substantial adaptive capacity, but also significant vulnerabilities. The overarching goal of the adaptation recommendations is to create a more climate-resilient New York State.

Our current understanding of how the Earth's climate system will change does not provide the level of accuracy and precision desired often by decision makers, so adaptation planning must include flexible responses. Flexible adaptation enables stakeholders to take actions and put strategies into place that can be adjusted over time as climate science matures and initial adaptation efforts yield valuable lessons.

New York's Climate Action Plan Adaptation Technical Work Group

The Adaptation Technical Work Group was charged with identifying measures to safeguard New Yorkers' public health, infrastructure, ecosystems, and environment from the impacts of climate change. The Technical Work Group was comprised of more than 25 individuals including representatives from State and local government, academia, utilities, environmental justice groups, non-governmental organizations, environmental groups, and the insurance industry. The group was co-chaired by NYSERDA and DEC, with facilitation provided by the Center for Climate Strategies.

The Technical Work Group used the work of the NYSERDA-sponsored project entitled, Integrated Assessment for Climate Change Adaptation Strategies in New York State, also known as "ClimAID," as a foundational resource for its work. The ClimAID project provided New York- specific climate projections and climate vulnerability analyses, and strategies to reduce the detrimental effects of climate change on the State's economy, ecology, and public health. The project team was led by researchers from Columbia University, Hunter College, and Cornell University, with additional partners including Rutgers University, the Mt. Sinai School of Medicine, and New York University. The draft ClimAID summary report is included as Appendix H. The full report will be available at www.nyserda.org/programs/Environment/EMEP/. Information from other ongoing initiatives also provided valuable input to the process, including New York's Sea Level Rise Task Force, The Nature Conservancy's *Rising Waters*, and New York City's *PlaNYC*.

The Adaptation Technical Work Group developed policy options around the following concepts:

- Reduce physical, social, or economic impact of climate change.
- Take advantage of new opportunities emerging from climate change.

To facilitate discussions, the Adaptation Technical Work Group members divided themselves into eight subgroups, each of which developed recommendations for review by the entire Technical Work Group. Each subgroup addressed one of eight sectors: agriculture, coastal zones, ecosystems, energy, public health, transportation, telecommunications and information infrastructure, and water resources.

The process to assess risks and vulnerabilities was based on the latest climate projections for New York State and built on the process used in the ClimAID project. While the ClimAID project focused primarily on producing adaptation strategies to reduce vulnerabilities and exploit opportunities, the Technical Work Group took the process one step further by generating policies and some mechanisms to implement the strategies in New York State. Technical Work Group members prioritized adaptation strategies according to climate-risk levels, vulnerability and exposure, cost effectiveness, distributional and equity concerns, and institutional capacity and capability. Other factors considered include regulatory, design, and engineering standards; legal structures; and insurance opportunities. An overview of each recommended strategy is included later in this chapter. More detailed descriptions of each recommendation are available at www.nyclimatechange.us.

New York is just beginning climate adaptation planning. This Adaptation Plan should be viewed as a living document and must be revisited on a regular basis to incorporate the latest scientific research and knowledge, including actual climate impacts and the effectiveness of the proposed strategies. Such periodic reassessment will permit development of flexible adaptation pathways and increasing adaptive capacity.

The Adaptation Planning Process[1]

While New York has a wide range of vulnerabilities to changing climate, it also has the potential to adapt to and take advantage of some of these changes. Some of the hazards associated with climate change include higher temperatures leading to greater incidence of decreased air quality, and heat stress caused by more frequent and intense heat waves; increased droughts and extreme rainfall affecting food production, natural ecosystems, and water resources; and sea level rise causing enhanced flooding in coastal areas.

Climate change poses challenges for decision makers because of the uncertainties inherent in climate projections and the complex linkages among climate change, physical and biological systems, and socioeconomic factors. Fortunately, there is already a large body of knowledge on climate change that will assist in developing strategies to reduce vulnerability and building adaptive response capacity.

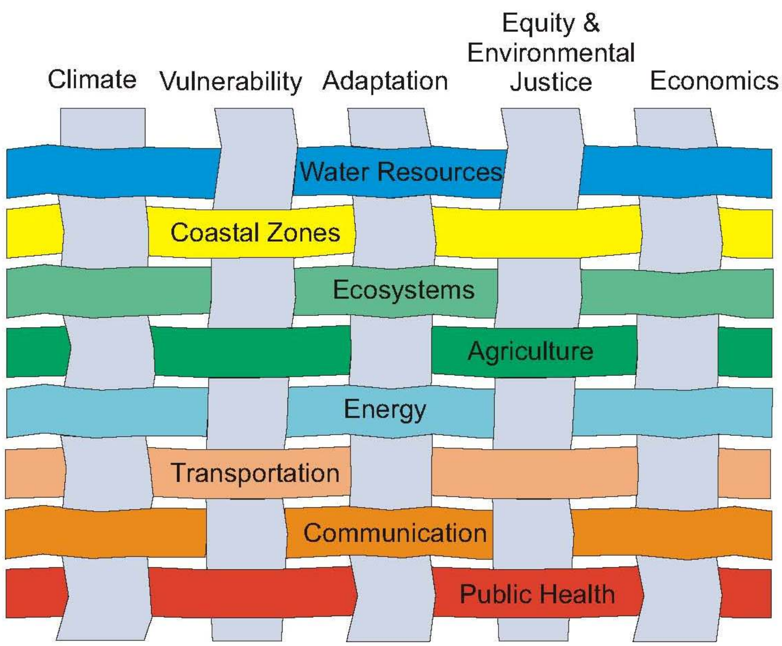
[1] Much of this discussion is based on the work of the ClimAID team.

A New York State climate change adaptation plan must consider a number of components:

- Understanding how the *climate* in New York State might change,
- Identifying potential *vulnerabilities* to a changing climate,
- Assessing *risk* levels of those vulnerabilities,
- Developing *adaptation strategies* that will help to minimize those risks,
- *Prioritizing* strategies, considering other adaptation tools, and developing an overall adaptation plan that is coordinated with greenhouse gas mitigation efforts.

Figure 11-1 from ClimAID illustrates five integrating themes across the eight sectors studied.

Figure 11-1. Relationship of Adaptation Sectors to Integrating Themes



The following elements were considered as part of the evaluation of adaptation strategies:

- Cost: What are the general costs of the proposed strategy, including human and other resources? This assessment can yield a rough measure of benefits and costs to the extent that the consequences are measured in economic terms, but there will be important non-economic consequences as well.
- Timing: The timing of implementation should be considered relative to the timing of impact; if the impact will occur in a time frame comparable to the time required for implementation, there is need for immediate consideration.
- Feasibility: How feasible is the strategy for implementation? Are there organizational, policy, legal, or engineering concerns; or expected technological changes that would affect feasibility?

- Efficacy: To what extent will the strategy, if successfully implemented, reduce the risk?
- Robustness: Is there the potential to install equipment or upgrade infrastructure that is resilient and designed to withstand a range of climate hazards? Are there opportunities for flexible adaptation pathways?
- Co-benefits: Will any strategies have effects on another stakeholder or sector? Is there potential for cost-sharing? Are there impacts on mitigation of greenhouse gases? Are there impacts on the environment or a vulnerable population?

Other important factors that must be taken into consideration include environmental justice, equity, social justice, sustainability, institutional context, and unique circumstances.

Indicators and Monitoring

The monitoring of climate change variables and other factors that might directly or indirectly influence risks and adaptation strategies is an important component of any adaptation plan. Monitoring of key indicators can help to initiate course corrections in adaptation policies and/or changes in timing of their implementation. Indicators must be devised and tracked over time to provide quantitative measures of climate change and its impacts, and the efficacy of adaptation strategies.

Summary

Climate hazards are likely to produce a range of impacts on the urban and rural fabric of New York State in the coming decades. Adaptation strategies described in this report can provide the basis for adaptation planning for decision makers who must work to reduce future impacts. These adaptation strategies will also produce benefits today, since they will help to lessen the impacts of current climate hazards. Some adaptation strategies also have the co-benefit of reducing greenhouse gasses.

Regular monitoring of climate and impacts indicators is critical. Indirect climate change impacts, including effects resulting from climate change impacts in other regions, must be considered as well. By continually evaluating this evolving information, New York State can best develop robust and flexible adaptation pathways that maximize climate and societal benefits while minimizing climate hazards and costs.

Adaptation Recommendations: Common Themes

Several common themes emerged from the sector-specific recommendations. Many of these common themes represent steps that must occur before other recommended actions could be implemented:

- Dissemination of climate change information to decision makers at all levels is critical to adaptation planning. Using academic and governmental resources New York State should develop the capacity to disseminate the best available climate projections, including associated uncertainties. These projections would be updated periodically and be the standard for decision making across the state. This capacity could be provided through State support of a Climate Science Institute— a collaborative effort of qualified academic institutions that could provide guidance on applications of climate projections.

- New York State should develop capacity to identify and monitor climate change indicators, including indicators of climate factor interactions, to provide necessary information to decision makers..
- New York State should develop a framework for describing, monitoring, assessing, and reporting progress on adaptation efforts within the state. An assessment of adaptation efforts by local governments, State agencies, and federal programs should be started to collect baseline information. This will help identify gaps in information, research, or tools needed for decision making and will help better prioritize next steps. Adaptation information should be shared and efforts coordinated among all levels of government.
- Support for research and development is necessary to develop new strategies and technological advances, and to provide the proper detail and confidence for recommended strategies.
- Emergency management capabilities across the state must be evaluated in light of climate projections to determine where these capabilities will be compromised. Emergency warning systems, access and availability of cooling centers, barriers to emergency evacuation, and the effects of power and communications outages must be assessed.
- Education and outreach at all levels are critical to the success of climate change adaptation efforts. Climate science should be incorporated in education curricula to bring the most current, science-based information to tomorrow's leaders. Targeted outreach to affected communities will also be necessary.
- Certain groups will be disproportionately affected by climate change; it is necessary to identify these groups and ensure their participation throughout adaptation planning processes. Climate change risks, vulnerabilities, and capacities to adapt are uneven across regions, sectors, households, individuals, and social groups. Equity concerns emerge because climate change impacts and adaptation policies can worsen existing inequalities and can also create new patterns of inequities. The impacts of climate change adaptation policies on different populations, areas and industries must be considered and addressed.
- Immediate action is needed. Current state investment decisions and policies as well as infrastructure siting and design decisions should be informed by climate projections to ensure necessary adaptive capacities the best use of state resources. Many recommendations focus on vulnerable populations that are already likely to experience adverse climate effects.

Many of the recommendations are based on existing state programs and policies. While specific opportunities for integration are not explicitly mentioned in these policy summaries, additional information on related efforts and potential implementation mechanisms will be available in the policy adoption descriptions at www.nyclimatechange.us.

Adaptation Recommendations

Summaries of the recommendations from the Adaptation Technical Work Group are listed below, by sector subgroups.[2] Detailed descriptions will be posted at www.nyclimatechange.us.

Agriculture

Vision Statement

Develop and adopt strategies and technological advances that recognize agriculture as a critical climate and resource dependent New York State industry that is inextricably linked to Earth's carbon and nitrogen cycles, and ensure that in 2050, the agricultural sector is not only viable, but thriving in a carbon-constrained economy, and is continually adapting to a changing climate.

Background

Agriculture is a significant component of the New York economy; it includes large wholesale grower-shippers selling products nationally and internationally, a substantial dairy industry, and thousands of small farm operations selling direct retail and providing communities throughout the state with local, fresh produce. Farmers will be on the front lines of coping with climate change, but the direct impacts on crops, livestock, and pests, and the costs of farmer adaptation will have cascading effects beyond the farm gate and throughout the New York economy. While climate change will create unprecedented challenges, there are likely to be new opportunities as well, such as developing markets for new crop options that may come with a longer growing season and warmer temperatures. Taking advantage of any opportunities and minimizing the adverse consequences of climate change will require new decision tools for strategic adaptation. Adaptation will not be cost- or risk-free, and inequities in availability of capital or information for strategic adaptation may become a concern for some sectors of the agricultural economy.

The agriculture sector in New York State encompasses more than 34,000 farms that occupy about one-quarter of the state's land area (more than 7.5 million acres) and contribute $4.5 billion annually to the state's economy. New York is the dominant agriculture state in the northeast and typically ranks within the top five in the United States for production of apples, grapes, fresh-market sweet corn, snap beans, cabbage, milk, cottage cheese, and several other commodities.

Climate Impacts

Warmer temperatures, a longer growing season, and increased atmospheric CO_2 could create opportunities for farmers with enough capital to take risks on expanding production of warmer temperature-adapted crops (e.g., European red wine grapes, peaches, tomato, watermelon), assuming a market for new crops can be developed. However, many of the high-value crops that

[2] Much of the text in the Background and Climate Impacts sections of each sector description has been drawn from the ClimAID report.

currently dominate the state's agriculture economy (e.g., apples, cabbage, potatoes) and the dairy industry benefit from the state's historically relatively cool climate. Some crops may have yield or quality losses associated with increased frequency of drought; increased summer high temperatures; increased risk of freeze injury as a result of more variable winters; and increased pressure from weeds, insects, disease, or other factors. Milk production per cow will decline in the region as temperatures and the frequency of summer heat stress increase, unless farmers adapt by increasing the cooling capacity of animal facilities.

The impacts from climate change will occur on top of non-climate stressors already affecting the sector. For example, as with many other businesses in New York and elsewhere, agriculture is sensitive to the volatile and rising costs of energy. Also, New York farmers are affected by often rapidly changing consumer preferences and demands of supermarket buyers; increasingly, farmers must consider global market forces and international competition as well as competition from neighboring states. As a final example, too much as well as too little rainfall is currently a recurrent problem for farmers in New York. Currently, summer precipitation is insufficient to fully meet the water needs of non-irrigated crops most years, while brief, intense rainfall events can have detrimental effects on crops. Climate change is likely to exacerbate these challenges.

Recommendation 1. Support research, development, and deployment of agricultural adaptation strategies that simultaneously manage on-farm GHG emissions and adaptation concerns.

The development of a coordinated statewide research, development, and deployment (R,D &D) program focused on agricultural adaptation strategies is necessary to ensure that New York State agriculture is positioned to respond to changing climatic conditions. This program could also identify research needs and opportunities that could be addressed by private industry. Research and development of the various adaptation practices and strategies should be disseminated to the agricultural community in a coordinated fashion. This effort will likely be a partnership among private and public entities, including universities.

Specific Actions

A. Support the introduction of existing varieties and the development of new varieties that can take full advantage of the beneficial effects of climate change.

Introduction of plant varietals that are adapted to extreme heat events and have increased drought tolerance and pest resistance will reduce climate-related vulnerabilities. Implementation should include the following:

- Development of varieties that are optimized for increasing levels of atmospheric CO_2;
- Introduction of new crop varietals from other regions into New York State;
- Development of crops with increased tolerance to climate stresses. These stresses include summer heat stress; and drought, frost/freeze and extreme precipitation events. These traits can be developed using conventional breeding, molecular-assisted breeding and genetic engineering.

Potential Cost

Low to moderate when compared to the cost of no action. Opportunity to encourage private/public partnerships in this effort (seed companies).

Timeframe for Implementation

Near term: Some research in progress. A more coordinated and focused approach would permit more efficient use of scarce resources.

B. Develop improved responses to extreme weather events (frost, freeze, heat, precipitation).

The ability of farmers to employ new and improved methods of protecting crops from extreme weather events would further reduce climate-related risks. These methods could include the following:

- Development of new pruning strategies;
- Shifting planting dates;
- Improving the efficiency of irrigation practices;
- Improving cover crop and mulching practices;
- Continued optimization of feed rations to reduce the effects of heat stress;
- Continued research on improving the cooling capacity and efficiency of new and existing livestock facilities.

Potential Cost

Relatively low when compared to the cost of no action.

Timeframe for Implementation

Near term: Many of these low-cost strategies have already had some level of research and represent low-cost/high-return strategies with a relatively low level of risk.

C. Develop improved responses to increased weed, disease and insect threats.

Providing agriculture, forestry, and communities with the tools to manage weed, disease, and insect threats in the most environmentally sound manner will require concerted and continued research efforts, which should include, at a minimum, the following:

- A primary focus on non-chemical control strategies for looming weed, disease, and insect threats;
- Development of target-specific chemical control methods with reduced environmental impacts;
- Continued research into species disruption effects of climate change specific to agricultural pest control;
- Development of pest-resistant plant varieties.

Potential Cost

Relatively low to moderate when compared to the cost of no action (i.e., no adaptation). The use of traditional means to manage new and increasing pressure from weed, disease and insect threats carries inherent environmental risks. Significant opportunities exist for private/public partnerships.

Timeframe for Implementation

Near term: Many of these low-cost strategies have already had some level of research and represent low-cost/high-return strategies with a relatively low level of risk.

D. Increase the accuracy of the existing real-time weather warning systems.

Improved delivery of state-of-the-art weather forecasts will be needed to inform growers of extreme events and to allow farmers to take appropriate measures to protect at-risk crops. Needs include the following:

- Development of sophisticated real-time weather monitoring and forecasting; current guidelines for many agricultural practices are based on outdated observations and the assumption of a stationary climate.
- Continued regional and climate science and modeling research to discern between normal climate variability and long-term climate shifts

Potential Cost

Low when compared to the cost of no action.

Timeframe for Implementation

Near term: Accurate weather forecasts in real time are critical to farmers making daily management decisions. Monitoring and forecasts also provide technical specialists and researchers with critical information related to the movement of weeds, diseases, and insects.

E. Support the development of decision-making tools to assist the agricultural community in adapting to climate change.

Tools may include methods for assessing the cost and benefits of crop diversification, shifting planting dates and/or locations, introduction of new varieties, changes in management strategies, and infrastructure changes. These tools will be crucial in determining the optimal time for adaptation investment. Needs include the following:

- Development of new economic decision tools for farmers that incorporate the best available science;
- Development of new decision tools for policy makers that integrate economic, environmental, and social equity impacts of agricultural adaptation efforts.

Potential Cost

Relatively low to moderate when compared to the cost of no action. Decision-making tools also help research and implementation dollars to be invested efficiently.

Timeframe for Implementation

Near term and requiring continual revisions to account for improving adaptation strategies.

F. Increase climate change impact education and outreach efforts to agricultural producers.

Inform agricultural producers of the impacts of climate change and enable the delivery of applied research and decision-making tools to the farm level. Ensure that adaptation strategies are integrated into farm management systems.

Potential Cost

Relatively low, especially when coupled with agricultural mitigation efforts as proposed in Climate Action Plan Mitigation Strategy AFW4, Integrated Farm Management Planning and Application.

Timeframe for Implementation

From 2010 -2013, build the technical capacity necessary to deliver this type of program, including pilot-programs. In 2013 roll out the statewide integrated program.

G. Ensure equity is incorporated into programs targeting agricultural adaptation.

In addition to regional variability in vulnerability related to the scale of impacts from climate change, there is also vulnerability due to the diversity of farm size in New York State. Small family farms with little capital to invest in on-farm adaptation strategies are most at risk and less able to take advantage of cost-related scale economies associated with such measures. Survival of many smaller farms will hinge on making good decisions regarding not only the type of adaptation measures to take but also the timing of the measures. The most vulnerable farmers will be those without access to training about the full range of strategies or those who lack adequate information to assess risk and uncertainty.

Potential Cost

Relatively low for development of decision-making tools and outreach and education efforts. Relatively low to moderate for cost-shared incentive programs.

Timeframe for Implementation

2010 -2013. Development of programs to address equity concerns. 2013. Statewide integrated program roll-out.

Impacts/Vulnerabilities Addressed

Some crops may have yield or quality losses associated with increased frequency of drought, increased summer high temperatures, increased risk of freeze injury as a result of more variable winters, and increased pressure from weeds, insects, disease, or other factors. Milk production per cow will decline in the region as temperatures and the frequency of summer heat stress increase unless farmers adapt by increasing the cooling capacity of animal facilities.

Environmental Justice Considerations

In New York State, there is a range of equity and environmental justice (EJ) issues at the intersection of climate change and agriculture. Particular agricultural sectors, regions, and crops will be most at risk from exposure to climate change and burdened by adaptation measures. Adaptation to climate change will put additional stresses on the fragile and economically important dairy industry in the region. Regional vulnerabilities include farmers on Long Island facing a disproportionate risk of crop damage from increasing storm frequency. Finally, certain crops have disproportionate vulnerabilities, such as perennials for which the cost and economic risk of changing crops as an adaptation strategy is sometimes much higher than for annual crops.

In addition to supply-side dimensions, climate change also may impact agricultural demand. Changes in climate both in New York State and in other regions may disrupt supply chains, leading to closing of retail centers and limiting consumer access to markets. Low-income farmers with insufficient information and training or without access to credit or infrastructure are particularly at risk when conditions demand immediate flexibility and require the ability to quickly line up alternative supply lines and retail locations.

Under such conditions, rural, resource-dependent communities may feel pressure to supplement incomes or diversify their business beyond agriculture but may lack the training or capital necessary to engage in such strategies. Decreasing yields and the high costs of adaptation may translate into significant downstream job losses and cascading economic effects across rural communities. Low-wage, temporary, seasonal, and/or migrant workers are particularly exposed to these shifts.

Examining equity in adaptation involves evaluating existing vulnerabilities, but it also requires evaluating the unintended outcomes, externalities (secondary consequences), and emergent processes of specific adaptation strategies. Successful adaptation by individual farmers or regions may create downstream inequities. As some farmers successfully adapt, other farmers may experience relative increases in inequality related to rural income and agricultural productivity. Certain industries (such as the grape and wine industries) also may consolidate in such ways that it becomes difficult for smaller businesses to enter the market. Increasing chemical inputs, such as fertilizers and pesticides, may create or exacerbate inequitable distributions of human health burdens, or negatively affect waterways, disproportionately impacting low-income or natural resource-dependent communities involved in hunting- and fishing-related revenue. Furthermore, degrading land and community health could drive down property values, exacerbating geographic inequities. Finally, increasing natural resource use, whether it is water for irrigation or energy for cooling, may result in increased utility costs and prices. These increases are felt most by low-income families who proportionally spend more on these basic goods than middle- and upper-income families.

Addressing and avoiding spillover effects in the implementation of adaptation measures require engaging local communities and agricultural managers in each stage of the planning process. This includes mechanisms for expressing and addressing property disputes and conflicting claims to resources, collaborative regional planning across sectors and communities, and training/retraining to provide information regarding strategies and best practices. In particular, adaptation strategies focused at regional or state scales have the capacity to marginalize local actors who are unable to capitalize on social or economic networks or access policymaking procedures.

More broadly, equity should be considered along every part and process of the agriculture food-supply chain. For example, climate stress on agriculture could impact the quality, accessibility, and affordability of local produce. This has implications for food security among low-income groups, communities with fragile connections to markets offering nutritional options, or those otherwise burdened by pre-existing poor nutrition.

Co-benefits and Unintended Consequences

Climate change may provide an incentive for farmers and consumers to take advantage of some opportunities that benefit both the farmer and the environment. Some of these opportunities may eventually be applicable to carbon-offset payments in emerging carbon-trading markets:

- Conserve energy and reduce greenhouse gas emissions (increases profit margin and minimizes contribution to climate change);
- Increase soil organic matter (improves soil health and productivity and, because organic matter is mostly carbon derived from CO_2 in the atmosphere via plant photosynthesis, reduces the amount of this greenhouse gas in the atmosphere);
- Improve nitrogen-use efficiency (synthetic nitrogen fertilizers are energy intensive to produce, transport and apply; and soil emissions of nitrous oxide increase with nitrogen fertilizer use);
- Enter the expanding market for renewable energy using marginal land for wind and solar energy, biomass fuels, and energy from anaerobic digestion of manure and food processing wastes ;
- Improve manure management (reduces nitrous oxide, methane and CO_2 emissions, and can be used as renewable energy source in manure digesters);
- Increase consumer support—from households to large institutional food services—of local “food shed” networks.

Adaptive actions taken to address specific climate change vulnerabilities may have additional effects beyond their primary intentions. In some cases adaptive actions may raise new problems, while in others it is possible to design actions with multiple co-benefits.

- Increased water use and increased chemical loads to the environment. Increases in water and chemical inputs will not only increase costs for the farmer but may also have society-wide impacts in cases where the water supply is limited, by increasing the reactive nitrogen and pesticide loads to the environment, and the risks to food safety, and by increasing human exposure to pesticides.

- Increased energy use and greenhouse gas emissions may be associated with some adaptation strategies. Examples include increased use of cooling fans in livestock facilities, more energy use to pump irrigation water as more farmers expand irrigation capacity or pump from deeper wells, and increased energy use associated with increased use of products that are energy intensive to manufacture, such as some fertilizers and pesticides.
- Changes in land use could result from changes in cropping systems and other farm adaptations. Harvesting of wooded areas for biofuel crops and increased diversion of corn acreage for biofuel markets are possible. Such effects can be averted with appropriate strategic planning, and efforts toward this end have been initiated in the *Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply for New York State* (NYSERDA 2010). Land clearing for expansion of food or forage crop acreage may occur, particularly if other production regions of the country are more adversely affected by climate change than New York.
- Cascading negative effects on rural economies (see Environmental Justice Considerations above).

Recommendation 2. Incorporate anticipated increases in the incidence of weeds, diseases, and insect threats due to climate change in current detection, monitoring, and integrated pest management efforts.

An overall increase in the number of outbreaks of a wider variety of insects and pathogens is likely. Additionally, there are strong empirical reasons for expecting climate change and/or rising levels of CO_2 to benefit undesirable (noxious and invasive) weeds more than crops. New York State is fortunate to have existing statewide programs that target these specific threats while minimizing social, environmental, and economic costs. This policy recommendation has the dual purposes of initializing a comprehensive evaluation of existing programs to identify gaps; and leveraging existing state programs through expansion of outreach and education materials and curriculum, research and development of new management strategies, and enhanced coordination of monitoring, detection, and response efforts. Since many of these threats (specifically insects) have impacts beyond the farm that require similar responses, the Community Integrated Pest Management Program is included in the policy recommendations. (Note: Ecosystems Recommendation 1 discusses invasive species.)

Specific Actions

A. Conduct a formal evaluation of the capacity of existing federal, State, and local agriculture and forestry programs or systems focused on identifying and monitoring existing and emerging weed, disease, and insect threats as a response to a changing climate.

Federal, State, and an increasing number of local governments have programs focused on addressing the threats of weeds, disease, and insects in an economically and environmentally sound manner. An evaluation and gap analysis of these programs is necessary to address problems that may reduce the ability to adequately respond to these increasing threats in a cost-effective and proactive fashion.

Potential Cost

Cost of a review and evaluation should be relatively low.

Timeframe for Implementation

2010-2011. This recommendation should be implemented in the near term to ensure state resources are expended efficiently.

B. Develop coordinated protocols and multiple response tactics such as the development and deployment of pest-resistant plant varieties, regional coordination for early detection, and rapid-response approaches to emerging threats.

Existing State programs focused on agricultural and forestry threats are important mechanisms for ensuring the viability of these industries, which will increasingly face these threats under a changing climate. Integrated pest management programs are important mechanisms for communities to address infestation problems in housing, schools, recreational facilities, houses of worship, and other gathering places.

Potential Cost

For the past several years the Integrated Pest Management (IPM) program has been funded through a legislative appropriation of approximately $1 million annually for the agricultural IPM program and $400,000 for the community IPM program. Due to State budgetary constraints, funding for the 2010-2011 budget year was cut to $500,000 for agricultural IPM and $0 for community IPM. Historically, the IPM program has used the state IPM allocation to leverage $2-$3 million for New York State by obtaining grants from federal and private sources. With significantly reduced State funding, much of this leveraged funding will be lost. The New York State Cooperative Agricultural Pest Survey program has been funded exclusively through federal funds at $235,000 annually for the past several years. The public benefit of expanding these and similar programs is expected to significantly outweigh the cost of full programmatic funding.

Timeframe for Implementation

2010–2012. Restoration to historical funding levels should occur in the very near term as some programs that have experienced reduced levels of funding have had to cut staff and programs. 2012–2020: Expanded funding should occur in areas identified in the comprehensive review and evaluation of existing programs and be consistent with the timeline found in the Climate Action Plan Mitigation Strategy for IPM under AFW 4 1.2(e).

Impacts/Vulnerabilities Addressed

Resources being impacted include all agricultural crops and forests. The increase in weeds, disease, and insect pressure will result from several climatic factors including higher temperatures, increased frequency of intense precipitation, and increased CO_2.

Environmental Justice Considerations

Decreasing yields and the high costs of adaptation may translate into significant downstream job losses and cascading economic effects across rural communities. Low-wage, temporary, seasonal and/or migrant workers are particularly exposed to these shifts.

Co-benefits and Unintended Consequences

Early detection and rapid response to emerging or increasing weed, disease, and pest pressure while minimizing the use of chemicals to control these pressures will provide for reduced chemical loads to the environment. This will result in improved water and air quality, and improved public health. Employing a comprehensive and integrated approach to addressing these concerns will also decrease input costs for the farmer.

Recommendation 3. Evaluate and develop mechanisms to more effectively protect livestock from the effects of greater temperature variability and extremes.

The dairy industry in New York is likely to be affected by rising temperatures under climate change. These changes are expected to cause longer and more frequent episodes of heat stress for dairy cows, resulting in potential production losses and reduced calving rates. Mechanisms to protect dairy livestock from the projected temperature changes should be developed.

Specific Actions

A. Channel appropriate resources to continue research, development, and deployment of livestock protection measures and techniques such as climate-related modifications to feed management systems and approaches.

Short-term impacts of heat stress in dairy cows include decreases in feed intake and milk production; long-term effects include higher incidence of lameness and poorer reproductive performance. Modification of feed rations has proved to partially ameliorate heat stress effects in dairy cows.

Potential Cost

A comprehensive strategy of feed management that addresses multiple environmental concerns at the same time is a relatively low-cost approach under which multiple public benefits can be realized. The difficulty is assigning or accrediting benefits to individual funding sources, which are often based on single-resource objectives.

Timeframe for Implementation

Should be consistent with the timeline for Precision Feeding for Mitigation found under Climate Action Plan Mitigation Strategy AFW 4 1.3(f), which begins in 2013 and progressively ramps up to meet 2050 targets.

B. Support the increased installation of energy-efficient cooling systems and other structural or mechanical interventions.

Increasing the cooling capacity of existing livestock facilities is an obvious adaptation strategy to address heat stress in livestock but will bring with it increased expenditures in energy costs. Opportunities to deploy energy-efficient systems and maximize on-farm generation of clean renewable energy to power these systems should be encouraged and supported.

Potential Cost

Cost of providing technical assistance will likely be relatively low. Costs of providing financial assistance to make structural and mechanical modifications will be relatively moderate to high. Costs to deploy renewable energy technologies will be relatively high. Multiple funding programs exist for the implementation of renewable energy technologies and the conduct of energy efficiency audits, as well as implementation of energy efficiency measures. Ability to use necessary structural and mechanical modifications as an eligible cost-share when coupled with renewable energy technologies to address heat stress in livestock as part of an adaptation strategy should be explored.

Timeframe for Implementation

Heat stress in livestock is already having a negative impact across New York State; there is also a high certainty that this will continue for the foreseeable future. Investments made now will be less expensive than in several decades. Many of these practices will require significant planning and design as well as capital. To ensure continued competitiveness and long-term viability of the New York State livestock (dairy) industry, these policy options should be pursued in the near term. Additionally, timelines for the complementary mitigation policies have been established with near-term and long-term goals.

Impacts/Vulnerabilities Addressed

The New York State Livestock Industry will likely experience production loss and reduction in calving rates due to heat stress. The ClimAID assessment concluded that negative economic impacts on the New York State dairy industry will be substantial unless dairies are able to adapt.

Environmental Justice Considerations

Vulnerability and capacity to adapt to climate change may vary substantially across different dairy regions in New York State due to differences in climate change exposure, regional cost structures, farm sizes, existing farm infrastructure, and overall productivity. Should climate change induced heat stress have a highly detrimental effect on dairy farming in the state overall, those regions with higher concentrations of dairy farms are likely to experience a more substantial economic disruption.

Differences in farm and herd size are also potentially significant factors in determining vulnerability and capacity to adapt to climate change. Comparison of small versus large farms throughout the state reveals significant differences in the costs, milk production per cow, capital efficiency, income, and profitability. All of these differences may affect the overall capacity of smaller farms to adapt to climate change, particularly if such adaptation requires significant new outlays of capital for the purchase and installation of cooling systems in dairy barns, as well as additional costs associated with energy for operating the equipment, and the installation of on-farm renewable energy generation.

Co-benefits and Unintended Consequences

- Contributing to the competitiveness and long-term viability of a significant, albeit currently struggling, sector of the upstate rural economy;
- Contributing to the size diversity of New York State livestock farms;
- Increasing the energy efficiency and renewable energy capacity of New York State, leading to greenhouse gas reductions.

Coastal Zones

Coastal Zones Adaptation Vision Statement

By 2050, all coastal waterfront communities, including those in the Hudson River estuary, and critical coastal resources and infrastructure, have prepared for and are protected from the changing climate.

Background

The U.S. Coastal Zone Management Act of 1972, as amended in 1996, defines the coastal zone as the land inward of the shoreline needed to control or manage uses that are likely to directly and significantly impact coastal waters or are likely to be "affected by or vulnerable to sea level rise." New York State considers coastal waters to extend three miles into the open ocean and up to the state lines of Connecticut and New Jersey along the shore. In this assessment, the coastal zone is considered to include the shoreline of New York State, including coastal wetland areas and inland areas adjacent to the shoreline that are likely to be affected by sea level rise and coastal storms. Also considered are the potential effects of climate change up the Hudson River to the Federal Dam at Troy and the influence rising ocean temperatures may have on migratory and sedentary fish and shellfish populations.

Coastal ecosystems include near-shore sub-tidal areas, the low-marsh intertidal zone, high-marsh, beaches, dunes, stream channels, rocky platforms, sea grass meadows, algal beds, and tidal flats. Even in a densely populated urban environment such as New York City, these coastal ecosystems provide numerous functions and values. Tidal marshes provide wildlife habitat, storm surge protection, wave attenuation, pollution absorption, and aesthetic appeal. More than 300 species of birds spend part of their life cycle in New York's coastal shores, feeding, resting, or nesting. Every May and June, thousands of horseshoe crabs come to spawn on the sandy beaches of Long Island, New York City, and Westchester County. Many bird species depend on the horseshoe crab eggs or other invertebrates of the tidal zone to replenish their fatty reserves and continue on migration routes along the Atlantic flyway.

Coastal marshes and wetlands are highly sensitive and must maintain a delicate balance as they are affected by rapid sea level rise, wave erosion, sediment deposition, and other forces; these important ecosystems provide wildlife habitat, protect coastlines against storms, and absorb pollution. New York State's coastal marshes are limited to the north and south shores of Long Island, New York City, Westchester County, and Hudson River. In the tidally influenced portion of the Hudson River Estuary (up to the Troy Dam), the dominant ecological communities are freshwater and brackish tidal marshes, freshwater tidal swamps, tidal creeks, mud and sand flats, and freshwater sub-tidal aquatic beds. However, these are limited to north of the Tappan Zee Bridge, as there is little or no break in shoreline armoring (bulkheads and riprap) from Manhattan to the bridge.

The New York State coastline is comprised of a unique combination of glacial bluffs, pocket beaches, and extensive barrier island—bay systems. Long Island is particularly vulnerable to the effects of shoreline erosion since it is largely formed of sand and gravel deposits left by the retreating glaciers after the end of the last ice age around 20,000 years ago. The south shore of Long Island is a sandy environment consisting largely of barrier islands, spits, and back-barrier salt marshes that are very erodible and subject to inundation.

Climate Impacts

The coastal zone of the New York City metropolitan region faces both ongoing and future natural hazards of flooding, beach erosion, and sea level rise. The anticipated global sea level rise due to climate warming will have a significant impact on New York’s coastal areas, in addition to other impacts like ocean circulation changes and higher water temperatures. The effects of global sea level rise will be amplified in New York State due to coastal subsidence caused by ongoing adjustments of the Earth’s crust to the melting of the ice sheets that began 20,000 years ago.

New York's coastal zones are becoming more developed, increasing the consequences of flooding and coastal erosion. Sea level rise will greatly amplify current risks to coastal populations and will lead to permanent inundation of low-lying areas, more frequent flooding by storm surges, and increased beach erosion. Saltwater could reach farther up the Hudson River and estuaries, contaminating urban water supplies, while increased water depth could permit the tide and storm surges to propagate faster up the Hudson River to the Troy Dam, increasing flood risk far from the ocean coast.

Sea level rise may become the dominant stressor acting on vulnerable salt marshes. Loss of coastal wetlands reduces fish and shellfish populations. Higher water temperatures also affect these populations. Some marine species, such as lobsters, are moving north out of New York State, while other species, such as the blue claw crab, are increasing in the warmer waters.

High water levels, strong winds, and heavy precipitation resulting from strong coastal storms already cause billions of dollars in damages and disrupt transportation and power distribution systems. Barrier islands are being dramatically altered by strong coastal storms as ocean waters wash over dunes, create new inlets, and erode beaches. Warming ocean waters have the potential to produce stronger storms by increasing the source of energy for these storms.

Non-climate-related stresses will compound the effects of climate change. In the coastal region, most of these are associated with human consumption of natural resources and land-use practices. For example, coastal development, construction of organized drainage, and impervious surfaces has led to a reduction in groundwater recharge and degraded coastal water quality. The interconnection among precipitation, land use, and local fish populations has also been documented, suggesting that increased urbanization may lead to a reduction in stream biodiversity. In addition to water-quality-related stresses, fish stocks and other marine ecosystems may be affected by harvesting practices, disease, normal population dynamics (increased predation), and recruitment processes. Over-development along the coast increases the demand for groundwater, which could lead to drawdown of the aquifer and increased saltwater intrusion. Coastal infrastructure inhibits natural migration of marine systems, including wetlands and barrier islands.

Impacts and Vulnerabilities Addressed for All Sea Coastal Recommendations

Sea level rise will progressively affect both human and natural systems, affecting water levels on the ocean and estuarine coastline including the Hudson Estuary to the Troy dam; shortening flood-recurrence intervals; increasing risk and geographic extent of coastal hazards such as storm-surge-related flooding, erosion, and groundwater intrusion. New York State needs the best available climate data to best plan for climate impacts. As outlined in the “Common Themes” section of this chapter, the provision of climate data and projections could be facilitated through state support of a Climate Science. The guidance that would be provided by this organization would be extremely helpful to decision makers in all sectors affected by climate change.

Recommendation 1. New York State should endorse a coordinated set of projections for sea level rise and associated changes in flood-recurrence intervals in all coastal areas, including the Hudson River to the Federal Dam at Troy, for use by State and local agencies and authorities for planning and decision-making purposes.

New York State should formally endorse projections for sea level rise and associated changes in flood-recurrence intervals in all coastal areas. It is necessary to factor this information into planning and decision making now to reduce risk to communities and infrastructure vulnerable to sea level rise and strong storms and to conserve coastal natural systems, where the greatest threat from sea level rise is the construction of protective barriers that will prevent them from naturally migrating inland in response to rising waters (see Recommendation #2). Columbia University, NASA/Goddard Institute for Space Studies has developed projections for sea level rise for the entire coastal area of New York State based on the findings and methodology of the Intergovernmental Panel on Climate Change (IPCC) and leading climatologists and glaciologists. These projections have been adopted by the New York State Sea Level Rise Task Force (SLRTF), New York City Panel on Climate Change (NPCC), and the NYSERDA Statewide Climate Impacts and Adaptation Assessment (ClimAID). However, projections should be regularly updated, modified, and refined.

Potential cost

There would be no direct cost to endorse the recently developed projections of the New York State Sea Level Rise Task Force, NYC Panel on Climate Change, and ClimAID. The cost of updating projections in the future may be minimal, since projections are expected to be based on existing global and regional models. The adoption of sea level rise projections offers the opportunity to change planning and decision making to reduce future impacts. Some coastal development opportunities may not be pursued as projections of vulnerability are factored into permitting decisions. If no projections are adopted, New York State could incur significant long-term costs from flood damage and potentially damaging *ad hoc* responses to flood events. Funding will be needed to support the revision of statewide projections of climate change on a regular basis.

Timing of implementation

This recommendation should be implemented immediately. In New York State people and infrastructure are currently at very high risk of a powerful storm event in coastal areas. Coastal ecosystems are at greatest risk from human decisions to erect protective barriers in response to flood events. These risks are increasing over time due to sea level rise. The endorsement of sea level rise projections, followed by State policy, regulatory actions, and decision making changes, will support new planning and development processes in coastal areas aimed at reducing these risks.

Environmental Justice Considerations

Incorporation of projections of future conditions in State policies, planning, and decision making will make State spending more efficient by emphasizing appropriate development. Identification of area of greatest risk and the direction of resources to vulnerable communities within such areas would help reduce risk to those communities. Vulnerable communities will need assistance if they must relocate from high-risk areas, and there may be community objections to changes in State spending necessary to address sea level rise.

Co-benefits and Unintended Consequences

Adoption of sea level rise and storm-recurrence would provide the basis for a wide variety of State and local planning efforts. See recommendations 2-5.

Recommendation 2. Integrate sea level rise and flood-recurrence interval projections into all relevant agency programs and regulatory, permitting, planning, and funding decisions.

All State agencies should factor the projections of sea level rise and associated impacts from Recommendation 1 into relevant aspects of long-term planning, programming, permitting, regulating, and funding decisions. As necessary, the State should seek and/or provide technical guidance to make appropriate policy changes. Agencies should require or complete analyses of storm and sea level rise impacts over the design life of proposed projects in State permitting and funding decisions. Agencies should regularly update, modify, and refine guidance documents and plans based on current and new information on sea level rise. Local governments should also incorporate considerations of sea level rise into planning, zoning, and permitting decisions.

Potential cost

Although incorporation of sea level rise projections into agency decision-making *per se* would have minimal staff costs, resulting decisions could include costly capital outlays, reduction of some economic opportunities, and potential controversy. For example, denial of permits within a greater portion of the jurisdictional adjacent wetland area, may lead to legal challenges regarding private property rights. However, incorporation of these projections into agency decision making can lead to better planning for future conditions, prevention of loss, and avoidance of the larger dramatic and potentially catastrophic costs of inaction.

Timing of implementation

Immediate action is necessary to respond to the causes and impacts of sea level rise and climate change. Given current agency cooperation on adaptation efforts, this recommendation could reasonably be implemented within two to five years. Delays in planning for current and increasing risks of sea level rise and coastal hazards will result in greater the risk to humans, infrastructure and ecosystems.

Environmental Justice Considerations

Incorporation of sea level rise projections in agency decisions would likely enhance protection of communities within areas of environmental justice concern. For example, sea level rise projections should be used to prioritize the analysis of potential toxic exposures in Significant Maritime and Industrial Areas (SMIA) and inform Waterfront Revitalization Programs (WRP). However, there is the potential for some decisions to affect such communities disproportionately, for example by resulting in decreased property values or reduced opportunities for economic development. Agency decisions must include clear evaluation and description of risk, robust public participation, and enhanced efforts for public involvement in areas of environmental justice concern. With increased regulatory protection against building in flood zones, a tradition of construction on cheaper land that historically is flooded may be prevented, saving state and community resources.

Co-benefits and Unintended Consequences

Specifics vary by program and type of decision, but co-benefits of accounting for sea level rise in regulatory decision making would generally include minimizing the extent of erosion and coastal flooding and inundation, thereby enhancing protection of critical natural habitats providing new opportunities for passive recreation; reducing the risk of disruption of important communication, transportation, and health services; improving land-use planning; reducing potential for forced relocation; and reducing expenditures for shoreline armoring and beach nourishment. Unintended consequences could include intensified land use outside the coastal zone, capital outlays for elevation and relocation, and political ramifications.

Recommendation 3. Identify and map areas of greatest current risk from coastal storms and greatest future risk from sea level rise and coastal storms in order to support risk reduction actions in those areas

New York State should take action immediately to define the most vulnerable coastal areas and revise standards for development and redevelopment to reduce risk in these areas, taking into account the progressive nature of sea level rise. Regulatory and planning programs to reduce risk will require identification, classification, and mapping of high-risk areas including the following:

- Areas at greatest risk from sea level rise;
- Areas at risk from storm surge with current sea levels;
- Areas at risk from storm surge with sea level rise.

In addition, criteria should be developed to identify areas that may be sites of dune, barrier island, and/or wetland migration in response to sea level rise. Maps of the coastal zone should be updated to include these areas. All of the above maps should be updated on a regular basis and the most up-to-date maps should always be used for official decision making.

The following information will be needed to fully assess vulnerability: localized projections of climate effects; projections of storm surge; environmental information such as high resolution elevation and bathymetry; spatial information for natural, built, and human resources; socio-economic data; and development models such as build-out scenarios.

This recommendation is consistent with and critical to the implementation of several recommendations of the New York State Sea Level Rise Task Force (SLRTF) and the ClimAID Statewide Climate Impacts and Adaptation Assessment.

Potential cost

The New York State Office of Cyber Security and Critical Infrastructure, in coordination with the NYSDEC and NYSERDA, is seeking to initiate a mapping mission to collect high resolution elevation data using light detection and ranging technology (LiDAR) on the coastal regions of New York State. High resolution contours of 1 foot are desired to be developed for all coastal areas of Long Island and the Hudson River estuary from its mouth at New York City, north to the Troy Dam. This effort would provide the resolution necessary to map communities and critical infrastructure at greatest risk of sea level rise in the near term (next 30-50 years), and to project the most likely path of inland tidal wetland migration in response to sea level rise. The total cost, including the development of maps, is estimated to be nearly $1 million. The combined costs of the development and update of storm surge projections, build-out scenarios, and tidal wetland migration areas could be significant but may benefit from federal support.

Timing of implementation

Recommendations for enhanced elevation mapping should be advanced immediately. At a minimum, digital base maps from the National Flood Insurance Program could be utilized as the basis for mapping projected flood plain inundation in 2050 and 2100. The technology exists to complete revised storm-surge projections and build-out scenarios, but funding is needed for research to identify coastal areas most suitable for tidal wetland migration. With adequate funding the extension of interactive mapping tools with high-resolution elevation data to enable visualization of future sea level rise and storm surge scenarios could take 2-5 years to develop.

Environmental Justice Considerations

Assessment of areas vulnerable to sea level rise could be used to identify program and planning needs to serve less affluent communities and to enable effective adaptation in those areas. Public investments could be used to support communities that have a lack of capacity to address the highest risks from coastal flooding. However, there is the potential for updated mapping products to result in decreased property values or reduced opportunities for economic development in areas that are highly vulnerable to flooding.

Co-benefits and Unintended Consequences

Identification of high-risk coastal areas would allow identification of priorities for capital investment funding to reduce risk, enhanced management planning for at-risk natural habitats, preservation of areas for public access and passive recreation, and the identification of risk to communication, transportation, and health services. Unintended consequences could include the development of land-use conflicts and the political ramifications of mapping high-risk areas coastal areas with high property values.

Recommendation 4. Reduce vulnerabilities in coastal areas at risk from sea level rise and storms (coastal risk management zone) and support increased reliance on non-structural measures and natural protective features to reduce impacts from coastal hazards.

Where appropriate, the preference for new development and re-development in the *coastal risk management zone* should be for projects or actions consistent with policies and programs that emphasize reliance on natural protective features and non-structural measures, such as elevation and relocation, to minimize negative impacts from coastal storms, erosion and sea level rise. Support should be provided to regional and/or local planning that aims to reduce risk from sea level rise and coastal hazards, to projects or actions identified in plans to conserve natural protective features and to secure opportunities for habitat migration in response to sea level rise, and to implement site-appropriate structural and non-structural measures to reduce risk of coastal hazards. Decision makers must be cognizant of the sensitive nature of land-use decisions and provide for local participation in decisions. Policies and programs must be consistent with the New York State Coastal Management Program Policies (Article 42) and Coastal Zone Management Act and should accomplish the following:

A. Development of Coastal Resilience Plans

Direct public investment, programs, and policies toward regional, county and/or local planning offices in coastal areas to support the development of long-term, regional-scale coastal resilience plans. Opportunities to develop partnerships at the federal level should also be pursued. Coastal resilience plans would be developed with the participation of the appropriate local governments and authorities. They should strive to reduce vulnerability in the *coastal risk management zone* through non-structural measures wherever possible; to identify areas of significant public investment, water dependent uses, and/or critical infrastructure that require structural protection because options for relocation, elevation, or employment of non-structural measures are not feasible; and to outline opportunities to reduce vulnerability during recovery and restoration following high-intensity coastal storms.

Potential Cost

State support is needed for the funding, guidance, and technical assistance necessary for the development of Coastal Resilience Plans and a policy shift toward a preference for non-structural solutions. Overall costs would be low, provided supporting recommendations on data acquisition and mapping are completed, compared to the costs of inaction.

B. Assistance in Funding Measures to Reduce Risk

Direct public investment, programs and policies to assist regional, county, and/or local planning offices in coastal areas to implement the risk-reduction measures outlined in approved coastal resilience plans.

Potential Cost

In the last five years, New York State spent more than $22.6 million in projects to protect public infrastructure, and commercial and residential property in high-risk coastal areas from erosion and flooding. Tens of millions of dollars are being allocated for coastal protection structures in the coming decades. Funding for these types of projects should be redirected over time to reduce vulnerability in coastal communities and support non-structural measures that will reduce long-term risk from coastal hazards with minimal ecosystem impact.

Timing of implementation

Modification of State coastal policies and programs to advocate and support preparation of coastal resilience plans should be proposed in the near term. Other planning supported by the State or involving State facilities or infrastructure should be coordinated with coastal resilience plans. Specific criteria that should be addressed in coastal resilience plans and the standards by which such plans would be evaluated for completeness should be identified. Plan preparation will take time and should be started as soon as possible. It will take a minimum of 2- 5 years for the first coastal resilience plans to be prepared after they are initiated. The completion of plans in all of the coastal areas of New York State would take several years depending on the commitment of funding.

Environmental Justice Considerations

Less affluent communities and individuals will have difficulty finding adequate resources to develop coastal resilience plans. Lower income community members in low-lying coastal areas may also have more at stake than, for example, second-home owners on the coast, and less time and resources to devote to participating in local planning efforts, and their needs may be overlooked if they don't have adequate representation. Assistance for developing plans, adapting public infrastructure and facilities, and addressing the needs of private low-income property owners is needed. Incentives should ensure participatory planning in low-income communities.

Co-benefits and Unintended Consequences

- Community planning for sea level rise will help identify critical development, infrastructure, and natural resource assets for risk management.
- Planning to reduce sea level rise impacts is more likely to secure natural resources than individual or uncoordinated actions in response to storm events as they occur. It is also possible that mapping of natural resources and systems will improve as a result of regional planning.
- Vacated lands could be converted to public-access points with broad community benefits.

- Allowing natural features to migrate and adjust to changing conditions via natural processes (breaching, washover, migration, etc.), unhindered by development improves their long-term survivability and flood-protection benefits to communities.

Recommendation 5. Develop a long-term interagency mechanism to regularly evaluate climate change science; set research priorities to foster adaptation; coordinate programming, regulatory, and funding actions; and assess progress in adapting to climate change and sea level rise

A permanent mechanism is needed to ensure interagency and multi-organizational coordination; to review projections of the anticipated impacts of climate change on a regular basis following the IPCC schedule (roughly every 5 years); to develop priorities for federal, State, and local research and policy and regulatory initiatives to respond to climate change; and to oversee progress in Council-recommended policy implementation, including the recommendations of the SLRTF and the ClimAID statewide impacts assessment. Prioritized recommendations for federal policy changes should also be developed since federal programs and policies often contribute indirectly to increasing or maintaining risk. Opportunities for regional coordination should also be investigated. The creation of a New York State Climate Science Institute would greatly assist these efforts.

With broad support at the executive level this recommendation could be highly effective at addressing state management of resources. Effective interagency communication would reduce duplication of efforts, allow expression of a broad range of perspectives on challenges, and a pool of resources and strategies to address them, and would provide a structure for policy adjustments, improving resiliency as new and better information becomes available.

Potential cost

Agencies will require staff to organize the interagency effort and advance these recommendations, develop products and disseminate information, and facilitate integration of new policies and programs into agency operations. Funding will be needed to monitor climate, impact, and adaptation indicators.

Timing of implementation

Action is needed immediately to advance agency coordination, initiate discussions with partner agencies, and establish information priorities. This recommendation could be implemented within 2 years.

Environmental Justice Considerations

Groups or communities with the least economic resources will be disproportionately affected by climate change because they are most likely to be living in more vulnerable areas and living in less durable homes, and have the least personal resources to enable them to adapt. The proposed interagency work group could offer a forum to discuss environmental justice issues and potential solutions, identify long-term funding so advocates for environmental justice can participate, and provide a venue for addressing related needs in state agency operations.

Co-benefits and Unintended Consequences

True interagency coordination on climate change would have an enormous benefit to regional and local governments. Regulated entities in the coastal zone must deal with an array of uncoordinated agency funding and regulatory programs that can confuse even the most seasoned of local officials. Consolidation of policy and regulatory priorities, funding programs, and technical assistance, and integration across agencies, could conserve both state and local resources and tax dollars. At a minimum, the interagency group offers an opportunity for State agencies to present unified information concerning climate change and sea level rise and a forum for two-way communication with communities and community groups on climate change adaptation needs. If climate change projections, and protective policies and regulations are not adopted to reduce vulnerability in high-risk coastal areas, New York State could incur significant long-term costs into the billions of dollars and increased risk to life and property.

Ecosystems

Vision Statement

Ecological systems will continue to sustain healthy, diverse, well-distributed and abundant populations of fish, wildlife, plants, and human communities that are adapted to survive and thrive in a world impacted by unprecedented and accelerating climate change.

Background

New York State covers an area of 54,077 square miles, including 47,047 square miles of land, 1,894 square miles of inland lakes and rivers, and 3,988 square miles of the Great Lakes. Variations in topography and in proximity to bodies of water cause large climatic variations and distinct ecological zones that support the complex web of biological diversity and provide important ecosystem services.

Valuable ecosystem services provided by New York’s landscapes include harvested products (food, timber, biomass, and maple syrup), clean water and flood control, soil conservation and carbon sequestration, biodiversity support and genetic resources, recreation, and preservation of wild places and heritage sites. New York’s ecosystems recharge groundwater supplies and reduce soil erosion by creating catchments that enhance rainwater infiltration into soils as opposed to allowing rapid runoff of storm water into streams. The healthy vegetation of landscapes helps to stabilize and conserve soils, and also sequesters carbon above ground in the standing biomass of trees and perennial plants and below ground in the form of roots and soil organic matter. The diverse flora and fauna supported by New York landscapes play a role in maintaining earth’s biological heritage, and the complex interactions among species benefit society in many ways, such as natural control of insect pests and disease. Genetic diversity will be essential for the natural adaptation of ecosystems to environmental stresses such as high temperatures and drought that will be exacerbated by climate change. In addition, genetic diversity has potential economic value in the search for new pharmaceuticals or organisms or compounds with biotechnology applications.

Ecosystems, as defined here, encompass the plants, fish, wildlife, and resources of all natural and managed landscapes (e.g., forests, grasslands, aquatic systems) in New York State except those land areas designated as agricultural or urban. This sector includes timber and maple syrup industries, and tourism and recreation businesses conducted within natural and managed ecosystems. It also encompasses interior wetlands, waterways, and lakes as well as their associated freshwater fisheries and recreational fishing.

The impacts of climate change cannot be viewed in isolation, as other stressors are also affecting ecosystems and will affect vulnerability to climate change. While society and policymakers are likely to focus on ecosystem services, adaptation interventions by natural resource managers often will be implemented at the level of species, communities and habitats. As climate changes and the habitable zones of wild species continue to shift northward and/or up in elevation throughout the century, natural resource managers will face new challenges in maintaining ecosystem services and difficult decisions regarding change in species composition.

Climate Impacts

The initial impacts of climate change on species are already apparent, with documented accounts of changes in the seasonal timing of events like bud-break or flowering and species range shifts across the Northern Hemisphere. Within the northeastern United States, researchers have documented earlier bloom dates of woody perennials, earlier spring arrival of migratory birds, and other biological and ecological responses. Species and ecosystems are responding directly to climate drivers and indirectly to secondary effects, such as changes in timing and abundance of food supply, changes in habitat and increased pest, disease and invasive species pressure. Ultimately, biodiversity, net primary productivity, vegetation water use, and biogeochemical cycles could be affected by climate change. To date, however, there is no unequivocal evidence of climate change impacts on ecosystem services such as carbon sequestration or water storage and quality in New York State. The certainty in projecting climate change impacts diminishes as projections are scaled up from individual species and ecosystem structure to ecosystem function and services.

Within the next several decades New York State is likely to see widespread shifts in species composition in the state's forests and other natural landscapes, with the loss of spruce-fir forests, alpine tundra, and boreal plant communities. Warmer temperatures will favor the expansion of some invasive species into New York, such as the aggressive weed, kudzu, and the insect pest, hemlock woolly adelgid. Some habitat and food generalists (such as white-tailed deer) may also benefit. Additionally, higher levels of CO_2 tend to preferentially increase the growth rate of fast-growing species, which are often weeds and other invasive species. Both of these climate factors could also increase the productivity of some hardwood tree species, provided growth is not limited by other factors such as drought or nutrient deficiency.

Lakes, streams, inland wetlands, and associated aquatic species will be highly vulnerable to changes in the timing, supply, and intensity of rainfall and snowmelt, groundwater recharge, and duration of ice cover. Increasing water temperatures will negatively affect brook trout and other native coldwater fish.

Recommendation 1. Continue to support and maintain the Invasive Species Task Force, Invasive Species Council, Invasive Species Advisory Committee, and Partnerships for Regional Invasive Species Management (PRISMS) and support the implementation of the recommendations of the Invasive Species Task Force.

Invasive species pose a serious threat to the state's environment and economy, and these threats are exacerbated by the threat of climate change. Through the creation of the Invasive Species Task Force, New York State has taken proactive steps to address the spread of aquatic and terrestrial invasive pests and pathogens and to ensure state agencies, NGOs, businesses, and researchers are coordinated in their efforts to control this threat. In order for the state to be properly prepared to rapidly respond to emerging invasive species threats from a changing climate, investments must be made to implement the recommendations of the Invasive Species Task Force (ISTF).

The Invasive Species Council (ISC) has been established through legislation to continue the coordination of invasive species management across the state, enacting an important recommendation of the ISTF. In addition, the Invasive Species Advisory Committee has been formed and is helping to coordinate the broader efforts of outside partners and to provide important recommendations to the ISC. Both of these committees should be continued and supported to ensure that these important efforts continue. As these efforts progress, the state should ensure the federal government, neighboring states, municipal leaders, and NGOs are active participants in mitigation and response efforts. The continuation of the PRISM is an important way to achieve that coordination.

The ISC recently completed a final report on development of a regulatory system for non-native species that would prevent the importation and/or release of certain non-native species into the state and regulate the importation and sale of other invasive species. The recommended system would create the first official lists of invasive species for New York State. The recommendations in this report should be enacted, and an official regulatory system that would prevent future introductions of invasive species should be established.

As rapid response plans are developed and implemented to address emerging threats, these plans must include specific steps and funding to remediate the damage caused to the affected ecosystems. This will ensure that native ecosystems are healthy, productive, and resilient in the face of climate change. Also, all such invasive species response and management efforts must be coupled with a strong public outreach effort that educates and engages private landowners and the public on these restoration efforts.

Potential Cost

Aquatic and terrestrial invasive species cost the state and businesses millions of dollars to control and in lost productivity, and these costs will increase as climate change causes a wider distribution of invasive species. Although the continued operation of the Invasive Species Council and Invasive Species Advisory Council has minimal costs associated with it, the implementation of the recommendations could be quite costly. However, when the recommended actions are considered as preventative measures, and the costs of no action are included in the cost determination, it is likely that the cost of prevention is much smaller that the impact of no action. A discussion of this is included in the ISTF report.

Timing of Implementation

Near-term, as the impact is currently being experienced and must be addressed. Since it is hard to predict exactly which invasive species on the horizon will impact New York's ecosystems, investing in the creation of a rapid response plan is critical to the capacity to address emerging invasives that may take 10-20 years to enter the state.

Environmental Justice Considerations

The spread of certain pests and pathogens, e.g., West Nile virus, is increasing and lower income communities may have fewer resources available for prompt and effective treatment. However, by proactively controlling invasive species, impacts to these communities can be reduced. There are opportunities to coordinate with adaptation recommendations from the public health sector.

Co-benefits and Unintended Consequences

By investing in the control of invasive species now, the state will realize improved agricultural health and output, improved public health, improved water quality, improved ecosystem resilience, and improved habitat value for species. However, these control measures may potentially increase costs of transportation of goods in the state and increase costs for certain recreational activities such as boating and fishing.

Recommendation 2. Ensure that New York State's ecosystems sustain healthy, diverse, well-distributed, and abundant populations of fish, wildlife, plants, and human communities that are adapted to survive and thrive in a world impacted by unprecedented and accelerating climate change.

Specific Actions

A. Support State agency efforts to incorporate an ecosystem-based management approach that factors ecosystem function, services, and biodiversity into decision making, including management plans, funding decisions, and policies.

Established as the result of the 2006 New York Ocean and Great Lakes Ecosystem Conservation Act (Act), the New York Ocean and Great Lakes Ecosystem Conservation Council (NYOGLECC) has a goal of integrating ecosystem-based management (EBM) and smart-growth principles into state programs that manage human activities affecting ocean and Great Lakes ecosystem health[3]. Much of New York State's response to climate change would benefit from an ecosystem-based management approach, as developed through the above initiative, and should be applied on a statewide basis.

[3] See Draft Summary Report of Agency Guidelines and Recommendations. http://nyoglecc.org/reports.html

Potential Cost

Continued NYOGLECC activities are being undertaken within existing agency operating budgets. Several council agencies are incorporating EBM principles into their respective organizational structures without significant additional cost or creation of new programs.

Timing of Implementation

EBM integration underway for State agency decision making has multiple timelines. Overall, NYOGLECC has advanced or completed priority recommendations on schedule according to its 2009 report. Continuation of this work is critical to developing additional momentum within the NYOGLECC member agencies as well as to the expansion of the concept to other agencies and broader regional entities and organizations.

Environmental Justice Considerations

An ecosystem-based management approach, by definition, includes the human component of the ecosystem as an integral part of the planning process. Environmental justice communities in New York State's coastal areas are particularly susceptible to many of the projected impacts of climate change, and an EBM approach will help to provide comprehensive solutions that target environmental and human needs. EJ communities must be involved with the planning and decision making from the start.

Co-benefits and Unintended Consequences

An EBM approach leads to greater efficiencies and effectiveness in the application of government funds to advance ecosystem goals and specific projects.

B. To enable ecosystems to better respond to changing climate conditions, incorporate adaptive-management principles, techniques, and approaches into New York's forest-management policies and programs.

The State of New York manages more than 775,000 acres of state forests recognized for sustainable management by the Forest Stewardship Council and the Sustainable Forest Initiative. The State holds conservation easements on an additional 700,000 acres, some of which is managed for timber production. On these lands the state should develop forest best management practices (BMPs) for adaptation to climate change and management for carbon sequestration. These BMPs could also be used by private forestland owners, who own the majority of the state's 18.5 million acres of forests.

Potential Cost

While funding for the research component of this recommendation would be substantial, little of the cost would fall on the State of New York. The benefits of the research would be applicable over the northeastern states that share common forest types; therefore, probable sources of funding would be those traditionally used by the academic research community (e.g., National Science Foundation, Environmental Protection Agency, U.S. Forest Service).

The Department of Environmental Conservation already manages 768,000 acres for timber production. Therefore, the costs of giving priority to management practices that maintain the resiliency of forests stressed by climate change would be minimal. Rather, it requires a redirection of management objectives. Additional costs would be necessary in the demonstration component of this recommendation. This could be accomplished by adding four demonstration foresters to the DEC staff located across the state. An alternative approach would be to enhance Cornell University's Cooperative Extension Service by an equivalent amount. The estimated cost of this would be approximately $500,000 per year, including salary, travel, and operating expenses.

Timing of Implementation

The impact of changing forest practices is measured in decades, not years. Therefore, it is important to implement BMPs immediately to realize the carbon benefits of forest management that would occur by mid-century. The demonstration portion of this recommendation should begin in 2011 using the best information available on the influence of climate change on forests and on carbon storage and sequestration. At the same time, the demonstrators would be emphasizing the flexibility associated with adaptive management practices so that adjustments in forest management could be made as more research becomes available or as landowner objectives change.

Environmental Justice Considerations

There is little impact on environmental justice in the traditional use of the term. However, it is important to point out that average incomes in rural areas are, on average, lower than in urban areas.

Co-benefits and Unintended Consequences

Forests play an intriguing role in climate change in that the composition of forests are likely to change if there is significant climate change, while at the same time they can play a role in mitigating the impacts of climate change. A related issue is the potential for woody biomass as a substitute for fossil fuels as an energy source. The potential for solid fuels in the form of pellets, gasification as a source of heat and electricity, and liquid fuels such as ethanol is in its infancy but will likely grow. Thus, the combination of impacts of climate change on forest composition, the potential for improved carbon sequestration and storage, and the potential for forest products as a source of energy that may be more carbon neutral than fossil fuels is of high priority.

C. Protect and enhance the stability and function of stream, river, and aquatic coastal systems to accommodate changing climate conditions.

Safeguarding the integrity and increasing the resilience of stream, river, and aquatic coastal systems and associated wildlife corridors will greatly bolster the capacity of fish and wildlife to meet the many challenges of climate change. The following four inter-related strategies will address this goal:

- Maintaining and improving aquatic habitat connectivity by removing or mitigating man-made aquatic barriers including culverts, dams, and shoreline armoring;

- Increasing the protection for in-stream habitat features such as cold-water refugia, oxygen-rich riffles and runs, and natural shorelines with undercut banks and overhanging vegetation;
- Removing pollutants, including heat, from runoff entering water bodies;
- Maintaining hydrologic flows consistent with the needs of fish and wildlife and the functions of streams and rivers.

Shoreline corridors provide effective means of movement and dispersal of fish and wildlife. As such, they enable species to adjust their ranges in response to changing climate and environmental conditions. Much of the landscape is fragmented with human development, including subdivisions, roads, and commercial and industrial development. On the coast many shorelines are armored, preventing habitats like tidal wetlands from responding to sea level rise. This inhibits the ability of many species to adjust their ranges. However, New York has a rich and widely distributed network of streams and rivers. Providing shoreline buffers to coastal, stream, and river systems can provide the “transportation” system for fish and wildlife—both aquatic and terrestrial—to move on the landscape and establish new ranges in response to climate change.

Potential Cost

Protecting and restoring shoreline buffers will be a highly cost-effective strategy. Regulatory programs that protect existing buffers would require staffing. Although not inexpensive, these efforts are cost effective because they maintain existing habitats, offer a wide array of additional social and environmental benefits, and prevent other societal costs (e.g., addressing the effects of flooding along stream corridors). Incentive programs that pay to restore or protect shoreline buffers would vary in cost depending on the nature and magnitude of the restoration required.

Timing of Implementation

Adopting policies to protect and restore buffers should be undertaken immediately; it is a no-regrets action that has both short-term and long-term benefits. Buffers are already being restored in the state, so elevating this as a priority could result in very rapid implementation. This is a durable effort that could continue to restore additional buffers as future opportunities arise. Implementation of large-scale restoration programs would be a longer-term endeavor, with 86,000 miles of streams and rivers in the state, and 3000 miles of ocean and estuarine coastline, most of which have some degree of impact. It would be helpful to divide the state into priority watersheds and shoreline areas to concentrate initial attention and funding on the most critical areas.

Environmental Justice Considerations

This strategy would have positive impacts on all communities in the state, including EJ communities. Creating green space along shorelines and stream corridors improves the local environment and contributes positively to the quality of life in highly urbanized areas. Since the environmental justice community may have the least means to address the impacts of climate change, actions in environmental justice areas should be given high priority. Providing adequately sized road stream crossings such as bridges and culverts will significantly decrease the frequency and severity of flooding at these key junctures, improving safety for the traveling public and residents alike. Conserving the natural processes of tidal wetlands, dunes, and barrier islands can also contribute to coastal flood protection from strong storms.

Co-benefits and Unintended Consequences

The co-benefits of protecting and restoring riparian buffers are numerous: improved flood protection, improved protection of transportation infrastructure and surface drinking waters, improved water quality, increased availability of important habitats, increased property values, reduced threats of erosion (including to agriculture lands), improved public health, decreased costs of drinking-water treatment, decreased costs of farming, improved recreation opportunities, and reduced liability insurance premiums. Conversely, by protecting additional land adjacent to streams, there will be a somewhat reduced availability of developable or farmable land with perhaps a corresponding decreased tax base for local communities, although this probably would be offset by the reduced cost of infrastructure maintenance and improved quality of life benefits.

Recommendation 3. Develop a research and monitoring plan to detect, record, and analyze changes in species, habitat composition, natural cycles, and fish and wildlife health, and effectively address current and future threats in changing climate conditions.

To effectively manage the natural resources of New York State, practitioners must understand the baseline condition of species, habitats, and population trends. Rapidly changing climate and associated changes in habitats and ecological community structure will likely increase fish and wildlife exposure to stressors (both existing and those caused by climate change), compromise their ability to adapt to stress, and affect the ability to detect harmful trends in fish and wildlife ecology and health. An increase in the capacity to identify key stressors is needed to inform management decisions and abate threats. Assessments of species' and habitats' climate vulnerabilities, including exposure sensitivity and adaptive capacity, should be used to prioritize conservation actions.

The information from baseline condition surveys, stressor identification, and vulnerability analyses will directly inform the development of a research and monitoring plan for New York. Such a plan should be based on explicit, predictive, and measurable objectives and indicators, and include monitoring protocols that can reliably detect signs of climate change impacts.

Potential Cost

Developing a research and monitoring plan will not be of extremely high cost and can most likely be done with current staff *if prioritized*. On the other hand, implementing the plan will have high start-up costs and will be fairly labor-intensive. This is a primary reason why most New York entities have not conducted whole-scale resource monitoring to date, though there are exceptions.

Inaction on this recommendation is far more costly to society and ecosystems in the long term than is implementation. Sound science forms the basis of effective adaptation strategies in response to expected impacts from climate. In addition to the loss of ecosystem services gained directly and indirectly from nature, New York also stands to lose tens of millions of dollars annually from various grants and federal funding if it cannot demonstrate effectiveness of its conservation actions..

Timing of Implementation

The advent of climate change has increased the need for, and urgency of, developing and implementing a monitoring plan.

Environmental Justice Considerations

This recommendation would provide benefits across the state and all communities. Science-based projections of future conditions and vulnerabilities will assist in identifying communities most at risk, result in more efficient state spending and reduce long-term risk.

Co-benefits and Unintended Consequences

The research and monitoring detailed above will assist in incorporating adaptive-management principles into New York's natural resource management programs, protecting the stability and function of stream and river systems, developing and implementing an education and outreach strategy, and protecting and managing important migratory and dispersal corridors. To be effective, all of these activities must be based on sound science. This recommendation will also increase partnering efforts, maintain and leverage funding, help prioritize conservation actions, and maintain critical ecosystem services.

Conversely, by allocating staff time and dollars to research and monitoring, other management programs may be negatively affected in the short term. This will most likely be offset by greatly informing future management efforts to achieve the most cost-effective conservation actions.

Recommendation 4. Expand climate change education and outreach initiatives for students, landowners, and local governments. Include sound scientific information on the potential impacts of climate change on natural areas and ecosystem services.

Developing outreach and education mechanisms based upon up-to-date and reliable climate change data is a necessary component of the Climate Action Plan and the State's Climate Smart Community Program. Climate change education should be a component of general science curricula, and teachers across New York State and at all levels should be provided with reliable scientific information and have access to a suite of curriculum materials, including study lessons and student activity plans related to climate change.

On-the-ground and accessible demonstration sites reinforce climate education initiatives. The State should seek to secure funding and incentives for environmental educators to develop interpretive materials and assist schools in climate change education. Further, the State should encourage all agencies with programs related to education, resource management, and community planning to develop materials and displays that demonstrate the impacts associated with climate change and the role of each agency in the mitigation of these impacts.

Education and outreach to private landowners and land managers are critical to advancing on-the-ground climate-smart land management practices. State agencies involved in resource management should provide landowners and local governments with information on climate-smart BMPs related to planting climate resilient species, stochastic event planning, and optimizing wildlife habitat, managing riparian buffers, and controlling invasive species. Expanding and focusing current community technical assistance efforts to include standardized climate-smart BMPs is one way to expand education and outreach mechanisms to landowners and land managers across New York State.

Potential Cost

The costs of integrating climate education modules into general science curriculum standards are varied and long-term, and depend largely on the needed course materials relative to the level of training. The cost to New York State agencies to construct and implement climate demonstration sites and projects is immediate and short-term, but as learning sites for students and citizens would yield long-term benefits. The costs associated with expanding outreach to landowners and local communities may be offset substantially by effective coordination of non-governmental and state technical assistance initiatives.

Timing of Implementation

For New York State to successfully meet current and future challenges associated with climate change, education and outreach policy and mechanisms must be implemented immediately. Currently, there are successful efforts being undertaken across New York State; however, these initiatives must be expanded to adequately prepare New Yorkers for the myriad of impacts associated with climate change. Education and outreach to students, landowners, and local communities will require ongoing strategies, immediate implementation, and long-term resolve.

Environmental Justice Considerations

Education and outreach activities should be multi-lingual and multi-cultural, and include input from environmental justice communities as to the most effective means of communication.

Co-benefits and Unintended Consequences

The co-benefits associated with efficient education and outreach of students, landowners, and local communities are vast and varied. They include improved land management practices on private lands; expanded community energy efficiency, development, and planning initiatives; increased locally conserved lands; expanded green-technology workforce; clean-energy innovation; constituent support for environmental policies; increased wildlife habitat suitability as a result of changing land management practices; and increased wildlife habitat connectivity. Unintended consequences associated with pursuing dynamic goals include effort fragmentation resulting in inefficiency, complex delivery mechanisms that reduce effectiveness, and cross-effort redundancy. Progress metrics must be clearly established upon policy and mechanism implementation due to the ongoing nature and qualitative components inherent to many education and outreach initiatives.

Energy

Vision Statement

Ensure that the energy generation and delivery infrastructure throughout the state will prepare for, and adapt to, a changing climate by building system resilience, while providing the public with clean, safe, and reliable services.

Background

Energy is derived from a wide variety of fuel sources and technologies in New York State. Roughly 49 percent of the state's electricity is generated in-state using fossil fuels; nuclear power (30 percent) and renewables (21 percent) account for the balance. The generation mix varies widely in different parts of the state. The state's annual electricity load has increased by about 4.3 percent per year. New York City is by far the largest load zone in the state, responsible for approximately one-third of total annual electricity demand statewide

Thermal energy needs are satisfied in a variety of ways. New York State is home to more than a dozen district energy systems, which centrally generate steam, hot water, or cold water and distribute it to customers via a series of underground pipes. Natural gas and heating oil are the most commonly used sources of heating fuel in buildings around the state.

Reliable energy systems are critical to commerce and quality of life. New York State's electricity and gas supply and distribution systems are highly reliable, but weather-related stressors can damage equipment, disrupt fuel supply chains, reduce power plant output levels, or increase demand beyond the energy system's operational capacity.

Climate Impacts

Global climate change is expected to alter both average climate and the frequency and intensity of extreme weather events in New York State, affecting energy demand, system efficiency, and power supply potential. In certain cases, climate change may help New York's energy system function more smoothly, by eliminating weather-related supply chain problems through milder winter weather in some areas for example. However, climate change is more commonly predicted to adversely affect system operations, increase the difficulty of ensuring supply adequacy during peak demand periods, and exacerbate already-problematic conditions, such as the urban heat-island effect.

Impacts of climate change on energy demand are likely to be more significant than impacts on supply. Decreases in heating demand will primarily affect natural gas markets, while increases in cooling demand will affect electricity markets; such changes will vary regionally.

On the supply side, more frequent heat waves will cause an increase in the use of air conditioning, stressing power supplies and increasing peak demand loads. Increased air and water temperatures will affect the efficiency of power plants. Transformers and distribution lines for both electric and gas supply are vulnerable to extreme weather events, temperature, and flooding. Coastal infrastructure in downstate areas is vulnerable to flooding as a result of sea level rise and severe storms.

Renewable generation may also be affected. Hydropower, located primarily in upstate areas, is vulnerable to drought and changes in precipitation patterns. The availability and reliability of solar power systems are vulnerable to changes in cloud cover, although this may be offset by advances in technology; wind power systems are similarly vulnerable to changes in wind speed and direction. The effect of climate change on biomass as an energy feedstock is unclear, though biomass availability depends to some degree on weather conditions during the growing season.

The indirect financial impacts of climate change may be greater than the direct impacts of climate change. These indirect impacts include those on investors or insurance companies linked to vulnerable energy system assets or on customers forced to grapple with changing energy prices resulting from changing climate conditions.

Recommendation 1. Ensure the accuracy of electric demand and peak demand forecasting for planning purposes and build resilience for meeting peak demand.

Currently, forecasts of long-term energy use and peak demand are based on historical use of electric and gas utilities. Forecasts do not currently reflect the energy requirements that would result from changes in temperature or greater occurrences of heat events anticipated in the future resulting from climate change.

Specific Actions

A. Incorporate best available projections of changes in seasonal average temperatures and increased frequency of extreme heat events in near- and long-term demand forecasting for electricity and natural gas.

Peak demand forecasts in particular should be revised to incorporate predicted higher seasonal average temperatures and increased frequency of extreme heat events. These climate impacts will likely result in increased energy use and/or increased reliance on demand response, energy storage, and other energy resources to meet peak demands.

B. Plan to meet regional demand growth and improved system resiliency through local implementation of demand response and energy efficiency measures, greater use of localized distributed generation, energy storage, other energy-supply technologies, and smart-grid technologies, beyond those efforts already underway and planned.

The current regulatory and planning frameworks should be made more flexible and adaptable to a rapidly changing climate and related adaptation and mitigation efforts and accommodate new and emerging technologies more quickly to meet emerging needs.

Impacts/Vulnerabilities Addressed

Higher seasonal average temperatures and greater frequency of heat events will contribute to transmission line sags and to increased energy demands, possibly resulting in additional stress on distribution transformers. Energy-demand forecasts are already implemented to ensure that regional distribution capacity exceeds projected peak-load demand, thereby ensuring reliability of energy services. The regional load-planning process is an appropriate location for integrating temperature increases into demand forecasts, because problems with reliability will have disparate impacts based on where people live (e.g., urban heat islands). Furthermore, identification of energy efficiency and renewable distributed generation opportunities through this process can decrease the need to build additional distribution infrastructure. Planning for long-term increases in temperature will result in a more holistic approach to balancing the costs between distribution infrastructure and demand-reduction opportunities.

Energy demand will be impacted heterogeneously throughout the state. Some distribution systems will be impacted more than others, depending on regional characteristics. Rural areas could likely be impacted to a lesser extent than urban areas where there is a measurable heat-island effect.

Potential Cost

This recommendation calls for more effective planning and for incorporating projected temperature changes into demand forecast modeling. Doing so may add to the complexity of forecasting, but the increase in costs should be minimal. Identifying load conditions under high-temperature scenarios will facilitate more accurate cost/benefit comparisons between options for delivery infrastructure and for demand-reduction.

Timing of Implementation

Near-term: Incorporation of temperature increases into regional long-term load planning should begin at next opportunity (2-5 years).

Environmental Justice Considerations

There is concern over localized impacts of energy use and a desire to ensure that reductions in energy use result in localized emission reductions that improve regional air quality, including opportunities associated with peak-demand generation units. Better regional demand forecasting and planning can protect overburdened communities by accurately projecting future infrastructure requirements and identifying new sources of power or energy savings that reduce emissions for EJ neighborhoods by siting these facilities elsewhere, distributing the negative effects of power production, or reducing the need for operating those units presently located in or near affected communities, while maintaining electric system reliability.

Recommendation 2. Increase utilities' and energy providers' resiliency to climate-related impacts.

Climate models predict that higher ocean and atmospheric temperatures will contribute to the addition of energy to the global hydrologic cycle. As a result, it is predicted that New York State and the northeastern United States will experience more frequent and intense storm events. Higher wintertime temperatures may also contribute to more frequent ice storms. Electric outages that resulted from the March 2010 nor'easter storm in downstate New York demonstrated that heavy of precipitation coupled with high winds can be damaging to the electric transmission and distribution system. Many utilities in the southeastern United States operate in areas where high-energy storms occur. The exchange of risk-management criteria between southeastern and northeastern utilities helps to establish the best management practices that maintain reliability at the lowest achievable cost and should continue.

Specific Actions

A. Ensure that best available projections concerning the frequency and severity of extreme storm events are incorporated into State and regional emergency response plans.

State and regional emergency response plans should continue to work with a spectrum of stakeholders including utilities, first responders, community organizations, and individual households to gather necessary information, share it effectively, and use it to continuously improve emergency preparedness.

B. As part of a statewide vulnerability assessment and planning effort, ensure that detailed statewide maps are available to assist in identifying areas and infrastructure at high risk from storm and flood damage.

Energy infrastructure includes electricity generation, transmission, substation, and distribution facilities; interstate natural gas pipelines, storage facilities, compressor stations, and local distribution systems; propane facilities; and transportation and storage systems for a wide range of petroleum products (including pipelines, large and small-scale storage tanks, barge and rail operations, and various transfer facilities). Development of inventories of this infrastructure and potential vulnerabilities to climate change is critical to prioritizing protection of existing facilities.

C. Work with organizations such as the Electric Power Research Institute (EPRI) and NYSEARCH (a voluntary sub-organization within the Northeast Gas Association) to survey and assess utility industry best practices for increasing resilience to climate change.

Development of effective protocols and procedures for considering climate change-related risks in decisions to locate, design, and build energy infrastructure, both to maintain the reliability of existing systems and to meet the future energy needs is important. To incorporate innovations and best practices in climate adaptation, the State energy- planning process should evaluate strategies and techniques employed by utilities, regulators, and independent power producers regionally, nationally, and internationally. This evaluation process would examine the appropriateness of strategies and techniques for particular regions in the state.

Impacts/Vulnerabilities Addressed

Outages on the electric distribution system during storm events can limit delivery of health care and emergency services, banking, commerce, and air conditioning, heating, communication, and transportation pathways. Currently, no central resource to identify areas of the state most likely to experience one or all of the possible impacts exists. Recommendation 2.B. calls for a centralized state mapping system to document the areas of high risks of weather-related damage to infrastructure. This information will inform utilities and the Public Service Commission (as well as other infrastructure-owning stakeholders) about which areas are most susceptible to wind-tunnel effect, flooding, ice formation, erosion and other impacts from major storm events and which factors should be addressed in their infrastructure's risk assessments.

Differences in the manner in which infrastructure will be impacted by major storms across the state is a primary reason for identifying infrastructure risk through a central mapping program. Some distribution systems are more likely to be impacted by coastal storms from mid to late summer, whereas others are more likely to be impacted by severe snow and/or ice storms in the winter. Some utilities will also be susceptible to both types of storm events. Differences in regional characteristics will be a determining point for benchmarking.

Potential Cost

It is assumed that utilities and generators will upgrade their infrastructure to more resilient equipment as storms events become more frequent as a result of climate change. This set of recommendations seeks to minimize the cost of this process through analysis, climate forecasting, and benchmarking. Specifically, the cost of building resilience to climate change can be minimized or avoided if infrastructure is prioritized and triaged based on compelling long-term benefits and/or risk reduction (e.g., avoiding significant outages).

Timing of Implementation

Near to mid-term (10 years): Planning for and coordinating greater communication among emergency responders, utilities, and their customers, and independent power producers should proceed on an ongoing basis. Tracking infrastructure damage caused by storm-related incidents, initiating benchmarking between utilities, and developing best-management practices should be completed within the next 5-10 years.

Environmental Justice Considerations

During periods of storm activity, fuel and electric distribution can be compromised, as can communication pathways. Currently, utilities maintain records and prioritize restoration of services for individuals with home health care needs, emergency service providers, and hospitals. A significant or serious public health problem could arise if both electric power and communication networks are compromised at the same time. Leading up to and preceding large storm events, communicating with this at-risk population will be a critical and necessary public health concern. Communication efforts should be multi-lingual.

Public Health

Vision Statement

Begin planning now to protect and promote public health by reducing individual and community vulnerability to the potentially significant public health consequences of climate change.

Background

A diverse state, with populations spread unevenly over urban and rural service areas, New York is one of 26 states that rely primarily on a county-based system for public health service delivery. Local health departments operate under the authority of either the county legislature or local board of health. The result is a highly decentralized system with a non-uniform provision of core services. For example, local health departments provide environmental health services in 37 out of New York's 62 counties, while the State Department of Public Health provides service to the other areas. The New York State Public Health Council has identified this decentralization of public health service delivery as a key obstacle to efficient coordination of programming and data resources for climate-health preparedness. The Council has recommended regional, multi-county initiatives, which are proven models for more efficient and equitable distribution of expertise and services.

In an effort to improve health care provision, in 1996 New York State initiated a data and knowledge communication program linking a wide range of partners, including hospitals, local health departments, nursing homes, diagnostic centers, laboratories, insurance provider networks, and federal agencies. Current communication networks—Health Alert Network (state and city levels), the Health Provider Network, and the Health Information Network—are viewed as "both very helpful and very underutilized" by the Public Health Association of New York City. However, as a result of non-standardized data systems, the value of these networks across user groups is compromised. These would be appropriate organizations to target for climate-health educational outreach and to evaluate climate-health interventions.

Some current health conditions are considered potentially sensitive to the changing climate. Cardiovascular disease is the leading cause of death in the state and is made worse by extreme heat and poor air quality. Childhood asthma is an important current health challenge in many parts of New York State, especially in the five counties that comprise New York City, and is made worse by poor air quality. New York State has experienced the emergence of several vector-borne diseases (those spread by carriers such as mosquitoes and ticks) in the past few decades.

Climate Impacts

Climate change vulnerabilities in the public health sector are, to a large extent, those in which public health and environmental agencies are already engaged. However, climate change places an additional burden on public health agencies that are already burdened by low levels of staffing and funding. Climate-related risk factors include heat events, extreme storms, disruptions of water supply and quality, decreased air quality, changes in timing and intensity of pollen and mold seasons, and alterations in patterns of infectious disease vectors and organisms. Demand for health services and the need for public health surveillance and monitoring will increase as climate continues to change.

As a result of these climate risks, some climate-related health vulnerabilities have emerged. Heat-related illness and death are projected to increase, while cold-related death is projected to decrease. Increases in heat-related death are projected to outweigh reductions in cold-related death. Cardiovascular and respiratory-related illness and death will be affected by worsening air quality, including more smog, wildfires, pollens, and molds. Allergy and asthma cases are projected to increase and become more severe.

Vector-borne diseases, such as those spread by mosquitoes and ticks (e.g., West Nile virus), may expand or their distribution patterns may change. Water- and food-borne diseases are likely to increase without adaptation intervention. Water supply, recreational water quality, and food production will be at increased risk due to increased temperatures and changing precipitation patterns.

More intense storms and flooding could lead to increased stress and mental health impacts, impaired ability to deliver public health and medical services, increased respiratory diseases such as asthma, and increased outbreaks of gastrointestinal diseases.

These vulnerabilities span a range from the relatively direct, data-rich, and well understood to more complex, multi-factorial systems for which both data and models are currently underdeveloped. Uncertainties pervade any effort to predict either direct or indirect health impacts of climate change. These uncertainties increase the importance of building resilience into the public health system to cope with inevitable surprises to come. Vulnerability assessments combined with a full accounting of uncertainties will help in prioritizing climate-health preparedness plans, informing communities on which actions should be taken first which information gaps are most critical to fill.

Recommendation 1. Improve or establish robust public health mechanisms to reduce the potential for heat-related morbidity and mortality in New York State.

Projections indicating that extreme heat events in New York State are likely to increase in frequency, intensity, and duration point to the need for mechanisms to reduce the potential for heat-related morbidity and mortality. These mechanisms include expanded outreach and education activities, assessment of the adequacy of existing heat warning systems and cooling center programs, working with utilities to address health needs associated with heat-related power outages, working with community-based organizations to provide assistance to vulnerable populations, and implementing a statewide plan to reduce the urban heat-island effect.

Specific Actions

A. Assess the adequacy of existing heat-warning systems and, as necessary, expand the capacity of existing cooling-center programs. For the latter, factors that should be considered include siting, potential transportation obstacles, effects of power outages or flooding, and other needs of vulnerable population/communities.

As heat-related climate events increase in frequency and severity, significant additional resources may be needed to prevent heat-related morbidity and mortality. A thorough assessment of existing systems and programs must be undertaken as soon as possible.

Potential Cost

State and local agencies will need additional staff resources to effectively implement this action. Other partners, such as academic researchers and community representatives, also may seek compensation for their efforts. Significant capital costs are likely to be associated with the siting of any additional cooling centers, relocating existing cooling centers, and with any necessary maintenance of cooling centers. Costs of staffing and operating some cooling centers and providing for public transportation to cooling centers also may be significant.

Timeframe for Implementation

New York State already uses systems to warn people about excessive heat. Therefore, while the recommended assessment of existing systems should begin in the near term, it has somewhat less urgency than some of the other recommended public health strategies and actions described in this section. Given the anticipated increase in the frequency and intensity of extreme heat events, work to begin expanding and enhancing cooling center programs should begin as soon as possible.

B. Enhance existing education and outreach activities, employing multilingual and culturally sensitive approaches and making use of appropriate media to increase awareness of the public health consequences of heat exposure and measures to avoid heat-related morbidity and mortality. Efforts should target particularly vulnerable populations.

Education and outreach may be the single most important way to reduce heat-related morbidity and mortality. To achieve effective awareness of heat-warning systems and use of cooling-center programs, efforts should be tailored to reach target audiences. Additionally, many vulnerable people lack personal mobility and may not be easily reachable via public-service announcements. Often they will be under physician care for chronic medical conditions; it may be effective to work with physicians and managed-care organizations to help get information to vulnerable patients, and to provide a communications link that those patients can use to call for help. Physicians and managed-care organizations might also be in the best position to identify those most vulnerable according to medical condition, language, and residential information (e.g., living on the top floor).

Potential Cost

One or more agencies should be provided with the necessary staffing resources to implement this action or be directed to reallocate existing resources. Additional costs will include those associated with publishing and distributing printed materials, purchasing space and time for commercial media message distribution (e.g., newspaper, radio, television) and social-networking media via the Internet, and necessary training (e.g., training of people to effectively deliver key messages).

Timeframe for Implementation

Implementation of this action should begin immediately upon adoption of a final Climate Action Plan, as heat-related illness and death are already a problem under current climate conditions. Since outreach programs already exist, refinement or expansion of the efforts may be achieved relatively quickly.

C. Coordinate with utilities to develop an approach to address the public health needs resulting from power disruptions associated with extreme heat events.

A spectrum of stakeholders including state and local agencies, utilities, and community organizations must work together to identify the best ways to protect public health if heat events result in power disruptions. Local electricity generation resulting from demand response programs also can exacerbate poor air quality.

Potential Cost

It may be possible to accomplish initial planning efforts by redirecting existing resources. Possible costs associated with any necessary actions identified by the initial planning efforts are unknown at this time.

Timeframe for Implementation

Implementation of this action should begin as soon as possible.

D. Expand upon existing community-based volunteer networks and, as needed, establish additional networks to identify and assist vulnerable populations including senior citizens, people with impaired mobility, and people with limited English-language proficiency.

Volunteer efforts may be needed to augment outreach and education activities in order to better protect the most vulnerable populations in climate-related emergency situations. Volunteers would need climate change education and awareness training. Such networks could become part of existing community-based emergency preparedness activities.

Potential Cost

See 1-B above.

Timeframe for Implementation

See 1-B above.

E. Develop and implement a statewide "Green Cool-down Plan" to reduce the heat-island effect, with a particular focus on the most vulnerable communities.

Reflective building materials and green space can significantly reduce heat islands. Because communities with the least amount of green space often suffer most acutely from the heat-island effect, a plan to address and mitigate this phenomenon's negative impacts would be of significant benefit. The proposed statewide "Green Cool-down Plan" could build on existing programs and plans focused on creating open space and recreational facilities, promoting urban forestry and agriculture, and employing green infrastructure practices. Augmenting building codes to maximize reflectivity of roofs, windows, and exterior walls in vulnerable urban neighborhoods should also be considered. These actions would contribute to both mitigation and adaptation efforts in the state.

Potential Cost

Initial costs of developing this plan should not be substantial as they probably would be limited to providing agencies and authorities with adequate staff resources and expertise (or redirecting existing resources) to develop an effective plan. Costs of implementing the plan could be substantial, but these costs probably would, to a greater or lesser extent, be balanced by the cost benefits achieved after implementation.

Timeframe for Implementation

Ideally, implementation would begin as soon as sufficient staff resources are available.

Impacts/Vulnerabilities Addressed

Climate change is likely to increase the frequency, intensity, and duration of extreme heat events in New York State. Extreme heat can directly cause an increase in heat-related morbidity and mortality, including increased risks for those with medical conditions such as cardiovascular disease, renal disease, emphysema, and others. Extreme heat also may lead to increased electricity demand, potentially resulting in short-term blackouts and brownouts, which can lead to other health effects. Weather conditions associated with extreme heat events often are associated with an overall decline in air quality.

All New Yorkers are vulnerable to the range of possible public health consequences associated with extreme heat events. However, certain sensitive populations are thought to be especially at risk for heat-related morbidity and mortality. The effects of extreme heat may be exacerbated in urban areas because of urban heat-island effects. Additionally, some people (e.g., in more rural, northern areas) may less readily acclimatize to heat and may be more sensitive to extreme heat events.

Environmental Justice Considerations

Research indicates that while the health consequences of climate change may affect all sectors of society, low-income people and people of color are likely to experience the greatest harm. These same populations often have limited transportation choices, as well, restricting their capacity to move to cooler areas or cooling centers. The California Climate Adaptation Strategy identifies factors that could contribute to health inequities related to people’s exposure to extreme heat:

- **Chronic illness co-morbidity:** Some low-income and minority communities may have a higher prevalence of chronic illnesses that place individuals at greater risk of heat-related illness. Especially vulnerable are people who are receiving treatments at home that require electricity to operate and those who may have no means of transport to a medical clinic or facility.

- **Exposure to urban heat-island effect:** Low-income individuals and people of color are often concentrated in urban areas subject to the heat-island effect.
- **Access to air-conditioning:** Low-income individuals are less likely to have air conditioning. Differences in air conditioning prevalence have been shown to exacerbate racial differences in mortality due to heat effects
- **Occupation:** Some workers (e.g., agricultural and construction workers, road crews) are especially at risk of heat illness due to the combination of outdoor work in hot weather and jobs demanding physical exertion.
- **Fear of crime:** People in some communities (e.g., low income communities) may be reluctant to open doors and windows for ventilation during heat waves for fear of crime.

Co-benefits and Unintended Consequences

Public access to cooling centers and other air-conditioned spaces during extreme heat events can help to reduce people's exposure to outdoor air pollutants such as ozone, reducing the risk of air pollution-related health effects. Implementing a statewide "green cool down" plan to reduce urban heat-island effect can potentially reduce energy use, resulting in reductions in greenhouse gas emissions. This also can reduce energy costs. Increases in the amount of urban green space (e.g., through urban forestry or the creation of additional urban park space) also can contribute to healthier lifestyles if people take advantage of such spaces for exercise and recreation.

Recommendation 2. Educate, empower, and engage all New Yorkers to foster a better understanding of the public health consequences of climate change and take actions to reduce or eliminate those consequences.

The success of public health adaptation strategies will require that all New Yorkers, from policy makers and government officials to the general public, have access to information about the health consequences of climate change and the importance of allocating resources to reduce or eliminate those consequences.

Specific Actions

A. Raise the awareness of policy makers, State and local government officials, community leaders, businesses, institutions, health-care providers, and the general public about the public health significance and related costs of climate change.

Statewide awareness of the public health consequences of climate change is essential to the success of climate change adaptation.

Potential Cost

Initially, the costs associated with implementation will be those for adequate staff resources to develop the education and outreach program. Since this will be an ongoing campaign, those costs will be ongoing. Additional costs will include those associated with publishing and distributing printed materials, purchasing space and time for commercial media message distribution, social networking via the Internet, and training. Implementation costs should be compared to the costs of no action.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

B. Create effective outreach materials and mechanisms focused on vulnerable and/or hard-to-reach populations, identify key health and mental health-care providers for training and capacity building, and establish sustained community dialogues that communicate critical information.

The creation and dissemination of multilingual and multicultural outreach materials and the identification of outreach mechanisms will be more effective with input from key community stakeholders, including health care professionals, religious and civic leaders, and community-based organizations. Such community leaders are often best positioned to communicate the possible public health consequences of climate change and its impact on their particular town, city, or neighborhood.

Potential Cost

The costs of this action are a subset of the costs of 2-A, above.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

Impacts/Vulnerabilities Addressed

There is an immediate need to provide effective communication to improve understanding of climate change and advance a public sense of urgency. Individuals can then see the local impact climate change can have on their lives, from day-to-day to extreme weather events. Preparing and alerting the public of these events provides an opportunity for climate change communication.

Environmental Justice Considerations

Different cultures, languages and literacy levels pose challenges to any public health education and outreach effort. While these challenges may be present in any population or community, they all are likely to be present in environmental justice communities, which are likely to be among the communities at the greatest risk of climate-related public health consequences. Implementing this recommended strategy will require an awareness of these challenges and the incorporation of approaches (e.g., employing a multilingual approach that incorporates cultural differences) to overcome them. Collaboration with community leaders also can help to identify approaches to overcome communication challenges.

Co-benefits and Unintended Consequences

Public health and safety messages must be received, understood, and acted upon to be effective. Cultural, linguistic, and technological advances in health and safety communication mechanisms, strategies, and techniques may help to inform difficult-to-reach populations. Lessons learned in trying to inform people about ways to reduce the health impacts of climate change may help to improve all public health communication programs.

Recommendation 3. Assess and improve the capacity of existing public health preparedness, response, and recovery programs to respond to climate-related impacts and direct resources where needed.

A number of the potential health consequences of climate change are associated with events that may result in public health emergencies (e.g., floods, severe summer and winter storms, extended power outages). While New York currently has robust public health preparedness, response, and recovery programs, the capacity of those programs to handle the anticipated increase of extreme weather-related events must be evaluated and any necessary measures to enhance the capacity of the programs should be implemented.

Specific Actions

A. Assess and, as necessary, enhance the capacity of existing preparedness, response, and recovery programs.

Measures such as expanding capacity for coordination and communication, evaluating existing early warning systems and the logistical feasibility of evacuation plans, and enhancing overall preparedness of the public health response to the potential increase in severe climate-related events may require additional planning and resources.

Potential Cost

Initial costs of performing the necessary assessment(s) may be limited to staff resources needed (e.g., through redirection of existing staff resources). Costs for enhancing/expanding program capacity are unknown at this time.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

B. Determine how existing telecommunications technology and social networking systems can be better integrated into early warning and evacuation systems.

In the era of texting, Twitter, and Facebook, information of interest to an individual can be, and often is, communicated in real-time. These technologies have already proved to be extraordinarily valuable in crisis situations and should be fully incorporated into the emergency management system.

Potential Cost

The costs of this action are a subset of the costs of 3-A, above.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

Impacts/Vulnerabilities Addressed

In terms of emergency management, the most vulnerable populations are those that are not able to prepare for, respond to, or recover from emergency events without significant support because of their social, physical, or mental status (e.g., people at hospitals, nursing homes, or that require oxygen therapy; disabled or homeless people).

Environmental Justice Considerations

The potential for climate change to affect people's health in communities that already experience inequitable environmental burdens is discussed elsewhere in this section.

Co-benefits and Unintended Consequences

Any climate-change-related enhancements to public health preparedness and emergency management programs in New York State will better prepare those programs for all public health emergencies.

Recommendation 4. Build community resilience and integrated public health capacity to reduce human health impacts of climate change.

The effects of climate change on natural systems and the built environment can result in a spectrum of adverse public health consequences. The health consequences can be reduced by implementing measures to enhance the ability of individuals and communities to recover from climate change impacts and measures to help facilitate an efficient, coordinated public health response to climate-related events. These measures include planning for climate change at the state and local levels, directing the resources necessary to increase the climate resilience of individuals and communities, and coordinating emergency preparedness planning with a range of local entities.

Specific Actions

A. Consider the possible public health-related impacts of climate change in planning, programs, policies, and regulations.

Currently state and local agencies often make planning, policy, and regulatory decisions without considering climate change and the corresponding public health implications. This can decrease community resilience and increase climate-related risks and impacts. Future planning should include community resiliency planning efforts already underway.

Potential Cost

Given the numerous entities to which this action would be applicable and the diversity of programs, policies, and regulations, the cost of this action is likely to be significant.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

B. Increase the resilience of communities by providing additional support for healthy-built environment concepts, such as smart growth and green infrastructure, and for local and urban agriculture initiatives that strengthen food security.

Healthy-built environment concepts will help attenuate flooding, reduce the urban heat-island effect, and reduce air pollution, all of which are likely to be exacerbated by climate change and affect public health. Additional resources (both state and federal) should be directed to adaptation strategies that also protect and improve human health as critical components of building community climate change resilience. Implementation of these concepts will also lead to improved human health overall, which will make individuals more able to cope with the effects of climate change, such as extreme heat events. These efforts can yield mitigation co-benefits as well by reducing greenhouse gas emissions.

Potential Cost

Additional staff resources or redirection of existing staff resources will be necessary for the planning and program design activities. Costs of implementing the plan(s) that would be developed could be substantial, but these costs likely would, to a greater or lesser extent, be balanced by the cost benefits achieved after implementation.

Timeframe for Implementation

Ultimate implementation of this action could occur over the longer term (e.g., 5-10 years), but planning activities could begin as soon as adequate staffing resources are available.

C. Require that emergency preparedness plans include coordination and communication among critical stakeholders such as community-based organizations, local businesses, local health departments, utilities, and local government leaders.

Coordination and communication with key stakeholders, including people who live and work in a community, are integral aspects of well-formulated emergency preparedness plans.

Potential Cost

The costs of this action are a subset of the costs of 3-A, above.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

Impacts/Vulnerabilities Addressed

Climate change impacts in multiple sectors can have indirect effects on public health. These effects can compound the more direct public health impacts of change in climate and weather patterns. Adequate integrated public health capacity and the resilience of communities will serve to reduce the consequences of climate change discussed throughout this document.

Environmental Justice Considerations

Some New York communities of color and low-income status already suffer from disparities in health outcomes and disproportionate burdens of environmental insults. These communities, especially in urban areas, typically have limited access to resources such as adequate health care, nutritious food, adequate housing, and safe neighborhoods (see the NYS 2009 Energy Plan Environmental Justice Brief). Furthermore, lower incomes can restrict opportunities to engage in health promoting behaviors. For these reasons, low income communities and communities of color are particularly vulnerable to the impacts of climate change on public health, essential resources, and infrastructure. These communities may lack the resilience necessary to effectively adapt to changing climate and recover from impacts to public health and resources.

The combination of limited access to essential resources (such as health care, clean air, and others), and elevated incidence or prevalence of some health outcomes, results in the vulnerability of many communities of color or low income. Solutions include ensuring equity in access to resources and reducing health disparities.

Co-benefits and Unintended Consequences

Community resilience and integrated public health capacity that are developed in an effort to promote adaptation to climate change can have many co-benefits. Communities that are prepared to absorb the stresses of climate change impacts with minimal public health consequences will also be best prepared to absorb shocks from natural disasters unrelated to climate change, as well as from terrorism, crime, and other threats. Since programs that bolster resilience to climate change also impart resistance to other threats, efforts can be carried out collaboratively with other preparedness and capacity-building programs and the program costs shared.

Recommendation 5. Evaluate and enhance, as necessary, the capacity of existing surveillance programs for vector-, food-, and water-borne diseases and disease-causing agents to monitor and respond to the anticipated climate change-related increase in such public health threats.

New York State currently has extensive and robust programs for detecting, preventing, and controlling vector-, water-, and food-borne diseases, and disease-causing agents. However, changes in temperature and precipitation are likely to cause changes in the distribution and numbers of disease-causing vectors and changes in the quality of water used for drinking, recreation, and food production. These changes may result in increases in the incidence of some diseases (e.g., Lyme disease, West Nile virus, eastern equine encephalitis, *Salmonella* food poisoning). New York should implement measures so that existing programs, at both the State and local levels, are adequately prepared for the possible increase in these kinds of diseases and disease-causing agents.

Specific Actions

A. Evaluate the capacity of existing programs, enhance surveillance of disease and disease-causing agents, and enhance the capacity of public health programs that control disease-causing agents.

New York State programs for the detection, prevention and control of vector-, water-, and food-borne diseases, and disease-causing agents are likely to require additional resources.

Potential Cost

Although uncertain, it may be possible to accomplish the evaluation of existing program capacity with limited additional staffing resources. The costs associated with any necessary program enhancements are unknown at this time but could be estimated as part of the evaluation of existing program capacity and would be offset to a degree by the avoided health impacts.

Timeframe for Implementation

Since New York State already has extensive and robust programs in this area, immediate implementation may not be necessary. If feasible, initial implementation of this action (i.e., the recommended program evaluation) should begin as soon as adequate staffing resources are available.

B. Provide necessary assistance to local governments.

Much of the burden of responding to extreme climate variability and climate change will fall upon local governments. Mechanisms for providing assistance to these entities will be essential.

Potential Cost

Costs of determining the kinds of assistance that may be needed for local governments are a subset of the costs of 5-A. Costs of actually providing any necessary assistance to local governments could be substantial but are unknown at this time.

Timeframe for Implementation

Same as for 5-A, above.

C. Expand analytical laboratory capacity to support essential environmental monitoring, disease surveillance, and outbreak investigation/control activities.

Adequate analytical laboratory capacity is a critical component in detecting and preventing vector-, water-, and food-borne diseases.

Potential Cost

Additional staffing may be needed to evaluate existing laboratory capacity. The cost of any possible expanded analytical laboratory capacity is unknown at this time.

Timeframe for Implementation

Same as for 5-A, above.

Impacts/Vulnerabilities Addressed

The interaction of climate, vector populations, and other factors in determining incidence of vector-borne illnesses remains complex and not adequately understood. Validated models to predict future vector-, water-, and food-borne disease incidents in New York under extreme climate variability and climate change scenarios are not available. Even qualitative assessments remain highly uncertain. This recommendation would help address these gaps.

Environmental Justice Considerations

People with compromised immune systems will be particularly vulnerable to the increase in infectious diseases resulting from climate change. In addition, people of color, people living in remote areas, and persons of low socioeconomic status are often medically underserved, and so are potentially more likely to delay treatment for infections.

Small communities with limited resources to direct toward water and wastewater infrastructure may have a relatively high risk for water-borne illness. Similarly, small communities that rely on surface water supplies may find those supplies threatened by increased chemical and microbial contamination resulting from the impacts of climate change.

Co-benefits and Unintended Consequences

Implementation of this recommendation may improve New York's capacity to prevent and control many vector-, water-, and food-borne diseases that are not related to climate change. For example, microbiologists and epidemiologists that investigate food-borne *Salmonella* outbreaks resulting from climate change are also available to investigate outbreaks due to many other agents.

Implementation may also improve New York's capacity to respond to agents that may be deployed by bioterrorists. The U.S. CDC lists plague (*Yersinia pestis*), botulism (*Clostridium botulinum* toxin), and viral hemorrhagic fevers among its Category A (high-priority) bioterrorism agents. Category B (second-highest priority) bioterrorism agents include food safety threats (e.g., *Salmonella* species, *Escherichia coli* O157:H7, *Shigella*); viral encephalitis (alphaviruses [e.g., Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis]); and water safety threats (e.g., *Vibrio cholerae*, *Cryptosporidium parvum*). These potential bioterrorism agents are also vector-, water-, and/or food-borne disease agents.

Recommendation 6. Assess and prepare for the significant public health risks associated with hazards related to sea level rise.

Rising coastal waters and the associated potential increase in storm surges can cause widespread coastal flooding, which may result in a range of adverse public health and safety outcomes. The risks to be addressed include storm surges, flooding, poor indoor air quality, saltwater contamination of public water supplies, post-traumatic stress, increases in disease vectors, inundation-related contamination problems, impaired access to health care, and loss of food security.

The SLRTF has been assessing the anticipated effects of sea level rise and developing recommendations for state action to address them. This Climate Action Plan recommendation supports the implementation of the public health recommendation[4] developed by the Sea Level Rise Task Force. Additional information can be found in the Coastal Zones section of this chapter.

Potential Cost

Additional agency staff resources are likely to be needed to implement this action.

Timeframe for Implementation

Implementation should be initiated as soon as possible after New York State adopts the recommendations of the SLRTF. According to the draft SLRTF recommendation, full implementation may occur within two to five years.

Impacts/Vulnerabilities Addressed

Sea level rise itself and the associated potential increase in storm surges are likely to cause an increase in coastal flooding. Forecasted storm surges from coastal storms may result in population evacuations that will displace people from home and work, which can have a range of possible health consequences including lack of access to medications and routine or emergency

[4] http://www.dec.ny.gov/energy/45202.html

medical care. Health care facilities may be at risk of flooding and may require evacuation, relocation, or protection (e.g., by floodwall construction). The flooding that may occur has the potential to cause a range of adverse public health consequences.

Environmental Justice Considerations

As with all of the potential health consequences of climate change, sea level rise and its attendant consequences will likely have the greatest effect on some people who are members of ethnic and racial minorities and people who are poor. People in these groups may live in areas that are subject to severe flooding from coastal storms, yet these areas may be poorly prepared to avoid the consequences of flooding. Poor people may lack the resources and means to evacuate high-risk areas and many, if not most, will have limited options in securing temporary or permanent alternative housing. Any loss of community centers, senior centers, and public recreational facilities may have a greater effect on poor than on more affluent communities. Overall, most of the possible effects (e.g., contamination resulting from combined sewer overflows and releases of toxic materials, power outages, mold growth) probably will have greater consequences for the poor. Actions to adapt to sea level rise must, as a priority, address the public health issues that will be confronted by these most at-risk populations.

Co-benefits and Unintended Consequences

Measures to avoid the public health consequences of sea level rise may include the construction of new dwelling units, commercial space, and other structures away from flood-prone areas. New construction initiatives will present opportunities to create healthier built environments. Climate-smart building practices can increase the energy efficiency of buildings and lead to energy cost savings for building owners and occupants.

Recommendation 7. Conduct and support research on the public health consequences of climate change and their effective incorporation into adaptation strategies.

A New York State research plan on the public health aspects of climate change would enable a more thorough understanding of the possible consequences of climate change. The plan also would provide a foundation for assessing the effectiveness of adaptation strategies so that those strategies can be optimally designed and modified to reduce or eliminate the health consequences of climate change.

Specific Actions

A. Develop a research agenda that includes making use of health impact assessments, developing appropriate health indicators, and assessing the effectiveness of adaptation technologies.

Developing a coherent research agenda focused on climate-related public health impacts and issues will help shape public policy and facilitate more efficient and effective use of scarce public resources. This research, together with monitoring and surveillance efforts, could help to identify and refine strategies to reduce the impacts of climate change on human health, reduce uncertainties about the possible impacts, and design effective adaptation strategies.

Potential Cost

It may be feasible to develop a research agenda by redirecting existing staff resources. New York State agency costs of performing any research may be partially offset by seeking grant funding.

Timeframe for Implementation

Immediate or even near-term implementation of this action is probably not essential, but if feasible, implementation should be initiated as soon as necessary resources are available.

B. Develop participatory methods to assess the effectiveness, accessibility, and quality of public health-related climate change adaptation programs.

To further strengthen and develop measures, policies, and programs focused on the public health dimension of climate change adaptation, New York State should develop and implement assessment methodologies and practices designed to fully engage a wide spectrum of stakeholders, especially those members of the public most at risk from particular climate change-related health impacts such as heat-related morbidity and mortality, post-emergency mental distress, and respiratory, cardiovascular, and other diseases.

Potential Cost

While it may be feasible to perform this activity by redirecting existing staff resources, some limited additional staffing may be required.

Timeframe for Implementation

Same as for 7-A, above.

Impacts/Vulnerabilities Addressed

Climate-related risk factors include heat events, extreme storms and storm surge events, disruptions of water supply and quality, decreased air quality, and alterations in patterns of infectious disease vectors and organisms. Demand for health services and the need for public health surveillance and monitoring will increase as climate continues to change. Climate change places an additional burden on public health agencies that are already burdened by low levels of staffing and funding.

Environmental Justice Considerations

Expanded research can improve the understanding of potential health impacts to traditionally underserved groups that are likely to be affected by climate change.

Co-benefits and Unintended Consequences

Research to advance public health adaptation to climate change would enable proactive measures and overall community public health and resilience. Developing methods to link and quantify relationships among climate change, changes in energy production and use, air pollution, and health outcomes would provide opportunities for improved public health protection and its associated societal benefits.

The costs of investing in public health research will be offset by reduced health care costs resulting from improved preparedness and adaptation (Ebi et al., 2009). Ebi et al., 2009 concluded: "(g)iven the real risks that climate change poses for U.S. populations, the National Institutes of Health, Centers for Disease Control and Prevention, U.S. Environmental Protection Agency, and other agencies need to have robust intramural and extramural programs with funding of >$200 million annually. Despite the risks, extramural federal funding of climate change and health research is estimated to be <$3 million per year."

Telecommunication and Information Infrastructure

Vision Statement

Prepare for, and adapt to, a changing climate by building increased resilience into the communications infrastructure via opportunities for system-level redundancy, diversity, risk management, and review.

Background

Telecommunications infrastructure is vital to New York State's economy and welfare; its capacity and reliability are essential to the effective functioning of global commerce and the state's economy and are especially vital during emergencies. The sector has important public functions, but it is largely privately operated. The rapid technological changes inherent in the sector mean that the planning horizons and life spans for much of its infrastructure are at best on the order of a decade. The sector is tightly coupled to the energy sector, with power outages affecting the reliability of communication services; many of its communication lines also are located on the same poles as power lines. Modern digital technologies, including communication services based on fiber optics, broadband, and the Internet, can be more vulnerable to power outages than traditional landline technology.

A focus of the communication infrastructure sector is how to ensure that the perpetual introduction of new technologies enhances the reliability and uninterrupted access to services, rather than degrading these services. Such a focus is essential both now and in the future, when the perils from climate change may increase.

Climate Impacts

Communication service delivery is vulnerable to hurricanes, lightning, ice, snow, wind storms, and other extreme weather events, some of which are projected to change in frequency and/or intensity. Communication lines and other infrastructure are vulnerable to the observed and projected increase in heavy precipitation events and resulting flooding and/or freezing rain. In coastal and near-coastal areas, sea level rise in combination with coastal storm surge flooding will be a considerable threat later this century. The delivery of communication services is sensitive to power outages, such as those resulting from the increased demand associated with heat waves, which are expected to increase with climate change.

Under current climate conditions and severe weather events, there are already serious vulnerabilities that in many instances prevent the telecommunications sector from delivering services to the public that are resilient to extreme events. If the sector could be made more resilient to the current climate, then the incremental threat from climate change is likely to be more manageable.

Recommendation 1. Agencies and authorities, including municipalities, with jurisdiction over communication infrastructure, should prepare detailed inventories of telecommunications facilities, networks, and corridors; prioritize critical infrastructure; and complete climate vulnerability assessments of critical infrastructure and corridors within their jurisdictions.

All agencies and authorities, including municipalities, with jurisdiction over communication infrastructure, should prepare inventories of existing and proposed critical infrastructure and infrastructure corridors to assess their vulnerability to the impacts of climate change. Inventories should encompass the wide variety of elements and technology included in New York State's telecommunications sector, including cable television, Internet, network services, telecommunications, and medical and emergency services. The inventory should identify the most critical systems and facilities.

The inventories should be used to conduct vulnerability assessments for critical infrastructure. These assessments should rely on State-accepted climate change projections and consider how these projections may impact each communication facility and component over time. Assessments should also include detailed financial and social impact analyses that account for interdependencies within the sector and between the communications and energy sector. This information should be incorporated into long-term planning, design, funding, and operation of communication infrastructure at the State and local levels.

Development of inventories and vulnerability assessments must be coordinated across jurisdictions to eliminate duplication of efforts and allow for prioritization of critical infrastructure at the State level. While the costs of these assessments and actions to reduce the vulnerabilities to communication infrastructure could be significant in the near term, they may be dwarfed by the potential costs related their failure as the result of a changing climate.

Specific Actions

A. Agencies and authorities with jurisdiction over telecommunications infrastructure in New York State should identify and inventory existing and proposed communication components, facilities, networks, and corridors; and prioritize infrastructure that is essential to support critical state and local functions such as emergency preparedness and response capabilities.

The purpose of these inventories is to identify all communications infrastructure and prioritize infrastructure that is vital to the health, safety, and welfare of the people in the state. The inventory process must be coordinated among responsible agencies to eliminate duplication of effort and allow for prioritization of infrastructure statewide. Prioritization of infrastructure should be based on critical movement of data volume, type and, number of users, and the ability to interconnect regions within both New York State and adjacent states. Information should be provided to all communication agencies to assist in inventory preparation.

Potential Cost

Estimates to prepare baseline inventories differ according to municipality or agency jurisdictional size, resources, and communication infrastructure.

Timeframe for Implementation

The dependency of the state and its residents on telecommunications infrastructure necessitates that an effort to inventory critical infrastructure should be undertaken in the near term.

B. Agencies and authorities should conduct vulnerability assessments using New York State-accepted climate change projections to assess the impact of projected climate change on priority communication infrastructure.

Vulnerability assessments should be conducted using state-accepted projections for climate change such as those developed through the NYSERDA-sponsored ClimAID project. Vulnerability assessments should include detailed financial and social impact analyses including interdependencies of facilities and communication infrastructure.

Potential Cost

Regionally downscaled climate projections have been developed as part of the ClimAID project. Statewide, this effort is broadly estimated to require a staff time effort in the several millions of dollars. Some cost will be associated with updating climate projections on a regular basis.

Timeframe for Implementation

The vulnerability assessments should be undertaken in the near term and build on the inventory. The vulnerability assessment should be updated on a periodic basis to incorporate revised climate projections.

Environmental Justice Considerations

Key community-level infrastructure may be at risk from the effects of climate change, which could especially affect underserved EJ communities. Accessibility is a critical concern when planning evacuation and emergency procedures. New York State should give special considerations to those communities dependant on landline communication due to lack of access to wireless technology. Future prioritization of adaptation strategies and funding should coordinate with local community resiliency plans and incorporate impacts to all communities, especially EJ communities.

Recommendation 2. Incorporate state endorsed climate change projections into all relevant planning, design, funding, and operational decision making within New York State's telecommunication and information infrastructure sector.

When facilities such as communication networks are designed, planners project data-transfer volume so that the design will be adequate for future needs. Similarly, projections are available for future climate conditions. Climate change poses structural as well as operational hazards to the state's communication infrastructure. The growth of the telecommunication networks and data-transfer volume and the variability of climate change result in highly dynamic conditions for the communication sector. The level of dynamism in the sector can be expected to increase in the future.

A coordinated interagency effort should begin now to develop and implement specific design policies to incorporate projected effects of climate change into the design of facilities as appropriate for their expected design life. In this way the risks to communication infrastructure and users, and the costs of premature replacement, may be reduced or avoided.

Specific Actions

A. State agencies responsible for the management of communication infrastructure should develop specific design and operational guidance based on climate change projections and incorporate it into communication projects and investments.

The projects being designed and built today will face significant climate-related changes in conditions during their design lives. A well-designed facility, built with provision for those anticipated future conditions, offers major savings over one that will quickly become obsolete and require replacement. Examples of specific actions include avoiding installation of fiber optic cables in areas that are at high risk of flooding or sea level rise, and ensuring that communication centers that are in zones at high risk of flooding and sea level rise are identified and their relocation opportunities evaluated.

Potential Cost

Tens of thousands of dollars in staff time to develop needed guidance and criteria based on state-accepted climate projections.

Timeframe for Implementation

A significant opportunity exists to incorporate the most recent regional projections for climate change based on the best available science into state agency decision-making processes.

B. Direct funding as available for adaptive changes to existing critical communication networks used for emergency preparedness and response that are at greatest risk from climate impacts.

There are critical communication networks that are a major component of emergency preparedness plans (evacuation networks) and emergency response plans (relief supply networks and access to recovery responders and equipment). If these networks are not changed to make them more resilient to future extreme weather events projected by climate change forecasts, emergency preparedness and response plans could be adversely impacted.

Potential Cost

No estimated cost for addressing this recommendation has been developed at this time. A realistic cost cannot be prepared until the potential impacts and adaptive changes have been identified.

Timeframe for Implementation

Near term (1-3 years): New York State is increasingly vulnerable to large storm events in coastal areas that can cause service disruptions and threaten public safety.

Environmental Justice Considerations

The specific impact on EJ communities is not known at this time. As the critical communication networks serve both EJ communities and non-EJ communities alike, it is anticipated that this recommendation will allow more resilient emergency evacuation networks and resilient response to weather-related emergencies to EJ communities.

C. Develop models, guidance, standards, and financial support where possible to help local governments implement adaptive measures for priority communication infrastructure.

New York State design standards and guidance currently provide the framework for design for county and municipal communication agencies across the state and for much private development as well. Local agencies do not have the resources to develop specific criteria of their own, and local standards and guidance are most often modeled on those of county or State entities.

Potential Cost

Tens of thousands of dollars in staff time to produce guidance for local officials.

Timeframe for Implementation

As soon as possible.

Environmental Justice Considerations

Specific impacts are not known at this time; however, increased resiliency of the communication sectors could positively affect all state residents.

Recommendation 3. Where feasible and cost effective, reduce vulnerability of telecommunication infrastructure to extreme weather events through efforts to increase redundancy, shift toward a more distributed network, and reduce the interdependency of communication infrastructure and between communication and energy infrastructure.

Specific Actions

A. Foster a shift toward a more distributed network of communication infrastructure, including expansion of wireless services.

This will ensure that critical operational elements will not be lost if a specific location is impacted by an extreme event (e.g., flooding). Grouping different types of critical infrastructure, such as ducts and wiring, in one location or facility can increase vulnerability. By increasing the geographic diversity of communication centers, there is less chance that multiple networks will fail at the same time. For example, redundant switching nodes could be developed in several locations to ensure system operation should one node go out of service. Diversity may also be increased by having communication services use fiber optic rings in the local loop or set up alternative switching when a central communications center fails.

Potential Cost

Significant investment in some areas. Incremental costs associated with planned capital investments for system upgrades.

Timeframe for Implementation

As soon as possible.

B. Planning for investments in communications infrastructure and for changes in operations should support, and be coordinated with, adaptation and operations of other sectors, particularly the energy sector (e.g., smart grid).

Potential Cost

Large-scale investment— in the many millions of dollars; may be integrated into capital investment cycle.

Timeframe for Implementation

Coordination activities should begin as soon as possible.

C. Ensure system redundancies for communications infrastructure, including communication towers, at high risk of flooding and high winds.

Potential Cost

Large-scale investment—can be integrated into capital investment cycle.

Timeframe for Implementation

As soon as feasible in coordination with capital investment cycles.

Environmental Justice Considerations

Siting of additional communication infrastructure should take into account EJ considerations.

Recommendation 4. Improve the dialogue on climate resiliency between state agencies and private telecommunications service providers and provide increased accountability for service disruptions

Specific Action

A. To provide increased accountability carriers and other communication service providers should be required to report compliance with the Federal Communications Commission's standards

A significant challenge of the privatized sector is that reports of service outages to federal and State regulators are not accessible to the public and are not uniformly mandatory across the different types of services. In addition, service provider networks are not required to report on their vulnerability to extreme events or the quality of their service. It is recommended that reliability, survivability, and diversity be promoted according to FCC's Network Reliability and Interoperability Councils. Better reporting could be achieved by requiring service providers to file regular reports with the Public Service Commission. It may be necessary to improve reporting mechanisms and other areas of dialogue in this industry to ensure resiliency of this sector.

Potential Cost

Many tens of thousands of dollars of personnel hours

Timeframe for Implementation

As soon as reasonable.

Environmental Justice Considerations

No immediate, identified issues.

Transportation

Vision Statement

Advance transportation and land-use choices that increase the resilience of the state's transportation system to climate change; address specific regional vulnerabilities and those in common, including known infrastructure deficiencies; and be consistent with the state's commitment to smart growth land use, recognizing that all decisions must seek to safeguard and improve the safety and mobility of people, and goods and services with regard to social equity.

Background

New York State is home to a 113,000-mile network of interstate and State highways, including 16,000 bridges, a 4,600-mile rail network, which includes the largest mass transit system in the U.S., some 500 public and private aviation facilities, more than 130 public transit operators, four port authorities, and numerous private ports. Transportation contributes about 10 percent of the state's economy—about $100 billion annually.

The highest concentration of transportation infrastructure is generally located in regions that are population centers and vital drivers of the global, national and, state economies. Threats to these dense metropolitan transportation systems (especially New York City) would have far-reaching impacts.

Ground transportation systems (roads and rails) in coastal population centers are often placed underground in tunnels very close to or below sea level. Since transportation is a networked system, delays, failures, and catastrophic failures in one system can affect other systems.

Transportation occurs by different modes: land, air, and water. On land, it can be divided into road, rail, and pipeline. The goods of transport are people and freight (the latter including raw materials, supplies, finished products, and waste). In urban concentrations, mass transit systems serve the commuting populations going to and from daily work, school, shopping, etc. In suburban and rural areas, largely private vehicular transportation on roads and highways dominates but also reaches the central business districts of cities. Long-distance and interstate traffic on the roads is complemented by railway, water, and air transport.

Climate Impacts

The impacts of climate change have significant consequences for the transportation sector. Over the next few decades, heat waves, heavy precipitation events, and windstorms are likely to dominate the causes for moderate, more frequent transportation problems such as flooded streets and delays in mass transit. By 2050 at the latest, sea level rise and storm surge will become more significant threats. By later this century, this threat will be so severe that major adaptations will have to be in place, not only in the coastal zone, but all the way to cities including Troy and Albany as sea level rise and storm surge propagate up the tide-controlled Hudson River. Low-lying transportation systems such as subways and tunnels, especially in coastal and near-coastal areas, are at particular risk of flooding as a result of sea level rise and heavy-precipitation events.

Materials used in transportation infrastructure, such as asphalt and train rails, are vulnerable to increased temperatures and frequency of extreme heat events. Air conditioning requirements in buses, trucks, and trains, and ventilation requirements for tunnels will increase. Runways will require lengthening in some locations since hotter air provides less lift, necessitating higher speeds for takeoff.

The Great Lakes may see a shorter season of winter ice cover, leading to a longer shipping season. However, reduced ice cover is also likely to mean an increase in lake effect snow events, which cause various transportation problems.

Air- and land-based transportation systems are vulnerable to ice and snowstorms, although requirements for salting and snow removal may decrease as snow tends to turn more often into rain. Freeze/thaw cycles that disturb roadbeds may increase as winter temperatures rise. New York State has the most days per year of freezing rain in the nation. This affects air and ground transportation directly, and indirectly through electric and communication outages.

Recommendation 1. Encourage all State, regional, and local transportation agencies and authorities, including municipalities with jurisdiction over transportation infrastructure, to prepare detailed inventories and climate vulnerability assessments of critical transportation infrastructure and corridors within their jurisdictions.

All State, regional, and local transportation agencies and authorities, including municipalities, with jurisdiction over transportation infrastructure should prepare inventories assessing the vulnerability of critical transportation infrastructure and corridors from the effects of climate change using best available, State-endorsed climate change projections. These vulnerability assessments should include a baseline inventory of all transportation infrastructure and consider how projected climate change would affect each facility. Inventories should include detailed financial and social impact analyses. While the costs of new assessments and reducing the vulnerabilities of the state’s transportation systems could be significant in the near term, such costs are expected to be dwarfed by a failure to address the changing climate.

Specific Actions

A. Key transportation corridors, designated according to the critical movement of people and/or freight and their importance to intra- and interstate travel, should be provided to transportation agencies.

As a necessary step prior to preparing inventories, New York State should identify key transportation corridors (see also recommendations 5 and 6), including both highway and non-highway routes (examples of such routes are existing coastal evacuation routes). Designation of key corridors should be based on critical movement of both people and freight and the ability to interconnect regions within New York State and adjacent states. Information should be provided to all transportation agencies to assist in inventory preparation.

Potential Cost

Statewide, this effort may potentially cost $5-15 million. Included in this estimate are paid hours of staff currently in state or agency service and consultant staff.

Timeframe for Implementation

This effort is estimated to take 12-18 months and would occur concurrently with work under Recommendation 1.B.

B. New York State should endorse a coordinated set of climate change projections and provide these to State transportation agencies, regional and local planning agencies and authorities, local municipalities, and other transportation stakeholders such as privately owned railroads, airports and marine shipping operators.

To ensure consistency of these transportation inventories, New York State should endorse projections for climate change variables and impacts such as sea level rise, heat indices, precipitation rates, in particular rainfall intensities, and extreme-storm events.

Refinement of the model projections and regular updates should be conducted.

Potential Cost

The majority of the climate projection work is complete. Refinement of models and updates will be relatively low cost.

Timeframe for Implementation

This effort would be an ongoing exercise.

C. Integrate climate change into vulnerability assessments, which should include a baseline inventory of existing and proposed transportation infrastructure and analyses of potential financial and social impacts based on climate projections endorsed by New York State.

Using climate change projections and key corridor definitions, all State transportation agencies, regional and local planning agencies and authorities, and local municipalities should assess the vulnerability of all transportation infrastructure and corridors within their jurisdiction from the effects of climate change, including consideration of how climate change projections would affect each facility in given timeframes. Inventories should include financial and social impact analyses. Each individual agency, authority, and municipality should consider all New York State identified key transportation corridors, including interdependencies of adjacent agencies facilities. This underscores the need for statewide agency collaboration and communication during the development of each inventory

Potential Cost

Estimates to prepare baseline vulnerability inventories differ depending on municipality/agency jurisdictional size, resources, and transportation infrastructure. Statewide, this effort is broadly estimated to cost up to $15 million dollars

Timeframe for Implementation

Baseline Vulnerability Inventories: This effort is estimated to take12-18 months and would occur following efforts under 1-A and 1-B.

D. To facilitate investment decisions evaluate which freight and passenger transport systems are most resilient to climate change.

New York State should determine which transportation modes, structures, and facilities are the most resilient to climate change using the inventory created under this recommendation and the long-term vision for transportation from Recommendation 4. Various metrics, such as dollar-value-risk per person served and tons of CO_2 per passenger miles traveled would be applied to projects so that they can be evaluated consistently across the state. Results of this effort would be used in recommending priorities for infrastructure investment. New York State should prioritize infrastructure investments that support the Climate Action Plan adaptation-planning processes and greenhouse gas reduction efforts.

Potential Cost

Estimates to accomplish the administrative planning associated with this task range from $1-$5 million. This estimate is garnered from similar state agency costs and is largely based on staff time and does not include actual engineering implementation costs that cannot yet be estimated.

Timeframe for Implementation

This effort is estimated to take 12-18 months and would closely follow work completed under recommendations 1-A and B but would occur prior to work under Recommendation 6-B. Work under Recommendation 5 would be used in Recommendation 1-C.

Impacts/Vulnerabilities Addressed

Vulnerability assessments should take into account all potential climate change impacts on this sector. In particular, rising sea levels, more frequent and severe riverine flooding, higher temperatures, and generally increasing variability of weather should be considered.

Environmental Justice Considerations

Key community-level infrastructure may be at risk from the effects of climate change, which could especially affect underserved communities. New York State should give special considerations to those communities dependant on mass transit due to lack of access to cars. Accessibility is a critical problem when planning evacuation and emergency routes. Future prioritization of adaptation strategies and funding should coordinate with local community resiliency plans, and incorporate impacts to all communities, especially environmental justice communities.

Co-benefits and Unintended Consequences

Vulnerability inventories would help identify both existing and future infrastructure problems and needs, especially in areas where aging infrastructure may already be at risk even without future climate change. New York State can use these assessments in prioritization of capital dollars. Building resiliency and efficiency into the state's transportation system in order to better adapt to climate change will also dramatically reduce GHG emissions, having a significant effect on climate change mitigation. Costs could include intensified land uses in certain areas, capital outlays, and political ramifications.

Recommendation 2. Prioritize transportation infrastructure that is essential for emergency preparedness and response capabilities.

Protecting critical transportation routes, such as those that are a major component of emergency preparedness plans (evacuation routes) and emergency response plans (relief supply routes and access to recovery responders and equipment), from climate-related impacts should be a priority for New York State. If these routes are not altered or protected so that they are more climate resilient, emergency preparedness and response plans could be adversely impacted.

Specific Action

A. Direct funding, as available, for adaptive changes to critical transportation routes used for emergency preparedness and response that are at greatest risk from climate impacts.

New York State should direct funding for adaptive changes to critical transportation routes used for emergency preparedness and response that are at greatest risk from climate change impacts. There are critical transportation routes that are a major component of emergency-preparedness plans (evacuation routes) and emergency-response plans (relief supply routes and access to recovery responders and equipment). If these routes are not changed to make them more resilient to future extreme weather events projected by climate change forecasts, emergency preparedness and response plans could be adversely impacted by future weather events.

Potential Cost

No estimated cost for addressing this recommendation has been developed at this time. A realistic cost cannot be prepared until the potential impacts and adaptive changes have been identified.

Timeframe for Implementation

Near-term (1-3 years). New York State is increasingly vulnerable to climate change, especially large storm events in coastal areas.

Impacts/Vulnerabilities Addressed

Disruption of emergency preparedness plans and response due to climate change impacts on transportation facilities.

Environmental Justice Considerations

The specific impact on environmental justice communities is not known at this time. As the critical transportation routes serve both EJ communities and non-EJ communities alike, it is anticipated that this recommendation would allow more resilient emergency-evacuation routes and resilient response to weather-related emergencies in EJ communities.

Co-benefits and Unintended Consequences

This proposal would assist in reducing the backlog of maintenance work on key transportation routes.

Recommendation 3. Incorporate State-endorsed climate change projections into all relevant planning, design, and operational decision making within New York State's transportation sector.

When facilities such as highways are designed, planners project future traffic levels so that the design will be adequate for future needs. Similarly, projections are available for future climate conditions. Most significant of these for the transportation sector are rising sea levels and increased flooding due to increased runoff from increasingly intense storms and rainfall. Unlike traffic congestion, these changes pose structural as well as operational hazards to the state's infrastructure. Yet transportation agencies currently design their projects, not for anticipated future conditions, but for the conditions of the past, even though those conditions have undergone documented change and are predicted to continue to change in the future.

A coordinated interagency effort should begin now to develop and implement specific design policies to incorporate projected effects of climate change into the design of facilities as appropriate for their expected design life. Efforts should be made to reduce runoff from existing sources to offset projected increases. In this way the risks to infrastructure and users and the costs of premature replacement can be reduced or avoided.

Specific Actions

A. To the extent feasible, State transportation agencies should develop specific design criteria and operational guidance based on climate change projections, to be incorporated into current and future transportation projects and investments.

Transportation infrastructure projects such as highway and rail embankments, bridges and culverts, and yard facilities, typically have design lives of 50 years or more. In many cases, the expectation is that the life of the project will then be further extended by rehabilitation. The projects being designed and built today will face significant climate-related changes in conditions during their design lives. A well designed facility, built with provision for those anticipated future conditions, offers major savings over one that will quickly become obsolete and require replacement.

Potential Cost

Tens of thousands of dollars in staff time. This figure does not include actual engineering implementation costs that cannot yet be estimated.

Timeframe for Implementation

As soon as possible, since some transportation infrastructure projects are currently being designed and, once constructed, will last for decades. Unless these projects account for future climate conditions, they may be at risk from future climate impacts.

B. Stormwater management techniques and approaches should be incorporated wherever possible into existing contributors and across all sectors— private, commercial, municipal, etc.

Greater stormwater runoff control is necessary to reduce pressures, especially on urban drainage systems. Stormwater is currently regulated for new projects, but contributions from existing, unmanaged sources will continue to increase unless those sources can be retrofitted to reduce runoff. This effort should include an assessment of opportunities to create or maintain open spaces with permeable surfaces, to lessen the degree that storm surges will sweep toxic substances inland.

Potential Cost

Incremental increase to large expenditure for retrofitting existing runoff sources, depending on how aggressive action is targeted.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

C. Develop models, guidance, standards, and financial support where possible to help local governments implement adaptive measures for priority transportation infrastructure.

New York State design standards and guidance currently provide the framework for design for county and municipal transportation agencies across the state and for much private development as well. Local agencies do not have the resources to develop specific criteria of their own.

Potential Cost

Tens of thousands of dollars in staff time. This figure does not include actual engineering implementation costs that cannot yet be estimated.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

Impacts/Vulnerabilities Addressed

Planning should take into account all impacts of climate change on this sector, in particular sea level rise, increasing rainfall and storm intensities, more frequent and severe flooding on rivers and streams.

Environmental Justice Considerations

Infrastructure improvements should take into consideration environmental justice issues and seek collaboration at the local level.

Co-benefits and Unintended Consequences

Undesirable consequences of designing for future increases in sea level, storm surge, and flood discharges may be environmental effects. Higher embankments have wider footprints and, in low-lying areas, may encroach more into wetlands. Regulatory agencies may be reluctant to issue permits for structures to accommodate future conditions. Culverts that are oversized for today's conditions may spread lower flows too thin for fish passage. Care to mitigate these problems as much as possible would be necessary.

Recommendation 4. The New York State Transportation Master Plan should consider and incorporate State-endorsed climate projections.

The Transportation Master Plan projects trends in usage of personal vehicles, non-vehicular travel, public transportation, and freight movement to 2030, and seeks to guide transportation planning and investment to meet those needs. It does address the need to reduce greenhouse gas emissions, thus helping to mitigate their effect on climate change, but it does not address the changes that will occur, even if all the mitigation goals are achieved. These changes will reshape demographic, economic, and travel trends by the end of the century and beyond. Planning for long-lived infrastructure must include those factors that will shape the needs and use of that infrastructure beyond the near term.

Specific Action

A. Policy direction for the siting, design, operation, and maintenance of key transportation infrastructure elements should include climate change projections for the entire proposed useful life of those elements.

The current Transportation Master Plan attempts to steer the course of transportation planning to meet the expected needs of the state to 2030. However, the effects of climate change are expected to increase over periods well in excess of this planning horizon. At the same time, the typical life cycles of many transportation infrastructure elements are also well in excess of a 20-year planning window. Efficient and effective transportation planning and resource allocation must consider the full life cycle of these elements.

Potential Cost

The decision to develop a long-range Transportation Master Plan will in itself have minimal cost. The implementation of such a plan is likely to involve major and continuing capital outlays. Relocation of major transportation facilities, or raising them above expected flood levels, will require a tremendous increase in funding, even while existing systems must be maintained as new ones are developed to replace them. Each project that is undertaken on vulnerable facilities without such planning is one that will suffer premature obsolescence and require more costly replacement or retrofitting as the effects of climate change are felt.

Timeframe for Implementation

The State should take immediate action to develop and implement long-range planning that incorporates the effects of climate change. The long life cycles of transportation infrastructure elements guarantee that they will be affected.

Impacts/Vulnerabilities Addressed

All climate-change impacts to this sector should be considered, in particular rising sea levels, more frequent and severe riverine flooding, higher temperatures, and generally increasing variability of weather.

Environmental Justice Considerations

EJ considerations and input from EJ communities should be included in siting and design efforts.

Co-benefits and Unintended Consequences

Adoption of a truly long-range Transportation Master Plan could spur economic development, as businesses see that preparations are being made for a long-term stable system to meet their transportation needs. A responsible transportation plan could influence development and land-use decisions that would reduce the overall vulnerability of the state to climate change. In the nearer term, the large capital outlays needed to develop this new transportation system may have a dampening effect on the state’s economy and will certainly face significant political challenges.

Recommendation 5. Transportation investments in New York State must be consistent with smart growth/transit-oriented development principles.

"Sprawl" refers to dispersed, homogeneous, and automobile-dependent land use patterns. Current policies and planning practices did not intend to encourage sprawl but have contributed to dispersed developmental patterns in many areas of the state. These developments favor automobile use over walking and transit, resulting in limited travel options. Smart growth encourages more efficient land-use patterns and transit-oriented development, and intelligent land-use choices, such as not building critical infrastructure in a potentially vulnerable location.

Smart-growth principles discourage development of remote properties or large swaths of previously undeveloped land. Natural systems, such as wetlands, forests, and barrier islands, provide services such as flood protection, storm buffering, and water infiltration that would be prohibitively expensive to replicate with human-built systems. In addition, smart growth would encourage infill and transit-oriented developments. This type of growth and development would provide two adaptation benefits: preservation of natural systems that provide adaptation services and less infrastructure exposed to climate impacts. Increased travel options will provide transportation system redundancy that can be utilized if certain components of the transportation network were to fail due to weather extremes.

Transportation and land use must be planned together. The effective integration of transportation and smart growth helps ensure success in other climate adaptation and mitigation measures related to ecological corridors, agriculture and food security, watershed management, water access and distribution, etc.

Specific Actions

A. Infrastructure investments should be assessed for their ability to implement the Transportation and Land Use Technical Work Group long-term vision for transportation, reducing vulnerability to climate impacts while improving travel choices and transportation network efficiency.

New York State should develop strategic approaches to lower the severity of climate impacts and reduce system vulnerability to climate change impacts. State efforts to incorporate compact land-use patterns and transit-oriented development (TOD) into growth strategies and master plans should continue.

Where Recommendation 1D considers different types of infrastructure, this recommendation considers the location of that infrastructure.

Effective implementation of smart-growth policies would help focus climate change adaptation efforts on population centers and critical transportation routes, while helping to reduce future climate risk through intelligent and directed land use and transportation investments.

Increased travel options that result from compact development and better planning will provide choices and alternatives that can be used if certain components of the state's transportation network were to suffer damage or failure as a result of climate change impacts.

Potential Cost

The Governor's Smart Growth Cabinet should remain operational. Capital expenditures will be necessary to provide attractive incentives to local communities promoting smart growth.

Incorporating smart-growth/TOD principles into agency decision making and local planning efforts would have minimal direct costs. However, resulting decisions likely will necessitate higher implementation costs. It is critical to note that the costs resulting from no-action (i.e., business as usual) transportation and land-use planning would likely be much higher. Land-use patterns would continue to be unsustainable, the State would not be able to minimize critical points of failure and the transportation system would remain vulnerable to climate change.

Infrastructure investments are always costly, for both new infrastructure and existing infrastructure upgrades. Using the inventory developed under Recommendation 1, this recommendation aims to make spending more efficient in the long term in two primary ways:

- Directing funds away from new infrastructure with high climate risk and toward infrastructure with low climate risk and high adaptive capacity;
- Directing funds toward existing infrastructure that is deemed critical to adaptation capacity.

Timeframe for Implementation

This action should be implemented as soon as possible. Transportation, land-use, and planning decisions being made today will influence growth and development for the next several decades. New York State should start now to effect significant change in development patterns and transportation infrastructure in order to adequately adapt to climate change impacts.

B. Infrastructure investments should be designed and constructed to protect and preserve natural resources and ecosystems that provide essential climate-adaptation services or benefits in addition to meeting transportation needs.

Ecosystems provide critical and varied services, which are typically unrecognized and under-valued but must be preserved. Natural systems, such as wetlands, forests, and barrier beaches, provide services such as flood protection, storm buffering, and water infiltration that would be prohibitively expensive to replicate with human-built systems. Smart growth would discourage development of remote properties or large swaths of previously undeveloped land, allowing natural systems to provide climate-adaptation services and reducing exposure of infrastructure to climate impacts.

Potential Cost

Municipalities may require additional staff or incur costs by hiring consultants to accomplish ecosystem evaluations. State agencies will require staff hours to provide guidance. Administrative planning costs, based on staff hours, are estimated to be under $1million statewide, annually.

Timeframe for Implementation

Transportation, land-use, and planning decisions being made today will influence growth and development for the next several decades. New York State should start as soon as possible to effect any significant change in development patterns and transportation infrastructure to adequately adapt to climate change impacts.

C. Incorporate redundancy and travel choices into the transportation system to adapt to climate change impacts that may affect certain components of the transportation network.

Serious and sustained financial choices and investments that increase investment in transit (or shared low-carbon and zero-carbon modes) and existing infrastructure are needed to build redundancy and provide travel choices in the transportation network. Planning and building for a greater emphasis on shared modes of transportation will build efficiency and resiliency into transportation systems, reducing vulnerability to climate change impacts.

Potential Cost

The cost of this action is not yet quantified and will depend on the specific policies employed. Costs may be in the form of tax incentives for developers or grants for local governments.

Timeframe for Implementation

New York State should start as soon as possible to effect any significant change in development patterns and transportation infrastructure to adequately adapt to climate change impacts.

Impacts/Vulnerabilities Addressed

Significant shifts in population and business may occur in response to the increase in flooding and coastal inundation, resulting in new or altered transportation needs. Any component of the transportation system that exists in close proximity to water or in low-lying areas will be vulnerable to damage or diminished function as a result of climate change.

Environmental Justice Considerations

Economically disadvantaged citizens need transportation choices and typically rely on public transportation. Implementing this recommendation and expanding transit options throughout the state would benefit these groups. It has been shown that coordinated and well-planned transit-oriented development typically improves economic conditions and raises property values. However desirable this may be, sensitivity to the risk of pricing out poorer residents that might no longer be able to afford to live in these communities is necessary.

Co-benefits and Unintended Consequences

Co-benefits and costs are similar to EJ considerations. Seniors will also benefit from having additional transportation choices. The most significant co-benefit of this recommendation is that inverting mode-split and building resiliency and efficiency into the transportation system will also dramatically reduce GHG emissions, having a significant effect on climate change mitigation. Costs could include intensified land uses in certain areas, capital outlays, and political ramifications.

Water Resources

Vision Statement

As water is vital to New York's economic and environmental future, the State must pursue actions that will maintain this rich resource in the face of climate change and increase resiliency to the effects of climate change.

Background

New York State has an abundance of water resources. Despite having only 0.3 percent of the world's population, the state is bordered by lakes containing almost two percent of the world's fresh surface water: Lake Erie; Lake Ontario, and Lake Champlain. Central New York is home to the Finger Lakes, which are the largest of the state's 8,000 lakes as well as some of the largest inland water bodies in the United States. The state has several high yielding groundwater aquifers, particularly those of Long Island. It has an average rainfall of almost 40 inches, which readily supplies numerous small municipal reservoirs as well as the extensive New York City reservoir system located in the Catskill Mountains and lower Hudson River Valley.

Water resources are managed by a diverse array of large and small agencies, governments, and institutions, with little statewide coordination. In 2000, New York State's 19 million residents consumed approximately 2,200 million gallons per day of fresh surface water and 890 million gallons per day of fresh groundwater for public water-supply, irrigation and industrial uses. Of this nearly 3,100 million gallons per day of consumption, only about 10 percent was for industrial and agricultural use. This water comes from a diverse range of sources, each with different levels of vulnerability to climate change.

New York State's water and wastewater treatment infrastructure is in dire need of repair and upgrade. A needs survey conducted by DEC in cooperation with the New York State

Environmental Facilities Corporation (EFC) and the U.S. Environmental Protection Agency (EPA) determined that $36 billion of water treatment improvements and $40 billion of wastewater treatment improvements are necessary in New York State. The anticipated added challenges associated with a changing climate will only exacerbate the situation.

Although New York is a water-rich state, it must continue to strengthen its capabilities to better understand and manage its water resources. This is especially true given the growing demand for water, including water for human consumption and energy production. As other parts of the country experience large changes in drought frequency and intensity, New York's water resources may become a defining economic asset resulting in the migration of people and businesses into the state. This may bring some economic benefits but will also present new challenges as pressure on water resources increases. This potential has been recognized in the Great Lakes-St. Lawrence River Basin Water Resources Compact. New York State's water budget should be assessed to better understand the availability, limitations, and allocations of water and how that budget intersects with economic development, population growth, and ecological health. This would also allow for better planning of water resources for competing uses, including agricultural, industrial, ecosystem, and human uses.

Climate Impacts

Although there are several water-quality concerns directly linked to average air temperatures, in general, hydrologic processes are dependent on multiple interacting climate factors. In addition to temperature, possible future changes in timing and quantity of snow, rainfall, and evaporation will all have impacts on the state's water resources.

Rising air temperatures intensify the water cycle by driving increased evaporation and precipitation. The resulting altered patterns of precipitation include more rain falling in heavy events, often with longer dry periods in between. Such changes can have a variety of effects on water resources.

- The frequency of heavy downpours has increased over the past 50 years. This trend is projected to continue, causing an increase in localized flash flooding in urban areas and hilly regions.
- Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable development within floodplains.
- Less frequent summer rainfall is expected to result in additional and possibly longer summer dry periods, affecting water supply systems with limited storage.
- Reduced summer flows on large rivers and lowered groundwater tables could lead to conflicts among competing water users.
- Increasing water temperatures in rivers and streams will affect aquatic heath and reduce the capacity of streams to assimilate effluent from wastewater treatment plants.

Because New York is already experiencing water-resource challenges, the recommendations provided here represent actions that will enhance New York's water resources legacy. The anticipated effects of climate change add urgency to implementing these recommendations; however, these actions would also serve to improve water resources in the state independent of climate change.

Recommendation 1. Enact into law Governor's Program Bill #51-Water Withdrawal Regulation (S.8280-A/A.11436-B) to authorize implementation of a comprehensive statewide water management program to better regulate the use and consumption of the state's water resources.

This legislation directs DEC to implement a statewide permitting program for significant water withdrawals; generally, systems with a capacity of equal to or greater than 100,000 gallons per day would be regulated. Currently, water uses are managed by a piecemeal regulatory scheme; on Long Island, groundwater withdrawals are subject to a DEC permit, and in the Delaware and Susquehanna river basins, water withdrawals are regulated by the applicable interstate river basin commission. Elsewhere, only public-water supplies are regulated. This legislation would provide a rational and more consistent statewide approach. This legislation would provide DEC with more comprehensive information on water uses across the state and allow DEC to better manage New York State's water resources, which will become increasingly important as water availability changes with a changing climate. Additionally, this legislation would allow DEC to meet one of its obligations under the Great Lakes-St. Lawrence River Basin Water Resources Compact. Under the Compact, DEC must implement a regulatory program for all water withdrawals in New York's portion of the Great Lakes Basin by December 2013. Without this new program, New York State would continue to lack the necessary data to fully understand the statewide level of water demand for water supply; commercial, industrial, and agricultural uses; and the state's ability to meet future demand in a changing climate.

Potential Cost

DEC staff would be required to promulgate regulations and manage the new permitting program.

Timing of Implementation

The statewide permitting program would be implemented upon adoption of regulations by DEC, which would require passage of the legislation.

Recommendation 2. Build greater resilience to projected climate change impacts into drinking-water and wastewater infrastructure systems.

New York State communities should prepare for increased frequency and intensity of flooding and short-term drought due to climate change. Infrastructure must be adaptable and designed to be resilient to a changing climate to avoid service disruption and costly damage, particularly to drinking-water and wastewater infrastructure, which can have dramatic impacts to public health, ecosystems, and local economies. Real-time monitoring systems should be used to evaluate vulnerability of facilities and determine strategic upgrades and replacement of existing infrastructure. Planning and design standards for new and, where feasible, upgrades to existing water infrastructure should emphasize the use of smaller and more distributed systems that foster groundwater recharge, system redundancies for critical populations, and systems that are adaptable to and operable under a wide range of flood and drought conditions to reduce vulnerability of human and natural systems to the effects of climate change.

Specific Actions

A. The State and all other governmental bodies with jurisdiction over drinking and wastewater infrastructure should, as part of their asset management strategies, prepare detailed inventories of critical water infrastructure within their jurisdictions and conduct climate vulnerability assessments that consider changing climate conditions and potential climate impacts over the full intended service lives of the identified infrastructure.

Potential Cost

The costs of modifying planning and permitting processes to accommodate new risk assessment processes to evaluate infrastructure decisions are considerable. However, accurate information is required for planning, especially for new infrastructure projects that will cost many millions or even billions of dollars. The costs of no action could be enormous. Disruptions to critical infrastructure can cause the loss of essential services, public-health impacts, and hardship to local residents; compromise economic activity; and entail costly repair and reconstruction.

Timing of Implementation

Near-term. As potential impacts are determined and adaptation actions are prioritized, water managers can implement certain no-regrets actions; that is, climate change considerations can add momentum and potentially expedite initiatives that have already been identified as priorities. By factoring climate projections into infrastructure investment decision making now, better choices will be made regarding how to deal with aging infrastructure and how to make existing and new infrastructure climate resilient in the future. By wisely incorporating climate-change impacts into infrastructure decision making now, authorities can avoid costly adaptation efforts later.

Environmental Justice

Implementation of this strategy will increase the resiliency of critical infrastructure throughout New York State, providing a benefit to all. However, this strategy may have a particular environmental justice benefit by focusing attention on neglected infrastructure in vulnerable urban communities with more limited adaptive capacity. In addition, because many water-treatment facilities and other water infrastructure are located in EJ communities, the proposed vulnerability assessments will identify particular problems and challenges before they become acute, thus helping to mitigate negative impacts on host communities.

Co-benefits and Unintended Consequences

By increasing the resiliency of infrastructure, service disruptions will be reduced, limiting the health consequences that may arise from disruption of critical services, e.g., wastewater treatment or public transportation. Through better design of wastewater treatment plants, release of untreated waste into water bodies due to infrastructure flooding can be reduced, eliminating a potential source of environmental pollution. A flexible system can maximize operational approaches to adaptation such as green infrastructure that can produce a spectrum of co-benefits, including air-quality improvements and energy savings. Such a system can also potentially result in the design and implementation of smaller, infrastructure improvements that have lower cost and impact, consume less energy, and reduce hydrological impacts, but still effectively meet needs. Co-benefits of infrastructure-capital upgrades could include additional features to increase water-supply storage or flood prevention.

B. Relevant State and local agencies should update permit and design standards for drinking-water and wastewater infrastructure to factor in projected climate impacts, particularly precipitation-related events such as more intense rainfall events, reduced winter snow cover, and increased frequency of short-term droughts.

Potential Cost

An update to the hydrologic data that inform infrastructure design standards (TP 40) is currently funded and underway; however, resources will have to be dedicated to appropriately integrate the updated data into agency design standards.

Timing of Implementation

Updated hydrologic data should be incorporated into design standards by relevant agencies immediately upon completion. The USDA Natural Resources Conservation Service has funded the Northeast Regional Climate Center to provide updates to current rainfall frequency estimates. An assessment of ongoing programs and activities would inform investment in additional data collection and research.

Environmental Justice

This action would provide greater protection to the most vulnerable communities by reducing flooding of critical infrastructure in low-lying areas and ensuring the sustained quality of drinking water.

Recommendation 3. Adopt statewide and region-wide comprehensive sustainable water-resources-management strategies that consider climate change to preserve water quality and water quantity for human and natural communities, and encourage watershed-wide collaboration.

The natural hydrologic cycle is shaped by and adapted to accommodate a wide range of hydrologic and hydraulic conditions while being resilient to damage. Where State polices can mimic the efficiency of natural processes they will enhance the state's ability to adapt to climate change. Storm-water, wastewater, and water-supply permit guidance should reflect this goal.

Sound watershed management is a key component of sustainable water policy. A comprehensive sustainable water-resources strategy would fully recognize groundwater and surface water as a single, integrated resource that is essential to the ecological integrity and economic vitality of the state. Watersheds do not function based on political boundaries, and impacts to water quality and quantity are cross-jurisdictional. Inter-municipal and inter-agency collaboration to manage water resources is essential. In addition, climate impacts to water resources and management strategies will vary across the state and region due to varying levels of urbanization and infrastructure investment, economic factors and planning priorities, and the water needs of natural systems. For this reason many water issues are best addressed on a watershed or sub-watershed level and regional and intermunicipal watershed plans are needed. Where watersheds cross state boundaries, region-wide approaches should be developed.

Planning at this scale should include the following:

- Regional water budgets to ensure that the quality and quantity of surface water and groundwater are conserved and protected, particularly for critical waters;
- Regional conservation of wetlands and critical fish and wildlife habitats;
- Identification of regionally important projects needed to adapt to impending impacts of climate change and sea level rise, including protection or management of water supply, water quality, living resources or aquatic resources;
- Climate impacts on the Great Lakes, resulting in changing lake conditions and lake levels and related water-management issues.

Specific Actions

A. All water-related permit programs and policies should minimize alterations and disruptions to the natural hydrologic cycle to the extent possible. Regulatory agencies should implement this recommendation at multiple scales, including site-level planning and construction, as well as more regional watershed scales.

Technical guidance and design standards should be created and incorporated in storm-water, wastewater, and water-supply permit guidance, and permit reviews and approvals. This guidance and design standards should strive to maximize the ability of infrastructure and to mimic the hydrologic cycle through the following:

- Couple water-supply withdrawals and wastewater infrastructure to limit water transfer between watersheds to ensure that used water is returned to its donor source, reducing infrastructure and energy costs, helping to meet the needs of aquatic life, and providing for renewal of ground and surface-water resources;
- Require the reuse of wastewater and gray water in new development;
- Develop and enforce a zero-runoff storm water policy for new construction and maximize infiltration of storm water onsite at existing developed sites;
- Provide stronger protection for the preservation of natural hydrologic pathways by minimizing land disturbance, avoiding sensitive areas (e.g., steep slopes, recharge areas sustaining groundwater dependent ecosystems, wetlands, and stream corridors), avoiding soil compaction, and reducing impervious surface area;
- Require the use of resilient (e.g., drought-tolerant) native tree cover and plantings, and the removal of invasive species where landscaping is done.

Potential Cost

Although revising policy to address the need to mimic natural hydrology wherever possible may have minimal financial impact on state agencies, it is a paradigm shift in thinking and may require considerable costs to local project sponsors to meet new requirements. Federal and state funding agencies involved with water projects, such as EFC, DEC, DOH and EPA should require these types of recommended actions.

Timing of Implementation

A phased implementation approach could be taken over the next decade to comprehensively weave these philosophies into water policy, funding, and programs.

Environmental Justice

Without careful planning, there is the potential for some decisions to affect such communities disproportionately, for example, by resulting in decreased property values or reduced opportunities for economic development. Agency decisions should include robust public participation, with enhanced efforts for public involvement in areas of environmental justice concern.

Co-benefits and Unintended Consequences

Co-benefits of minimizing disruption of the natural hydrologic cycle include improved water quality, integration of many environmental program goals, improved flood-water attenuation, improved groundwater recharge, protection of river corridors, improved in-stream health, and reduced stream sedimentation.

B. Create mechanisms to foster development and State approval of regional intermunicipal watershed-management plans that address expected climate change impacts and to protect and improve the quality, quantity, and ecological function of surface and groundwater resources, while balancing human health, safety, and socio-economic factors.

Watershed management plans should be developed at the watershed or sub-watershed level by regional, State, and local officials; they should be officially endorsed and adopted by local governments and approved by relevant State agencies. State funding for water infrastructure should be conditioned upon completion of intermunicipal watershed management plans. These plans should include vulnerability assessments to inform planning efforts that consider factors such as water availability, flooding, and water quality. Vulnerability assessments done on a more localized basis should incorporate projected regional impacts, which are critical for effective State-level planning and protection of New York State's water resources.

Local and regional watershed planning will also address knowledge and management gaps related to groundwater systems, such as the extent, quality, and quantity of groundwater systems, and the role of groundwater in supporting ecological systems as the climate changes. Rural residents rely primarily on groundwater for drinking water and other domestic use. Climate change has the potential to negatively affect groundwater recharge; new development should be limited in areas where groundwater resources are already stressed. While the protection of groundwater may be regulated for human uses, current measures do not consider groundwater requirements for the maintenance of ecosystem integrity. This consideration is necessary for the protection of ecosystems. Projections of future water availability, human use, and ecosystem requirements should be updated regularly as new climate and water-use information is developed.

Potential Cost

Research leading to the characterization of groundwater resources has traditionally been conducted by the USGS with resources to meet local match requirements provided by cooperating agencies. TEPA also provides grants to the National Rural Water Association for groundwater assessments for towns on a case by case basis. Additional state resources for mapping and assessment of groundwater sources could improve planning decisions and ensure sufficient drinking-water resources are available for new development. The preparation of watershed-management plans has been funded in part by the New York State Department of State under Title 11 of the Environmental Protection Fund Local Waterfront Revitalization; and DEC, with CWA Section 319 funding, and grants under the Hudson River Estuary Program. Technical assistance in the preparation of watershed management plans could be provided outside of the State grant-assistance context, albeit at a lesser level, with the need for geographic targeting by limited agency staff.

Timing of Implementation

The preparation of intermunicipal watershed-management plans is ongoing in New York State. Incorporation of climate change adaptation can begin immediately. The mechanism for formal state approval of intermunicipal watershed-management plans could be established within a year.

Environmental Justice

Water-quality testing occurs for public water supplies; however, the same scrutiny is not afforded to private water supplies, such as private wells. Watershed-management planning could focus on surface waters, groundwater, or both, including water for human uses (e.g., consumption and recreation that supports local economies), as well for sustaining water-dependent ecosystems. For those communities that have difficulty providing matching funds for State grants, a lesser local match may be needed to encourage participation in watershed-management planning.

Recommendation 4. Allow "room for rivers." Acknowledge the dynamic nature of rivers on the landscape and strive to reduce risk to critical infrastructure and human development as the risk of flooding increases with climate change.

While a patchwork of interrelated river-corridor, wetland, and floodplain programs exists at the federal, State, and local levels, no comprehensive river-corridor program exists. Agencies with jurisdiction over streams, rivers, and their channels, corridors and floodplains should create policies and regulatory approaches to protect the dynamic nature of river corridors and strive to reduce risk to communities through non-structural measures like land-use planning and the elevation and relocation of highly vulnerable structures.

Specific Actions

A. Coordinate with key federal and local stakeholders such as the Federal Emergency Management Agency (FEMA), U.S. Department of Agriculture, and county soil and water conservation districts to identify and map areas of greatest current risk from riverine flooding and erosion due to movement of rivers across the landscape.

Flood-mapping efforts must be modernized to be an effective tool in emergency planning. Flood maps should be completed and updated using climate change projections and flood studies and made electronically accessible to local governments. In partnership with federal agencies, multi-layered, geographic-information-system mapping should be used to identify, classify, and map high-risk areas. Critical data include high-resolution elevation and bathymetry; spatial information for natural, built, and human resources; socio-economic data; sites that, if flooded, could contribute to toxic contamination; and development models that include build-out scenarios. DEC's floodplain-management program currently has only indirect enforcement capability. Legislative reform is needed to ensure wise management of floodplains.

B. Work with federal agencies to reduce new development in areas at high risk of riverine flooding and undertake long-term managed relocation or elevation of existing structures in these areas. Restructure disaster-recovery policies to ensure that redevelopment efforts strive to reduce long-term risk.

New York should eliminate incentives for development in high-risk floodplain areas. Federal disaster-recovery policies should be reformed so that reconstruction of damaged homes and infrastructure incorporates current standards and knowledge of flood risks due to climate change, rather than simply funding replacement-in-kind of damaged structures and systems.

Potential Cost

FEMA, in partnership with DEC, is mapping areas at greatest risk for riverine flooding in New York. However, the considerable costs (tens of millions of dollars) associated with conducting flood studies and collecting the high-resolution elevation data necessary to generate accurate maps statewide has left many areas of the state still without accurate maps. Additional resources to conduct flood studies and collect high-resolution elevation data using LiDAR (Light Detection and Ranging) technology would allow for complete and accurate mapping of areas at greatest risk. In the absence of resources to complete the mapping, in the near term incentives could be provided to local governments to regulate floodplains and to limit development along stream and river corridors at minimal cost. New York State could also institute a setback regulation for river and stream corridors through State law; however, the mapping effort described above would have to be completed at considerable cost to enable enforcement of this regulation.

As the risk of large flood events increases so does the cost of State response and assistance during and after flood events. It may soon become more cost effective to map and regulate areas at greatest risk of flooding to reduce vulnerability. Significant resources will also be needed to support elevation and/or relocation of structures in high-risk areas.

Timing of Implementation

Implementing a program to reduce the vulnerability of structures and facilities in areas at high risk of flooding should begin soon, as this effort would take many years of planning due to its complexity, the need for the creation of an advisory committee, and perhaps the eventual creation of a State law to reduce the vulnerability of structures, homes, and facilities to flooding.

Environmental Justice

Stricter management of floodplains can depress property values in areas no longer deemed developable. Any program to move people out of these regions or discourage development in floodplains would require adequate mechanism for compensation and reestablishment of households outside of the floodplain.

Co-benefits and Unintended Consequences

Enhanced protection of riparian corridors offers many co-benefits, integrating many DEC and environmental program goals, including enhancement of riparian areas as greenhouse gas sinks, providing upland wildlife habitat, protecting water quality, improving flood-water attenuation, increasing biodiversity, and enhancing public access and scenic beauty.

Recommendation 5. Incorporate water-related climate projections into State and local emergency-management planning.

Specific Actions

A. State emergency-management and local hazard-mitigation plans should incorporate the best available projections of climate-related impacts, such as increased frequency of extreme rainfall, coastal storms, temperature extremes, and short-term droughts.

Expected increases in the frequency of extreme climate events should be factored into emergency planning, response, and recovery capacity. Floods tend to be relatively localized. Droughts may affect the whole state at once, but their significance will vary depending on local resilience (e.g., some groundwater-fed water supplies and those supplied by the Great Lakes may not be as significantly affected). Mitigation will necessarily include improving infrastructure to optimize system redundancy and flexibility.

B. Establish appropriate legal mandates, secure stable funding, and develop guidance for participatory vulnerability assessments and adaptation-planning processes at the local and regional levels.

While climate change is global, its impacts will be felt on a local level. Flooding is expected to increase in many areas of the state; the location, extent, and severity of flooding may be very different from that currently experienced. Drought will also have locally and regionally disparate effects. Hundreds of communities within New York State will be affected by climate change; appropriate resources, including funding and guidance, are necessary for communities to plan for the mitigation of their particular risks.

Potential Cost

The development of State guidance for local governments to help them conduct vulnerability assessments that include the best available climate information should be of relatively low cost. Costs associated with assessments and planning will require staff time at the local level as well as some funding for coordination efforts at the local and regional levels, and guidance and tools should be designed to minimize these costs.

Timing of Implementation

Climate projections should be incorporated into emergency-response plans immediately. Vulnerability assessments and specific adaptation-planning efforts should begin following the development of guidance and tools for local assessments.

Environmental Justice

Some low-income communities and communities of color are particularly vulnerable to the impacts of climate change, and may lack the resilience necessary to effectively adapt to changing climate and recover from impacts. Implementing guidance and planning efforts, especially at the local level, will require the incorporation of approaches specific to the needs of these communities (e.g., employing a multilingual approach that incorporates cultural differences).

Chapter 12
Multi-Sector Policies and Issues

A number of issues and policies were identified by members of the Technical Work Groups as having cross-sectoral impacts or considerations. This chapter of the Climate Action Council (Council) Interim Report summarizes the environmental justice concerns and considerations raised by environmental and community-based representatives; near- and long-term workforce training requirements for a clean energy economy; marketing, education, and outreach; and a subgroup report that addressed the impacts and strategies related to the transition to electric vehicles.

Environmental Justice Considerations and Concerns Related to the Climate Action Plan Process and to Policy Options Development

The transition to a low-carbon economy and the projected consequences of climate change will have disparate impacts across the different communities (urban, suburban, and rural), sectors and demographic groups of New York State. From the very beginning of the Climate Action Plan process, the Council made assessing how any proposed climate change mitigation and adaptation policies would affect the most vulnerable New Yorkers a priority. Communities and households struggling with poverty, unemployment, health problems, political disenfranchisement and other challenges will often lack an adequate understanding of the climate-related risks they face and/or the necessary resources to adapt effectively to rapidly accelerating climate change.

To ensure that concerns and issues of importance to New York State's most vulnerable communities were adequately addressed in the process, the Council made a determined effort to reach out to and integrate input from a spectrum of community-based or focused organizations and environmental justice (EJ) groups. From the very beginning, individuals who represented these viewpoints and who could also bring to bear different regional perspectives were invited to join the Technical Work Groups that formed the backbone of the Climate Action Planning effort. Additional EJ and community-based or focused representatives were later added to each Technical Work Group to further strengthen the community perspective. Key EJ stakeholders were also asked to join the Integration Advisory Panel, a body charged with considering cross-cutting and multi-sectoral issues that emerged during the process.

In addition to this representation on the Technical Work Groups, the Council partnered with the New York State Department of Environmental Conservation's (DEC's) Office of Environmental Justice to implement an unprecedented outreach effort focused on community-based organizations and EJ stakeholders across the state. This effort included organizing two statewide videoconferences, hosting a series of EJ Coordination and Advisory teleconferences at critical points in the process, and circulating survey instruments on the proposed mitigation and adaptation policies to a wide variety of stakeholders.

The videoconferences, held in March and May, were broadcast from DEC's headquarters in Albany to the agency's regional offices in Buffalo, Syracuse, and New York City and were open to the public. The EJ Coordination and Advisory teleconferences afforded a broader group of stakeholders an opportunity to learn about the Climate Action Plan process and offer their input and advice about key issues to the EJ and community-based or focused representatives serving on the Technical Work Groups. Finally, the two surveys that were distributed across the state afforded stakeholders an opportunity to submit their views about the potential negative and positive aspects of the mitigation and adaptation policies under consideration. The results of these surveys were consolidated and distributed to the membership of the Technical Work Groups and made available to the general public online.

Holistic Approach to Environmental Justice and Climate Change Policy

In addition to the extensive outreach, coordination, and input-gathering effort described above, EJ concerns were incorporated into the analytical effort to identify and design potential policies at a fundamental level. The full description of each proposed policy (see online appendices) features a discussion of any significant EJ considerations that came out of the Technical Work Group deliberations or that were identified as a result of stakeholder input or further staff analysis. The short policy descriptions contained in the main body of the Climate Action Plan also highlight any EJ concerns under the "Special Considerations" section. The explicit integration of EJ concerns in the Climate Action Plan's deliberative and analytical processes reflects a commitment by New York State to approach these critical environmental policy areas in a holistic fashion. Accordingly, many of the proposed policies that emerged from the different Technical Work Groups have explicit or implicit benefits for EJ communities, including reductions in air pollution, additional resources for community development, and the upgrading or phasing out of aging infrastructure and facilities.

There are many examples of how the proposed Climate Action Plan policies will benefit EJ communities in each of the sectors. In policy option PSD-1, which is focused on siting power generation, the Council explicitly acknowledges the role of EJ communities and the need to take into consideration the cumulative impacts of various environmental burdens as part of the siting process, and implementation of PSD-8, which addresses Existing Fossil Fuel Plants Policies, would result in improved efficiency and the reduction of emissions in neighborhoods that host power plants. Community and EJ stakeholders strongly endorsed the smart growth principles and initiatives featured in several of the policies such as TLU-10, which called for supporting the establishment of Priority Growth Centers, or TLU-11's call for more Transit-Oriented Development. Finally, many stakeholders expressed support for the focus on workforce development and green collar jobs found in many of the policies, indicating that this was an important issue for their communities as New York begins to move to a low-carbon economy.

While many of the proposed policies have specific EJ implications, over the course of the Climate Action Plan process, several overarching concerns about the potential shift to a low-carbon economy and New York State's efforts to adapt to climate change emerged. These included the need to increase attention and devote resources to facilitating meaningful public participation and community engagement, the importance of preserving and expanding procedural safeguards in official decision-making processes such as permitting and siting, and the application of fair share principles with respect to the distribution of burdens and amenities.

Effective Community Engagement and Public Participation

Research shows that most Americans do not feel a personal connection to climate change-related issues. They are aware of it, they may even rank it as a concern, but according to a 2008 Pew Research Center for People and the Press, they do not perceive it as a near-term priority on par with economic concerns.[1] In fact, despite increasingly forceful calls from the scientific community for urgent action, climate change has slipped to the bottom of the list of American priorities. Given the additional socioeconomic stresses they face, this dynamic is likely to be even stronger in low-income communities and communities of color.

One of the key ingredients found in communities across the world that have successfully engaged on climate change-related issues is the presence of strong and sustained local leadership.[1] Community and EJ stakeholders engaged in the Climate Action Plan process repeatedly stressed the need to incorporate adequate public awareness-raising and community engagement measures into the Climate Action Plan. They stressed that without sustained local dialogues to educate community members and build support for the various policies, the desired paradigm shift to a low-carbon economy would be much more difficult. Already, because of past difficulties, misunderstandings, and procedural missteps, many EJ leaders are wary of official decision-making and planning processes that they feel have served them poorly in the past. Explicitly acknowledging and addressing such problems and shortcomings was identified as a critical component of developing and implementing the Climate Action Plan.

Communicating effectively about climate change is a formidable challenge. Efforts to convince the public of the urgency of the problem and translate climate change-related risks into a near-term danger on par with other imminent societal and personal threats have not been successful. Community and EJ stakeholders discussed the reality that awareness-raising and public education activities around climate change often have been piecemeal and sporadic, and have lacked the kind of targeted, New York-specific context to make them as effective as possible. Given the relatively low-level of awareness and understanding of the risks and hazards associated with most climate shocks in EJ communities, stakeholders identified a need for more coordinated, statewide awareness-raising activities that include tools and guidance to help communities frame climate-related risks within a local context.

Informed and aware households and communities represent an invaluable asset to State and local authorities with respect to climate change. Community and EJ stakeholders indicated that making use of this asset fully would require consultation, participation, assessment, and planning at levels lower than municipal government. Thus, they argued that adequate resources and technical assistance devoted to community capacity building

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[1] Psychology of Climate Change Communications, *Columbia University Center for Research into Environmental Decisions. 2009.*

should be an integral part of New York State's Climate Action Plan, but they pointed out that State programs have not always provided resources for this kind of effort.

For example, stakeholders repeatedly cited the expiration of the Intervenor Fund established under Article X of the Public Service Law governing the construction and operation of electric generating facilities with capacities of 80 megawatts or more as a great model mechanism for community-level capacity building. The Intervenor Fund channeled resources to localities and community-based organizations to help defray the costs of technical experts and consultants. Article X expired in 2003. While revival of this mechanism is being considered as part of the Power Supply and Delivery (PSD) Technical Work Group's efforts, it has potential applicability beyond the siting of proposed power generation facilities.

Permitting, Siting, and Environmental Impact Assessment

Community and EJ stakeholders raised concerns about the implications of some of the proposed policy approaches for hard-won procedural safeguards designed to ensure adequate access to official decision making in areas such as permitting, the siting of facilities and infrastructure, and conducting environmental impact assessments. Specifically they cited language regarding the need to "overcome barriers" as troubling. They contended that "EJ communities have long been victimized by proposals that evade zoning and siting law review" and that carving out exceptions in order to advance climate change-related goals would be strongly opposed. As an example, they pointed to a specific controversy that occurred in New York City in 2000, when the New York Power Authority (NYPA) met with determined resistance to a plan to site natural gas-fired turbines exclusively in EJ communities. A lawsuit and citywide protests ensued, resulting in a court order directing NYPA to prepare an environmental impact statement.

Implementation of many of the policies proposed for inclusion in the Climate Action Plan by the different Technical Work Groups could have implications for siting and environmental impact assessment. For example, implementation of PSD-3, which is focused on increasing development and dissemination of energy storage technologies, should take account of the implications of siting such facilities in EJ communities where power generation facilities are already clustered. Similarly, in considering PSD-9, which is focused on Technology, Research, Development, and Deployment, stakeholders cited the need to apply the precautionary principle to forestall unforeseen long-term health impacts in cases where relatively new and untested technologies were deployed in overburdened communities.

As part of the Climate Action Plan process, EJ stakeholders have emphasized the importance of assessing the cumulative risks and impacts of different types of stressors, facilities and infrastructure on the health and quality of life of communities. The term "cumulative risks and impacts" refers to a combination of factors that result in certain communities or sub-populations being more susceptible to environmental stressors of varying kinds, including being more exposed to environmental toxins, or having compromised ability to cope with and/or recover from such exposure.[1] Because of the breadth and nature of the policies proposed for the Climate Action Plan, stakeholders highlighted the potential for implementation to either increase cumulative impacts or decrease them depending on the specific design of individual policies and the interactions among several of them in a given community. The importance of adequately analyzing the public health implications of the proposed policies was also emphasized.

Finally, timely access to information and transparency were advanced as critical issues that cut across all the policy areas. The central importance to EJ communities of processes that required formal public notice and participation procedures such as federal and State permitting was repeatedly stressed by stakeholders.

Waterfront Facilities and Public Health

Throughout the community-focused and EJ coordination and advisory dialogue, various concerns about the vulnerability of waterfront facilities, such as wastewater treatment plants, petroleum/chemical bulk storage sites, and solid waste management facilities, and the risks they represent to surrounding communities in the context of climate change were raised by the stakeholders. In particular, the medium- and long-term contamination consequences associated with coastal flooding proved a source of considerable concern.

The types of hazards associated with storm surge and other inundation events are numerous. In addition to injury and death caused by the direct contact with flood waters, such events can lead to a host of environmental health risks due to direct contamination of homes and other buildings, contamination of drinking water sources with either infectious or chemical material, and disruption of sewage systems and of solid waste collection and disposal systems. Flooding could also potentially lead to the contamination of water bodies such as reservoirs, ponds, and lakes. Typically, it is during the recovery phase in the aftermath of an inundation event that these kinds of environmental impacts become apparent.

The following critical knowledge gaps related to epidemiological risk factors and public health interventions have been identified already in the literature on the public health impacts of floods:

- The mental health impacts of flooding, especially the long-term impacts, and their principal causes, which have been inadequately researched even in high-income settings;
- The nature and magnitude of mortality risks in the period after flooding;
- Quantification of the risks of infectious and vector-borne diseases following floods;
- The effectiveness of warning systems and public health measures in reducing flood-related health burdens;
- The health-related costs of flooding that are often given little weight in decisions about specific interventions;

- Quantification of the degree to which climate and land use change will contribute to flood risk and associated health burdens in different settings.[2]

Specifically, stakeholders indicated a need to analyze the potential health risks associated with human exposure to toxins during and after storm surge events, particularly in areas of high-population density. They advocated for the development of maps with overlays of all industries and toxic materials associated with specific industrial processes in areas vulnerable to storm surge and coastal flooding.

Fair Share of Burdens and Benefits

Equity concerns and ethical considerations have been increasingly applied to international, national, state, and local efforts to address climate change, drawing on some of the debates originating in the environmental justice movement.[3] Historically, a fundamental principle of the EJ movement is that no population should be forced to bear a disproportionate share of the environmental consequences resulting from industrial, commercial, or municipal operations or from the execution of government programs and policies.

Community and EJ stakeholders observed that achieving this ideal within the context of a transition to a low-carbon economy and climate change means more than just treating communities in an equitable manner. They pointed out that the reality that, by definition, overburdened EJ communities are not starting at the same place as more affluent, politically powerful communities and that balancing this legacy of environmental pollution and burdens in the context of climate change would require a more nuanced approach. Specifically, stakeholders argued that overburdened communities merited a greater proportion of the beneficial demonstration projects, pilot programs, and innovative policy initiatives being proposed for inclusion in the Climate Action Plan. In addition, they contended that any efforts to streamline approval processes or remove barriers to innovation or implementation must take into account existing burdens in and potential detrimental impacts on vulnerable communities.

Near- and Long-Term Workforce Training and Development Requirements for a Clean Energy Economy

The Residential, Commercial/Institutional, and Industrial (RCI) Technical Work Group identified *near-term* workforce training and development as a priority policy option within that sector during the Climate Action Plan process. However, this issue cuts across all Technical Work Groups, as each sector of our economy seeks to implement new technologies and practices for a clean energy economy and makes permanent changes in the way we, as a state, use our resources. The existence of a suitably skilled workforce is assumed in the quantification of all other policy options in this Interim Report. Specific examples of training needs that would be necessary to implement the policy options

[2] Ahern, Mike, Kovats, R. Sari, Wilkinson, Paul 2005. "Global Health Impacts of Floods: Epidemiologic Evidence." *Epidemiologic Reviews.* Johns Hopkins Bloomberg School of Public Health.

[3] Cutter, Susan. 1995. "Race, Class and Environmental Justice." *Progress in Human Geography* 19:107-118.

identified during the Climate Action Plan process were identified for all mitigation Technical Work Groups and are incorporated into the Workforce Training and Development Policy (RCI-6). (See Chapter 6 for the policy summary. The complete Policy Options Document is available at www.nyclimatechange.us.)

Workforce training and development are primarily intended to improve productivity (quality of production output) by improving the knowledge, skills and abilities of the workforce. The Workforce Training and Development policy option examines the following *near-term* workforce development strategies and programs:

- Energy efficiency;
- Site-based clean and renewable energy resources;
- Power supply and demand;
- Smart grid technologies;
- Codes and standards;
- Agriculture, forestry, and waste;
- Transportation;
- Manufacturing and other related areas.

Opportunities to prepare and expand upon current workforce training, continuing education, credentialing, licensing, on-the-job training, recruitment and job placement efforts are identified. Initiatives will focus on the following:

- Mid-stream decision makers and building professionals in the residential, multifamily, and commercial building sectors;
- Industrial and power systems engineers and skilled technicians;
- Manufacturing engineers and technicians;
- Biorefinery, upstream, or feedstock production training related to biomass energy as well as downstream training for conversion facility personnel;
- Integrated farm management processes and systems;
- Forest management focusing on upstream workers;
- Waste reduction, recycling, and composting

Workforce training also was addressed by the Economic Development Subgroup (see the Building Block #2 section of Chapter 13: Stimulating a Clean Energy Economy in New York) but from a *long-term* perspective, focusing instead on developing strategies that identify and respond to workforce development needs as they arise and on education and training of future generations of workers that will be needed for the low-carbon economy

A skilled workforce must exist for companies to grow and locate in the State. In an innovation-based economic model, a full spectrum of skill levels is needed. A dynamic workforce development system designed to meet the needs of a low-carbon economy must take a long view to develop the human capital needed to prepare New York and capture the benefits of a clean economy. The K–12 system must educate children in math and science more effectively, help them understand the need for environmental sustainability and alternatives to a carbon-based economy, and prepare them for entrepreneurship. The higher education system must continuously evolve to reflect the needs of the changing economy through new curricula and through the establishment of low-carbon economy-centered certifications and degree programs. Incumbent workers must have access to workforce development programs to help them continuously upgrade their skills to meet the needs of their employers. Finally, new energy service jobs, combined with proper training, would create opportunities for professionals to remain and work in New York and create pathways out of poverty, an equally important social objective.

The Economic Development Subgroup identified elements of the workforce development system necessary to evolve with the changing economy, key market barriers that must be addressed by a comprehensive workforce investment strategy over the 2050 planning horizon, and the need for public revenues for workforce development and training programs.

Outreach, Education and Capacity Building for Acceptance and Adoption of the Climate Action Plan and the Creation of a Low-Carbon Economy

Many State agencies are active participants in the Climate Action Plan process, and it is necessary that these agencies are fully committed to implementation of the Climate Action Plan, achieving the goal of 80 by 50, and the creation of a low-carbon economy. Government should not only lead by example but will be responsible for developing an implementation strategy that is effective in meeting program goals and that guides the transition to a low-carbon economy in a cost-effective, and politically and socially acceptable manner.

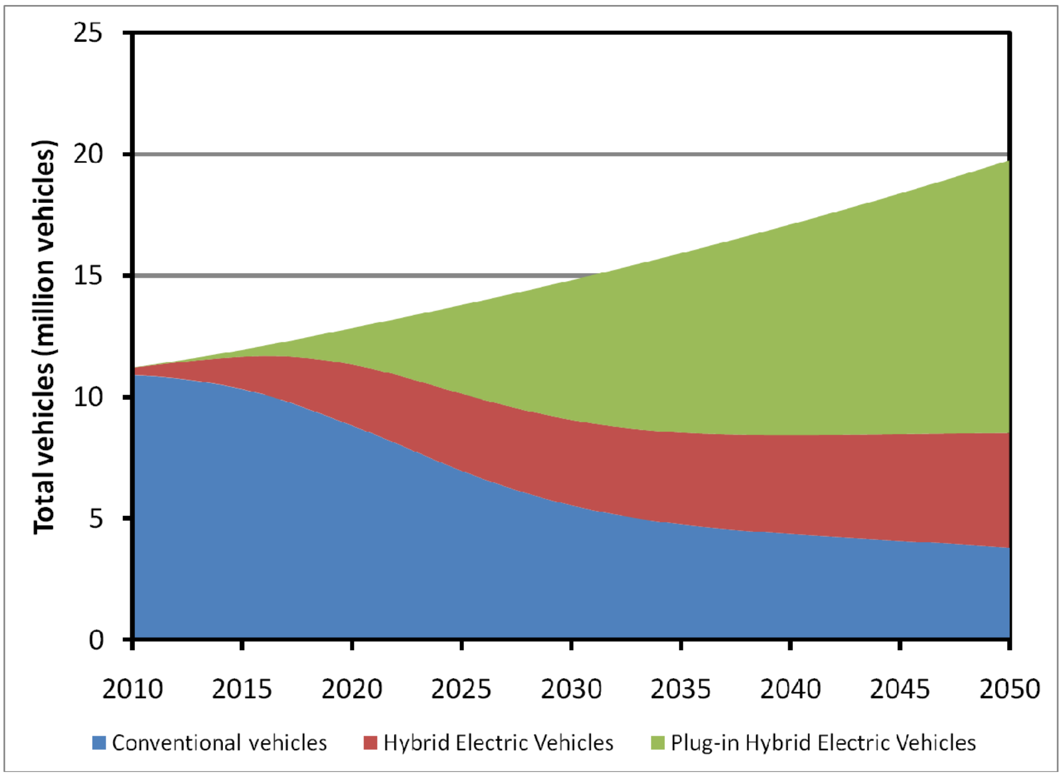
The full engagement of State agencies and local governments should begin with an internal outreach and education effort that promotes the Climate Action Plan and will be pivotal in the development of programs, information, and incentives. Climate change considerations should be part of routine government activities and decisions. Such an effort will help communicate that the policies designed to achieve our greenhouse gas (GHG) goals need not be burdensome but can lead to more efficient operations.

A parallel robust, well-funded, and effective external outreach, education, and awareness-raising effort should focus on the substantial economic, social, and environmental benefits the Climate Action Plan will generate. A public campaign would be based on the lessons of and responses to the government outreach and education plan. Without critical support from the public, some officials charged with implementing aspects of the Climate Action Plan may have little motivation or desire to devote capital resources and personal energy required to achieve its ambitious goals. Implementation of many of the policy options will prove more challenging without widespread support. Messaging should emphasize budget control, safety and security, health, and smart investment approaches that account for uncertainty such as sea level rise and the consequences and costs of no action.

Summary of the Impacts and Strategies Related to the Transition to High Penetration of Electric Vehicles: Conclusions of the Electric Vehicle Subgroup

The full report of the Electric Vehicle Subgroup is attached to this Interim Report as Appendix G.

Figure 12-1 presents on estimate of market penetration developed in a recent New York plug-in hybrid electric vehicle study



Draft Report: *Grid Impact of Plug-In Hybrid Electric Vehicles*. Electric Power Research Institute. 2010. NYSERDA Agreement 10995.

At present, the transportation sector produces 39.5% of New York State's combustion-based inventory of GHG, with the gasoline-fueled light-duty vehicle sector being responsible for the vast majority of those emissions. Plug-in electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and fuel-cell vehicles (FCVs) powered by hydrogen derived from electrolysis offer the potential to displace a significant portion of this petroleum consumption by using electricity for all or portions of vehicle trips. If this electricity had a low- or near-zero-carbon intensity, the carbon footprint from this segment could be nearly eliminated. A cross-sectoral electric vehicle subgroup was established to identify the impacts to multiple economic sectors of a transition to a high penetration of grid-powered vehicles and to establish a consensus, where possible, on a comprehensive, multisectoral strategy to achieve this penetration.

Impacts of High Penetration of Grid-Powered Vehicles on Several Economic Sectors

The members of the subgroup identified many impacts of a transition to high penetration of grid-powered vehicles on several economic sectors, as listed below:

Power Supply—Generation

- Through the mid-term (2025), the state has adequate generation capacity to accommodate the maximum (30%) anticipated penetration of EVs and PHEVs.
- Smart charging to minimize grid impacts will be necessary.
- New York's current off-peak generation mix provides PHEVs significant GHG reductions as compared to conventional vehicles; however, the grid will be required to be near carbon-free to maximize GHG reductions.

Transmission

- Through the mid-term (2025), the state's transmission grid has adequate capacity to accommodate the maximum (30%) anticipated penetration of EV and PHEVs with smart charging.

Distribution

- Near- to mid-term: local distribution (transformer) upgrades are likely to be necessary.
- Longer term: large numbers of EVs requiring quick charge may require local storage.
- Business models, polic,y and regulatory actions encouraging smart charging and allowing third-party sale of electricity may be necessary.

Charging Infrastructure

- Building codes addressing Level II and Level III charging in new residential and commercial garage construction will significantly reduce costs.
- Building codes that address garaging hydrogen-fueled vehicles should be part of the long-term solution.
- Policy and regulations should encourage the development of a variety of business models for charging or refueling (battery swap, etc.).

Vehicles

- PHEVs, EVs, and FCVs that have acceptable performance are a reality.
- Vehicles that derive their fuel from the electric grid are likely to become a cost-effective means of achieving carbon-free mobility.
- In the near term, incentives will likely be necessary to induce adoption. Gas may have to reach $4/gallon and research and development (R&D) will be needed to improve

performance and reduce cost before EVs and PHEVs are economically compelling without incentives.[4]

- In the near- and mid-term, battery-powered vehicles will predominate. The advantages of fuel cell vehicles having greater range, performance, and quick-fill capacity may, when vehicle costs are reduced, lead commercial fleets initially and later private vehicles to invest in localized hydrogen infrastructure based on electrolysis from off-peak carbon-free grid power.

Identified Strategies to Facilitate Transition to High Penetration of Grid-Powered Vehicles

The members of the subgroup identified several strategies to facilitate transition to high penetration of grid-powered vehicles:

- Provide near- and long- term support of R&D for renewable technologies, methods to reduce carbon from fossil sources and vehicle-to-grid technology, battery chemistry, and innovative business models (battery leasing, battery change out, etc.). Increase R&D for energy storage technologies that can accommodate large quantities of excess power generated from renewable sources and base load nuclear power for on-demand and Level III quick-charge vehicle charging. Demonstrate technical options for vehicle charging.
- Develop technologies (energy storage, smart charging) and policies (EV electric rates) that facilitate and promote vehicle charging at times when the carbon intensity of the grid is lowest. Stationary electrical storage may be necessary to minimize negative grid impacts and allow the utilization of excess renewable electricity generated in off-peak times.
- De-carbonize the electric grid to the greatest extent possible.
- Develop, strengthen, and expand financial incentives and rate structures that will encourage low- or zero-carbon generation and off-peak, valley-filling charging. Establish an electricity rate structure with incentives for EV owners to charge during off-peak hours with highest incentives during overnight hours. Rates should encourage vehicle-charging load growth that is consistent with minimized negative impact on the grid and that provides positive economic incentives to consumers. PHEV-specific dynamic pricing may be one way to introduce dynamic pricing to consumers. Financial incentives and disincentives for desired market transformation and behavior change among consumers will be necessary to accelerate low-carbon vehicle market penetration.
- Adopt smart charging systems that recognize that grid emergencies, could mitigate the extent and severity of emergencies, Explore financial incentives for providing transmission level grid support. Techniques such as smart charging, load shifting, and stationary storage all have the potential to mitigate most of the anticipated distribution system problems for the next decade.

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[4] National Academies, *Transitions to Alternative Transportation Technologies,* 2010.

- Assess the feasibility and potential need for quick electric charge, hydrogen filling stations, and hybrid bio-PHEV infrastructure to meet the variety of duty cycles, cost constraints, and vehicle user needs. Continuous improvements in vehicle technology will be needed together with significant long-term infrastructure investment. Public policy should be technology neutral and, in the near term, focus on low-carbon vehicle incentives such as feebates for low-carbon vehicles, and tax credits and buy-downs for fueling infrastructure.
- Develop and implement financial incentives and disincentives for desired market transformation and behavior to accelerate low-carbon-vehicle market penetration. Manufacturer competition may be the most cost-effective way to reduce vehicle cost, with battery manufacturing capacity and robust demand being dominant factors. A robust market can be encouraged through incentives, adequate charging infrastructure, and education. Policy mechanisms like a low-carbon fuel standard, vehicle purchase feebates, or other carbon pricing mechanism will be needed for EVs/PHEVs to be economically competitive in the near term.
- Infrastructure investment will also be a necessary element and may require adjustments in public policy and public investment. Standardize physical interconnections (plugs, voltages, etc.) and communications protocols of infrastructure.
- Revised tariffs would allow charging infrastructure providers to resell electricity they purchase from utilities. Costs for infrastructure upgrades should not be borne by individual customers. A preferred alternative is to use revenue derived from a broader base to cover the cost of upgrades specific to the supply of electricity for plug-in vehicle charging.
- Promote the installation of advanced metering to enable consumers to benefit from favorable electric rate structures.
- Land use considerations include preferential parking, high-occupancy-vehicle lanes, and lower tolls for low-carbon vehicles.
- Support and develop awareness-raising and capacity-building efforts including consumer education programs that make use of all appropriate media such as television, newspaper, and the Internet. This effort should include public policy and financial support such as tuition assistance for educational and workforce development programs at appropriate institutions of higher learning.
- Develop standards that are compatible with smart-grid and Level III charging and building codes that require both residential and commercial new garage construction, to provide circuitry that conforms will enable lower cost market penetration and safer and more reliable service. Policy and regulations should encourage standardization of vehicle charging interfaces at the regulated utility level and with vehicle manufacturers.

Chapter 13
Stimulating a Low-Carbon Energy Economy in New York

Introduction

Economic growth and responsible stewardship of the environment must coexist and must be designed to be complementary. The key is to invest in businesses and in environmental practices that simultaneously promote job growth while helping society mitigate and adapt to climate change. While some policy options discussed in this plan may impose costs on society in the near term, many provide economic benefit today and even greater benefit in the future.

Developing New York's clean energy economy[1] offers one of the most viable means of stimulating environmentally sustainable economic activity in New York in the 21st century. New York has a long history of progressive energy and environmental policy action, as discussed elsewhere in this Interim Report, and such early action is the foundation upon which the State's 80 by 50 planning process is being built. The State's leadership in clean energy provides many examples of the economic development and in-State job creation value of such investments (see Table 13-1 at the end of this chapter).

Much has been written about the potential growth of the burgeoning clean energy economy, and the competition for these emerging markets is global. President Obama has stated that "the nation that leads the clean energy economy will lead the global economy." China is aggressively pursuing dominance in the supply of new clean energy products,[2] and Germany is establishing itself as a leader in several efficiency industries.[3] In the U.S., the Pew Center on Global Climate Change[4] reports that the clean energy economy is emerging as a vital component of America's new economic landscape; many states are trying to revitalize their economies on the prospect of worldwide market expansion for clean energy products and services.

But not all regions will emerge as market leaders. The successful regions will be those which build on strategic assets, which make investments of adequate scale and duration, and which have broad business, political and public support for these ventures.

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[1] "Clean energy economy" in this section is the broad definition of all industries and sectors contributing to a low-carbon economy. This includes energy efficiency, renewable energy, low-carbon transportation technologies and systems, and lean manufacturing, similar to the definition used by the Pew Charitable Trusts in its report, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments Across America. June 2009.*

[2] Center for American Progress. Out of the Running: How Germany, Spain, and China are Seizing the Energy opportunity and why the United States Risks Getting Left Behind, March 2010. See also: Breakthrough Institute and The Information Technology and Innovation Foundation, Rising Tigers, Sleeping Giants: Asian Nations Set to Dominate the Clean Energy Race by Out-Investing the United States. November 2009.

3 The Economist. The Green Machine: A Second Wind for Germany. March 11, 2010.

4 The Pew Charitable Trusts. The Clean Energy Economy: Repowering Jobs, Businesses and Investments Across America. June 2009.

New York is well positioned to compete in this economic race: New York has long been a leader in energy technology innovation and commercialization, with a well established world-class research infrastructure, and is home to a major financial and venture capital industry. New York has a superior higher education system, the natural resources necessary to power a low-carbon economy, and a productive and skilled labor force that can readily transition into new energy industries and markets.

This chapter first details New York's significant clean energy assets and then describes the building blocks critical for nurturing our clean energy economy. Finally, this chapter presents strategies designed to promote long-term and sustained economic growth in New York related to clean energy technologies and innovations for the future low-carbon economy. These strategies can make New York a regional, national, and international hub of clean technology industry and innovation— with the goal of creating good jobs for New Yorkers.

These strategies can make New York a regional, national and international hub of clean technology industry and innovation for the future low-carbon economy – with the goal of creating good jobs for New Yorkers.

While other chapters of the Interim Report focus on policy options to reduce greenhouse gas emissions and to adapt to a changing climate, this chapter attempts to bridge climate policies with strategies to foster clean energy business growth and clean energy job creation. It does not attempt to measure the economy-wide impacts of climate policy, but work is underway to develop such analyses. (These economic assessments, including analysis of macroeconomic impacts of proposed policies, will be presented in the final Climate Action Plan and will require re-evaluation in progressively greater detail throughout policy development and implementation.)

New York Clean Energy Assets and Limitations

New York Clean Energy Assets

The unique regional differences in New York's economy provide a wide variety of advantages for the state. Upstate New York has strengths in innovation and high-tech industry, value-added manufacturing, and large amounts of untapped renewable energy potential and natural resources. Both Rochester and Albany rank among the top ten most patents per capita across the U.S.[5] and the State ranks 2nd in total number of clean energy patents (see Figure 13-1).[6] New York City and downstate regions complement upstate assets with large investment and financial services, access to venture capital, and the country's largest consumer market. The state routinely scores well in national rankings of innovative, knowledge-based economies in the country, such as in

[5]Greenberg, A.. *The Knowledge Economy: America's Most Innovative Cities.* Forbes Magazine. May 24th, 2010. http://www.forbes.com/2010/05/24/patents-funding-jobs-technology-innovative-cities.html.

[6]Heslin, Rothenberg Farley & Mesiti, P.C. *CleanTech Patent Index. 2009.*

the Kauffman report, which ranks New York as 5th best prepared to transition into a new knowledge based economy.[7]

Types of Capital in New York State

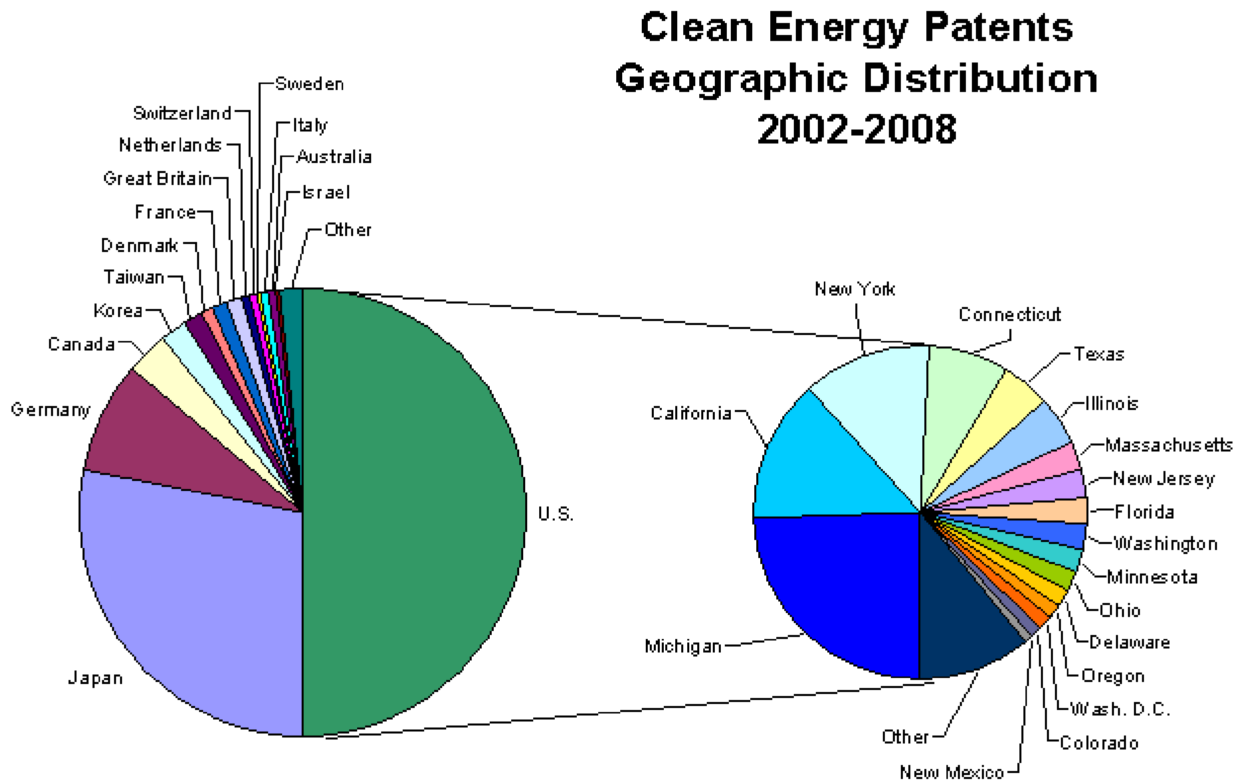
- **Human capital:** New York State boasts one of the most educated workforces in the country. Overall, 31% of New Yorkers have a bachelor's degree, and 14% hold a graduate degree. New York's workforce is the 4th most educated in the country, below only Massachusetts, Maryland, and Connecticut.[8] Human capital is the most valuable asset in an innovation, knowledge-based economy.
- **Financial capital:** Despite an ailing economy, New York City remains the global financial capital. The city is home to many Fortune-500 corporations and has one of the largest banking centers. This immense source of financial capital, if targeted correctly, will be pivotal in funding new technology and startup companies throughout the transition into a clean energy economy.
- **Natural capital:** New York State has vast assets in low-carbon natural resources that will help fuel the clean energy economy including wind, solar, hydro, and biofuels. According to the New York State Energy Plan, if fully developed, these renewable resources could meet nearly 40 percent of New York's projected primary energy needs in 2018[9].
- **Manufacturing infrastructure:** New York State has an extensive manufacturing infrastructure (and associated labor force), particularly in the upstate region, that could be transitioned into new growth markets in clean energy.

[7] Atkinson and Andes, The 2008 State New Economy Index, Benchmarking Economic Transformation in the States, Kauffman Foundation. November 2008.

[8] The Brookings Institution Metropolitan Policy Program, The State of Metropolitan America. 2010.

[9] New York State Energy Planning Board, 2009 State Energy Plan. December 2009.

Figure 13-1. Clean-Energy Patents: Geographic Distribution 2002–2008



Source: Heslin, Rothenberg Farley & Mesiti, P.C.

Academic and Research Institutions

New York State is home to a large number of leading universities and research centers, including two Ivy League universities, seven members of the Association of American Universities, over 20 major research institutions, and a wide breadth of smaller colleges.[10] New York State ranks 2nd in the country in number of doctoral scientists and currently enrolled graduate students and 3rd in the country in the number of doctoral engineers.[11] These institutions play a critical role in the development of the state's vital human capital assets, and we must ensure the state continues to have the employment opportunities necessary to retain this talent.

However, these academic and research institutions provide more than just an educated workforce: they conduct the initial research and development for new technologies that are commercialized in the private sector. Recently, five New York research laboratories were awarded multimillion-dollar Energy Frontier Research Centers grants by the U.S. Department of Energy. These research centers, at SUNY Stony Brook, Brookhaven National Laboratory, Columbia University, Cornell University, and General Electric Global Research, are working to

[10] New York State Energy Planning Board. 2009 State Energy Plan,. December 2009.

[11] New York City Investment Fund. Cleantech: A New Engine of Economic Growth for New York State. January 2007.

dramatically transform the new energy technologies available to the industry. The State helped fund these New York proposals in order to leverage the sizable federal funds.

New York universities have also entered the emerging field of nanotechnology, which promises advancement in clean energy technologies, including photovoltaics, battery storage, and other renewables. The College of Nanoscale Science and Engineering of the University at Albany is the first college in the world dedicated to the emerging disciplines of nanotechnology. The college's $6 billion-dollar complex already employs 2,500 scientists and has attracted 250 industry sponsorships.[12] The above section highlights only a few examples of research and development being conducted at universities throughout the state.

Training Institutions

At the community college and local levels, New York State has recently developed an extensive network of clean energy training programs at 32 facilities across the State. These programs have conducted over 16,000 trainings of individuals in new energy efficiency and renewable energy markets and are poised to continue to develop the workforce needed for critical components of a low-carbon economy. [See Highlight Box]

Industry and Private Enterprise

Industry and private enterprise is the most important sector of the economy regarding job growth. Fortunately, the state currently has 67,000 employees in the management, scientific, and technical consulting services industry and 54,000 employees in the scientific research and development sector.[13] These industries pay average salaries of $98,000 and $64,000 respectively, both well above the state average.[14] Although these jobs are only a small portion of the innovation and clean energy economy, they are representative of the economic benefits involved in a transition to a low-carbon economy. Furthermore, these sectors will transition easily into the new economy and thus provide a strong base of human capital that can be expanded on. When coupled with growth in value-added manufacturing, the potential for economic growth and creation of jobs is dramatic.

Industries and private corporations throughout New York have already been successful in creating or attracting clean energy businesses and jobs. The sector already boasts 3,300 clean energy businesses employing over 34,000 people, making the State a national and international leader in the sector.[15] These businesses include large corporations and small startups alike. For example, General Electric recently opened its $45 million Renewable Energy Global Headquarters in Schenectady, New York. Emphasizing smart growth principles, GE created 650 new jobs in the city, with the capacity for growth in the future. Another example of new economic development is Global Foundries' new semiconductor manufacturing facility in

[12] College of Nanoscale Science and Engineering. University at Albany, http://cnse.albany.edu/

[13] U.S. Department of Commerce, Bureau of Economic Analysis – regional Economic Accounts. http://www.bea.gov/regional/index.htm#gsp

[14] United States Department of Labor, Bureau of Labor Statistics.

[15] The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments Across America, June 2009*.

Saratoga County, currently the largest economic development project in the country.[16] This facility is expected to bring over a thousand jobs to the local economy.

Over the last decade, New York has lost 40 percent of its manufacturing jobs, well above the national average.[17] The transition to a clean energy economy could provide value-added manufacturing jobs to a region with a surplus of skilled workers with manufacturing experience and underutilized industrial sites, particularly in upstate New York. GE and Global Foundries are only examples of the many existing and potential economic development opportunities available to the state. Recognizing that other states have faced manufacturing job losses and will seek to lure manufacturing plants to their borders, the more quickly New York is able to form the culture of innovation that can create new energy businesses, the more likely that capital, talent, and other businesses will find New York an attractive place to locate.

Public Institutions and Government

Another set of assets New York has to help catalyze economic development through clean energy and climate policy are its public institutions and units of state and local government. These institutions can together bridge academic, private, and public research and development programs by streamlining government incentives and funding while fostering a culture of cooperation within the clean energy sector. An economic transition on the scale required for achievement of the 80 by 50 goal will require substantial and coordinated public planning and guidance.

Specific Clean Energy Core Competencies in New York

The New York Academy of Sciences recently conducted an assessment of areas of economic growth potential in New York.[18] It identified four economic growth areas and enabling technology core competencies in New York: advanced materials, biotechnology, information technology, and clean technology. The Academy further identified six areas within clean technology with the greatest economic promise for the state: photovoltaics, energy storage, fuel cells, bioenergy, smart electric grid, and integrated building technologies (Figure 13-2). These innovation assets align with the technologies needed for a low-carbon future.

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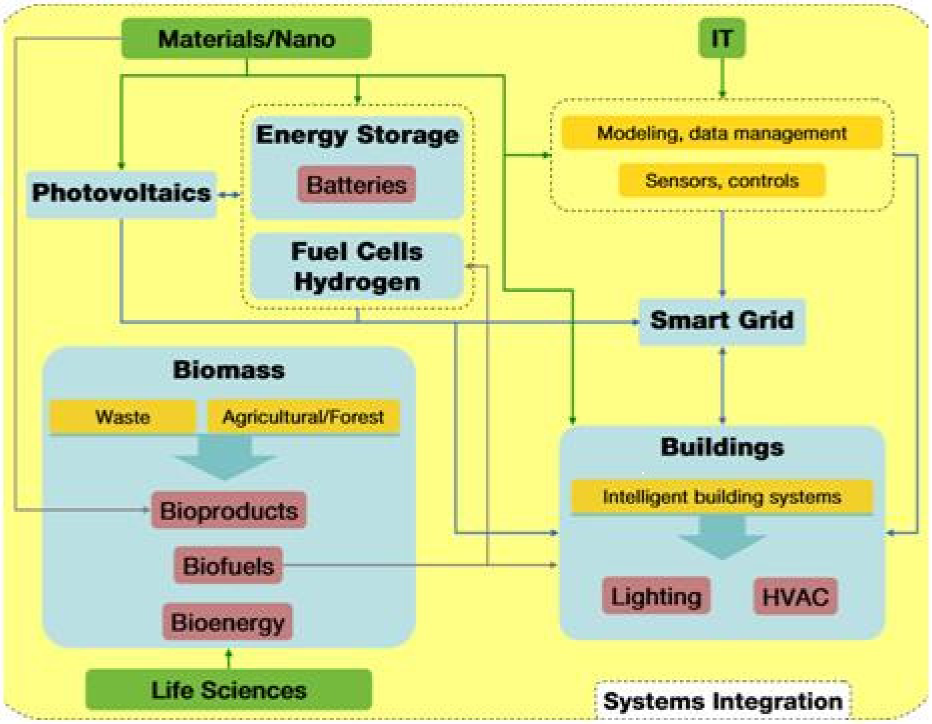
[16] Saratoga Technology + Energy Park. http://step.nyserda.org/index.html.

[17] New York City Investment Fund. Cleantech*: A New Engine of Economic Growth for New York State*. January 2007.

[18] New York Academy of Sciences. *Innovation & Clean Technology in New York State: A New Economic Engine*,.August 2010.

Figure 13-2. Clean Energy Innovation Assets in New York



Source: New York Academy of Sciences

New York Clean Energy Limitations

Social Capital and Integration Networking

While New York has significant assets, they are not fully integrated with each other and with the transition to a cleaner economy. As a result, developments in one sector of the economy can sometimes have difficulty translating into other areas. For instance, while New York leads the nation in research and development, only 4 percent of academic research in New York is funded from industry.[19] This is below the national average and demonstrates the potential for more university-industry collaboration. While New York is home to more than 20 major research institutions, and its universities place it 2nd among the states in attracting federal research and development (R&D) funding, these universities lag behind in incubating new companies.

The growth of an innovation economy requires many connections among many participants, much like a natural ecosystem. Key participants include university researchers, technology developers, sources of capital, entrepreneurs and executives, service providers, business advisors, and others with a stake in commercializing new energy technologies. Better networks in New York would accelerate technology commercialization by promoting the early formation of multifaceted teams to bring new technology to market and by reducing the time and costs involved in identifying and engaging suitable commercialization resources such as capital, key

[19] The Pew Charitable Trusts. The Clean Energy Economy: Repowering Jobs, Businesses and Investments Across America. June 2009.

personnel, complementary capabilities, and strategic partners. Some promising public and private sector activities are underway to address this gap.[20]

Venture Capital

Despite the large financial industry in New York City, one of the problems arising from the lack of integration networking is inadequate venture capital investments. Venture capital is a critical component for an economic transition of this magnitude. These investments are necessary to move products and technologies from the research and development phase into demonstration and commercialization. As Figure 13-3 demonstrates, New York venture capital investments lag behind other traditional high-tech centers of innovation and entrepreneurial. If this pattern continues, New York will risk losing advances in research and development to startups in other parts of the country.

Regulatory and Tax Structure

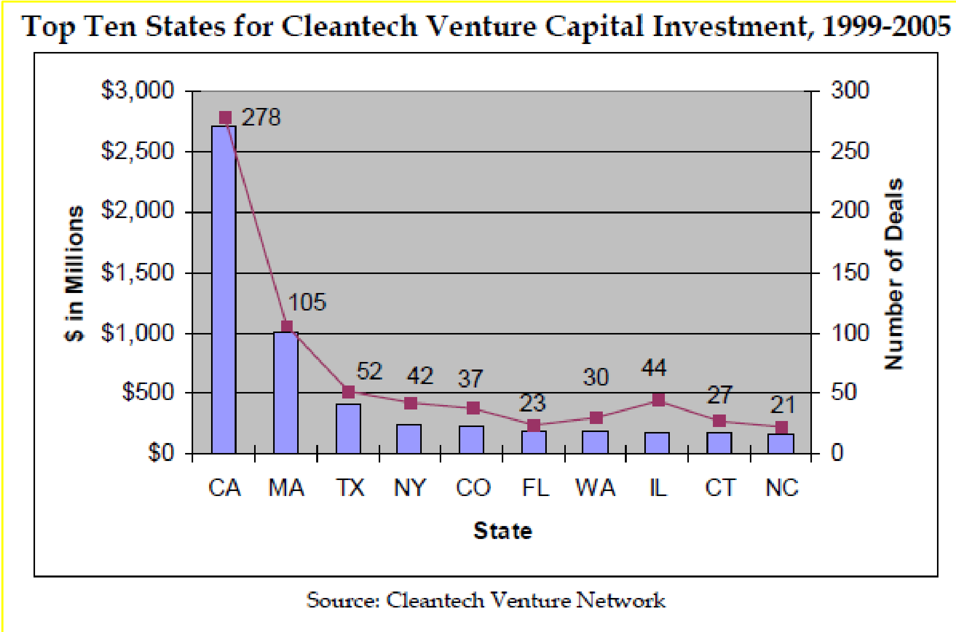
New York must ensure that its tax system, fee structure, and regulatory environment all encourage rather than discourage economic activity in targeted industries. The cost of doing business is a primary factor in firms' location decisions, and the entire range of State policies and laws can affect a business's costs— from fees to licensing requirements to property taxes to tax treatment of investment income. The State must undertake a comprehensive analysis of all impediments to clean energy job and business growth in order to identify barriers and suggest policy and statutory solutions.

Legislative and Regulatory Uncertainty

Uncertainty and risk associated with a developing economy can slow the generation of new companies, the entry of entrepreneurs into the market, and the flow of investor capital. The current legislative and regulatory uncertainty regarding climate policy, both at the federal and state levels, may be a barrier to entry or expansion for firms and individuals. Regulatory and legislative actors can help by building future certainty regarding laws, goals, and responsibilities throughout the state. This was a clear recommendation offered by a number of investors in the clean energy sector, convened as part of the Climate Action Plan process. New York State has the opportunity to obviate much of this concern by clearly integrating into all its policies the core values of wise use of energy and the in-state production of abundant clean energy.

[20] See Upstate Venture Connect. www.uvc.org

Figure 13-3. Venture Capital



Policy Options to Drive Clean-Energy Economic Growth in New York

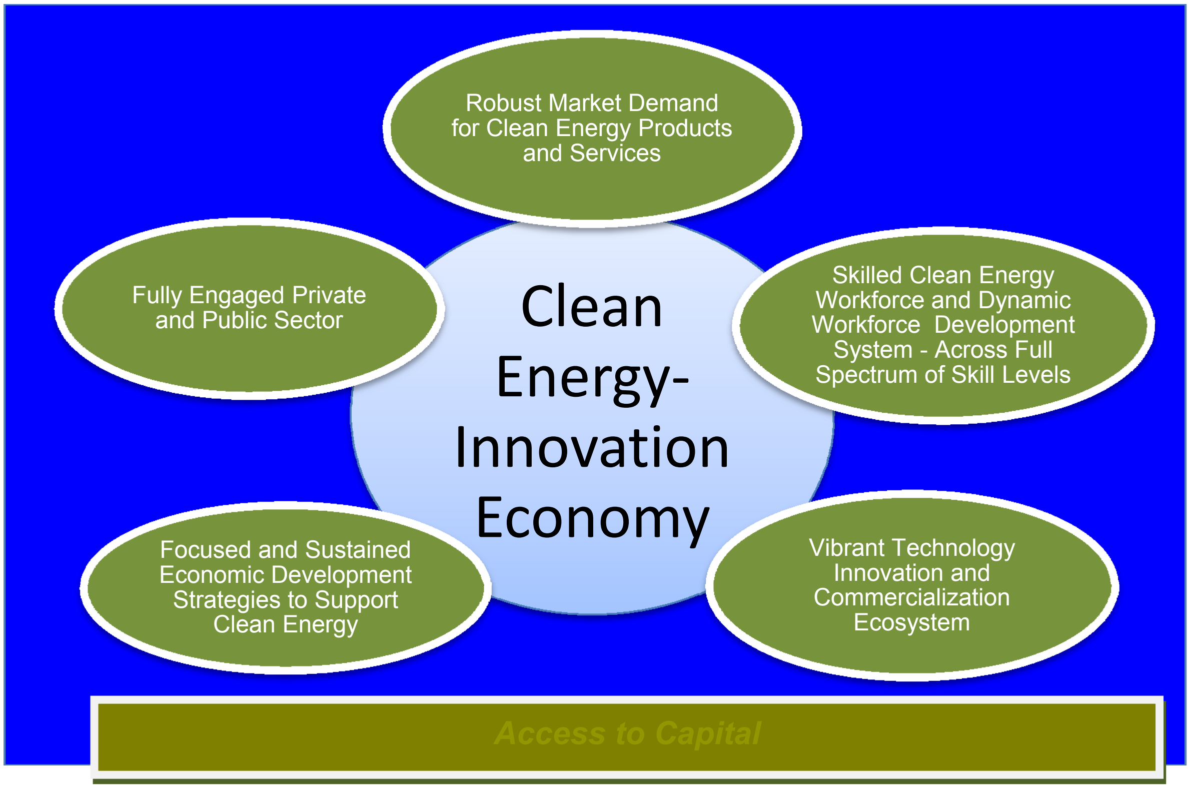
Figure 13-4 illustrates the major building blocks of an innovation-based clean energy economy:

- Robust market demand for clean energy products and services,
- Skilled clean energy workforce and dynamic workforce development system,
- Vibrant technology innovation and commercialization ecosystem,
- Focused and sustained economic development strategies to support clean energy,
- Fully engaged private and public sector.

Each of these elements is critical, along with the fundamental access to capital.

A portfolio of policies strategically designed to support these critical elements would maximize economic development potential in New York and, if properly executed, would turn climate policy into an engine for economic growth.

Figure 13-4. Building Blocks of a Clean Energy-Innovation Economy



Building Block #1: Creating Robust Market Demand for Clean Energy Products and Services

Strong market demand must exist in order for companies to make investments in facilities, manufacturing, services infrastructure, and R&D. Demand can be created through a variety of policies at the international, national and state levels. Such policies include market-pull policies (e.g., the Renewable Portfolio Standard, or RPS), financial incentives/disincentives (e.g., a carbon tax), regulations and/or codes, procurement guidelines, and a variety of other mechanisms addressed through this Interim Report. Market demand is the foundation for advancing a clean energy economy.

The greenhouse gas mitigation policy options presented throughout this Interim Report would stimulate local demand for clean energy technologies and services (see Chapters 5 through 8) and thereby lay the foundation for a clean energy economy in New York. While policies that drive larger markets (i.e., national and regional policies) will mobilize more private capital and will do so more quickly, history has demonstrated that State policies can move markets in the clean energy arena and create local economic growth.[21,22] Just as we have seen several European nations surpass the U.S. in the commercial development of solar and biomass technologies

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[21] New York Renewable Portfolio Standard Evaluation Report. March 31, 2009.

[22] Lawrence Berkeley National Laboratory. Renewable Portfolio Standard in the United States: A Status Report with Data Through 2007. April 2010.

because of public policy support and a motivated customer base, New York's climate policies have *the potential* to significantly stimulate the local clean energy economy.

It is important to note, however, that not all clean energy/climate policies will necessarily create local jobs. For example, a Renewable Portfolio Standard that is met through the acquisition of out-of-state renewable energy credits is not likely to directly create jobs in New York, although it will bolster overall demand for renewable energy products. Energy efficiency policies, on the other hand, have the dual benefit of not only being the most cost-effective greenhouse gas mitigation options but of also providing substantial local benefits in the form of installation and service jobs. This in part has been a strong driver behind policies such as the Green Jobs Green NY legislation. From the perspective of supporting new technology firms, Columbia University's Amar Bhide has identified "venturesome consumption" as a key driver for value-creating innovation for venture-backed firms and notes that local markets enable the growth of new technology firms.[23]

One of the key issues for any state or region in designing such policies is the timing and level of financial incentive. Regions and states that move out ahead of other areas with more aggressive policies will capture the attention of investors and companies looking to grow in clean energy. On the other hand, the policy design must avoid over-incentivizing and creating markets that are not sustainable. Policymakers must carefully weigh the costs incurred by the consumer in subsidizing a low-carbon technology vs. the benefits in terms of stimulating local jobs, environmental protection, etc. In considering this for electric energy efficiency and renewable resource policies, the price suppression benefits should be factored into the analysis, given that investments in energy efficiency and renewable energy can have the effect of lowering the net cost of electricity to *all* consumers. [See Table 13-1]. All of these factors must be carefully considered in designing policies that stimulate market demand.

Building Block #2: Designing a Dynamic Workforce Development System

A skilled workforce must exist in order for companies to grow and locate in the State. In an innovation-based economic model, a full spectrum of skill levels is needed— from the technician servicing customers' repair and installation needs to the chief executive officer needed to attract investment and run a company. A dynamic workforce development system meeting the needs of a clean energy economy must take a long view to develop the human capital needed to prepare New York and capture the benefits of a clean economy. The K-16 system must educate New Yorkers in math and science, help them understand the need for environmental sustainability and alternatives to a carbon-based economy, and prepare them for entrepreneurship. The higher education system must continuously evolve to reflect the needs of the changing economy through curriculum modifications and through certifications or degree programs. Incumbent workers must have continuous access to education and training to upgrade their skills throughout their working career in order to meet the changing needs of their employers. Finally, nurturing the entire spectrum of skill levels will keep professionals living and working in New York while creating pathways out of poverty to raise the standard of living for our most vulnerable populations.

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[23] Bhide, A. The Venturesome Economy: How Innovation Sustains Prosperity in a More Connected World. Princeton University Press. 2008.

Chapters 6 and 12 of the Interim Report identify a range of specific workforce development needs largely associated with requirements for installing and servicing new energy technologies and ensuring that we have skilled labor all along the supply chain. This Clean Energy Economy Chapter looks more broadly at the educational and workforce development needs over the long term and identifies ways to grow the human capital needed to move New York State toward a low-carbon future.

The State must invest in a dynamic workforce development system that can position its workforce for jobs in growth markets.

Because we cannot predict the technologies in future demand, we must develop the means to identify and respond to workforce development needs as they arise. Robust information sharing among the stakeholders involved in K-16 education, higher education, worker training, and industry[24] is necessary to create a workforce development system that is not only comprehensive along the entire spectrum of skill levels but is also dynamic enough to nimbly adjust curricula and trainings as technologies and employer needs evolve. This information-sharing must be incorporated into a continuous feedback loop among constituents— businesses, employees, and educators. As needs, technologies and gaps evolve, the workforce development system must be designed to also evolve.

Such a system includes three essential elements:

- **Labor market characterization:** Assessing, projecting, and monitoring market demand and describing the labor market characteristics of the state's high-priority clean energy sectors, including staffing patterns, skill requirements, earnings, career ladder opportunities, occupational trends and labor supply, and demand assessment. Widespread deployment of new technologies is not possible without trained a installation and service workforce.
- **Program development:** Designing programs to meet supply and demand. Must identify needed skills and expertise, map gaps in available workforce skills, inventory, and design training programs/apprenticeships. Must meet needs of all participants (workers, employers) by addressing barriers to training and employment and engaging economically disadvantaged communities.
- **Coordination:** Full spectrum of training activities (public sector, private sector) to leverage resources, to market opportunities, and to establish certifications and standards. Note that "clean energy jobs are not unique to the clean energy industry, and require the same range of education, skills and earnings as jobs in other energy sectors and jobs in the construction and manufacturing industries."[25]

These strategic elements are neither driven by the market nor sustainable in the market without public support, and a workforce with the requisite skills to properly analyze, design, install, and

[24] ARRA New York State Department of Labor grant for green-business survey.

[25] New York State Department of Labor. New York State's Clean Energy Industry: Labor Market and Workforce Intelligence. May 2009.

maintain industrial and technological advances will not evolve as quickly as needed without public investment. Intervention will continue to be particularly vital for reaching traditionally underrepresented and economically disadvantaged communities and populations.

The past several years have seen a precipitous decline in federal support for state-administered workforce development programs. New York State has not supplemented the decreased federal dollars. To ensure adequacy of resources, policymakers will need to dedicate revenues for workforce development. Allocating a portion of Climate Action Plan public investments to workforce development can help ensure the ability of the workforce development system to change with the needs of employers and the labor force, particularly by supporting the critical incorporation of real-time labor market and workforce intelligence into program and curriculum development.

The methodological basis for public workforce investment strategy over the 2050 planning horizon is not likely to change from that of today. This includes addressing the following:

- Barriers and bottlenecks that prevent the market from producing the requisite workforce development activities necessary to achieve the goals of the Climate Action Plan;
- Breadth of services: K-16, continuing education for adults, continuous access (both availability and cost) for skills upgrades;
- Comprehensively cataloging job and training opportunities; existence of gaps will justify and help direct use of public funds;
- Evaluation, measurement, and verification of the benefits of public investment in workforce development to support the Climate Action Plan; must set clear, relevant, and achievable goals.

Key market barriers that must be addressed by a comprehensive public workforce investment strategy over the 2050 planning horizon are likely the same as we face today:

- Matching outcomes to investments**:** The objective of clean energy workforce development programs is to improve worker proficiency in knowledge, skills, and abilities required of the jobs to manufacture, install, operate, and maintain the technology advances in clean energy. These goals cannot be measured by simple metrics, such as job placement rates or wage increases, but must instead be measured by more difficult metrics that would assess participants' increased skills or knowledge. The positive productivity effects of workforce development investments are conclusively documented in the literature, and this remains critically important in valuing the effectiveness of workforce development programs.
- Loss of income while participating in training: For many individuals, the immediate need to work to cover basic needs far exceeds the delayed greater income potential from not working and participating in training. Therefore, public workforce development investments must include sufficient funding for needs-related payments to encourage individuals to participate in training.
- Loss of business productivity while training employees: Some worker skills can be acquired only through on-the-job training, which can be costly to the business through lost productivity of its existing staff. Support for incumbent worker training and on-the-job

training through compensation for lost productivity is an important component of a workforce development portfolio.

- Need for employment-related supports: Remediation of employment barriers, such as transportation, child care, costs of tuition and materials, will remain an integral part of successful workforce development investments targeted at entry-level positions.
- Need for training capacity: Training infrastructure includes curriculum development, school startup and accreditations, and worker certification. It also includes the cost to properly equip workers with the requisite tools necessary for the job. Public workforce investments must provide support for capacity building to advance skills proficiency in installation work, operation work, and maintenance work in the clean energy industry.
- Need for marketing and outreach: The need to publicize the availability of training programs is particularly relevant in economically disadvantaged communities. Public workforce investments should include sufficient funding to promote clean energy training initiatives and opportunities, focusing initially on low-income residential building performance and urban ecology.

Building Block #3. Catalyzing a Technology Innovation and Commercialization Ecosystem

The challenges of 80 by 50 will not be solved with today's technology.[26] Experts across the globe are recommending substantial and sustained investment in energy and environmental technology R&D on top of new approaches to technology commercialization.[27] It is well documented that technology innovation is responsible for over half the U.S. annual GDP growth.[28] A full ecosystem comprised of inventors, entrepreneurs, financiers, and market experts will together spur creation of new clean energy companies that will take the necessary risks needed to produce new products and services. New York has the key ingredients for a robust job-creating energy-technology innovation system[29]'.With greater alignment of policies, New York could reap substantial economic gains related to emerging clean energy growth markets.

New York has a long history of supporting innovation in energy technology—dating back to the days of Edison and the demonstration of the world's first electrical grid, the world's first electrically illuminated city, and one of the largest renewable energy-hydropower developments in the early 20th century. From an organizational standpoint, the New York State Legislature had the foresight in the 1970s to create an institution to focus exclusively on innovation in energy technology and, specifically low-carbon energy technology, through the creation of the New York State Energy Research and Development Authority (NYSERDA). But meeting a challenge

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[26] Edmonds, Jae and Gerry Stokes. Launching a Technological Revolution in Climate Policy for the 21st Century: Meeting the Long-Term Challenge of Global Warming. Edited by David Michel. Center for Transatlantic Relations. 2003.

[27] International Energy Agency. Global Gaps in Clean Energy RD&D, 2010. See also Bill Gates: Gates Path to an Energy Revolution. New York Times,. August 24, 2010.

[28] Robert Sokolow, Nobel-Prize winning economist on innovation and growth economics. See also American Council on Economic Competitiveness.

[29] New York Academy of Sciences. Innovation and Clean Technology in New York State. 2010.

as transformative as 80 by 50 goes beyond a single organization's mission. Such a challenge will only be met through concerted and coordinated policy, program, procurement, and investment practices in all agencies of State government. And most importantly, such a challenge will only be met if we can unleash the creativity of private enterprise, where products will ultimately be introduced into markets.

The current global level of investment in energy technology innovation is nowhere near adequate to solve the energy-climate challenge, nor is it commensurate with the economic opportunities associated with new emerging growth markets.[30] However, there are signs of change. Large corporations are increasing their investments and partnerships in clean energy technology. Start-up companies are emerging with greater frequency in the clean energy business space. Venture capital investment in clean energy is at a record-high level nationally. And in the past few years, there has been a higher level of federal funding available for energy R&D relative to the past two decades.

The challenge to New York is to seize these economic opportunities, revitalizing and diversifying the State's economy— both by creating an environment that stimulates new high-growth start-ups and by encouraging continued investment in innovation and commercialization at larger, more established businesses that have the capital and human resources needed to make major improvements in technology.

Research and development is a critical component in an innovation system, but creating a vibrant technology innovation and commercialization ecosystem requires more than R&D. The State must actively promote innovation and entrepreneurship to bring the fruits of R&D investments to the market and to realize local economic benefits. The recommendations presented herein build on NYSERDA's three decades of experience in working with New York businesses to commercialize new energy technology and are supplemented with recommendations from stakeholders and several recent reports on actions needed to stimulate innovation in New York, including the Task Force on Diversifying the New York State Economy through Industry-Higher Education Partnerships (IHETF)[31], the Public Policy Institute of the New York State Business Council,[32] Center for an Urban Future,[33] the New York City Investment Fund,[34] and several review papers by the New York Academy of Sciences.

[30] United Nations Foundation, Scientific Research Society. Confronting Climate Change. February 2007.

[31] Task Force on Diversifying the New York State Economy through Industry-Higher Education Partnerships, Final Report. December 2009.

[32] Public Policy Institute. Transcending the Hamster Cage: Unfettering New York's Static Innovation Economy. January 2010.

[33] Center for Urban Future. Building New York City's Innovation Economy. September 2009.

[34] New York City Investment Fund. Cleantech: A New Engine of Economic Growth for New York State. January 2007.

The creation of new ventures, in particular high-growth ventures, is critical both to the State's climate strategy and to its economic development goals. Startup companies account for the bulk of job creation and economic growth. From 1980 to 2005, nearly all net job creation in the U.S. came from companies less than five years old.[35] Even though jobs are constantly being created and destroyed by businesses of all ages, high-growth startups compensate for job losses by firms that close, even during recession.[36]

The State must actively promote innovation and commercialization and entrepreneurship to bring the fruits of R&D investments to the market and to realize local economic benefits.

However the focus cannot be solely on directing State funding to capital for startup companies in the hopes of encouraging their formation and helping to sustain them through lean and dangerous early days. This strategy must be preceded by other policies that set the stage: For example, policies to enhance the entrepreneurial climate by providing entrepreneurial training and expanding access to technology are valuable strategies in their own right and often a necessary precursor for direct funding programs to be successful.[37] Examples of these corollary policies follow:

- To convert New York's research capacity to sustainable economic impact, the IHETF Final Report wisely calls for a statewide culture that emphasizes commercialization, and recommends a number of steps to foster this culture:
  - Changing practices at universities to emphasize entrepreneurship and technology commercialization;,
  - Calling on industry to engage universities strategically and to sponsor relevant research,
  - Increased availability of capital for seed stage companies and the creation of support structures that help entrepreneurs start up and grow,
  - Adoption of an economic development policy that emphasizes business creation and talent retention, rather than industry attraction,
  - Networking universities and their industry counterparts together.
- The current State Energy Plan also calls for policies and programs in line with the IHETF Report that create an environment encouraging innovation at each stage of the clean energy product and business cycle: from research, development, and entrepreneurship through value-added manufacturing. Continuing development of policies that foster the innovation ecosystem for clean energy technologies and supporting public-private partnerships to lower

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[35] Haltiwanger, Jarmin, and Miranda, Jobs Created From Business Startups in the United States, Kauffman Foundation, January 2009. http://www.kauffman.org/uploadedFiles/BDS_Jobs_Created_011209b.pdf)

[36] Horrell and Litan, After Inception: How Enduring is Job Creation by Startups?, Kauffman Foundation, July 2010. http://www.kauffman.org/uploadedFiles/firm-formation-inception-8-2-10.pdf)

[37] Lerner, J., Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed and What to Do About It, Princeton University Press, 2009.

the risk of investing in new energy technologies, are essential elements of a prosperous low-carbon future.

- In addition to creating an environment conducive to high-growth startups in clean energy, State policies and programs must further capitalize on the tremendous assets associated with the many large corporate R&D centers in New York, such as GE, IBM, and General Motors, all of which are making major investments in clean energy technology and markets. From an economic development standpoint, one of the key challenges in working with multinational firms is that the economic activity and commercialization activity cannot be constrained to any one state—these are highly competitive global operations. One successful new public-private partnership model that appears to provide value for large clean energy businesses as well as small startups is the New York Battery and Energy Storage Technology Consortium (NY-BEST). Under this collaborative effort, interdisciplinary industry and academic teams have been established to advance energy storage technology, with the public funding going to expand access to university talent in New York State needed by the industrial partner. This effort at networking helps to retain the economic activity in New York by building linkages and, as an example, has proved to be successful in helping to expand GE's battery business in New York State.
- Lastly, New York needs improved linkages between its technology and investment capital. The New York City Investment Fund, in its report *Cleantech: A New Engine of Economic Growth for New York State* suggests that the State could work with regional business organizations to establish periodic forums in which the venture community is exposed to technology developed at academic and industrial research facilities in New York.

Together, these and other measures applied to clean energy technologies can promote the innovation ecosystem with many connections among its participants— university researchers, technology developers, sources of capital, entrepreneurs and executives, service providers, business advisors, and others with a stake in commercializing new energy technologies. Such an ecosystem will accelerate technology commercialization by promoting the early formation of multifaceted teams to bring new technology to market and by reducing the time and costs involved in identifying and engaging suitable commercialization resources such as capital, key personnel, complementary capabilities, and strategic partners.

Looking beyond State policy, New York should advocate for national policies that play to New York's strengths in energy innovation (see also Chapter 14). For example, the federal R&D tax credit has again expired. New York should consider pushing for an aggressive and permanent federal R&D tax credit, which would benefit many industrial energy R&D activities in the State. Of paramount importance, New York State should advocate for substantial and sustained federal investment in energy R&D, without which progress toward a low-carbon future will be extremely slow. New York should also continue to encourage the U.S. Department of Energy to embrace new models for energy technology innovation, including those that are far more decentralized than the energy research models of the past few decades. These models can help support regional energy innovation consortia that can accelerate the pace of energy technology development and commercialization.

Building Block #4. Focused and Sustained Economic Development Strategies that Support Clean Energy

New York must embrace a model for economic development that builds on the state's strengths as a knowledge-based economy, with high-value-added manufacturing capabilities, recognizing that the state will struggle to compete in low-cost commoditized markets. The State's economic development policies should support the retention of jobs and the creation of new businesses and jobs in emerging high-growth markets, such as clean technology industries. The State's economic development policies must embrace the new emerging economy of the 21st century—an economy whose growth is based on innovation, knowledge, and entrepreneurship.

To position New York as a leader in the clean economy, the State should integrate into its core values the principles of wise use of energy and instate production of abundant clean energy. Codifying these values through a multi-generational commitment will help sway decision makers in commerce and investment to tie their futures to New York State. To build New York's prosperity in the emerging economy, policymakers should also link economic development strategy with nurturing and growing the clean economy.

Economic development strategies for the short term are very different from strategies for the long term. Decision makers today are called on to defend against poaching threats from other states and nations, to mitigate community upheavals from facility closures, and to sway multi-state businesses to consolidate operations in New York rather than in facilities elsewhere. Much of the work of economic developers in New York is to support and protect our existing commercial/industrial base.

Economic development strategies for the long term, however, are not tied to any specific business or immediate need but are focused on creating the culture and infrastructure needed to generate new economic activity: to grow the workforce through cutting-edge K-16 schools and workforce development programs, to grow innovation through R&D investments and support of entrepreneurs, to grow firms and businesses with technical assistance for expansion and for access to new markets, to grow investment by improving borrowers' access to capital, and to grow commerce through market generation.

> *To build New York's prosperity in the emerging economy, policymakers should link New York's economic development strategy with nurturing and growing the clean energy economy.*

Beginning immediately, the State should engage in the following activities:

- More strategically allocate monies made available each year for individual firm incentives to focus on high-growth areas such as clean energy. Relevant programs financed in New York State are administered by several agencies, including but not limited to Empire State Development, Department of Environmental Conservation, Department of State, Department of Labor, NYSERDA, and

New York State Foundation for Science, Technology and Innovation (NYSTAR). Strategic allocation could be accomplished in part through the annual budgeting process.

- Engage in a robust marketing campaign targeted to high-growth green firms, both startup businesses and expanding manufacturers, and both home-grown and out-of-state firms. Catalog and exploit our competitive advantages, including but not limited to
  - Hydro resources (good for water-intensive activities like food processing and microprocessor fabrication facilities*)*, multi-climate geography (test-bed for climate-based research);
  - Population/industrial center of massive eastern seaboard market;
  - Global financial center;
  - International connections (immigrant population, points-of-entry, United Nations, etc.);
  - Demographics (multilingual and highly educated populace, highly productive workforce);
  - Transportation infrastructure.
- Work more aggressively with existing New York scientists and researchers on commercialization of promising technologies. [See Building Block #3 above and Chapter 10 on RD&D needs].
- Change State procurement laws and practices both to strengthen New York State as a purchaser and to increase demand for products manufactured in New York [related to Building Block #1 above]. Specific actions could include the following:
  - Internalize true greenhouse gas costs of manufacture and transportation of purchased goods in order to preference those whose production is most aligned with the goals of the 80 by 50;
  - Work with the federal government to ensure that multilateral and bilateral agreements regarding energy and electricity procurement are aligned with climate change goals;
  - Consider revising the weighting on bids for RPS to increase the value of New York's economic benefits, giving greater priority for bids with relatively more New York-manufactured materials equipment and services with positive employment impacts;
  - Strengthen goals for State agency purchasing.[38]

The greater impact, however, will be structurally changing our economic infrastructure to align our education and workforce development systems, our regulatory framework, and our tax structure to encourage the growth and risk taking that will put New York on the top. Four critical long-term strategies to create the culture and infrastructure are identified below:

Long-term strategy #1: Align workforce training, K-12, and higher education with goals of clean energy.

- Develop entrepreneurship and ecology curricula; expand training in, and networks of, entrepreneurs (also noted in Building Block #3 above).

[38] Current statements of goals are embodied in Executive Orders #4, #111, and #142.

- Increase the focus on STEM subjects (science, technology, engineering, and math).
- Incorporate the diversity of New York's population in education and social programs.
- Adopt proposals developed in the IHETF and within the State University of New York's (SUNY) "Power of SUNY" strategic plan.

Long-term strategy #2: Provide public clean energy R&D investments and encourage private investments in R&D, innovation, and commercialization (related to Building Block #3 above).

- Greater performance-based public support of university research centers, university-industry partnerships, technology "de-risking" through public-private partnerships, and improved transition to private ventures especially in emerging markets.
- Create a State Venture Capital Investment Fund.
- Allow SUNY to restructure, creating marquee university centers.
- Enact a bond act to finance clean technology upgrades in New York's infrastructure.

Long-term strategy #3: Grow commerce through generating and nurturing the market for clean economy.

- Encourage networks of investors; facilitate relationship building and startup mentoring.
- Make New York State an early adopter of promising technologies.
- Bolster export assistance for New York manufacturers.
- Continuously upgrade transportation networks— air freight, rail cargo, and deep-water ports.

Long-term strategy #4: Create a tax and regulatory environment supportive of clean energy.

- Consumer behavior: encourage certain purchases (electric vehicles, Energy Star products, renewable energy fuels) and discourage certain purchases (high-GHG emitting fuels, old cars).
- Property-owner behavior: encourage green buildings (zoning, insurance benefits, and consumer taxes on non-green materials) and discourage high-risk or sprawl construction (zoning, higher fees to expand public services).
- Investor behavior: reward profit associated with green businesses, share risk through allowing tax write-offs of green-investment losses.
- Licensing/certification: make New York State the leader in defining certain niche areas of expertise in low-carbon clean energy markets (e.g., as has been done with the establishment of the Building Performance Institute in New York).

A state's financing structure can create an environment where technology firms are born and grow and thrive in the private market without government intervention. While taxes and fees are often considered simply a source of revenue, how they are structured can have significant impacts on decision making and economic behavior. While a comprehensive analysis of the tax and regulatory systems is beyond the scope of this paper, a temporary commission composed of both industry and State agencies should be created to study and propose reforms that would encourage business growth in New York's emerging clean energy economy.

Long-term strategy #5: As part of community revitalization, develop locations suitable for clean energy businesses.

Building Block #5: Encouraging Full Private and Public Sector Engagement

Achieving a goal as transformational as 80 by 50 is possible only with the full and sustained commitment of all levels of the public and private sectors. Success of the Climate Action Plan and the requisite clean energy revolution"will ultimately depend on linkages and support from the federal government, the State government, businesses and corporations, academic institutions, not-for profits, and municipal governments— each of which plays an important role in the transformation to a clean energy economy. And without support from the public at large, policymakers in New York will struggle to advance and sustain the ambitious climate-energy policies presented herein. In the current fiscal environment, these climate-energy policies will be competing for resources with other important policy and near-term social needs.

To facilitate this full engagement, we must: (i) capitalize on the unique roles that each entity plays in our society, (ii) engage a broad spectrum of society, and (iii) ensure that each entity is fully aware of the challenge and empowered to act.

Roles: The public sector's role in establishing a policy framework to internalize the price of carbon and stimulate innovation will be absolutely critical. Other important public sector roles such as supporting a robust educational system, sponsoring research whose benefits are either too long-term or high-risk for any individual private entity, investing in existing and new low-carbon infrastructure, and leading by example will be vital to this transformation. Businesses must be willing to invest in opportunities that are climate friendly and reduce the energy requirements for delivering the goods and service that they provide. Given a supportive policy climate, many businesses appear poised to do this.[39] Private companies can advance a technology into a commercial product, although some government risk sharing will be needed in the early stages of development.

Substantial private capital will be needed to transform our energy system and make the necessary physical investments. New forms of public-private partnerships will be needed to mobilize the capital required to achieve this transformation. New financing models for consumers will be needed to increase access to capital for energy efficiency and renewable energy investments. New financing models for technology developers and project developers will be needed to bridge the "valley-of-death.[40] New forms of loan guarantees will be needed to mitigate risk associated with first-of-a-kind large-scale projects. Specific recommendations clarifying and illustrating the roles of the many different participants in the emerging clean energy economy are described throughout this Interim Report.

[39] Jeff Immelt (General Electric) and John Doerr (Kleiner, Perkins, Caufield & Byers). Washington Post. August 3, 2009.

[40] Bloomberg New Energy Finance. Solutions to the Next Generation Clean Energy Project Financing Gap. June 21, 2010.

> *Realizing a transformation as significant as 80 by 50 will require the full and sustained engagement of the public and private sector—at all levels.*

Engaging a Broad Spectrum of Society: To accelerate and sustain a transformational shift to a clean energy economy in New York, a broad spectrum of society will need to be engaged and benefits must accrue to a diverse cross-section of the population. Jobs must be available for all skill levels, from so-called green collar positions to corporate positions. Ensuring this kind of broad and inclusive engagement will require a range of policy mechanisms, from targeted workforce development initiatives to community-based approaches and mechanisms for establishing effective training-to-jobs networks/programs, such as the use of existing local groups and institutions as informational and organizational hubs. These types of community-based efforts can also help to ensure that green jobs programs and initiatives take into consideration and build upon New York State's rich cultural and ethnic diversity.

Table 13-1 Economic Impacts of Clean Energy Investments

Energy Efficiency: An Investment in our Economy and the Environment
Energy efficiency investments have demonstrated a positive impact on the New York State economy. For the 11-year period from 1999 through 2009, New York's System Benefits Charge program has demonstrated that for every dollar invested in energy efficiency, New York State realizes $4.7 in statewide economic and environmental benefits. These benefits include the creation of 5,300 additional jobs in the New York economy. In addition, these energy efficiency investments have increased personal income by $1.7 billion, and improved the overall New York economy by increasing the gross state product by $2.4 billion.[41]
Renewable Resources: Creating Local Jobs with Local Resources
A recent evaluation of the State's Renewable Portfolio Standard (RPS) program shows that investments in renewable energy technologies can provide positive economic benefits. This analysis concluded that the RPS program resulted in creation of approximately 22,670 total job-years, including approximately 6,490 direct job-years and 16,180 indirect job-years.[42, 43] For every incentive dollar paid to support the construction of the new renewable energy facilities, the State realized over $6 of total economic benefit. In addition to the jobs created, the RPS program was also noted to reduce overall electricity costs for consumers, as well as result in economic benefit from reduced pollution that would have been otherwise emitted from fossil fuel power plants.

[41] NYSERDA. New York's System Benefits Charge Programs Evaluation and Status Report, Quarterly Report to the Public Service Commission, Quarter Ending March 31, 2010. Final Report. May 2010.

[42] Three construction jobs that are in effect for one year are the equivalent of three job years. A single job that persists for three years also represents three job years.

[43] KEMA, Inc. and Regional Economic Development Research Group, Inc.. NYSERDA Main Tier RPS Economic Benefits Report. November 14, 2008.

Energy Efficiency and Renewable Energy: Reducing the Price of Electricity

Analysis conducted for the 2009 State Energy Plan demonstrates that aggressive energy efficiency and renewable energy policies can result in reductions in electricity prices for New York energy consumers. When looking at energy efficiency, the State Energy Plan examined the impact to electricity prices if the current 15 by 15 policy goal was achieved. That analysis demonstrated that the net retail price of electricity paid by consumers is expected to be reduced by 0.4 to 0.9 cents per kilowatt hour, which would equal a total annual bill savings to ratepayers of $600 million to $1.4 billion in the year 2015. This analysis accounts for both the expected ***increases*** in annual customer bills to implement the program, as well as the expected ***decreases*** in annual customer bills due to the reduction in wholesale electricity prices due to the reduced need for electricity, and the reduced need for power generated by the most inefficient and expensive fossil fuel power plants and for importing electricity from outside New York.

The 2009 State Energy Plan also conducted a similar analysis to measure the effect on electricity prices of the 30 by 15 renewable energy policy goal. The renewable energy analysis demonstrated that the net retail price of electricity paid by consumers is expected to be reduced by 0.06 to 0.16 cents per kWh by 2018, which would equal a total annual bill savings to ratepayers of $93 million to $262 million. Like the energy efficiency analysis, this study accounts for both expected cost increases to implement the program, and the expected decreases in annual customer bills due to reduced electricity prices and the reduced need for electricity from fossil fuel power plants from imported electricity.

Energy Technology Development: An Investment in Economic Development

It is well documented that investments in technology innovation lead to economic growth. Evaluation of the System Benefit Charge energy R&D portfolio has shown that for every one dollar co-invested with New York business partners in energy product development, Gross State Product has increased by over four dollars.[44]

Clean Energy Workforce Development: Positioning New Yorkers for Jobs in a Low-Carbon Economy

New York State has been supporting energy efficiency and renewable energy workforce development and training initiatives for approximately 10 years, and has created a network of over 32 clean energy training facilities across the state. This includes the Center for Energy Efficiency and Building Science (CEEBS), headquartered at Hudson Valley Community College, an expansive network of 18 locations that develop and deliver workforce development building science training across the state. To date, over 5,150 students have been trained through CEEBS.

NYSERDA has also worked closely with groups such as the Building Performance Contractors Association, the New York State Builders Association, the US Green Building Council, the Association for Energy Engineers, and others to provide funding support for energy efficiency training to over 5,850 practitioners. Though this network, partners have provided training in solar water heating, small and large wind, geothermal, fuel cells, PV, and anaerobic digestion to 4,900 installers, designers, builders, and architects on renewable energy technologies.

Finally, NYSERDA is working with 25 new training partners to develop career pathways and other technical training initiatives that target low-income applicants with a priority to serve unemployed and underemployed individuals. Career pathway and technical training initiatives will train an additional 6,900 participants by June 2012.

[44] NYSERDA New York's Systems Benefits Charge Program Evaluation and Status Repor., Final Report. March 2010.

Chapter 14
National and Regional Action and Coordination

Introduction

Successfully mitigating the impacts that climate change will have on New York's people, environment, and economy will require coordinated policy and action by all levels of U.S. government—federal, State, and local. Given the global nature of the climate change challenge, federal government action will be essential to successfully position the American economy in an evolving international marketplace and to enable the United States to lead efforts to achieve a global solution. In addition, strong federal action will create a fertile arena for development of the new technologies that will be needed to achieve the scale of emission reductions needed. Further, federal action will help to establish a level playing field in the domestic economy, ensuring that all states have equal access to the opportunities that will arise from the growth of the clean energy economy and share in bearing any costs to achieve the policy.

In the absence of comprehensive federal climate and clean energy policy, American states have served the time honored role as the laboratories for climate change and clean energy policy development. New York in particular has played a pivotal role among states in climate change policy development and in recognizing that its domestic energy, environment, and economic development interests can be successfully augmented through participation in regional efforts. A regional platform with neighboring states can take advantage of access to larger markets for in-state products and services. The broader supply chain created throughout the region also provides for expanded opportunities for New York consumers. Further, the development of cooperative regional programs offers real proof that success can be achieved on the sub-national level and that certain strategies are perhaps best approached on this regional level, taking account of the local natural and human resources and needs.

State actions are also best accomplished when coordinated with local government activities. Local governments are beginning to assume critical roles in the implementation of various climate strategies. Several county and municipal governments in New York have engaged in climate action planning for their communities, while interest and participation in New York's Climate Smart Communities Program is consistently growing. Indeed, absent local government coordination and cooperation, many of the recommendations and program implementation needs in this statewide strategy could be frustrated. Finally, climate change is, at its core, a global issue that will require the dedicated action and attention by all governments, industries, and citizens. It is imperative over the long-term that the federal government identify and act upon the environmental responsibilities and economic consequences of national climate change policy and do so in a manner that can provide economic advantage. In the absence of an international treaty agreement or U.S. national climate or energy policy, New York State action has and can continue to demonstrate to both the federal government and the international community how creative and effective strategies can be developed at the local level and are appropriately translated for national and international application.

This chapter of the Climate Action Council Interim Report (Interim Report) identifies the necessary policy and programmatic action needed at the federal level as well as the opportunities posed by working on a regional platform with neighboring states to achieve New York's climate change goals. This discussion will address activities that New York has undertaken at the national and regional level and will identify certain policy options identified through the Climate Action Plan processes that will require development beyond the identified portfolio of state-focused policy options.

The Lay of the Land: Existing and Proposed National and Regional Programs

New York is not preparing a climate plan in a vacuum. New York has been actively engaged in working with regional partners and other national and sub-national jurisdictions in implementing climate change and clean energy programs. Although President Obama supports clean energy and climate protection, his administration has not been able to secure the support of Congress and it faces constant criticism for advancing agency-level climate protection policies. Even in the highly partisan political environment of Washington, DC, the Obama Administration is moving ahead with a number of programs spread across numerous agencies to support development of a low-carbon economy.

Climate Programs

Regional Partnerships

The Regional Greenhouse Gas Initiative (RGGI) is a prime example of an effective regional program that can inform the development of a national policy. Recognizing that electricity flows across state lines, the 10 RGGI states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) developed a regional cap-and-invest program that limits power sector emissions across the region. Rather than getting mired in the politics of handing out allowances to incumbent polluters, the RGGI states have opted for distributing the allowances via an auction and the states are using the proceeds to stimulate the clean energy economy. The RGGI states are now commencing a program review to evaluate the program's performance and determine what additional changes should be made to improve the program. Similar regional programs are being developed by western states and Canadian provinces (Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Ontario, Oregon, Quebec, Utah, and Washington, with other states, Canadian provinces, and Mexican states as observers) and by midwestern states (Iowa, Illinois, Kansas, Michigan, Minnesota, Wisconsin are members, with additional observer states).

RGGI has advanced several key principles that provide a foundation for a national cap-and-invest program. First, allowances must be recognized as an authorization to pollute the public's atmosphere, and they should be given away to private parties only for truly compelling reasons. The authorization to pollute also represents a very valuable resource that can be sold with the proceeds used to fund efficiency and clean energy programs that reduce electricity bills. Second, very strict criteria and standards for enforcing the integrity and genuineness of offsets is essential to the success of the whole program. Offsets that do not fully offset a complete ton of carbon dioxide would serve as counterfeit credits that threaten the integrity of an emission reduction program. RGGI has done an excellent job of protecting offsets by assuring their legitimacy. Most importantly, RGGI has demonstrated that properly designed market-based mechanisms for emission reductions can be engines, not impediments, to economic growth.

Given the success of their collaboration in the power sector, the RGGI states are also expanding their efforts into the transportation area. Environmental, energy, and transportation agency heads for the ten RGGI participating states, the Commonwealth of Pennsylvania, and the District of Columbia have agreed to form the Transportation and Climate Initiative (TCI), and are collaborating to develop regional strategies to reduce emissions from the transportation sector. One of the first TCI initiatives is evaluation and development of infrastructure needs for a key carbon reduction strategy—increasing the use of electric vehicles.

The Interim Report discusses several strategies that can be implemented on a regional level to maximize the climate benefits and avoid emissions leakage and competitive disadvantages to in-state industries. Among the strategies that are considered for regional implementation are a regional cap-and-invest program that would build upon the strong RGGI foundation (PSD-6), a regional low-carbon fuel standard (TLU-4), and regional pricing mechanisms for the transportation sector (TLU-12). In addition, the interim report recognizes that other policies to be implemented on a state level would benefit from regional implementation, including the low-carbon portfolio standard (PSD-6).

Ultimately, strong regional programs present a powerful model and foundation for federal and even international action. For example, regional cap-and-invest programs like RGGI and the Western Climate Initiative can be linked to form the foundation of a national climate program that would be implemented by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act or legislated by Congress. By acting first to develop the regional templates, New York and its regional partners are well-positioned to prosper under the eventual federal program. New York and other RGGI and western states are also participating in the International Carbon Action Partnership (ICAP), with a goal of developing the basis for an international market-based approach to reducing carbon emissions. New York's participation in ICAP helps to build support for international climate efforts.

Federal Climate Legislation

Congress has tried repeatedly to enact climate legislation in recent years. Each of the proposed bills was based on the common architecture of an economy-wide national cap-and-trade program that would be administered at a federal level. Each of the bills would establish an emissions cap that declines each year until the cap in 2050 is 17–20 percent of the initial cap. Each year, allowances up to the level of the cap would be issued. In early years, most of those allowances would be issued for free to various stakeholders while, in later years, most of the allowances would be auctioned, with proceeds being used to support the goals of the program. Compliance could also be achieved through offsets, which are emission reductions from outside the program, either domestic or international. These bills also included various complementary programs, including transportation measures and support for low-carbon technologies such as carbon capture and sequestration and renewable energy. The bills usually recognized a role for the states in achieving the climate goals, but many of them sought to preempt or displace state cap-and-trade programs, at least temporarily.

To date, these efforts have met with mixed success. In a close vote, split along party lines, the House of Representatives in 2009 passed the American Clean Energy and Security Act, to establish a national cap-and-trade program that would meet a target of reducing national emissions 83 percent by 2050 from a 2005 baseline (essentially the same as the goal of Governor

Paterson's Executive Order 24). Senate efforts to enact similar legislation, however, have all been unsuccessful.

It is unknown what form future federal legislative efforts will assume. When such legislation is finally enacted, New York will need to reevaluate the strategies that are in place to address climate change to identify those that should be altered or required to be discontinued as a result of the federal legislation. A comprehensive federal climate program that is designed to achieve the same level of reductions as New York's climate plan will lessen the need for several of the policy options identified in this Interim Report. Many of the strategies discussed in this Interim Report, however, will continue to have significant value both in achieving climate goals and in building a clean energy economy in New York and enabling New Yorkers to thrive in a climate-constrained world.

Regulation under the Clean Air Act

EPA has begun implementing regulations to reduce greenhouse gas (GHG) emissions, based on the Supreme Court's decision in *Massachusetts v. EPA* that carbon dioxide and other GHGs are air pollutants under the Clean Air Act. Earlier this year, EPA issued a determination that GHGs endanger public health and the environment, setting the stage for a variety of regulatory measures. First, EPA promulgated emission standards for automobiles and other light-duty vehicles for 2012–2016, and the Obama Administration has announced that EPA will be extending those standards to future years and heavy duty vehicles. Second, EPA has issued regulations that would govern major new sources of GHG emissions, which will have to implement the best available control technology for reducing such emissions.

In the absence of federal legislation, EPA can expand these efforts to include emission standards for new and existing power plants and industrial sources. In the coming years, EPA may issue new source standards under section 111 of the Clean Air Act for new cement plants, refineries and utility boilers, among other source categories. When it issues such standards governing GHG emissions from new sources, EPA is required to issue guidelines to the states for regulating such emissions from existing sources. Such state standards could take the form of plant-specific requirements or allowance-based programs if EPA determines that such market mechanisms constitute the best emission reduction system that has been demonstrated. In addition, the Clean Air Act provides states with the ability to implement programs to control such sources if it can demonstrate that its approach would achieve greater emission reductions than implementation of EPA's guidelines.

New York supports EPA's use of its recognized authority to complement and strengthen other regulatory measures identified in this report. In the transportation sector, stronger emission standards set by EPA are a critical tool for reducing GHG emissions because New York does not have authority to set its own emission standards (although it can adopt standards set by California). Regarding stationary sources, EPA programs that require all states to achieve emission reductions from existing sources will not only reduce national emissions more than New York can achieve acting alone or in partnership with other states, but they will also help to level the playing field on which New York industries compete with those in other states.

Federal Energy Programs

Energy Research and Development

Successful models of federally supported research and development activities include Energy Frontier Research Centers (EFRCs), Advanced Research Projects Agency-Energy (ARPA-E), and Energy Innovation Hubs. EFRCs target early stage research by leading researchers and are funded over a multi-year period at $25 million per year, aiming to solve grand challenges in the energy space. ARPA-E employs a more entrepreneurial funding model targeted at further developing cutting-edge technologies that are often considered high-risk technologies. Energy Innovation Hubs complement these two programs by supporting collaborative cross-disciplinary teams in priority technology areas to help speed the commercialization of the technologies. In addition to providing direct support for research and development activities, the federal government can encourage private investment by providing tax credits for investments in energy research and development.

Federal Subsidies and Other Measures to Support Energy Projects

The federal government—primarily the U.S. Department of Energy (DOE)—devotes substantial resources to the support of all types of energy projects, including renewable energy, nuclear power, carbon capture and sequestration and even fossil fuel extraction. Examples include:

- Production tax credits and investment tax credits constitute a primary means of federal support for renewable energy projects, but the availability of such credits will expire in 2011 unless they are extended by Congress.
- Loan guaranties for new nuclear plants; nuclear energy also benefits from the liability framework provided by the Price-Anderson Act, pursuant to which the federal government backstops the liability of plant owners for plant accidents.
- DOE support for carbon capture and sequestration (CCS), including the FutureGen project, which is intended to demonstrate the success of CCS at a commercial scale, and numerous grants nationwide for CCS applications.
- Support for fossil fuel extraction in the form of favorable tax treatment and access to federal lands and waters at below market lease rates.
- Tax credits for homeowners and businesses to purchase energy efficient products and vehicles, and renewable systems (solar, wind, and geothermal).

The federal government's loan guarantee and tax credit programs have been effective in advancing new technologies in the marketplace. These programs are critical to helping mitigate investment risk and spurring private financing of large-scale demonstrations and manufacturing facilities of new technologies that would otherwise have been difficult to secure. Available tax credits are helping homeowners and businesses overcome the cost barrier s to purchase of efficiency and renewable technologies. Over the next few years, as the nation continues to grapple with an underperforming economy, financing for large infrastructure projects and investment in energy efficient and clean technologies is expected to remain tight, thereby making these federal programs all the more necessary to bringing clean energy technologies to market. Several of these tax credits are set to expire and Congress should look to extend those where the market has not yet matured to the point where purchases are being made routinely by consumers

Recommendations for National and Regional Efforts to Advance New York's 80 by 50 Goal

For some climate policies, it will be to New York's advantage to be a first mover, taking advantage of economic opportunities and enhancing quality of life. For other policies, meeting the climate challenge requires more than action by New York alone. As reflected in many of the policies in the Interim Report, New York will pursue regional partnerships that achieve more change, in a more equitable manner, than New York acting alone. In the near future, however, substantial emission reductions will be needed nationwide and internationally to mitigate the profound damage from climate change. National efforts will not only help to achieve the climate goals underlying this effort, but they will also enable New York businesses to compete on a level playing field with their competitors in other states and nations. Therefore, the adoption of comprehensive policies by the federal government is a high priority for New York.

Many of the measures identified in this interim report are also effective in reducing emissions when implemented on a regional scale. Regional programs result in more emission reductions, they help to maintain a level playing field, and they limit the emission leakage that can result from some State programs. Leakage occurs when, as a result of a State program, some emitting activity moves to other states or sectors that are not covered by the program at issue, sometimes resulting in overall higher levels of carbon emissions. This unintended consequence of state-based or regional approaches can be effectively limited or eliminated when program requirements are dispersed over the broadest possible universe of program participants.

Participation by New York in national and regional programs can result in greater reductions at a lower marginal cost than programs implemented by a single state. New York should take advantage of the financial resources offered by the federal government to support clean energy deployment in New York, with its attendant economic benefits. New York should also seek to leverage federal research and development investments to develop the technologies needed to achieve the 80 by 50 goal. More detailed opportunities for such collaboration are described below.

New York should seek the implementation of national or regional market mechanisms to price carbon and reduce emissions.

Lack of specific action by the federal government has maintained the status of GHG emissions as an economic and environmental externality to the economy. Externalities arise when market actors who are responsible for a negative consequence, in this case the climate change resultant from GHG emissions, are not provided sufficient information, incentive, or economic signal to change behaviors to account for the externality. Thus, a fundamental goal of climate policy is to establish an economic price on carbon emissions from all sectors as a means to internalize the externality. Placing a price on carbon enables economic actors to assess market options based on the going-forward cost they will incur as a result of their GHG emissions, and determine the optimal activity to manage such costs. As a result, the environmental and climate damages associated with GHG emissions will be fully incorporated into economic decision making.

Federal inaction to date has created a large degree of uncertainty regarding future carbon pricing, resulting in a high-risk business environment and frustrating development of alternate technologies. For example, GE's CEO Jeffrey Immelt, long a proponent of national climate policy action, recently stated that, “the U.S. needs to establish a long-term price signal on carbon emissions in order for companies to provide appropriate funding for innovation regardless of fuel, as well as revive nuclear energy.”[1]

Carbon pricing can take a variety of forms, including regulatory mechanisms, such as a carbon tax, regulatory fees and permit requirements, or market-based mechanisms such as cap-and-trade or cap-and-invest programs. Although these mechanisms differ in policy design and program specifics, they all have the same effect of accounting for damages associated with GHG emissions. Given the relative large contribution of carbon emissions from energy-using activities, identifying and internalizing the cost of carbon in energy consumption should drive increased energy efficiency and investment in lower-carbon emitting energy sources. As a result, establishing a price on carbon will allow markets to contribute to solving the problem of GHG emissions.

Market-based solutions are often preferred to regulatory solutions because they can be economically efficient if properly designed. This efficiency maximizes net societal benefits by decreasing emissions in the least-cost way. Rather than forcing emission reduction through uniform technology mandates, market solutions allow market actors flexibility to select least-cost methods of emission reduction. Not only do market mechanisms increase efficiency but placing a price on emissions can also establish strong incentives for technological innovation. Market-based solutions have been successful in several environmental programs, albeit at a smaller scale than is needed to achieve climate mitigation goals, including chlorofluorocarbon trading for stratospheric ozone protection, sulfur dioxide trading under the U.S. Clean Air Act to combat acid rain, and nitrogen oxide trading to reduce smog in the eastern United States. Given the broad impact of these environmental needs and the comparative wide-scale impact of carbon emissions on climate change, use of market-based solutions has become a preferred option in the climate policy dialogue.

New York and its interested stakeholders should continue to advocate for federal legislation that helps to achieve climate goals, treats all states equitably, and establishes the strong federal-state partnership that is needed to fully address climate change, ensuring that State efforts continue to have value in the context of a national cap on emissions and that early adopter states/regions do not get penalized under a federal program. Also important is to develop a national policy that maintains the integrity of market signals by allocating allowances based on economic principles, not political reasons.

Until a comprehensive federal program is in place, statewide and regional policies seeking to develop price signals serve as important early steps in the process to establish national programs and can provide the building blocks for such national efforts. When EPA evaluates how best to use its authority under the Clean Air Act to regulate GHG emissions, it should seek to build on the success of RGGI and the other regional programs. Coordinated regional programs can serve as the foundation for a homogenous national carbon market that will create a more level playing field for businesses and industry across the country. Coordinated regional policies can also reduce the emission leakage that occurs if emission reductions in one area are offset by an

[1]Albany Times-Union, *U.S. energy policy is 'stupid,' Immelt says.* Kim Chipman and Rachel Layne. Bloomberg News. Sept. 24, 2010.

increase in emissions in another. In electricity and other markets, uneven application of carbon price signals could create competitive disadvantage, raise prices for some consumers over others and fail to fully achieve the desired GHG emissions reductions.

Ultimately, an international market-based approach to reducing GHG emissions will provide the most cost-effective means of reducing emissions in an equitable manner. New York should continue to work with other states, nations, and other sub-national entities to create the foundation for an international carbon market. New York's participation in ICAP is an effective way to develop that common approaches and metrics that will be essential to the functioning of an international carbon market.

Leveraging the opportunities available under federal programs can help create a robust market demand for clean energy.

Federal policy plays an essential role in the development of clean energy in the United States and in New York specifically. Federal programs can help create demand for clean energy and facilitate the development of the supplies to meet the demand. Ultimately, a vigorous national renewable electricity standard could be a strong driver of such development. In the nearer term, New York should seek to leverage the opportunities that are provided by existing federal programs such as the availability of investment tax credits and production tax credits.

National Renewable Electricity Standard

Like a national market-based GHG reduction program, a strong national renewable energy standard will create strong market incentives for the development of clean energy resources, leading to innovation and cost reduction. A national standard must build upon existing state measures and should not be designed in an inflexible manner that prejudices New York and other early movers. If structured appropriately, a national program for renewable energy purchase requirements will help to level the playing field among the states. It should not be structured in a way that creates economic disparities or favors the economic development needs of one state or region over another.

Any national renewable electricity program that is predicated on the long-range transmission of electricity must consider the technical feasibility of the transmission and distribution system to deliver such energy without eroding local reliability rules and standards. Unintended consequences that could frustrate climate initiatives should be avoided. For example, although transmission upgrades can help provide a larger market for clean energy technologies and services, they should not be allowed to interfere with expanded opportunity for renewable energy businesses located in New York.

Continued Production and Investment Tax Credits

The availability of production and investment tax credits for renewable energy projects has been a major stimulus for renewable energy development. At the same time, however, these programs often serve to complicate the financing of renewable energy development by businesses that may not have an existing tax liability to offset with the credits. Nevertheless, if an energy transaction is properly designed to take advantage of the credits, it can lead to the deployment of renewable energy in New York in support of the goals of this plan. New York agencies and authorities should be mindful of the opportunities and limitations and support New York businesses is their efforts to reap the benefits of these federal programs.

These credit programs are due to expire in 2011, absent an extension by Congress. Although New York should advocate for the extension of such programs and it should also consider accelerating the implementation of the current renewable portfolio standard to take advantage of the credits while they still exist.

Federal Support for State and Local Weatherization and Efficiency Programs

U.S. Department of Energy programs such as the State Energy Program and Weatherization Assistance Program provide states with annual funds to deploy commercially available technologies into the marketplace. These programs experienced a large increase under the American Recovery and Reinvestment Act (ARRA), and state programs were ramped- up accordingly. A new Energy Efficiency Conservation Block grant program was introduced under ARRA that provides states and local governments with funding for local projects. These types of programs, which can be tailored by each state to address its own needs, are an important source of ongoing base revenue. A mechanism to sustain federal funds for these critical programs at a robust level post-ARRA should be pursued. Falling back to the low historical appropriation levels does not allow New York and its local governments to take advantage of the infrastructure that has been built for delivery of these federal programs.

National electricity transmission policy should facilitate achievement of New York's climate goals.

Considerable debate has resulted from the development of national energy policies that seek to advance national program goals, for example national electric reliability standards or renewable energy programs, but do so in a manner that takes away from traditional state powers and authority. A more robust national transmission grid can help to achieve national climate goals in the long run but the development of a national grid must proceed in a manner that does not interfere with state climate goals and local renewable energy development.

One such controversy revolves around legislative proposals that would expand the authority of the Federal Energy Regulatory Commission (FERC) to override state authority to site transmission lines where such lines are proposed in areas of designated national interest. The Energy Policy Act of 2005 directed the Department of Energy to identify national interest electric transmission corridors (NIETCs), wherein FERC received new authority to approve transmission projects located within a designated NIETC that fail to receive state approval within a one-year time period. Such new backstop approvals could potentially override state-based decision-making, which is more accountable to local needs and concerns. While the NIETCs were identified in the context of augmenting system reliability, recent legislative proposals would expand this FERC backstop authority beyond the NIETC designation to include transmission projects to support national renewable electricity standard objectives.

In addition, FERC decision-making on cost allocation for multi-state projects has centered on what is known as the beneficiary pays principle. On a generalized basis, FERC will allocate the costs of a transmission project among the universe of designated beneficiaries in proportion to an administratively-determined benefit. In some cases, costs may be allocated among end-users, who may benefit from new energy supply sources, and generators, who may benefit from access to new markets. However, in many instances, FERC has designated the end-user as the sole beneficiary, making it fully liable for the total costs of transmission projects.

This combination of expanded FERC backstop authority and a beneficiary pays policy could have negative ramifications for New York and northeastern electric energy markets and potentially frustrate renewable energy and climate policy objectives. Predicating a national renewable energy policy on the long-range transmission of energy from certain qualifying renewable resources (e.g., wind resources located in midwestern states) to remote load that must meet the procurement requirements of the new program interferes with state sovereignty and can stifle the development of renewable energy in the consuming markets. Thus, expansion of regulatory decision-making at FERC to facilitate this outcome is likely to interfere with New York's own policy objectives to develop renewable energy resources and achieve in-state economic development. Further, long-range transmission of remote energy resources may not be delivered at an advantageous price and all potential costs of a renewable energy strategy should be considered prior to development of a program platform that creates inequities. Finally, if done too soon—before the renewable resources are developed in the midwestern states—the opening of new transmission capacity from the Midwest to the Northeast may also open new markets for highly carbon-intensive coal-based generation, thereby increasing emissions, frustrating northeastern climate policies, and interfering with the goal of reducing the leakage of emissions from RGGI and other climate programs in the northeast.

Federal agencies should cooperate to create and implement regulatory frameworks that foster energy efficiency and distributed renewable energy.

Federal policies fundamentally affect climate action activities at state and local levels. Such federal regulatory action must coordinate among the necessary federal agencies and entities to ensure success of new program structures and retain existing state-based policies and authorities as new national programs are created.

Property Assessed Clean Energy (PACE) financing seeks to address and overcome the most common obstacles inhibiting greater energy efficiency investment and retrofits. These include the sizable upfront costs, lack of appropriate financing and lengthy payback periods that may extend beyond the ownership of the home. Unlike a typical mortgage or loan, PACE loans are provided by local governments and municipalities rather than banks and are designed to be paid back to the local government through a property tax lien by a separate fee added to a home's property tax bill. As a result, the loan is tied to the property rather than the person who initially took out the loan. When the property is sold, the remaining energy efficiency and retrofit payments are then paid by the new owner. Furthermore, the payments are structured so that they are less than the savings associated with decreased utility bills, thus representing a net increase in disposable income.

PACE programs achieved considerable early success and adoption quickly spread across the country. The program originated in the city of Berkeley, California in 2008 and, as of June 2, 2010, there were 23 states with PACE legislation or pre-existing authority and 5 states with pending legislation. New York State has enacted a PACE financing program and several municipalities are in the process of designing and implementing local initiatives. The Obama administration supported the program as a key component of the American Recovery and Reinvestment Act of 2009 and the "Recovery through Retrofit" program that provides federal funding for PACE programs.

Despite this support, concerns with the interaction of PACE liens with more traditional home mortgages have affected the confidence of federal lenders Fannie Mae and Freddie Mac to advance this instrument. The mortgage companies' federal regulator, the Federal Housing Finance Agency (FHFA), has advised the mortgage lenders that they cannot lend to participants in PACE financing programs nor can an existing homeowner with a Fannie/Freddie mortgage join in a PACE program. With the two federally regulated companies owning about half of all U.S. mortgages, industry practices will likely follow suit and put an end to PACE financing.

This recent development regarding PACE programs highlights the contrary policies currently found at the federal level. Without a national energy policy applied across all sectors and branches of government, there will continue to be confusion and counteractive policies in place. Without an overarching federal policy in place, political and economic uncertainty will continue to restrain programs and investments that promise considerable economic, environmental, and social benefits. As New York has an interest in advancing the PACE program, the State should advocate for resolution of the FHFA concerns in a manner that preserves the value of the PACE program without negatively affecting the lending market.

New York should actively participate in national market transformation initiatives

To achieve the 80 by 50 goal, the most efficient products and supporting services must make their way into the market. This is best accomplished through joint action by states and the federal government to encourage the entire supply chain to produce, distribute, install, and service equipment to the highest efficiency and quality standards. Efforts should focus on a continuing process to assess the efficiency levels of products on the market and partnerships with industry to ratchet up efficiency and incorporate new technology solutions as rapidly as possible. Companies that sell and install such equipment must be trained and certified to ensure quality and certainty that measures are achieving their efficiency potential. Organizations such as the Consortium for Energy Efficiency, American Council for an Energy Efficient Economy, and Alliance to Save Energy and others work nationally to develop consensus around voluntary standards and market transformation strategies designed to accelerate efficiency. It is vital that New York continue to be a leader in this process and to push for introduction of advanced energy codes and product standards that raise the floor on efficiency, complemented by an evolving set of strategies that supports above-code actions. These types of market interventions must be sustained over the long term to avoid backsliding, and to be able to incorporate new technologies that will emerge in the future.

New York should take advantage of the federal government's advanced energy technology investment policy.

The significance of the 80 by 50 goal calls not only for accelerated deployment of the many existing low-carbon energy technologies and products that are currently available today, but also for the research and development of new energy technologies that can be deployed in the future to help meet the climate change challenge. Specific research and development needs to achieve a near-zero, low-carbon future are identified further in Chapter 10 of this Interim Report. The development of new clean energy technologies requires a substantial and sustained commitment from the federal government, similar to its level of research investment in other areas, such as health care and defense.

In testimony before the U.S. Senate Committee on Energy and Natural Resources in 2009, DOE Secretary Steven Chu remarked on the importance of federally supported energy research and development, saying "[w]e have many technologies in hand today to begin a transition to a low-carbon economy, and we are accelerating that work through the Recovery Act. But, over the long-term, we will need breakthroughs and better technologies to make the steep reductions in GHG emissions we need."[2] Secretary Chu went on to stress the importance of early stage technology investment, saying "It is imperative that government provide R&D funding, especially at the front end when private investments would not recoup the full value of the shared social good or when a new technology would displace an embedded way of doing business." Providing such support is especially critical given the current economic climate, where private companies are focusing their limited resources on shorter term, lower risk investments to advance their current technologies. New York supports the recent expansion of federal funding for energy technology research, development, demonstration and commercial deployment, and should advocate for sustained increased levels of federal support to accelerate the development of such technologies. New York should also seek to facilitate federal funding of research and development in New York, enabling New York to benefit from the associated economic opportunities for development of the clean energy economy.

Federal investment in, and support for, nuclear technology and carbon capture and sequestration will help New York achieve its climate protection goals.

In the short term, low-carbon renewable technologies will play a major role in transformation of New York's energy sector. In the longer run, advances in low-carbon baseload power technologies—such as carbon capture and sequestration (CCS) for fossil fuel-based technologies and new nuclear power technologies—will help to achieve a diverse energy portfolio that fosters carbon emission reductions in the long-term, while providing the needed levels of system reliability. The further development and deployment of these baseload technologies will assist in achieving the State's 80 by 50 goals while also preserving system reliability. Given the substantial financial commitment needed to advance the technology in these areas, the federal government is best positioned to make the necessary investments. However, New York should seek to take advantage of federal research dollars to fund research, development, and deployment of these technologies in New York.

Nuclear Energy

The federal government plays an essential role in the development of nuclear energy. The U.S. Nuclear Regulatory Commission (NRC) has exclusive jurisdiction over the siting of new nuclear plants. Moreover, the cost of new plants, the need for a permanent depository for radioactive used fuel, and the international implications of potential nuclear proliferation are all issues beyond the control of New York and other states. The strong federal role is also manifested by the Price-Anderson Act, which provides a federal backstop for nuclear liability, by the federal legislation that requires establishment of a permanent storage facility and by the substantial federal loan guaranties for new nuclear power.

The longstanding issues surrounding the reprocessing or disposal of used nuclear fuel and the decommissioning of nuclear units are particularly critical. New York awaits the results of the

[2] Statement of Steven Chu, Secretary of Energy, Before the Committee on Energy and Natural Resources, United States Senate. January 21, 2009. Hhttp://energy.senate.gov/public/_files/ChuTestimony.pdf

blue ribbon panel that is developing recommendations for dealing with high level radioactive waste now that Yucca Mountain is no longer a viable alternative. The issue of waste disposal must be addressed by the federal government before nuclear power is to play a role in a clean energy economy.

The recent applications to the NRC for new reactor development have all been for large scale units of several hundred megawatts. Many smaller scale reactors, however, are being developed and several are in service outside of the United States. Designs such as the Westinghouse IRIS unit feature enhanced safety, simplicity, and competitive economics and the GE-Hitachi PRISM unit is a below grade unit that uses recycled spent fuel from other plants and features passive cooling providing for greater safety and security. Commercial development of smaller units is desirable from several aspects including greater market penetration by many more developers, as the financial capital requirements are much lower and the ability to site units where most needed for load and voltage support. Small nuclear units may also be received more favorably by local communities because of the shorter construction time (less disruption), enhanced safety and security features, and potentially less burden on emergency preparedness organizations. The further development and deployment of this technology could be facilitated by federal economic incentives and loan guarantees and by the pre-approval of reactor designs, allowing for the expedited review of applications administered by the NRC.

Carbon Capture and Sequestration

The federal government supports the continued use of coal in the nation's fuel mix because it is a domestic fuel that limits reliance on foreign sources of energy. Coal mining is also a major economic driver in the Appalachian states and the northern Rockies. However, coal-fired power plants have carbon emissions that are more than double those of efficient natural gas-fired plants of a similar capacity. In an economy that is based on the 80 by 50 goal, coal can only be continued as a fuel if CCS is made commercially available. Therefore, the federal Department of Energy has devoted substantial sums to developing CCS technology.

New York's climate planning process recognizes that to continue generating electricity with fossil fuels means that CCS technology may play a critical role. Eventual coupling of efficient combined cycle natural gas technology with CCS will result in even lower emission rates than coal with CCS and will reduce the attendant environmental concerns associated with coal-fired generation, including emissions of mercury, sulfur dioxide, and other pollutants, and coal waste ponds. Therefore, New York could seek to take advantage of the federal research and development activities directed at CCS and will focus a portion of its own limited research and development funding on New York-specific development activities, including assessment of potential storage facilities and pilot projects involving gas-fired plants.

Regional and national transportation initiatives will be essential to achieving New York's climate goals.

The Transportation and Land Use (TLU) Technical Work Group has identified and discussed the inherent value of national and regional action on transportation policy needs, identifying critical work on several fronts. New York has already taken action on several of these initiatives, as permitted within its state authorities and powers. Specific recommendations for national action or expansion of regional activity are identified below.

More generally, New York should continue to engage federal agencies in developing national transportation strategies that facilitate the transformation of the transportation sector nationally. For example, New York has been and should continue to advocate for a change in existing federal funding formulas to increase the direction of federal investment to low-GHG transportation modes and raise the proportion of federal funds for transit, rail, and other modes that reduce GHG emissions.

Vehicle Standards

As mentioned above, the EPA has issued GHG emission standards for model years 2012-16 and has indicated an intention to strengthen these standards further in future years. Complementing EPA action, the U.S. Department of Transportation (DOT) has issued corporate average fuel economy standards (CAFE) that are commensurate with EPA's GHG emission standards. Taking into account the emissions inventory forecasts for activities covered by these regulations, ever-stronger GHG emissions and CAFE standards will be essential for New York to achieve its own statewide emission reductions. New York should actively participate in actions by these federal agencies to continuously advance standards that are consistent with the State's 80 by 50 emissions reduction needs from this sector over time.

Recognizing that national standards are a floor for performance, New York should continue to exercise its authority to work with California and other states to develop and adopt stricter California standards, as necessary to achieve climate goals. For example, Governor Paterson was recently joined by eight other governors (Maine, Massachusetts, Vermont, Pennsylvania, Maryland, Oregon, Washington, and New Mexico) in advocating for more aggressive vehicle standards starting in 2016, when the current standards are fully implemented, thus setting the stage for the next level of federal government action.

Low-Carbon Fuels

New York State is currently working with 10 other northeastern states to develop a regional framework for a low-carbon fuel standard, which would set standards for the carbon intensity of transportation fuels in the region and encourage the development and use of lower carbon fuels. As with the RGGI program and other activities in the TCI program, development of a region-wide low-carbon fuel standard (LCFS) can serve as an example of how regional market development can set the stage for national action. In addition to working on a regional platform, New York should seek to transfer program successes to shape a national program. Because transportation fuels markets are responsive to global market dynamics, a LCFS that is implemented on a broader scale will have more of an effect on the broader market for fuels. A national program would have to incorporate the concerns for sustainable biofuels that have been raised by New York in the regional LCFS process.

Regional Transportation Pricing Strategies

As described in the TLU chapter, a number of transportation and land use initiatives that can be adopted by New York would be more productive if implemented on a regional or national scale. For example, a multi-state transportation cap-and-trade program could develop a credit-based program wherein appropriate entities that provide transportation fuels to consumer markets would be permitted to hold and trade credits for the GHG emissions represented from the fuels they sell into the market. As with the RGGI program, such credits could be auctioned, with revenue contributing to public transportation and transportation system efficiency improvements.

Other identified policies worth pursing on a regional basis include collaboration on implementing pay-as-you-drive insurance or other pricing mechanisms that encourage reductions in vehicle miles traveled and that can be implemented in a manner to replace or supplement gasoline taxes. New York should continue to examine and develop appropriate policies with other regional partners.

Regional Rail Initiatives

By its nature, expansion of rail-based transportation options (both passenger and freight) should be pursued on a regional and/or national level. On a regional level, New York should engage neighboring states to plan and invest in infrastructure to support both high speed rail and freight initiatives, both of which should be designed to shift passengers and goods from air and roads to rail. New York should continue to work with its partners in the TCI to further develop a three-year work plan for freight initiatives, including the development of long-term approaches to move freight effectively and efficiently through the region while promoting economic growth, enhancing communities, and addressing GHG emissions. With respect to high speed rail, New York should continue to work with the Northeast Corridor Group to explore and develop options for implementation of high speed rail technologies and service among northeastern states, including intra-state New York services that link with regional services.

New York should advocate for strict national standards for new products and sources of greenhouse gas emissions.

In many areas—appliances, vehicles, and new sources of air pollution— the baseline efficiency or emission standards are set by the federal government. Recognizing that efficiency and emission reductions are achieved most effectively when incorporated into initial designs, these standards should be set at levels that will achieve the most substantial emission reductions from the outset. For example, the Department of Energy should be encouraged to set the most stringent efficiency standards for new appliances and electronic products and, as explained above, EPA and the U.S. Department of Transportation should set vehicle and emission standards respectively that support the national transition to a low-carbon transportation sector.

In many cases, more stringent state standards are preempted. Therefore, unless the federal government ensures that new products are highly efficient, it may be difficult for New York to meet its climate goals.

National education policy to foster innovation and technology is important to achieving New York's climate protection goals.

Integral to any economic policy that relies on innovation and technology advances in the energy and climate sciences area is an education policy that fosters interest in and provides sufficient opportunity and support for education programs in sciences, technology, engineering, and math (STEM) subjects.

Primary and secondary education opportunities have been given some modest support. The President's Council of Advisors on Science and Technology (PCAST) has advocated for an Educate to Innovate program, designed to provide support for these STEM education programs, to increase and expand the country's academic base, and to inspire young students to develop an interest in technical studies. New York should support the current PCAST recommendations as the baseline of support for primary and secondary education programs.

Support for primary and secondary education is only one piece of a long-term education policy that is needed to maintain the nation's competitive position among emerging economies throughout the world. Ensuring the strength of university programs and U.S. research institutions in the STEM subjects, especially with respect to advanced energy technologies, is equally fundamental to the development of a strategic American advantage in the clean energy and climate change arena. Strong national policies in this area are likely to benefit New York, given the concentration of existing academic and research institutions already thriving in the State. A high level of this academic and research activity is needed to attract the private technology development, and manufacturing opportunities that seek academic partnership to foster the innovation needed for technology, product, and services development. Continued federal support and focus on STEM research and advanced education will assist New York in maintaining this high level of activity.

The federal government should foster infrastructure investments that advance climate change program objectives.

A primary function of the federal government is to foster investment in essential infrastructure systems that permit individual citizens to live in a healthy and modern environment. At various times in the past, these massive investments have been focused on advancing technologies, transportation options and human services— such as roads, bridges, railroads, water systems, energy systems, housing, information, and telecommunications systems—to accommodate a growing population and an expanding economy. From these infrastructure investments, private industry was able to make investments for products and services, confident in the ability to move goods to all parts of the country and for export. This infrastructure also provided a level of economic efficiency that allowed the United States to gain economic advantage over most, if not all, other nations. Indeed, the 20th century American economic miracle would not have been possible without the developed infrastructure, in large part supported by the federal government.

While these 20th century investments have served their purpose, the nation is faced with new infrastructure needs that will be critical for the economy of the 21st century. The systems that are in place formed the foundation of an economy dependent upon carbon-based fuel resources. Going forward, investments should be directed to systems that require a lower-intensity fuel input or energy output. Major low-carbon infrastructure investments, such as high speed rail or electric vehicle charging systems, will require a strong commitment going forward. The federal government also has a significant role to play in the build-out of the nation's electricity infrastructure. Just as the government took the lead in investing in the interstate highway system, it should seek to develop a more intelligent electricity grid that is capable of better transmitting power from the source of generation to use, adapting to unexpected events, and incorporating large amounts of renewable energy resources.

Given the long life of infrastructure, the federal government should now begin to account for the carbon-reduction needs over the life of infrastructure investments. Continued commitments and assistance from the federal government should be assessed through a lens that accounts for the 40-year need to de-carbonize the economy, and seeks out strategic opportunities. Such assessments should develop a shadow price for carbon—in the absence of market or other price signals—that would be used in analyzing costs and benefits of alternative policy and investment options. In addition to changes in the decision making required for federal infrastructure investment, the federal government should also initiate a process to reprioritize near-term project and program activity throughout all administrative agencies of the government.

Federal and state policy should engage localities and communities as active participants in achieving climate goals.

Many of the policies recommended for further consideration require the active participation of local communities. Engagement of municipalities will be particularly critical given the local government roles in transportation planning and land use decisions. In a home rule state such as New York, with land use planning and control powers disbursed among more than 1600 municipalities, it can be difficult to develop regional solutions to sprawl and other smart growth issues without community participation.

However, many local governments lack the financial means, mechanisms, personnel, or expertise to undertake many climate actions. Federal and state programs, such as New York State's Climate Smart Communities program, can encourage and facilitate local action by providing funding, technical resources, practical assistance, and consistent tracking and reporting of successes and barriers.

Local governments also serve critical liaison roles with community organization and action, thus helping to expand citizen participation in the realization of climate strategies and goals. Local government actions are amplified as they are often adopted by residents, businesses and other organizations within a community, and local governments can be effective in actively encouraging behavioral change in residents.

New York should support efforts to achieve an international solution to climate change. Ultimately, a solution for climate change will require the participation of all of the world's community of nations. New York recognizes this truth and is committed to act. But climate change will not be solved by the actions of New York and other nations acting alone. Therefore, New York can play a critical role in providing an example of the policies that can be implemented worldwide to mitigate climate change.

Although the development of an international solution can be a painstaking process that takes decades of effort, New York should engage in efforts to achieve that goal. In addition to supporting the federal government's efforts to negotiate an international solution, New York can advocate more directly by engaging other nations and international actors and educating them about New York's own experiences in mitigating climate change while building economic opportunities.

New York and other states have already played an active role in supporting the federal government's efforts to obtain an international solution to climate change. State-level action is even more critical now that Congress has abandoned any efforts to pass climate legislation.

Conclusion

Achieving a comprehensive solution to global climate change requires New York to collaborate with regional partners and the federal government on emission reduction strategies, and to seek action across the community of nations. Although comprehensive federal legislation is preferable, until such legislation is in place, the federal government should seek to target its broad suite of policies and programs towards the goal of reducing carbon emissions. Towards that end, federal policies should promote low-carbon behavior, not the continued exploitation of, and reliance upon, fossil fuels.

Chapter 15
Acronyms and Abbreviations

$/t$CO_2$e	dollars per metric ton of carbon dioxide equivalent
15 by 15	NYS energy agencies' goal to implement energy efficiency programs reducing electricity demand by 15% by the 2015.
30 by 15	NYS goal to increase the NYS market share of renewable energy to 30% by the 2015.
40 by 30	NYS benchmark to reduce GHG emissions by 40% below 1990 levels by 2030
45 by 15	NYS energy policy to meet 45 percent of New York's electric energy needs from energy efficiency and renewable energy by the year 2015
80 by 50	NYS goal to reduce GHG emissions by 80% of 1990 levels by 2050
AARA	American Recover and Reinvestment Act
ACE NY	Alliance for Clean Energy New York
ADP	Adaptation
AEO	*Annual Energy Outlook* (U.S. DOE-EIA)
AFW	Agriculture, Forestry, and Waste Management
ARPA-E	Advanced Research Projects Administration—Energy
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
B100	fuel blend of 100% biodiesel
B20	fuel blend of 20% biodiesel and 80% gasoline
BAU	business as usual
BBtu	billion British thermal units
BCF	billion cubic feet
BLS	US Dept. of Labor Bureau of Labor Statistics
BMP	Best management practice
Btu	British thermal unit
CAES	Compressed-air energy storage
CAFE	corporate average fuel economy standards
CAP	Climate Action Plan
CARB	California Air Resources Board
CARB	California Air Resources Board
CCS	carbon capture and storage
CEEBS	Center for Energy Efficiency and Building Science (CEEBS)
CFL	compact fluorescent light
CH_4	methane
CHP	combined heat and power

ClimAID	Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CRP	Conservation Reserve Program (USDA)
DEC	(New York State) Department of Environmental Conservation
DOE	[United States] Department of Energy
DOT	[U.S.] Department of Transportation
E10	fuel blend of 10% ethanol and 90% gasoline
E85	fuel blend of 85% ethanol and 15% gasoline
EBM	Ecosystem-based Management
EC	Elemental Carbon
EEPS	Energy Efficiency Portfolio Standard
EFC	[New York State] Environmental Facilities Corporation
EFRCs	Energy Frontier Research Centers
EIA	Energy Information Administration (US DOE)
EISA	Energy Independence and Security Act of 2007
EJ	environmental justice
EMB	ecosystem-based management
EMEP	[New York] Environmental Monitoring, Evaluation, and Protection Program
EO	Executive Order
EPA	[US] Environmental Protection Agency
EPRI	Electric Power Research Institute
EV	electric vehicle
FCV	fuel cell vehicle
FEMA	Federal Emergency Management Authority
FERC	Federal Energy Regulatory Commission
g	Gram
GCM	global climate model
GDP	gross domestic product
GGE	gallons of gasoline equivalent
GHG	greenhouse gas
GREET	Greenhouse [gases] Regulated Emissions and Energy [use in]Transportation [model]
GSP	gross state product
GWh	gigawatt-hour (one million kilowatt-hours)
GWP	Global Warming Potential
GWP	global warming potential

HadCM3	(UK Met Office) Hadley Centre Climate Model Version 3
HDPE	high-density polyethylene
HDV	heavy-duty vehicle
HERS	Home Energy Rating System
HFC	Hydrofluorocarbon
HVAC	heating, ventilating and air conditioning
I&F	inventory and forecast
IC	Internal Combustion
ICAP	International Carbon Action Partnership
ICC	International Code Council
IECC	International Energy Conservation Code
IGCC	integrated gasification combined cycle
IHETF	Industry-Higher Education Partnerships
iLUC	Indirect land use change
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPM	Integrated Planning Model®
ISC	Invasive Species Council
ISO	Independent System Operators
ISTF	Invasive Species Task Force
kg	kilogram
kgN	kilogram Nitrogen
kV	Kilovolt
kW	Kilowatt
kWh	kilowatt-hour
LandGEM	Landfill Gas Emissions Model
lb	pound
lb	Pound
LCFS	low-carbon fuel standard
LCPS	low-carbon portfolio standard
LDPE	low-density polyethylene
LDV	light-duty vehicle
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design (Green Building Rating System™)
LF	landfill
LFG	landfill gas
LFGcost	landfill gas cost model

LiDAR	light detection and ranging technology
LIPA	Long Island Power Authority
LSE	load-serving entities
metric ton	1,000 kilograms or 22,051 pounds
mi	mile
MM	million
MMBtu	million British thermal units
MMt	million metric tons
MMtC	million metric tons of Carbon
$MMtCO_2$	million metric tons of carbon dioxide
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MSW	municipal solid waste
MTA	Metropolitan Transportation Authority
MW	megawatt (one thousand kilowatts)
MWh	megawatt-hour (one thousand kilowatt-hours)
N	nitrogen
N/A	not applicable
N_2O	nitrous oxide
NAS	National Academy of Sciences
NASA	U.S. National Aeronautics and Space Administration
NGCC	natural gas combined cycle
NGCT	natural gas combustion turbine
NIETCs	national interest electric transmission corridors
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPCC	New York City Panel on Climate Change
NPV	net present value
NRC	[US] Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory (US DOE)
NY-BEST	New York Battery and Energy Storage Technology Consortium
NYC	New York City
NYCDOT	New York City Department of Transportation
NYISO	New York Independent [Transmission] System Operator
NYOGLECC	New York Oceans and Great Lakes Ecosystem Conservation Council
NYPA	New York Power Authority
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation

NYSDPS	New York State Department of Public Service
NYSERDA	New York State Energy Research and Development Authority
NYSTAR	New York State Foundation for Science, Technology and Innovation
NYTO	New York Transmission Owners
O&M	operation and maintenance
OC	Organic Carbon
ODS	ozone-depleting substance
PACE	Property Assessed Clean Energy
PANYNJ	Port Authority of New York and New Jersey
PAYD	Pay-As-You-Drive
PCAST	President's Council of Advisors on Science and Technology
PET	polyethylene terephthalate
PFC	perfluorocarbon
PHEV	plug-in hybrid electric vehicle
PMEFC	proton-membrane exchange fuel cell
PRISM	Partnerships for Regional Invasive Species Management
PSC	[New York] Public Service Commission
PSD	Power Supply and Delivery
PV	photovoltaic
R&D	research and development
RCI	Residential, Commercial/Institutional, and Industrial
RD&D	research, development, and demonstration
RDD&D	research, development, demonstration, and deployment
RGGI	Northeast Regional Greenhouse Gas Initiative
RIT	Rochester Institute of Technology
RPS	Renewable Portfolio Standard
RTO	regional transmission organization
RTO	regional transmission organization
SBC	System Benefit Charge
SECCC	State Energy Conservation Construction Code
SEQRA	State Environmental Quality Review Act
SF_6	sulfur hexafluoride
SLRTF	Sea Level Rise Task Force
SMES	superconducting magnetic energy storage
SMIA	Significant Maritime and Industrial Areas
SO_2	sulfur dioxide
SO_4	sulfate

STEM	science, technology, engineering and math
SUNY	State University of New York
SWAP	State Wildlife Action Plan
t	Metric ton
T&D	Transmission and Distribution
tC	metric tons of carbon
TCI	Transportation and Climate Initiative
tCO_2e	metric tons of carbon dioxide equivalent
tCO_2e/MWh	metric tons of carbon dioxide equivalent per megawatt-hour
TDM	Travel Demand Management
TLU	Transportation and Land Use
TOD	Transit-Oriented Development
TRB	Transportation Research Board
TSD	transit-supportive development
TSM	transportation system management
TWG	Technical Work Group
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USFS	United States Forest Service (USDA)
USGCRP	US Global Change Research Program
V2G	vehicle-to-grid
VMT	vehicle miles traveled
WRP	Waterfront Revitalization Programs
WW	wastewater
yr	year
ZNE	zero-net energy

Appendix A
Executive Order Establishing the New York Climate Action Council

In August of 2009 Governor David A. Paterson signed Executive Order No. 24 setting a goal to reduce greenhouse gas emissions in New York State by 80 percent below the levels emitted in 1990 by the year 2050. The Executive Order also created the New York Climate Action Council with a directive to prepare a draft Climate Action Plan by September 30, 2010. Executive Order No. 24 is copied below.

Executive Order No. 24: ESTABLISHING A GOAL TO REDUCE GREENHOUSE GAS EMISSIONS EIGHTY PERCENT BY THE YEAR 2050 AND PREPARING A CLIMATE ACTION PLAN

WHEREAS, an emerging scientific consensus recognizes that the increased concentration of carbon dioxide in the atmosphere, along with other heat-trapping greenhouse gasses, resulting from the combustion of fossil fuels and other human sources, warms the planet and changes its climate; and

WHEREAS, many scientists warn that unmitigated climate change is expected to result in significant adverse impacts to our communities, economy and environment; and

WHEREAS, according to the scientific assessments of the United Nations Intergovernmental Panel on Climate Change, and other work, substantial reductions in greenhouse gas emissions by mid-century have the potential to minimize the most severe climate change impacts currently predicted; and

WHEREAS, the reduction of global warming and limitation of climate change effects requires a collaborative, international effort to reduce the emission of greenhouses gases around the globe; and

WHEREAS, New York and other states should work collaboratively with the federal government to develop and implement plans and policies that will achieve reductions in greenhouse gas emissions in the United States; and

WHEREAS, expanding and advancing energy efficiency and renewable energy projects will reduce greenhouse gas emissions and create new jobs; and

WHEREAS, New York State has demonstrated leadership in this effort by undertaking actions such as:

- Executive Order No. 2 (2008): Establishing a State Energy Planning Board and Authorizing the Creation and Implementation of a State Energy Plan;

- Executive Order No. 4 (2008): Establishing a State Green Procurement and Agency Sustainability Program;
- Creation of the Governor's Smart Growth Cabinet;
- Adoption of goals and practices for energy efficiency and green building technology in State buildings, and for the use of biofuels in State vehicles and buildings;
- Creation of the New York State Office of Climate Change in the New York State Department of Environmental Conservation;
- Participation in the Regional Greenhouse Gas Initiative, a ten-state cooperative effort to reduce greenhouse gas emissions from electric power plants by means of a cap and trade system;
- Creation of an Energy Efficiency Portfolio Standard, which is intended to reduce the State's electricity consumption by 15 percent below projected levels by 2015, complementing the State's System Benefit Charge and Renewable Portfolio Standard;
- The formation of a Renewable Energy Task Force and a Sea Level Rise Task Force;
- Collaboration with other northeastern and mid-Atlantic states on the development of a regional low carbon fuel standard;
- Establishment of a " 45 x 15" Initiative, which set a goal to meet 45% of New York's electricity needs through improved energy efficiency and clean renewable energy by 2015;
- Adoption of regulations establishing greenhouse gas exhaust emission standards for motor vehicles;
- Enactment of legislation requiring new motor vehicles to bear labels disclosing information to consumers about vehicle greenhouse gas emissions;
- Enactment of legislation establishing "green" residential and State building programs;
- Enactment of legislation expanding the State's "net metering" laws, allowing increased development of renewable energy by electricity customers;
- Enactment of Legislation expanding energy efficiency and clean energy initiatives of the New York Power Authority to public entities; and
- Investment of billions of dollars by the New York State Energy Research and Development Authority, the New York Power Authority and the Long Island Power Authority in existing, expanded and new energy efficiency and renewable energy programs; and

WHEREAS, it is appropriate to build upon the important environmental benefits obtained through these actions and to establish a State-wide goal for the reduction of greenhouse gasses, and to develop a plan that enables New York to participate fully in the national and international efforts to combat climate change.

NOW, THEREFORE, I, David A. Paterson, Governor of the State of New York, by virtue of the authority vested in me by the Constitution and laws of the State of New York, do hereby order as follows:

1. It shall be a goal of the State of New York to reduce current greenhouse gas emissions from all sources within the State eighty percent (80%) below levels emitted in the year nineteen hundred ninety (1990) by the year two-thousand fifty (2050).
2. There is hereby created a Climate Action Council ("Council") consisting of the Commissioners of Agriculture and Markets, Economic Development, Environmental Conservation, Housing and Community Renewal, and Transportation; the Chairs of the Public Service Commission, and Metropolitan Transportation Authority; the Presidents of the New York State Energy Research and Development Authority, Long Island Power Authority, New York Power Authority and Dormitory Authority of the State of New York; the Secretary of State; the Director of the Budget; the Director of State Operations; and the Counsel to the Governor. The Director of State Operations shall serve as the Chair of the Council.
3. The Council shall prepare a draft Climate Action Plan on or before September 30, 2010. The Council shall hold regional public comment hearings on the draft Plan, and shall allow at least 60 days for the submission of public comment. Thereafter, the Council shall prepare a final Climate Action Plan which shall be reviewed and, if warranted, adjusted annually by the Council.
4. In aspiring to meet the greenhouse gas emission reduction goal, the Council, in preparing the Climate Action Plan, shall:

    a. inventory greenhouse gas emissions within the State, including the relative contribution of each type of emission source;
    b. identify and assess short-term and long-term actions to reduce greenhouse gas emissions and adapt to climate change across all economic sectors, including industry, transportation, agriculture, building construction and energy production;
    c. identify and analyze the anticipated reductions, and the economic implications thereof, as a result of each action;
    d. identify the anticipated life-cycle implications, consequences, benefits and costs of implementing each action, including implications, consequences, benefits and costs to the State, local governments, business and residents from implementation of each option and action;
    e. identify whether such actions support New York's goals for clean energy in the new economy, including specific short-term and long-term economic development opportunities and disadvantages related to greenhouse gas emission reductions and the development and deployment of new and emerging technologies and energy sources;
    f. coordinate its activities with the State energy planning process of the State Energy Planning Board;

g. identify existing legal, regulatory and policy constraints to reducing greenhouse gas emissions, assessing the impacts of climate change, and adapting to climate change, and recommend ways to address any such constraints;
h. establish estimated timelines for considering and implementing actions; and
i. undertake such actions, and compile such additional material, as deemed appropriate by the Council in carrying out its responsibilities under this Order.

5. Members of the Council may designate an executive staff member to represent them and participate on the Council on their behalf, subject to the approval of the Chair. A majority of the members of the Council shall constitute a quorum, and all actions and recommendations of the Council shall require approval of a majority of the total members or their representatives.
6. The entities represented on the Council are authorized to provide the primary staff and other resources that are necessary for the Council to comply with this Order. In addition, every other agency, department, office, division and public authority of this State shall cooperate with the Council and furnish such information and assistance as the Council determines is reasonably necessary for it to comply with this Order.
7. The Council may convene advisory panels to assist or advise it in areas requiring special expertise or knowledge.
8. The Climate Action Plan is not intended to be static, but rather a dynamic and continually evolving strategy to assess and achieve the goal of sustained reductions of greenhouse gas emissions.

G I V E N under my hand and the Privy Seal of the State in the City of Albany this sixth day of August in the year two thousand nine.

David A. Paterson
Governor

Lawrence Schwartz
Secretary to the Governor

Appendix B
Description of New York State Climate Action Council Process

Creation of the New York State Climate Action Council

In August 2009, Governor David A. Paterson signed Executive Order 24 establishing the goal of reducing greenhouse gas (GHG) emissions from all New York sources to 80 percent below 1990 levels by 2050 and creating the New York State Climate Action Council (Council). The purpose of the Council is to assist New York in identifying the best opportunities to mitigate and adapt to climate change, reduce costs associated with climate change activities, and foster economic growth in New York.

The Council's Response to Date: In fulfillment of the requirements of the Executive Order, the Council has held six meetings between November 2009 and December 2010, and formed three external panels to assist and advise in areas requiring special expertise or knowledge: Technical Analysis, which consists of five Technical Working Groups; Multi-Sector Integration; and 2050 Visioning.

For planning and progress benchmarking purposes, the Council adopted an interim GHG reduction goal of 40 percent below 1990 levels by 2030, or one-half of the 80 by 50 goal at the mid-point between 2010 and 2050.

The Council and supporting panels crafted sector-specific vision statements that describe the major characteristics of each mitigation and adaptation sector in 2050 as necessary or desirable to achieve the 80 by 50 goal.

The Council and supporting panels reviewed over 300 multi-sector GHG mitigation policy options and approved for inclusion in this Report a package of draft mitigation policy options to reduce GHG emissions and address related energy and economic issues in New York State. Many of these draft recommendations have been individually analyzed for their likely GHG reduction potential and net direct cost or savings to the New York economy.[1]

The Council and supporting panels performed a systematic review of vulnerabilities to the effects of climate change and approved draft adaptation policy recommendations across eight sectors for inclusion in this Report.

The Climate Action Plan Process

The Council began the formal deliberative process at the first meeting of the Integration Advisory Panel and Technical Working Groups on January 14, 2010. The Integration Advisory Panel has met in person five times, and the five Technical Work Groups have met in person and

[1] Integrated analysis of the policies which takes into consideration policy interactions and overlaps, as well as macroeconomic, or indirect economic impacts on income, GSP, employment and prices, will be completed in the next phase of the Plan process.

by teleconference bi-weekly since January 2010. The five Technical Work Groups considered potential policy options in the following sectors:

- Power Supply and Delivery (PSD)
- Residential, Commercial/Institutional, and Industrial (RCI)
- Transportation and Land Use (TLU)
- Agriculture, Forestry, and Waste Management (AFW)
- Adaptation (ADP)

The four Mitigation Technical Work Groups (PSD, RCI, TLU, and AFW) focused on opportunities to mitigate GHG emissions or enhance the sequestration of atmospheric carbon dioxide within their respective sectors. The fifth, the Adaptation Technical Work Group, focused on policies that anticipated highly likely climate impacts over the next 100 years in eight economic and natural resource sectors, seeking to enhance potential benefits and reduce the cost and security risks associated with unavoidable climate impacts.

New York State agency participation has been extensive throughout the process, with project leadership and coordination provided by the New York Energy Research and Development Authority (NYSERDA) and the Department of Environmental Conservation (DEC). The Center for Climate Strategies provided facilitation and technical assistance to the process, including facilitation and technical support for each of the Technical Work Groups, based on a detailed proposal approved by NYSERDA.

The Technical Work Groups served as advisors to the Council and consisted of Council member agency staff and additional public, private and non-profit sector stakeholders with specific interest and expertise. Members of the public were invited to observe and provide input at all meetings of the Integration Advisory Panel and Technical Work Groups. A series of four public informational meetings were held around the State during the process. Planning process documents and deliberative and analytical products were posted to the Plan's public web site, which also provided an additional venue for public input.

Prior to a joint organizational meeting of the Integration Advisory Panel and Technical Work Groups the appointed participants attended a "2050 Visioning Conference" hosted by the New York Academy of Sciences and organized by Brookhaven National Laboratory. The focus of the conference was to place the challenge of the 80 by 50 goal into real-world context, and by example illustrate the kinds of transformational change needed to achieve the goal.

After getting organized and reviewing the preliminary inventory and forecast the Technical Work Groups crafted sector-specific vision statements with supplemental text providing detail about the sector's demand for and use of energy, as well as advisory comments on related matters.

Mitigation Policy Process: Following the development of the vision statements, the four Mitigation Technical Work Groups then generated an additional set of New York State-specific policy options to be added to the catalog of existing states actions. Catalog policies were reviewed by representatives of the environmental justice community and participants in

NYSERDA's ClimAID project with written comments added to each policy in the catalog reflecting their concerns for whether and how the policy might affect disadvantaged communities, or be affected by anticipated near-term climate effects.

Where available, an estimate of the general potential for each cataloged mitigation policy to reduce GHG emissions in New York and a rough estimate of the direct cost or savings per ton of emissions reduced were provided to Technical Work Group members. Most of these estimates were derived from research sponsored by NYSERDA and conducted by the Center for Climate Strategies, titled *Development of New York State Greenhouse Gas Abatement Cost Curves*.

Technical Work Group members also scrutinized and recommended enhancements to the New York State inventory and forecast of GHG emissions developed by NYSERDA with assistance from the Center for Climate Strategies (contained in the *New York Greenhouse Gas Emissions Inventory and Forecast* report and summarized in Chapter 3). The inventory, which begins in 1990, serves as the benchmark against which progress toward the 80 percent below 1990 emissions levels goal is measured. The forecast serves as the baseline or 'business-as-usual' projection of future emissions assuming no measures to reduce them are enacted beyond those already in place or approved.

The inventory and forecast and the analysis of most mitigation policies cover the six types of gases included in the United States (U.S.) Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The inventory and reference case projections include detailed coverage of all economic sectors and GHGs in New York State, including future emission trends related to energy, the economy, and population growth.

Once the Technical Work Groups had settled upon their broad sector visions for 2050, commented on the draft inventory and forecast, and reviewed the technical potentials and anticipated environmental justice and climate impact implications of the catalog policies, members engaged in a process of selecting priority policies for development and analysis. This process allowed the Technical Work Groups to regroup the catalog policies into logical policy bundles organized around sets of technologies, e.g., renewable electricity generation, or policy instruments, e.g., a renewable portfolio standard.

Technical Work Group-proposed priorities were reviewed by the Integration Advisory Panel and Council, ultimately yielding 39 priority policy bundles across the four mitigation sectors. The Technical Work Groups then set about the task of defining each policy as it could be implemented in New York State and specifying GHG reduction goals and timing. Each policy was developed using a template calling for:

- Policy Description
- Policy Design
- Implementation Mechanisms
- Related Policies and Programs in Place
- Estimated GHG Reductions and Costs or Cost Savings

- Key Uncertainties
- Additional Benefits and Costs
- Adaptation to Climate Change Considerations (if any)
- Environmental Justice Considerations (if any)
- Feasibility Issues

Once the policy design, goals and timing were settled, the Center for Climate Strategies analysts began to analyze the priority policy bundles designated for quantification. The analytical assumptions, data sources and methods were carefully reviewed and revised as needed by NYSERDA, DEC, other participating State agencies and Technical Work Group members. In some cases, multiple scenarios or sensitivity analyses were produced for policies or sub policies, and, depending on the results, policy designs were sometimes adjusted by the Technical Work Groups in response to the first analysis.

The four Mitigation Technical Work Groups have met in person or by teleconference bi-weekly through October 2010, not including small group meetings. Chapters 6 through 9 contain summaries of these mitigation policies including their analytical results. The analytical results presented here describe the potential effectiveness of the mitigation policies on a stand-alone basis; that is, it is assumed each policy is being implemented in isolation, and that none of the other recommended policies are implemented as well. This analysis generally does not consider interactions among policies or overlapping emissions reductions. It is therefore not appropriate to sum up the reductions or costs associated with individual policies in this Report to estimate a cumulative result.

Adaptation Policy Process: Unlike mitigation climate action planning, which has been undertaken in over 20 states and for which generally accepted methods have been developed, adaptation policy development is relatively new. A few other states have examined the adaptation challenge, but prior to the New York Climate Action Plan no state had attempted the comprehensive effort to investigate likely unavoidable climate impacts across eight sectors, assess their social, environmental, public health and economic risks, and propose dozens of measures to address them.

While there are many similarities, the Adaptation Technical Work Group followed a different process than that described above for the Mitigation Technical Work Groups. The Adaptation Technical Work Group was divided into eight sector subgroups as follows:

- Agriculture
- Ocean Coastal Zones
- Ecosystems
- Water Resources
- Public Health
- Transportation

- Energy
- Communications

Like the Mitigation Technical Work Groups, each Adaptation Technical Work Group subgroup crafted their own 2050 vision statement and then followed a formal process to guide the formation of recommendations. Informing this process were the draft results of the ClimAID research funded by NYSERDA and conducted by teams from Columbia and Cornell Universities, and the City University of New York, as well as the State Sea Level Rise Task Force and elements of New York City's PlaNYC.

The goals of the adaptation policies are somewhat different from the mitigation goals. Recommended adaptation polices seek to address one or more of the following:

- Prepare, protect, or improve climate resiliency
- Improve climate monitoring, surveillance and data collection
- Improve decision-making tools to enhance incorporation of climate projections in decision-making, permit and design criteria
- Evaluate and enhance New York's capacity to respond, e.g., through climate-informed emergency response plans and protocols
- Develop new strategies and promote advances in related technology through research and development
- Promote the inclusion of climate science in education curricula and other forms of educational outreach
- Improve coordination among federal, regional, state and local governments
- Identify and address equity issues

The Adaptation Technical Work Group created its own policy description template to fully describe their policy proposals and evaluate them according to criteria developed by the group. The adaptation policy template included the following:

- Climate Variables and Probabilities
- Impacts on Resources (Likelihood, Consequence, Magnitude)
- Timing of Risk and Overall Risk
- Adaptation Strategy
- Policy/Mechanism (Who, What, Where, How)
- Potential Cost
- Feasibility
- Timing of Implementation
- Efficiency

- Resiliency
- Environmental Justice Considerations (Distribution, Degree)
- Co-benefits and Costs
- Research/Information Needs

The Adaptation Technical Work Group has developed policy recommendations across the eight sectors, which are summarized in Chapter 11. The full Adaptation Technical Work Group met by teleconference 12 times since January 2010, with one in-person meeting, and the eight subgroups met dozens of times separately to develop their recommendations. As with the mitigation policies, the Integration Advisory Panel and the Council reviewed and commented on the adaptation policy sets as they were being developed.

Public Engagement: Key to the Climate Action Plan process design is the active engagement of the public. As shown in Appendix C, the Technical Work Groups and Integration Advisory Panel count among their members many representatives of environmental justice communities, business and industry, academia, non-government organizations, trade associations, regional and local governments, and state agencies. In addition to appointed membership on process committees, four public informational meetings were held including two with special focus on environmental justice concerns. An informational webinar will be provided, and three public hearings will be held to solicit comment on this Interim Report.

To facilitate ongoing public involvement, all Technical Work Group and Integration Advisory Panel meeting summaries, documents, drafts and work products were posted to the public web site www.nyclimatechange.us, which provided an opportunity to submit electronic comments or questions. In addition, every Technical Work Group and Integration Advisory Panel meeting or teleconference was open to the public, and each meeting agenda provided an opportunity for public comment or question.

In addition to the multiple public engagement opportunities described above, those living in economically disadvantaged communities have been represented and their concerns voiced through formal integration of environmental justice concerns throughout the process. Through representation on the Integration Advisory Panel and Technical Work Groups, and by incorporation of written comments and guidance at key junctures in the deliberations, the authors of these recommendations have heard and sought to incorporate these concerns into the policy designs.

In all, dozens of comments were received during Technical Work Group conference calls, about 25 comments and other inquiries were received through the web site portal, and approximately 125 people attended the first four informational meetings.

Next Steps

While the identification of mitigation and adaptation policies for New York and the quantification of a subset of these for their GHG reduction potential and cost is a major achievement, to fully satisfy Executive Order 24 more must be done. Public comment on this Interim Report will be taken for a 90-day period, during which three public hearings will be held.

Comments received will be reviewed by the Council and addressed in the draft Climate Action Plan as appropriate.

This Report identifies cross-sector policies and issues (Chapter 12), but the analysis contained here assumes each policy is implemented in isolation. The next phase of the planning process will consider all policy interactions and produce a methodologically correct 'sum of the parts' projection for Action Plan emission reduction potentials and costs.

Also to be included in the next phase is a macroeconomic analysis of the impact of the recommended policies on the broader New York economy. Costs and savings associated with policies in this Report consider only the direct costs and savings to society, defined as within the geographic boundaries of New York State. Secondary, indirect, or macroeconomic impacts such as statewide employment, income, energy price and Gross State Product impacts will be examined next with the results presented in the Final Climate Action Plan Report.

Many climate-sensitive policies are not new. Indeed, much progress has already been achieved through enactment of measures unrelated to climate concerns. Energy efficiency has long been both an economic and national security priority; the GHG benefits are considered 'co-benefits' of these policy goals. Likewise, many of the policies recommended here offer co-benefits of their own. In particular, efforts that result in reduced burning of fossil fuels often result in lowered emissions of pollutants other than CO_2. Criteria pollutants, such as particulates, sulfur dioxide, nitrogen oxides and air toxics emissions, may also be mitigated by climate-driven actions. Some of these pollutants adversely affect human health and, therefore, impose economic and societal costs. To more completely assess the value of these policies, the next phase of this planning process will include a co-benefits analysis to project the level of non-CO_2 pollutant reductions and estimate the related benefits in improved human health and reduced cost associated with treating resulting illnesses.

As discussed in Chapter 14, some of the most effective actions New York State could pursue would either require or greatly benefit from the participation of our regional neighbors or the federal government. Following the issuance of the Final Climate Action Plan Report in 2011, the State will move toward implementation of the Plan, which will require engagement with regional neighbors and the federal government on a variety of policy recommendations.

Critical to the charge of Executive Order 24 is demonstrating that the policies proposed here, after enhanced analysis and refinement, can achieve the goal of total statewide emissions 80 percent below New York State emissions in 1990. The analysis contained here covers the period from 2010 through 2030. Some key policies have also had GHG reductions estimated between 2030 and 2050, but cost estimates are limited to the next twenty years due to the increasing uncertainty associated with longer-range projections. The Final Climate Action Plan Report will therefore contain an additional analysis showing whether the 2050 goal will be achieved by the implementation of the Plan's recommendations.

Appendix C
Members of the Integration Advisory Panel and Technical Work Groups

New York Climate Action Plan Process
Integration Advisory Panel

Timothy Banach
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NYC Environmental Justice Alliance

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Gerry Gallagher
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Ashok Gupta
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Peter Iwanowicz
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Empire State Development Corporation

***Steve Corneli**
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Jim Gallagher
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***Ashok Gupta**
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***Mike Richter**
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Robert Teetz
National Grid

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Steve Hammond NYS Dept. of Env. Conservation
Karl Michael NYS Energy Research & Development Authority

New York Climate Action Plan Process
Residential, Commercial/Institutional and Industrial (RCI) Technical Work Group Members

*indicate IAP Member

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Appendix D
Overview of Current New York State Climate and Energy Policies

New York State has initiated or participates in programs on regional, state, and local levels that reduce greenhouse gas emissions and encourage energy independence, energy efficiency and renewable energy.

Greenhouse Gas Inventory and Reduction

The Regional Greenhouse Gas Initiative (RGGI)

New York is one of ten Northeastern and Mid-Atlantic states participating in the RGGI cap and invest program. The New York CO_2 Budget Trading Program (6NYCRR Part 242) and the CO_2 Allowance Auction Program (21NYCRR Part 507) took effect January 1, 2009. Emissions of carbon dioxide from electric power generating facilities will be reduced ten percent by 2018. Auction proceeds support statewide investments in energy efficiency, renewable and clean energy, and innovative carbon abatement technologies, as guided by the RGGI Operating Plan.

The Climate Registry

The Climate Registry is a partnership of businesses, environmental organizations and states with standards for estimating and reporting greenhouse gas emissions (carbon dioxide (CO_2), methane, nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)). Twenty-one New York public and private organizations have enrolled as Founding Reporters and committed to inventory and report their emissions under the Registry's protocol.

Adoption of California Vehicle Emissions Standards

California is the only state that is not preempted by federal vehicle emissions standards and, as a result, is permitted to set stricter standards than those that apply to the nation as a whole. Once a rule has been adopted in California, other states seeking standards for a higher level of emissions controls are permitted to adopt such California standards as well. New York has adopted the most recent California standards, which would reduce greenhouse gas emissions from cars by 37 percent and from light trucks 24 percent by 2016.

Regional Low-Carbon Fuel Standard

The Regional Low-Carbon Fuel Standard is a market-based, technologically neutral emissions-performance standard under development by 11 Northeast and Mid-Atlantic states (Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Pennsylvania) that will reduce the carbon intensity of transportation fuels sold in the region.

The Transportation and Climate Initiative

This initiative is a coordinated regional effort by 12 Northeast and Mid-Atlantic jurisdictions (Connecticut, Delaware, Massachussetts, Maryland, Maine, New Hampshire, New Jersey, New York, Rhode Island, Vermont, Pennsylvania, and the District of Columbia) to reduce transportation sector greenhouse gas emissions and further the development of a clean energy economy. The participating jurisdictions are working to reduce greenhouse gas emissions, minimize our transportation system's reliance on high-carbon fuels, promote sustainable growth, address the challenges of vehicle miles traveled, and help build the clean energy economy.

Climate Smart Communities

This program includes ten-point pledge for municipalities to reduce greenhouse gas emissions, prepare for climate change, and invest in green economies. Launched February 2009, the Climate Smart Communities Pledge has already been adopted by at least 85 New York communities.

Office of Climate Change

The charge of the Office of Climate Change is to lead development of programs and policies that mitigate greenhouse gas emissions and help municipalities and individuals adapt to the effects of climate change. In addition to implementing RGGI, the Office is developing the full suite of responses needed for significant emissions reductions and for successful adaptation to changing temperatures, sea levels, precipitation and other climate factors.

Energy Efficiency and Renewable Energy

45 by 15

Adopted in the 2009 State Energy Plan, this energy policy is designed to meet 45 percent of New York's electric energy needs from energy efficiency and renewable energy by the year 2015. Along with program requirements from the State's energy authorities, this policy is implemented by two key programs:

Renewable Portfolio Standard (RPS)

This program requires 30 percent of electricity in New York to be supplied from renewable energy sources by 2015 and provides financial incentives to support development of renewable energy sources. To date, the RPS has lead to the development of over 1300 MW of renewable power including large-scale facilities and thousands of customer-sited renewable resources. New York is one of 27 states to use a RPS to drive a transition to renewable sources of electricity.

Energy Efficiency Portfolio Standard (EEPS)

This program is designed to contribute to reducing energy demand **15 percent** from forecasted levels by 2015, through energy efficiency. This program is expected to provide more than $4 billion in benefits to customers, along with thousands of jobs to support energy efficiency programs, such as retrofitting outdated and inefficient residential, commercial and industrial properties and installing new energy efficient equipment. Additional energy efficiency gains are anticipated to contribute to the 15 percent reduction also include strengthening efficiency standards for appliances and buildings, and address energy efficiency opportunities for New York's largest energy consumer – State government.

System Benefits Charge (SBC)

The System Benefits Charge supports the implementation of a portfolio of energy efficiency and clean energy activities. The SBC program provides New York-based investment in research, development and demonstration of emerging energy technologies, supports business development of new companies that are providing innovative products and services, and provides support for accelerating the introduction into the market and use of energy efficiency and clean energy technologies. This program also provides targeted energy efficiency services for low-income customers.

Green Buildings

The Green Buildings Tax Credit Program provides state tax credits to owners and tenants of eligible buildings that meet certain energy and environmental performance standards. Large commercial and residential buildings that meet these standards will have lower environmental impacts than buildings that would otherwise meet a lower level of performance, based on existing building codes. The program is also designed to provide general information and foster contacts among building design teams and building owners to help new and rehabilitated commercial, industrial, and institutional buildings achieve higher levels of energy and environmental performance. In addition to the tax credit program, a new incentive program to foster interest in high-performance single-family residential buildings has also been initiated.

Renewable Energy Task Force

Comprised of 20 private-sector and government representatives, the Renewable Energy Task Force issued a Report in February 2008, listing 16 specific policy and program recommendations which constitute a roadmap to significantly increase the use of renewable energy in New York. Recommendations include greater solar energy production, expanding the State's RPS, and business incentives to attract renewable energy producers and expand the State's "green collar" workforce. This Report has launched several successful initiatives, including the Vehicle Miles Traveled Task Force, a Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply For New York[1], and other projects which will provide the foundation to advance the recommendations into sound energy and environment programs.

Net Metering

Net Metering allows electricity customers with qualified renewable energy systems – including home-based solar and wind systems and farm-based waste digester systems – to sell excess electricity generated by such facilities to the local utility. Several 2008 laws authorized expansion of the existing programs, increasing the maximum amount of energy that utilities are required to buy from host energy sites through net metering.

[1] NYSERDA Report 10-05. April, 2010.

State Operations Policies

Designed to affect State government operations and improve the energy and environmental performance of State assets and resources, several programs have been initiated and implemented through Executive Order (EO). These EO actions include:

Green and Clean State Buildings and Vehicles Guidelines (EO 111)

EO 111 requires State buildings to reduce energy consumption by 35 percent of 1990 levels by 2010, and mandates that State agencies select ENERGY STAR qualified products. Construction and renovations must follow Leadership in Energy and Environmental Design (LEED) green building standards.

State Green Procurement and Agency Sustainability Program (EO 4)

EO 4 promotes the State purchase of environmentally-friendly commodities, services and technologies, as well as agency sustainability and stewardship programs.

Use of Biofuels and Alternative Fueled Vehicles (EO 142)

EO 142 requires State agencies to phase in renewable heating and transportation fuels. The State is working to assess the environmental, social, and health effects of biofuels and has developed a Renewable Fuels Roadmap that lays out a sound future for New York in this area.

Climate Change Adaptation

New York State Sea Level Rise Task Force

The Sea Level Rise Task Force was created by the State Legislature in 2007 to assess sea level rise effects to the State's coastlines and to recommend protective and adaptive measures for coastal communities and natural habitats. The Task Force will produce a report of recommendations by January 1, 2011.

NYS Interagency Local Government Adaptation Workgroup

This ad hoc workgroup facilitates development of recommendations for local adaptation planning, decision-support tool development and cooperative management of pilot projects.

State Wildlife Action Plan (SWAP) Vulnerability Assessments

These habitat type vulnerability assessments and assessments of threats to species of special concern identify potential actions for SWAP.

Appendix E
Methods of Quantification

The Climate Action Plan used an overall analytical approach applied across the four greenhouse gas mitigation sectors. Key elements of the overall approach are described in the Quantification Methods Memorandum. The key elements are divided into the following three sections: Overall Approach, GHG Emissions and Emission Reductions, and Cost Analysis Methods. Separate memoranda, the "Common Assumptions Memos," focus on key analytical methods that are specific to each of the four Technical Work Group areas, and follow the Quantification Methods Memorandum.

Draft Quantification Methods Memorandum

New York State Climate Action Plan

Prepared for:

The New York State Energy Research and Development Authority
and
The New York State Department of Environmental Conservation
Albany, NY

Prepared by:

The Center for Climate Strategies (CCS)

July 23, 2010

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INTRODUCTION

The purpose of the Quantification Memorandum is to explain the methodologies and identify key assumptions for developing sector-specific estimates of greenhouse gas (GHG) emission reduction potential, incremental costs, and cost effectiveness for Climate Action Plan recommended policies for New York. This memorandum also addresses the data sources/types and methods that will be needed to support the analysis of sector-specific GHG mitigation policy options associated with statewide implementation of aggregated technologies and best practices.

The first part of this memorandum discusses key elements of the overall analytical approach that apply across all four Technical Work Group sectors. The key elements are divided into the following three sections: Overall Approach, GHG Emissions and Emission Reductions, and Cost Analysis Methods. Separate memoranda, the "Common Assumptions Memos," focus on key analytical methods that are specific to each of the four Technical Work Group areas.

Overall Approach

Emission Sources

The project was divided into four Technical Work Group sectors to analyze the emission reduction potential and associated costs of individual GHG mitigation policy options and reflect the relationship between reduction potentials and cost per metric ton of carbon dioxide equivalent (CO_2e) emissions avoided. The four sectors include:

(1) Residential, Commercial/Institutional, and Industrial (RCI);

(2) Power Supply and Delivery (PSD);

(3) Transportation and Land Use (TLU); and,

(4) Agriculture, Forestry, and Waste Management (AFW).

The analysis of policy options will focus on those that are or may be applicable in New York State. When relevant, and as allowed by the availability of data, budget and project time, the analysis will include geographic differences in the application and costs of mitigation policies (e.g., New York City versus the rest of the state). At a minimum, in-state emission reductions and costs will be estimated for technologies and best practices as applied in New York State.

Subject to review by the Integration Advisory Panel, emission reductions will also be estimated for technologies and best practices applied within the state that result in emission reductions outside of the state. For instance, a major benefit of recycling is the reduction in material extraction and processing (e.g., aluminum production). While a policy may increase recycling in New York, the reduction in emissions may occur where this material is produced. Where significant emissions impacts are likely to occur outside the state, this will be clearly indicated. However, for the purpose of counting emissions reductions against New York's goal, only in-state reductions will be included.

Fuel Cycle Coverage

For the purposes of this study, the full fuel cycle represents the range of activities associated with fuel extraction, processing, distribution, and consumption. For the PSD, RCI, AFW and TLU sectors, GHG reductions for each mitigation policy option will be based upon the full fuel cycle because information is available to support this type of analysis for these sectors. Tracking the full range of fuel use inputs is essential for accurately tracking fuel cycle carbon emissions for technology options displaying very different performance characteristics. The approach involves identifying all the possible stages of the fuel cycle and quantifying the fuel input per unit of energy produced (electricity or fossil fuel).

Fuel cycle impacts will be reported for each source for which information is available to support a fuel cycle analysis. Where fuel cycle emission reductions are captured, there will often be two sets of emission reductions estimated: the total fuel cycle reductions; and those estimated to occur within the state. For the purpose of counting emissions reductions against New York's goal, only in-state reductions will be included. In most cases, these will be difficult to separate based on available information. Therefore, by default, the in-state reductions will often be those associated with fuel combustion and known in-state processes. Emission reductions from in-state processes associated with non-combustion reduction sources include only those processes that are known to occur within New York State (e.g., landfill emission reductions, but not the upstream GHG emissions embedded in the waste component) and exclude processes where the geographic origin of the mitigated emissions is uncertain (e.g., emissions from extraction/processing/packaging of virgin materials into usable products).

Life Cycle Coverage

For the purposes of this quantification, life cycle represents the energy and materials used for manufacture, its energy use during useful life, and disposal and/or capacity to be recycled. As the Climate Action Plan Council has conveyed interest in reporting in-state GHG reductions – with fuel-cycle reductions considered as co-benefits – full life cycle analyses may not be performed. Should sufficient data and parameters become available to execute a full life cycle analysis, CCS will include life cycle analysis, listing life cycle GHG reductions as co-benefits.

Pollutant Coverage and Global Warming Potentials

The analysis will cover the following six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these gases will be presented using a common metric, CO_2e, which accounts for the relative contribution of each gas to global average radiative forcing by multiplying the emissions of each pollutant by its Global Warming Potential (GWP)—a unitless factor representing the ratio of the radiative forcing of each GHG to the radiative forcing of CO_2 (the GWP for CO_2 is 1). Table E-1 shows the 100-year GWPs published by the Intergovernmental Panel on Climate Change (IPCC) in its Second, Third, and Fourth Assessment Reports. To be consistent with the GHG emissions inventory and forecast for the state of New York, the 100-year GWP's published in the Second Assessment Report of the IIPCC will be used to convert mass emissions to a 100-year GWP basis. Use of the 100-year GWP's published in the IPCC's Second Assessment Report is also consistent with U.S. Environmental Protection Agency (EPA) and IPCC guidance for consistency with how U.S. national, state, and country-specific GHG emissions inventories have been developed in the past.

Qualitative information on the criteria air pollutants and toxic air pollutants will also be included when this information is identified for individual technologies and practices in order to support co-benefits analysis.

Table E-1. 100-Year Global Warming Potentials from the Second, Third and Fourth Assessment Reports of the IPCC

Gas	100-year GWP (2nd Assessment)[1]	100-year GWP (3rd Assessment)[2]	100-year GWP (4th Assessment)[3]
CO_2	1	1	1
CH_4	21	23	25
N_2O	310	296	298
HFC-23	11,700	12,000	14,800
HFC-125	2,800	3,400	3,500
HFC-134a	1,300	1,300	1,430
HFC-143a	3,800	4,300	4,470
HFC-152a	140	120	124
HFC-227ea	2,900	3,500	3,220
HFC-236fa	6,300	9,400	794
HFC-4310mee	1,300	1,500	1,640
CF_4	6,500	5,700	7,390
C_2F_6	9,200	11,900	12,200
C_4F_{10}	7,000	8,600	8,860
C_6F_{14}	7,400	9,000	9,300
SF_6	23,900	22,200	22,800

* The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor.

An inventory for elemental (black) carbon (EC) and organic carbon (OC) will also be developed, so that potential co-benefits related to climate forcing and regional haze can be assessed, at least in a semi-quantitative fashion. CCS will use methods that it has used in several other states to develop a base year and projection year EC/OC inventory.

Time Period of Analysis

Fuel cycle emission reductions and incremental costs will be calculated relative to the characteristics of the baseline that would otherwise prevail in New York up through the end of the planning period, 2030.

[1]Second Assessment: http://www.epa.gov/climatechange/emissions/downloads/ghg_gwp.pdf 1995. Because only a summary of the Second Assessment Report if available online, an EPA document is cited which has the table from the IPCC report.

[2]Third Assessment: http://www.ipcc.ch/ipccreports/tar/wg1/248.htm, 2001.

[3]Fourth Assessment: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf, 2007.

The analysis will report annual emission reductions for 2020 and 2030. The present value of the cumulative incremental costs, and undiscounted cumulative CO_2e emission reductions, will be reported for the period starting with the initial year of the phase-in of the policy, up through 2030. For example, if an RCI policy includes a complete phase-in over time of more efficient plug load technologies (i.e., computers, televisions, video machines, etc) the annual GHG reductions will be reported for the years 2020 and 2030. The present value of the cumulative incremental costs and the undiscounted cumulative emission reductions will be reported for the entire period from the beginning of the phase-in up through 2030.

Start and End Years for Analysis

The beginning of the analysis period for which GHG reduction benefits and incremental costs will be calculated is the year 2011, considered to be the earliest year for which GHG mitigation options could be introduced in NY. The end of the analysis period is 2030.

Transparency

Data sources, methods, implementation mechanisms, key assumptions, and key uncertainties will be documented and supported by references to provide transparency on how the key analytical outputs for each policy option were developed and applied. Information provided by the state agencies and project participants will be used to ensure best available data sources, methods, and key assumptions using their expertise and knowledge to address specific issues in New York State. Modifications will be made through facilitated discussions.

Key Analytical Outputs and Metrics

GHG emission reductions

Net GHG reduction potential in physical units of million metric tons (MMt) of carbon dioxide equivalent (CO_2e) will be estimated for each quantifiable policy for each target year, 2020 and 2030, and cumulative reductions through 2030. As noted earlier, full fuel cycle or life cycle analysis will be used to evaluate net energy (and emissions) performance of policy options, as appropriate. Net analysis of the effects of carbon sequestration will be conducted where applicable. (See the section on “GHG Emissions and Emission Reductions” for additional details.)

Costs

Net capital, operating and maintenance (O&M), and fuel costs will be estimated for each of the policy options that are determined quantifiable. Costs will be discounted as a multi-year stream of net costs to arrive at the “net present value cost” associated with implementing new technologies and best practices. It is proposed that costs be discounted for all options in constant 2005 dollars using a 5 percent annual real discount rate. The nominal discount rate will be calculated by adding the projected inflation rate over the analysis period.[4] Capital investments

[4]The inflation rate for the analysis period is assumed to be 2.2%, subject to approval by the Integration Advisory Panel and Climate Action Council. Capital and other costs reported in nominal dollars will be converted to 2005$ using the inflation rate for the NY state region as reported by the Bureau of Labor Statistics (http://www.bls.gov/ro2/news.htm)

will be represented in terms of annualized or amortized costs over the project period. Discounting will begin in this initial year of the analysis period (i.e., assumes investment occurs in the beginning of the year). Policies that result in energy savings relative to the baseline technology or practice may result in a cost savings (recorded as a negative value). As noted above, the discount rate will be kept constant for the evaluation of all GHG mitigation options - risk and uncertainly will be accounted for by calculating option-specific cash flows that account for policy, practice, or technology differences.

Cost-effectiveness

The cost effectiveness for each quantified policy will be calculated by dividing the present value cost by the cumulative (undiscounted) reduction in metric tons of GHG emissions. Because monetized dollar value of GHG reduction benefits are not available, physical benefits will be used instead, measured as dollars per metric ton of carbon dioxide equivalent (tCO_2e) or "cost effectiveness" evaluation. Both positive costs and cost savings (negative value) will be estimated as a part of compliance cost. When combined with GHG impact assessments, the results of these cost estimates will be aggregated into a sectoral summary table and sector and economy-wide stepwise marginal cost curves.

Direct vs. indirect effects

Socio economic impact of policy options and scenarios will include direct effects, but will not include indirect and distributional effects. Direct effects are those borne or created by the entities, households or populations subject to the policy or implementing the new policies; for example, a policy encouraging the purchase of advanced technology vehicles would include an evaluation of the incremental cost of the vehicles, and the savings on fuel cost and associated GHG emissions. Indirect effects are defined as those borne or created by the entities, households or populations other than those implementing the policy recommendation; in the above example, this could be the number of jobs created/lost by the alternative GHG mitigation investments, or the reduction in ambient air pollution concentrations. Distributional effects refer to the extent to which a GHG mitigation policy design may result in disproportionate impacts on different regions, sectors, communities, or households. Some examples of direct and indirect net costs and benefits metrics are included in Annex 1 at the end of this memo for purposes of illustration.

End effects

For GHG mitigation options whose lifetimes extend beyond the end of the analysis period (i.e., beyond 2030), only costs and benefits that fall within the analysis period will be fully included in the analytical results. For long-lived investments (e.g., public transport infrastructure, nuclear power plants) whose costs and benefits extend beyond 2030, GHG reductions up through 2050 will be quantified in order to be able to offer a direct comparison with the 80 by 50 goal. In order to make this comparison, sectoral business-as-usual GHG projections will be estimated for the 2031-2050 period using simple extrapolation techniques, except for technologies that mature at the end of the study period or decline in effectiveness discontinuously after 2030. Incremental costs in the 2031-2050 period will be accounted for qualitatively in the write-up of results.

Non-GHG (external) impacts and costs

Environmental co-benefits such as reductions in criteria air pollutants which in turn would lead to reduced public health impacts from productive activities in New York are to be analyzed separately. Qualitatively, CCS will document measures that are expected to have other non-GHG impacts, including water quality, water use, solid waste reduction, and environmental justice issues and will provide information as available and needed to support quantification of these impacts.

Biomass supply & demand

Within the AFW Common Assumptions memorandum, estimates of biomass supply will be prepared. Estimates are provided for all known feedstocks, including municipal solid waste fiber, in units of dry tons and million British Thermal Units (MMBtu). During the course of GHG quantification, CCS will maintain a spreadsheet to be used by the team to track demand by each mitigation approach (e.g., biomass to energy, liquid biofuels production).

Uncertainty / Sensitivity Analysis

Key uncertainties and feasibility issues will be identified and discussed qualitatively. For instance, the certainty of energy price forecasts and technology change rates may vary significantly across certain sectors and actions. Characterization of the source and potential magnitude of uncertainty will be useful to policymakers as they make future policy decisions. To the extent that data are available and time and resources allow, a quantitative assessment of uncertainty or certain parameter sensitivities will be included in the analysis of policy options by conducting sensitivity analysis.

GHG Emissions and Emission Reductions

New York State GHG Emissions Inventory and Forecast

To estimate statewide impacts associated with potential policies, information on current and future energy use and the extent of application (penetration) of both baseline and policy options will be needed. Working with CCS, NYSERDA has prepared a comprehensive GHG emissions inventory for 1990 through 2008 and a forecast to 2030 for all emission source sectors. The emissions inventory and forecast has been prepared at the state-level representing a planning inventory rather than a compliance inventory. Forecast data used to support the development of New York's 2009 State Energy Plan were used to revise the forecast of energy demand and emissions. Historical fuel use data used in preparing the inventory are provided in a separate publication; these data rely on data published by the U.S. Energy Information Administration.[5]

Calculation of Emission Reductions for Policy Options

Emission reductions for individual policies will be estimated incremental to baseline emissions based on the change (reduction) in emissions activity (e.g., physical energy units) or as a percentage reduction in emissions activity (e.g., physical energy units or emissions) depending

[5] Patterns and Trends, New York State Energy Profiles: 1993-2008, prepared by New York State Energy Research and Development Authority Energy Analysis Program.

on the availability of data. This information will be needed to support the cost-effectiveness calculation for each policy option.

Fuel- and pollutant-specific emission factors will be used to convert physical units of emissions activity to emissions. The emission factors will be based on those that NYSERDA uses to prepare the GHG emissions inventory and forecast for New York State, and are provided in the Sector-specific "Common Assumptions" memoranda. For fuel combustion sources, fuel-specific oxidation factors will be used with emission factors to estimate emissions. Fuel combustion oxidation factors refer to the percentage of fuel that is fully oxidized during the combustion process. Table E-2 provides the oxidation factors to be used for this analysis; these factors are based on those used in the EPA's most recent GHG inventory for the U.S.[6]

Table E-2. Fuel Combustion Oxidation Factors

Fuel	Oxidation Factor
Coal	0.990
Natural Gas and LPG	0.995
Distillate and Residual Oil	0.990
Municipal Solid Waste	0.980

Energy Conversion Factors

Energy conversion factors refer to the energy density of fuels used in New York. These factors are provided in the Sector-specific "Common Assumptions" memoranda. Energy conversion factors obtained from NYSERDA will be used for this project. Otherwise, default energy conversion factors will be taken from Table Y-2 (Conversion Factors to Energy Units (Heat Equivalents)) of Appendix Y in the EPA's most recent GHG Inventory for the U.S.[7]

Cost Analysis Methods

Cost Effectiveness

Because the monetized dollar value of GHG reduction benefits are not available, physical benefits are used instead, measured as dollars per tCO_2e (cost or savings per metric ton) or "cost effectiveness." Both positive costs and cost savings (negative values) are estimated as a part of mitigation cost. When combined with GHG impact assessments, the results of these cost estimates will be aggregated into a stepwise marginal cost curve that can be broken down by sector or subsector as needed, as well as sub state region for key measures.

The net cost of saved carbon of a proposed policy option is calculated by dividing the cumulative future streams of incremental costs, discounted back to the present time, by the cumulative

[6] U.S. EPA, April 2010. Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2008. Available at: http://epa.gov/climatechange/emissions/usinventoryreport.html.

[7] Available at: http:/yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/LHOD5MJTCL/$File/2003-final-inventory_annex_y.pdf.

undiscounted net CO_2e reductions achieved by the technology or best practice. Mathematically, the equation to be used is as follows:

$$CSC = \frac{\sum_{t=0}^{n} \left\{ \frac{((LC_m - LC_r) * A_t)}{(1 + D_r)^t} \right\}}{\sum_{t=0}^{n} (CO_2e_r - CO_2e_m)}$$

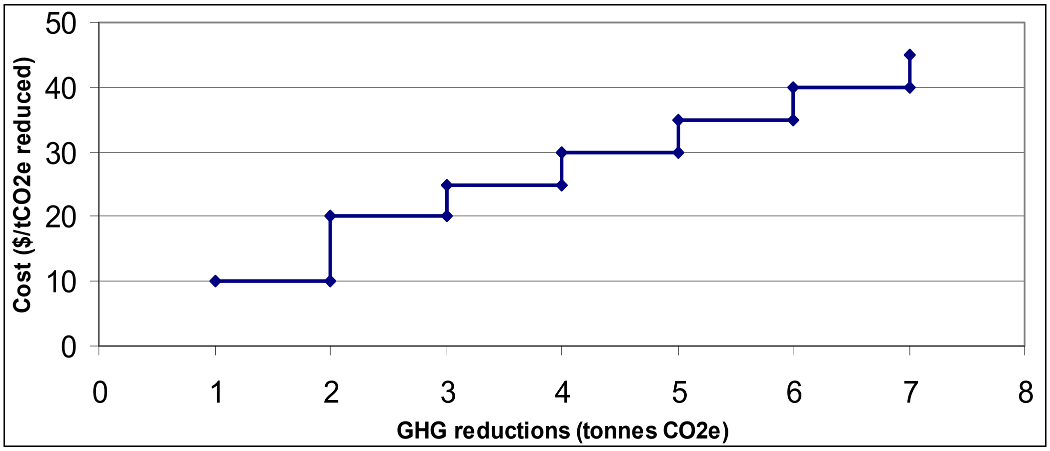
where:

CSC	=	Cost of saved carbon (or cost-effectiveness) of a technology or best practice, $/tCO_2e$ avoided
LCm	=	Levelized cost of a technology or best practice, $/activity unit
LCr	=	Levelized cost of the baseline or reference technology or best practice, $/activity unit
A	=	Amount of activity affected by the technology or best practice in year t, activity unit
Dr	=	Real discount rate, dimensionless
CO_2er	=	CO_2e emissions associated with the baseline or reference technology or best practice in year t, metric tons CO_2e
CO_2em	=	CO_2e emissions associated with a technology or best practice in year t, metric tons CO_2e
t	=	year in the evaluation period ($0 \le t \le 40$)

Activity units refer to a unit indicator of GHG emissions activity for a policy option. The activity units will vary depending on the Sector and within each sector the individual option. The activity units are used to normalize data for comparison of the policy option to the baseline. For example, for the Power Supply and Delivery sector, MWh of gross electricity generation could be used as the activity unit such that dollars per megawatt-hour ($/MWh) would be used as the activity unit for the “LCm” and “LCr” terms and MWh would be used as the activity unit for the cost terms in the equation.

The results of the analyses will be used to develop a GHG abatement cost curve which will rank each technology or best practice in the order of its cost effectiveness for reducing a metric ton of CO_2e emissions. This ranking will be represented in the form of a curve that is similar conceptually to Figure E-1. Each point on this curve represents the cost-effectiveness of a given policy option relative to its contribution to reductions from the baseline, expressed as a percentage. The points on the curve appear sequentially, from most cost-effective in the lower left area of the curve, to the least cost-effective options located higher in the cost curve in the upper right area.

Figure E-1. Example Cost Curve



The costs of each policy option that will be evaluated will be levelized and converted into dollars per activity unit. The cost components to be considered include capital, fixed O&M, variable O&M, and fuel costs. Other sector-specific costs (e.g., transmission of electricity) will be included as applicable to each sector.

The levelization calculation is similar to amortization and its purpose is to develop a level stream of equal dollar payments that lasts for a fixed period of time. The levelization formula to be used in the analysis is as follows:

$$LC = \frac{[PV * D_r * (1 + D_r)^t]}{((1 + D_r)^t) - 1}$$

where:

LC	=	Levelized cost of the a technology or best practice, $/activity unit
PV	=	Present value of discounted cost stream
D_r	=	Real discount rate, dimensionless
t	=	Levelization period, or number of years over which payments are to be made

There are several parameters that will be used in the levelization process. Some are technology-specific (e.g., plant lifetime, capacity factor), others are state-specific (e.g., state income tax rate), others are market-driven (cost of capital), while others are a matter of policy (e.g., real discount rate).

Capital Costs

Capital costs represent the material, equipment, labor, and other costs associated with the implementation of a policy option relative to the baseline or reference technology or practice. For policy options that require a capital investment, these costs will be annualized using a fixed charge rate (FCR), a factor that is the sum of the cost of capital (equals the cost of debt plus the cost of equity), taxes, and depreciation. Differences between public/private financing costs will be captured through sector-specific assumptions regarding equity/debt fractions and depreciation schedules. For long-term capital investments that extend beyond 2030, the investment will be annualized over its operational lifetime; only costs incurred within the 2011-2030 analysis period will be fully included in the presentation of quantitative results.

Annual O&M Costs

O&M costs refer to labor, equipment, and fuel costs related to annual operation and maintenance of policy measures and are differentiated into annual expenditures (i.e., variable O&M) and fixed expenditures (i.e., fixed O&M). Variable O&M estimates are provided in activity units over the full period of operation of the technology. O&M costs are described and included in the LCC when there is a differential between the baseline technology and the GHG-reducing alternative.

Forecast of Fuel Demand, Prices, and Costs

Fuel demand and price forecasts will be based on the information developed for New York's State Energy Plan. This information will include fuel demand and price forecasts for 2011 through 2030 by sector and fuel type in both physical (e.g., gallons, cubic feet, barrels) and energy (e.g., British thermal units [Btu]) units. The sectors covered include electricity generation; residential, commercial/institutional, and industrial; and transportation. The fuels covered include natural gas, petroleum (motor gasoline, kerosene, liquefied petroleum gas, distillate and residual oil), and coal, nuclear fuel, and renewable fuels (biomass and landfill gas). For the purpose of developing abatement cost curves, the fuel demand and price forecasts developed by NYSERDA, NYISO, and other sources will be used for all sectors. Fuel costs (including avoided fuel costs) will be calculated using this information along with fuel consumption estimates developed for each technology or best practice.

Avoided Electricity Generation Costs

For policy options in the RCI, agriculture, and waste sectors that reduce electricity demand, the amount and cost of electricity avoided will be estimated. Information on avoided electricity costs will reflect the consensus of the project research team, NYSERDA, and the Climate Action Council.

Interactions with the Regional Greenhouse Gas Initiative (RGGI)

RGGI is a ten-state agreement to reduce GHG emissions through a cap and trade system focused only on the supply of electric power. States within RGGI have negotiated a regional CO_2 emission cap for the power sector of 188 million short tons per year through 2014 (cap of 64 million short tons for NY), with the cap being strengthened by 2.5 percent per year over the period 2015 through 2018. The energy modeling undertaken to develop New York's State Energy Plan fully incorporates the RGGI program in the reference case forecast. Hence, all power sector GHG mitigation policies to be analyzed are considered incremental to the RGGI program since they will achieve greater GHG emissions than the RGGI program. In addition, a more stringent RGGI program itself will be analyzed as part of the PSD-6 option.

Documentation

Documentation of the work completed for each policy option for each sector will be completed in a template format that addresses the items listed below (among others) to ensure consistency for comparison of information and also assist with identifying data gaps that will be addressed.

Work Group Sector

Name of policy option

Policy Description

Policy Design (Goals and Timing for implementation and parties involved or affected by implementation of the policy.)

Implementation Mechanisms

Quantification: Estimated GHG Savings and Costs per $MtCO_2e$ (GHG reduction potential in 2020 and 2030, Cumulative GHG reduction potential, net cost, data sources, and quantification methods)

Key Assumptions and Uncertainties

Co-Benefits and External Costs (qualitative discussion)

Annex 1: Examples of Direct/Indirect Net Cost and Benefit Metrics

Note: These examples are meant to be illustrative and are not necessarily comprehensive.

A. Direct Costs and/or Savings

Transportation and Land Use (TLU) Sector

- Incremental cost of more efficient vehicles net of fuel savings, net of fuel savings.
- Incremental cost of implementing Smart Growth programs, net of saved infrastructure and service costs plus fuel savings and reduced consumption.
- Incremental cost of mass transit investment and operating expenses, net of any saved infrastructure and service costs (e.g., roads)
- Incremental cost of alternative fuel, net of any change in maintenance costs
- Net effects of carbon sequestration from land use measures

Residential, Commercial, and Industrial (RCI) Sectors

- Net capital costs or savings (or incremental costs or savings relative to standard practice) of improved buildings, appliances, equipment (cost of higher-efficiency refrigerator versus refrigerator of similar features that meets standards)
- Net operation and maintenance (O&M) costs or savings (relative to standard practice) of improved buildings, appliances, equipment, including avoided/extra labor costs for maintenance (less changing of compact fluorescent light (CFL) or light-emitting diode (LED) bulbs in lamps relative to incandescent)
- Net fuel (gas, electricity, biomass, etc.) costs (typically as avoided costs from a societal perspective)
- Cost/value of net water use/savings
- Cost/value of net materials use/savings (for example, raw materials savings via recycling, or lower/higher cost of low-global warming potential (GWP) refrigerants)
- Direct improved productivity as a result of industrial measures (measured as change in cost per unit output, for example, for an energy/GHG-saving improvement that also speeds up a production line or results in higher product yield)

Energy Supply (ES) Sector

- Net capital costs or savings (or incremental costs or savings relative to reference case technologies) of renewables or other advanced technologies resulting from policies
- Net O&M costs or savings (relative to reference case technologies) renewables or other advanced technologies resulting from policies
- Avoided or net fuel savings (gas, coal, biomass, etc.) of renewables or other advanced technologies relative to reference case technologies resulting from policies
- Total system costs (net capital + net O&M + avoided/net fuel savings + net imports/exports + net transmission and distribution (T&D) costs) relative to reference case total system costs

Agriculture, Forestry, and Waste Management (AFW) Sectors

- Net capital costs or savings (or incremental costs relative to standard practice) of facilities or equipment (e.g., manure digesters and associated infrastructure, generator; ethanol production facility)
- Net O&M costs or savings (relative to standard practice) of equipment or facilities
- Net fuel (gas, electricity, biomass, etc.) costs or avoided costs
- Cost/value of net water use/savings
- Cost/value of carbon sequestration from land use measures
- Reduced VMT and fuel consumption associated with land use conversions (e.g., as a result of forest/rangeland/cropland protection policies)

B. Indirect Costs and/or Savings across All Sectors

- Net value of employment and income impacts, including differential impacts by socio economic category
- Re-spending effects on the economy from financial savings
- Net changes in the prices of goods and services in the region
- Health benefits of reduced air and water pollution
- Ecosystem benefits of reduced air and water pollution
- Value of quality-of-life improvements
- Value of improved road and community safety
- Energy security
- Net embodied energy of materials used in buildings, appliances, equipment, relative to standard practice
- Improved productivity as a result of an improved working environment, such as improved office productivity through improved lighting (though the inclusion of this as indirect might be argued in some cases)
- Higher cost of electricity in the region

AFW Common Assumptions Memorandum - Draft

To: NYS Climate Action Plan Agriculture, Forestry, and Waste Management Technical Workgroup

From: Steve Roe and Brad Strode

CC: Tom Peterson, Jeff Wennberg, Randy Strait, Sandra Meier

Subject: Assumptions used in the quantification of options for the AFW Technical Work Group

Date: July 12, 2010

This memorandum summarizes methods, data sources, and key assumptions to be used to estimate the GHG reductions and costs for AFW sector mitigation options. The information presented here builds on the general approaches and data sources laid out in the overview quantification memorandum covering all sectors (including common emission factors, cost assumptions, etc.).

Quantifying reductions of GHG (particularly future reductions) is an inherently complex process and assumptions are important inputs into the quantification methodologies and models used to estimate mitigation costs and benefits. Models are representations of reality, and require the best available data on likely futures. An emphasis should be placed on using assumptions that are based on the best available data using local or regional data (when available) rather than national level data.

CCS has developed estimates of GHG emissions and forecasts for the AFW sector to supplement the inventory prepared by DEC (which primarily covered combustion sources). These inventory and forecast data are needed to support the development of mitigation cost curves and to provide context to the selection of mitigation priorities. For emission inventories previously developed by CCS, the only sector for which consumption-based emissions data are provided is the electricity consumption sector. Other sectors of the inventory tend to only include GHG emissions that occur within the state as a result of energy consumption or other GHG emission process (e.g., methane from landfilled waste). For example, for fuel combustion in the RCI and Transportation sectors, only the emissions associated with fuel combustion are provided, not those associated with the extraction, transport, processing, and distribution of each fuel. Similarly, for waste management, only emissions associated with waste management processes in New York would be included in the inventory (e.g., landfilling, waste combustion), not those associated with production and transportation of the initial packaging or product that became a component of the solid waste stream. In addition, emissions from the management of New York waste that is exported out of state are not included.

For some mitigation options, fuel cycle emission reductions can be estimated, and it should be recognized that there are likely to be at least a portion of emission reductions that occur out-of-state as a result of in-state mitigation actions:

- Fossil fuel consumption: inventory estimates are based only on the GHG emissions associated with the combustion of each fuel; fuel cycle emission reductions are estimated using GHGs from combustion plus the embedded GHGs from extraction, transportation, processing, and distribution;
- Solid waste management: landfill methane emissions or total GHG emissions are associated only with waste combustion and decomposition for in-state managed waste; fuel cycle emission reductions include the landfill/waste combustion emissions plus those associated with production and distribution of the initial packaging or product (e.g., net difference of use of virgin materials versus recycled materials). Also, emission reductions that occur out of state from reductions in exported waste should be captured in the analysis; and,
- Biofuels consumption: for fossil fuel displacement benefits, the inventory includes only GHGs from fossil fuel combustion; fuel cycle emission reductions are estimated using the fuel cycle gasoline/diesel emission factors compared to fuel cycle biofuel emission factors (captures total GHGs from fuel production, processing, and distribution).

For the AFW Technical Work Group, CCS will estimate the in-state GHG reductions for each mitigation option selected for analysis. Where data and methods are available to do so, CCS will also specify the fuel cycle emission reductions, reporting these reductions as co-benefits. This method is based on the most recent guidance from Climate Action Plan project leaders. CCS also strives to estimate fuel cycle reductions for GHG mitigation in the other work group areas (Areas); so, it is important for the Climate Action Council to understand the ramifications of this (e.g., measurement of fuel cycle GHG reductions against a GHG forecast that is not based on fuel cycle emission estimates).

Common assumptions used in the development of mitigation options in other sectors (especially energy supply and transportation) are also used for the quantification of many AFW mitigation policy options. These could include future costs of fossil fuels, electricity consumption-based emission factors, costs for new electricity generation, and future gasoline and diesel consumption. In the discussion of common assumptions for the AFW sector in the sections below, CCS also notes instances where the AFW analysis will borrow common assumptions from other sectors. These common assumptions have been documented in the overview quantification memorandum, as well as the Area-specific memos (e.g., Power Supply and Delivery (PSD), Transportation and Land Use (TLU)).

Quantification Process

The analysis includes spreadsheet modeling techniques in which assumptions are transparent and readily accessible for review. The assumptions delineated in the following document are for the quantification of the policy options developed by the AFW Technical Work Group. This quantification of costs and CO_2 reductions entails the following steps:

- Develop <u>stand-alone</u> GHG reduction and cost estimates for each quantifiable option;
- Once completed, the stand alone options will be adjusted to reflect existing actions;
- To assess the AFW emission reductions without double-counting, it is necessary to consider overlaps and interactions within the AFW policies and measures;

- Options will be also be modified to reflect overlaps between AFW options and other Technical Work Group options. Potential interactions occur between AFW policies and measures that deploy renewable energy with PSD; Residential, Commercial, and Industrial (RCI); and TLU mitigation measures.

Common Methods, Assumptions, and Data Sources for GHG Mitigation

Forestry - Afforestation/Reforestation: Assumed Sequestration Rates and Costs

Carbon sequestered by afforestation activities is assumed to occur at the same rate as carbon sequestration in average New York state forests. Average carbon storage rates were determined based on USFS GTR-NE-343,[8] assuming afforestation activity with a forest type distribution of 70% maple-beech-birch, 15% oak-hickory, and 15% white-red-jack pine. This distribution is reflective of the average forest composition in New York and is based on the major forest types identified by USFS.[9] A 45-year project period is assumed, such that the rate of forest carbon sequestration under afforestation projects for an average acre in New York was estimated at 1.1 metric tons of carbon (tC)/acre/year (see Table E-3).

Table E-3. Average carbon sequestration rate for afforestation projects

Forest type	Assumed Distribution	tC/acre (0 year)	tC/acre (45 year)	tC/acre/year
Maple-beech-birch	70%	0.8	50.6	1.1
Oak-hickory	15%	0.8	56.2	1.2
White-red-jack pine	15%	0.8	37.1	0.8
Weighted Average				**1.1**

tC/acre = metric tons of carbon per acre. Excludes soil organic carbon pool due to the uncertainty in those estimates.

For reforestation projects, CCS would also use data from the same publication to derive an average sequestration rate. Reforestation refers to projects occurring on lands that had recently been under forest cover (such as planting projects following clear-cut harvesting).

Estimated per acre costs for afforestation in New York were obtained from Walker et al. 2007,[10] who surveyed state foresters, regional foresters, or other foresters and related specialists in the USFS, universities, and forest companies, and reported the results on a state-by-state basis. Costs include site preparation, labor, seedlings, and herbivore protection (Walker et al. 2007). Average per-acre afforestation costs in New York were estimated to be $550 for both hardwoods and softwoods. This is a one-time cost incurred in the year of planting.

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[8] J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. USDA USFS Northeastern Research Station. General Technical Report GTR-NE-343. (This document is also published as part of the US DOE 1605(b) Voluntary GHG Reporting Program). See http://nrs.fs.fed.us/pubs/gtr/ne_gtr343.pdf.

[9] Carbon in United States Forests and Wood Products, 1987-1997: State-by-State Estimatesby Richard A. Birdsey & George M. Lewis. (available at http://www.fs.fed.us/ne/global/pubs/books/epa/states/NY.htm)

[10] S. Walker, S. Grimland, J. Winsten, and S. Brown. 2007. Terrestrial carbon sequestration in the Northeast: opportunities and costs part 3A: opportunities for improving carbon storage through afforestation of agricultural lands. Report to The Nature Conservancy Conservation Partnership Agreement by Winrock International, prepared with the support of the US DOE under Award No. DE-FC26-01NT41151.

Agriculture - Land Value and Conservation Easement Costs

If better information on conservation easement costs is not available for agricultural lands (e.g., historical in-state costs paid for conservation easements), the mitigation cost quantification will assume Conservation Reserve Program (CRP) annual payments as a proxy for easement costs.

CRP land annual payments for New York were projected across the mitigation period based on historical payments (see Table E-4), and is escalated to account for increased land value across the period.[11]

Table E-4. 2007 and projected CRP payments[12]

Year	CRP Enrollment (Acres)	Annual Payment (Thousand$)	Annual Payment ($/acre)	Annual Payment (revised to 2005$/acre)
2007	66,544	$4,863	$73.08	$66.29
2008	67,832	$5,040	$74.30	$67.39
2009	69,144	$5,223	$75.54	$68.52
2010	70,482	$5,414	$76.81	$69.67
2011	71,846	$5,611	$78.09	$70.83
2012	73,236	$5,815	$79.40	$72.02
2013	74,654	$6,027	$80.73	$73.22
2014	76,098	$6,246	$82.08	$74.45
2015	77,571	$6,473	$83.45	$75.69
2016	79,072	$6,709	$84.85	$76.96
2017	80,602	$6,953	$86.27	$78.25
2018	82,162	$7,206	$87.71	$79.56
2019	83,752	$7,469	$89.18	$80.89
2020	85,372	$7,741	$90.67	$82.24
2021	87,024	$8,022	$92.19	$83.61
2022	88,708	$8,314	$93.73	$85.01
2023	90,425	$8,617	$95.30	$86.44
2024	92,175	$8,931	$96.89	$87.88
2025	93,959	$9,256	$98.51	$89.35
2026	95,777	$9,593	$100.16	$90.85
2027	97,630	$9,942	$101.83	$92.37
2028	99,519	$10,304	$103.54	$93.91
2029	101,445	$10,679	$105.27	$95.48
2030	103,408	$11,068	$107.03	$97.08

[11] Under the Conservation Reserve Program (CRP), the USDA establishes contracts with agricultural producers to retire environmentally sensitive land. During the 10- to 15-year CRP contract period, farmland is converted to grass, trees, wildlife cover, or other conservation uses providing environmental benefits, including improvement of surface water quality, creation of wildlife habitat, preservation of soil productivity, protection of groundwater quality, and reduction of offsite wind erosion damages. The program also assists farmers by providing a dependable source of income. See http://www.fsa.usda.gov/Internet/FSA_File/annual_consv_2007.pdf.

[12] See http://www.fsa.usda.gov/Internet/FSA_File/annual_consv_2007.pdf

Agriculture - Tilling Practices

The reduction in fossil diesel fuel use associated with changing land use from intensive agriculture to alternative land use or practices is estimated at 3.5 gallons/acre.[13] The fuel cycle fossil diesel GHG emission factor is 12.3 tCO_2e/1,000 gallons.[14] This will be revised as needed to reflect the value assumed in the TLU section of this memorandum (i.e., based on the NYGREET model).

Agriculture – Fertilizer Application GHG Emissions and Costs

The fertilizer cost information provided in Table E-5 is taken from U.S. Department of Agriculture, Economic Research Service's U.S. fertilizer use and price information (see http://www.ers.usda.gov/Data/fertilizeruse/). A weighted price of applied nitrogen was derived from this information using the most recent data available from United States Department of Agriculture (USDA).

Table E-5. Average US price of common nitrogen fertilizers

Month/Year	Average U.S. farm prices of selected fertilizers				
	Anhydrous ammonia	Nitrogen solutions 30%	Urea 45-46% nitrogen	Ammonium nitrate	Ammonium Sulfate
Apr 2007	*$/short ton*				
	523	277	453	382	288
	N content (%)				
	82	30	46	34	21
	$/short ton nitrogen				
	638	923	985	1,124	1,371
2006	*US Consumption*				
	3,821,891	10,104,319	5,369,913	963,710	1,218,964
2006-2007	***Weighted $/short ton nitrogen***				
	862				

To predict fertilizer prices in the future, the historical growth rate for fertilizer prices was used. Nominal (unadjusted for inflation) growth in fertilizer prices between 1990 and 2007 averaged 7.96% growth.[15] However, when this figure is adjusted for inflation, this growth rate is significantly less dramatic. A growth rate for fertilizer price was used because fertilizer prices can fluctuate dramatically, and therefore holding these prices constant (in real dollars) did not

[13] Reduction associated with less intensive land use (e.g., fewer passes). The estimate is based on conservation tillage compared with conventional tillage, at http://www.conservationinformation.org/Core4Brochures/CTBrochure.pdf, accessed May 2008.

[14] Fuel-cycle emissions factor for fossil diesel from J. Hill et al., "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels," Proceedings of the National Academy of Sciences, 103(30):11206–11210. From the assessment used to evaluate U.S. soybean-based biodiesel life-cycle impacts. See http://www.pnas.org/cgi/content/full/103/30/11099.

[15] USDA ERS. Table 7. "Average U.S. farm prices of selected fertilizers." http://www.ers.usda.gov/Data/FertilizerUse/ Accessed 10/7/08.

seem an accurate estimate. Another option would be to tie fertilizer prices to natural gas prices, because natural gas costs make up 70 percent of all fertilizer production costs.[16] However, given the uncertainty involved in estimating natural gas prices, as well as the potential impact of price fluctuations (which will cause fertilizer prices to rise in the face of uncertainty), this method was not used.

The avoided fuel cycle GHG emissions (i.e., emissions associated with the production, transport, and energy consumption during application) were taken from Wood and Cowie.[17] The estimate provided for the U.S. (taken from West and Marland, 2001[18]) was 858 grams (g) CO_2e per kilogram of nitrogen (kgN).[19] In addition to the avoided fuel cycle emissions, land application nitrous oxide emissions also need to be accounted for. Traditionally, CCS has used information generated by the U.S. EPA's State Inventory Tool. In the absence of alternative data, CCS will use this tool to determine nitrous oxide emission estimates and the assumed emissions factor for nitrogen applied (i.e., X kg CO_2e / kgN applied). Combining these two emission factors provides a total emissions factor per kilogram of nitrogen applied.

Waste Management - Recycling Capital Costs

For other states, CCS has used a value of $129/household for recycling program capital costs, based on an analysis in Vermont.[20] CCS will research the availability of capital cost data specific to New York City and the rest of the state to determine whether more state-specific data are available.

Waste Management – Landfill and Compost Tipping Fees and Transportation Cost

Diverting waste from landfills can reduce costs by avoiding tipping fees. The average landfill tipping fee assumed to represent New York State is $45/ton.[21] Additional transportation and transfer costs are assumed to add $55 per ton to the total disposal cost. CCS will consult the AFW Technical Work Group regarding the potential growth rate of tipping fees. Tipping fees for composting facilities and recycling haulers must also be considered. Tipping fees for composting facilities can range from $15/ton to $50/ton depending on location and type of material being received. For other states, CCS has assumed a tip fee to recycling haulers of $10/ton.[22] It is to be

[16] Huang, Wen-yuan. "Impact of Rising Natural Gas Prices on U.S. Ammonia Supply." USDA. August 2007. http://www.ers.usda.gov/Publications/WRS0702/ Accessed 10/7/08.

[17] Sam Wood and Annette Cowie (2004) *A Review of Greenhouse Gas Emission Factors for Fertilizer Production* Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting.

[18] West, T. O. and Marland, G. 2001. A Synthesis of Carbon Sequestration, Carbon Emissions and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States. Agriculture, Ecosystems and Environment 1812, 1-16.

[19] These emission factors provide an estimate of the typical fuel cycle GHG emissions (including resource extraction, the transport of raw materials and products, and the fertilizer production processes) per unit weight of fertilizer produced (i.e., gCO_2e/kg fertilizer).

[20] P. Calabrese, Cassella Waste Management, personal communication, S. Roe, CCS, 2007.

[21] Personal communication from Resa Dimino of NYS DEC. Provided to B. Strode (CCS) via e-mail.

[22] J. Ketchum, Waste Management, personal communication with S. Roe, CCS, November 20, 2007.

assumed that recycling and composting facilities are closer to the point of generation and an incremental increase in these activities will not lead to a change in transportation costs.

Waste Management - Value of Recycled Materials

Current US market prices for recycled materials are available from the RecycleNet.[23] This service reports current prices for materials such as scrap metal and scrap plastic, as well as, curbside recyclables, including newspapers, office paper, loose waste paper, polyethylene terephthalate (PET), high-density polyethylene (HDPE), aluminum, steel cans, and glass. However, due to the large scale of variability in market prices for recycled material seen in recent years, the value of recycled materials is uncertain. DEC has indicated that NYC estimates total recycling revenues at $7 to $12 million per year.

Waste Management - EPA Waste Management Software Tools

EPA has several models that may be used to estimate GHG impacts or costs of waste management mitigation options.[24] The Landfill Gas Energy Cost Model (LFGcost-Web) estimates costs for landfill gas energy projects. The Waste Reduction Model (WARM) estimates GHG emission reductions from different waste management practices. The Landfill Gas Emissions Model (LandGEM) is a tool for estimating emissions from MSW landfills.

All AFW Sectors - Energy Consumption Emission Factors

Both fuel cycle and standard (fuel combustion) emission factors for energy consumption will be taken from the PSD and TLU quantification methods memoranda, as applicable (e.g., transportation fuels will be taken from the TLU section).

All AFW Sectors - Fuel Prices

As with emission factors above, assumptions for fuel prices will be taken from the applicable ES or TLU quantification methods memoranda.

All AFW Sectors - Electricity Capital Costs and Capacity Factors

Where these estimates are needed, they will also be taken from the PSD quantification methods memorandum.

All AFW Sectors - Renewable Incentives

Inclusion of the federal production tax credit (PTC) in the levelized cost estimates for renewables in the mitigation options analyzed needs to be considered. The federal Renewable Electricity Production Tax Credit has been around in some form since 1992 but seems to always be about to expire (currently December, 2012 for wind and December, 2013 for other renewable sources). The existing incentive for closed-loop biomass is 2.0¢/kWh. Electricity from open-loop biomass, landfill gas, and municipal solid waste resources receives a 1.0¢/kWh credit.

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[23] RecycleNet Spot Market Pricing, http://www.scrapindex.com/index.html.

[24] EPA Waste Management Tools, http://www.epa.gov/cleanenergy/energy-programs/state-and-local/by-topic/waste.html.

PSD Common Assumptions Memorandum - Draft

To: NYS Power Supply and Delivery Technical Workgroup

From: Bill Dougherty and Jeff Wennberg

CC: Tom Peterson, Randy Strait, Jared Snyder, Carl Mas

Subject: Assumptions used in the quantification of options for the PSD Technical Work Group

Date: August 4, 2010

This memo outlines proposed data sources used to quantify the greenhouse gas (GHG) impacts and costs for those PSD Technical Work Group policy options that are considered amenable to quantification. The memo will be reviewed in an upcoming Technical Work Group call so that comments on the assumptions may be made and alternative data sources recommended for Technical Work Group approval. Any changes to this memo will be incorporated and the revised memo will be used as documentation for the modeling results.

The scope of this memo only covers the major assumptions directly related to the quantification of the PSD policy options. Recall that the emissions reductions and costs in the quantification of the policy options occur against the backdrop of the GHG forecast that includes recent state actions. The effects of the policy options are therefore incremental to the activity projected under the forecast. The assumptions embedded in the New York Inventory and Forecast were reviewed during a PSD Technical Work Group call held early in the process.

Quantification Process

The analysis includes spreadsheet modeling techniques in which assumptions are transparent and readily accessible for review. The assumptions delineated in the following document are for the quantification of the priority policy options developed by the PSD Technical Work Group.

This quantification of incremental costs from the introduction of GHG mitigation options and their corresponding CO_2e reductions entails the following steps:

- Establish the levelized cost and GHG emission characteristics of the appropriate power supply resource(s) in the Baseline GHG forecast that would be displaced by the technologies in each priority GHG mitigation policy.
- Develop stand-alone levelized cost estimates for each technology included as part of a quantifiable policy option. Some policies might require that CCS evaluate different scenarios (e.g., renewable resource mix). This will be approached on a case-by-case basis through Technical Work Group-generated design of sensitivity analyses.
- Estimate the incremental costs and GHG reductions for each stand-alone policy.

- After the stand-alone analysis is complete, perform an integrated supply/demand analysis for the PSD sector that accounts for overlaps and any potential double counting among PSD, RCI, TLU, and AFW policies. To account for the issue of credit associated with emission reductions, we propose to start with the Mitigation Case demand forecast, then develop a GHG Mitigation Case capacity expansion plan to meet that demand. This implies a RCI-PSD option analysis sequence and seems most consistent with the way expansion plans would be developed, given demand foresight.

PSD Baseline

An understanding of the Baseline capacity expansion plan, annual electricity generation and associated GHG emissions will be based on the New York State GHG Emissions Forecast developed by NYSERDA (2009). Electricity transmission and distribution losses are estimated at 9 percent on average, based on modeling work done by NYSERDA and the New York Independent System Operator[25], and are assumed to be constant across all regions. As the Baseline forecast is only available through 2018, a linear extrapolation will be made out to the end of the analysis period (i.e., 2030) consistent with an assumption that the system emissions intensity rate (i.e., tCO_2e/MWh) for the 2019-2030 period is the same as the 2018 level. Technical supporting documents for the Baseline forecast (i.e., technology performance assumptions, fuel prices, capacity additions, etc) have been provided by NYSERDA and will be used to better understand the Baseline modeling outputs.

PSD Mitigation

Electricity generation from GHG mitigation technologies are calculated at the technology level and aggregated up based on the policy design. For instance, the electricity produced by renewable sources in the Renewable Portfolio Standard are estimated based on the stipulated resource mix relative to the mix of fossil resources that would be displaced in the Baseline. An assessment of the mix of fossil resources displaced in the Baseline will be made on a policy-by-policy basis in consultation with NYSERDA and the Technical Work Group.

Cost Assumptions

The incremental costs to implement the PSD options are the difference between the levelized costs of GHG mitigation options and the levelized costs of the resources displaced in the Baseline. The assumptions associated with costs calculations are:

- Forecasted fossil fuel prices for the PSD sector and well as technology cost and performance assumptions will be consistent with those used to develop the Baseline power supply forecast.
- Forecasted technology cost and performance assumptions for GHG mitigation options will be consistent with those used to develop the NYSERDA Cost Curve study. These will be augmented/adjusted as needed in consultation with NYSERDA and the Technical Work Group.

[25] Personal communication with Ted Lawrence at NYSERDA on November, 12, 2008.

Electricity Imports

The GHG emissions associated with electricity imports assumes that the emissions intensity over the analysis period is a constant 0.36 metric tons CO_2/MWh on a consumption basis. This is based the State Energy Plan "starting point" generation, demand, and GHG forecasts. It is assumed that cost impacts associated with changes in electricity imports are based on the annual wholesale electricity prices.

Effects of Recent Actions

Relevant recent actions that are not included in the NYSERDA forecast will be accounted for to the extent possible. We assume that the effects of the Renewable Portfolio Standard are included in the NYSERDA electricity and fuel forecasts. It is important to note that the 'Starting Point' only includes the 25 percent RPS. The 45 by15 policy is a bit complicated in that the new 30% RPS is linked to a reduction in load leading to an output where new renewable generation is not much larger. The existing Integrated Planning Model (IPM) runs for the different cases will be reviewed to assess the prospects for a parameterized analysis (i.e., no new IPM runs). In any event, this issue will be further discussed with NYSERDA as the quantification gets underway.

Other Assumptions

The following assumptions are generic to all options:

- Real discount rate: costs and benefits from each option are discounted at a 5 percent real discount over the 2011-2030 period as specified by the Climate Action Plan Quantification Methods Memorandum.
- GHG emission factors: Fuel-based emissions factors are as specified by the Climate Action Plan Quantification Methods Memorandum.
- Technological Change: The impacts of technology learning on capital costs of PSD technologies will be folded into the levelized cost calculations consistent with assumptions developed in the NYSERDA Cost Curve study. The ongoing NYSERDA review of solar-PV price forecasts should be completed by the time the quantification gets underway. In addition, we will aim to incorporate any recommended assumptions from the EPRI review of the Cost Curve study.

Moreover, the quantification of each of the PSD policy options requires additional assumptions that are germane to each option. These are identified in the design for each option and will be incorporated into the analysis in consultation with NYSERDA and the Technical Work Group.

RCI Common Assumptions Memorandum - Draft

To: NYS Climate Action Plan Residential, Commercial/Institutional and Industrial Technical Workgroup

From: Hal Nelson and Steve Bower

CC: Tom Peterson, Jeff Wennberg, Randy Strait, Karen Villeneuve, Jodi Smits-Anderson

Subject: Assumptions used in the quantification of options for the RCI Technical Work Group

Date: July 26, 2010

This memo outlines proposed data sources used to quantify the greenhouse gas (GHG) impacts and costs for those RCI Technical Work Group policy options that are considered amenable to quantification. The memo will be reviewed in an upcoming Technical Work Group call so that comments on the assumptions may be made and alternative data sources recommended for Technical Work Group approval. Any changes to this memo will be incorporated and the revised memo will be used as documentation for the modeling results.

The scope of this memo only covers the major assumptions directly related to the quantification of the RCI policy options. Recall that the emissions reductions and costs in the quantification of the policy options occur against the backdrop of the inventory and forecast. The effects of the policy options are therefore incremental to the activity projected under the inventory and forecast. The assumptions embedded in the New York Inventory and Forecast were reviewed at during the February 5th, 2010 RCI Technical Work Group call.

Quantification Process

The analysis includes spreadsheet modeling techniques in which assumptions are transparent and readily accessible for review. The assumptions delineated in the following document are for the quantification of the policy options developed by the RCI Technical Work Group. This quantification of costs and CO_2 reductions entails the following steps:

- Develop stand-alone cost estimates for each quantifiable option
- Once completed, the stand alone options will be adjusted to reflect existing actions such as the NYS energy efficiency portfolio standard and the April, 2010 customer sited renewable portfolio standard. These are actions that are not in the reference case forecast, but are likely to occur. Adjusting for existing actions eliminates potential "double counting" of greenhouse gas reductions.

- To assess the RCI emission reductions without double-counting, it is necessary to consider overlaps and interactions within the RCI policies and measures as they affect similar types of energy use.
- Options will be also be modified to reflect overlaps between RCI options and other Technical Work Group options. Potential interactions occur between RCI policies and measures that deploy renewable energy with Power Supply and Delivery (PSD) and Agriculture, Forestry and Waste (AFW) mitigation measures. One interaction that could be modeled is the effect of New York's renewable portfolio standard (RPS) and the Power Supply and Delivery policy options on the assumed carbon intensity of electricity delivered to the RCI sectors.

RCI Energy Reductions

Energy savings from efficient technologies and best practices are calculated at the technology level and aggregated up based on energy consumption at the relevant end use. For instance, the electricity savings from light emitting diode (LED) technologies are estimated based on the incremental energy efficiency of LED lighting over the assumed reference technology. These energy savings are then adjusted for lighting energy use as a percent of the RCI sectoral sales, less business as usual LED penetration. Electricity savings are also adjusted for transmission and distribution (T&D) losses according to the formula:

> *Eq 1). Annual energy efficiency deployment: [(technology or practice electricity savings) / (1-T&D losses)]*

Annual baseline energy consumption and GHG emissions will be derived from the most recent NYSERDA NYS GHG Emissions Inventory.

- The baseline electricity demand comes from the "starting point" forecast for RCI sectors through 2030.
- The fuel consumption forecast comes from most recent NYSERDA forecast.

Electricity T&D losses are estimated at 9 percent based on modeling work done by NYSERDA and the NY Independent System Operator[26]. Electricity T&D losses are assumed to be constant across all regions and load periods even though peak electricity T&D losses are higher than baseload T&D losses. Natural gas T&D losses are not initially accounted for as energy savings from avoided natural gas transmission and distribution usage are assumed to be modest. The GHG benefits from reduced gas demand will be discussed qualitatively, but if quantification of policies to conserve natural gas show significant reductions, then avoided fugitive methane emissions might be estimated.

Methodology for Avoided Carbon Dioxide (CO_2) Calculations

Energy reductions for fuel in physical units (Btu) will be converted into GHG emissions reductions according to their relevant emissions factors presented in the quantification methods memorandum. For electricity reductions, the GHG impacts for grid connected RCI policy options are quantified according to the following formula:

[26] Personal communication with Ted Lawrence at NYSERDA on November, 12, 2008.

*Eq 2). CO_2 Reductions in $year_t$: Electric efficiency deployment (GWh) in $year_t$ * CO_2 intensity in tons per GWh in $year_t$*

To estimate emissions reductions from policy options that are expected to displace conventional grid-supplied electricity (i.e., energy efficiency) a straightforward approach is employed based on input from NYSERDA and other stakeholders. Consumption-based emission intensity has been developed that accounts for emissions from imported power, instate generation as well as CO_2 emissions from transmission and distribution losses. A weighted average approach to instate generation and imports was employed based on the State Energy Plan "starting point" generation, demand, and GHG forecasts. Imports over the period were credited at 0.36 metric tons CO_2 / MWh for all periods. The consumption based intensity divides CO_2 emissions from the power sector by electricity demand (instead of generation).[27] Due to reductions in forecasted T&D losses as well as increased penetration of renewables and other lower carbon fuels, the forecasted emissions intensity in metric tons CO_2/MWh is forecasted to decline dramatically in NY in the near term. The following table shows the electricity emissions intensity assumptions employed:

Table E-6: Consumption-Based Electricity Emissions Intensity [2009 PLACEHOLDER]

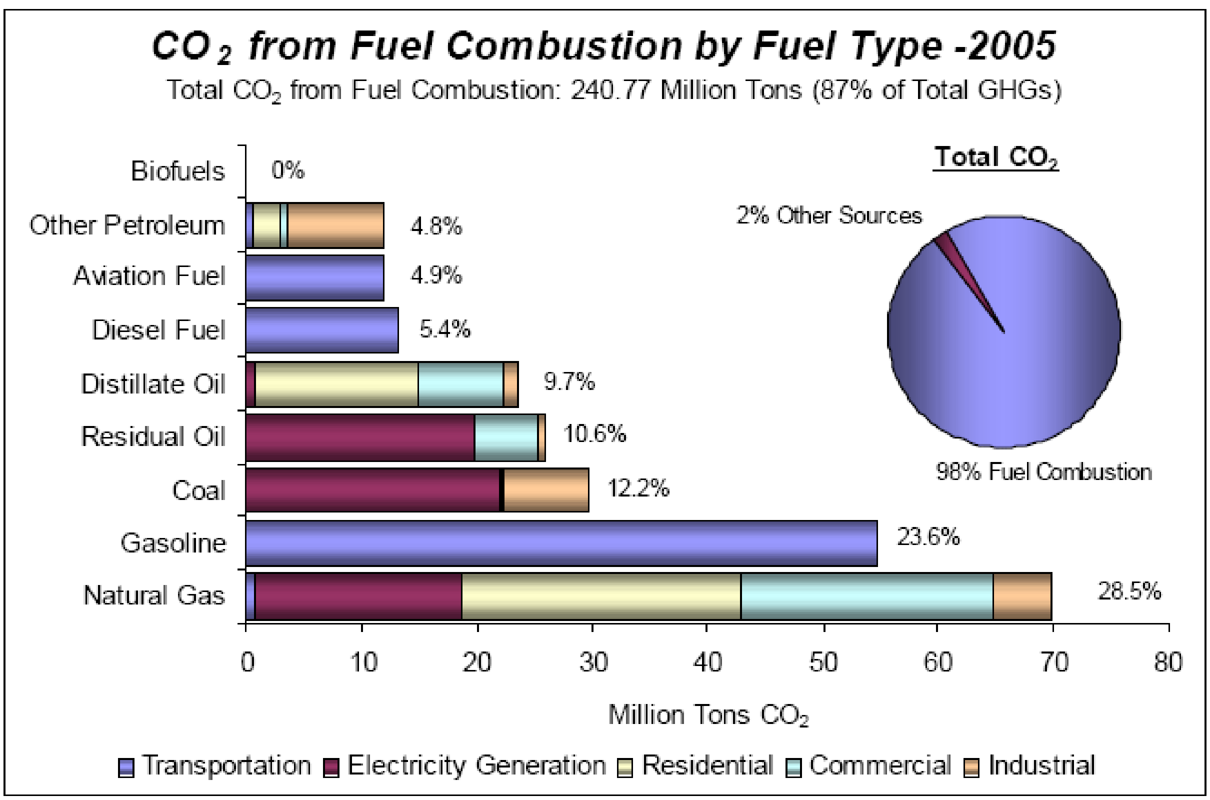
Year	Tonnes CO_2 / MWh
2006	0.42
2007	0.38
2008	0.35
2009	0.33
2010	0.31
2011	0.31
2012	0.30
2013	0.30
2014	0.30
2015	0.29
2016	0.29
2017	0.29
2018	0.29
2019	0.29
2020	0.29
2021	0.29
2022	0.29
2023	0.29
2024	0.29
2025	0.29

[27] The consumption based approach is slightly higher than the production based intensity. The consumption based approach makes more sense from a theoretical standpoint as emissions from T&D losses are mitigated from RCI end user activities.

Year	Tonnes CO_2 / MWh
2026	0.29
2027	0.29
2028	0.29
2029	0.29
2030	0.29

Current electricity load forecasts are available through 2030.
This approach provides a transparent way to estimate emissions reductions and to avoid double counting (by ensuring that the same megawatt hours (MWh) from a fossil fuel source is not "avoided" more than once). It can be considered a "first-order" approach; it does not attempt to capture a number of factors such as the distinction between peak, intermediate, and baseload generation; issues in system dispatch and control; impacts of nondispatchable and intermittent sources such as wind and solar; or the dynamics of regional electricity markets. These relationships are complex and could mean that policy options affect generation and emissions (as well as costs) in a manner somewhat different than estimated here. Nonetheless, this approach provides reasonable first-order approximations of emissions impacts and offers the advantages of simplicity and transparency that are important for stakeholder processes.

Figure E-2. 2005 CO_2 Emissions in New York State



Cost Assumptions

The cost to implement the RCI options are the net difference between the avoided costs of energy and the cost of the energy efficiency measures where:

*Net costs (benefits): Energy efficiency deployment * (avoided cost of energy – levelized cost of measures including administrative costs)*

The assumptions associated with costs calculations are:

- Forecasted fuel prices for the RCI sectors come from the most recent NYSERDA price forecast.
- Avoided electricity prices from Optimal (2010) for the RCI sectors are used for avoided costs and are estimated in the following manner:
    - For each year following the end of the available forecast period, the prices are changed by the annual forecasted change in price of electricity from table 67 of the detailed outputs to the AEO 2010 for the NERC region.[28]

Effects of Recent Actions

Relevant recent actions that are not included in the NYSERDA forecast will be accounted for to the extent possible. The federal Energy Independence and Security Act (EISA) of 2007 was signed into law in December 2007. This law contains several requirements that will reduce GHG emissions as they are implemented over the next few years. We assume that the effects of the EISA are included in the NYSERDA electricity and fuel forecasts.

Relevant updates to New York's mandatory building energy codes are also identified in the analysis. NYS' residential code is based on the 2004 International Code Council's International Energy Conservation Code (IECC). For commercial buildings New York references the 2003 IECC code and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 standards.

Planned activities such as the NYS Energy Efficiency Portfolio Standard (EEPS) 15% efficiency target by 2015 (45 by 15), as part of the Governor's proposal to have 45% of electricity come from renewables and energy efficiency, will be explicitly modeled as appropriate.[29] The April 2nd, 2010 RPS order will be included as a recent action "wedge" between what would have happened in the baseline through 2015 and the Climate Action Plan policies.

Evolving policies with market-driving effects such as the governor's Executive Order 111 for state buildings, which ends in 2010, New York City legislation in response to the Mayor's PlaNYC2030, and other currently planned energy efficiency interventions by NYSERDA, Long Island Power Authority (LIPA), and New York Power Authority (NYPA) will be analyzed, as

[28] http://www.eia.doe.gov/oiaf/archive/aeo08/index.html

[29] A scenario with the effects of the 15% energy efficiency savings by 2015 is estimated as the difference between the "starting point" load forecast and the 15x15 in the most recent forecast file.

budget and project time allow, to assess baseline penetration rates of selected efficiency measures.

Other Assumptions

The quantification of each of the policy options requires additional assumptions that are germane to each option and are described in detail in the policy option document. For instance, there are many building code assumptions in that policy option. However, the following assumptions are generic to nearly all options:

- Real discount rate: costs and benefits from each option is discounted at a 5 percent real discount over the 2010-2030 period as specified by the NY Climate Action Plan Quantification Methods Memorandum.
- Technological Change
    - An examination of historical energy efficiency equipment, including compact florescent lights, solar PV, heat pump water heaters, and other measures shows learning curves that result in capital cost reductions over time. The installed costs and value of energy savings are sensitive to future conditions. Learning curves will be used for selected measures to account for economies of scale in production which result in cost reductions over time. Learning curves will come from the most recent, reliable data sources.

TLU Common Assumptions Memorandum - Draft

To:	New York Climate Action Council
From:	Hillel Hammer
cc:	Tom Peterson, Jeff Wennberg, Randy Strait, Sandi Meier, Ernest Tollerson and Paul Beyer
Subject:	Analysis and Assumptions for Transportation and Land Use Policy Options
Date:	July 12, 2010

This memo summarizes key elements of methods of analysis aimed at estimating potential greenhouse gas (GHG) emission reductions and cost effectiveness of Transportation and Land Use (TLU) policy options in the New York State Climate Action Plan process. The process of policy analysis is intended to support state-specific design and analysis of draft policy options, while providing for both consistency and flexibility.

Key general guidelines for policy analysis as conducted by Center for Climate Strategies' consultants are presented first, followed by specific elements of policy analysis methods and assumptions for Transportation and Land Use issues.

1. GENERAL GUIDELINES FOR POLICY ANALYSES

The following outlines the central guidelines for policy analysis. For a complete description of all general guidelines for policy analysis, see *Draft Quantification Methods Memorandum—New York State Climate Action Plan*, July 2010 ('Quantification Memo').

Fuel Cycle Coverage

GHG reductions for each mitigation option in TLU will be based upon the full fuel cycle because information is available to support this type of analysis for this sector (see more in Section 2 below).

Life Cycle Coverage

As mentioned above, there are other mitigation policy options that will also have important life cycle impacts. These include those associated with reducing non-fuel consumables, such as concrete and steel. Life cycle impacts will be reported for each source for which information is available to support a life cycle analysis. For TLU, this will focus mostly on construction materials, where possible. It will not be possible to identify in-State versus out-of-state sources for these construction materials.

Pollutant Coverage and Global Warming Potentials

The analysis will cover the six Kyoto GHGs, presented as carbon dioxide equivalent (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing. This will be based on the approach outlined by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report, consistent with the draft GHG emissions inventory and forecast for the state of New York and with the U.S. Environmental Protection Agency (EPA) and IPCC guidance.

Time Period of Analysis

For each sector, life cycle emission reductions and incremental life cycle costs will be calculated relative to the characteristics of the Baseline that would otherwise prevail in New York up through the end of the planning period, 2030.

The analysis will report annual emission reductions for 2020 and 2030. The net present value of the cumulative costs, and cumulative emission reductions, will be reported for the period starting with the initial year of the phase-in of the policy, up through 2030. For long-term capital investments, the investment will be annualized over the lifetime of the project operation, and the portion included in the analysis period will be included.

Transparency

Analyses will be performed in spreadsheet format to the extent practicable, to enable maximum transparency and facilitate review. Exceptions to this will be only in cases where external models such as GREET are required (see details on the model in Section 2).

Data sources, methods, implementation mechanisms, key assumptions, and key uncertainties will be documented and supported by references to provide transparency on how the key analytical outputs for each policy option were developed and applied. Information provided by the state agencies and project participants will be used to ensure best available data sources, methods, and key assumptions using their expertise and knowledge to address specific issues in New York State. Modifications will be made through facilitated discussions.

Key Analytical Outputs and Metrics

GHG Emission Reductions

Net GHG reduction potential in physical units of million metric tons (million metric tons or MMt) of carbon dioxide equivalent (CO_2e) will be estimated for each quantifiable policy for target years 2020 and 2030, as well as the total for the entire analysis period.

Costs

Net capital, operating and maintenance (O&M), and fuel costs will be estimated for each of the policies that are determined quantifiable. Costs will be discounted as a multi-year stream of net costs to arrive at the "net present value cost" associated with implementing new technologies and best practices. It is proposed that costs be discounted in constant 2005 dollars using a 5 percent annual real discount rate. The nominal discount rate will be calculated by adding the projected inflation rate over the analysis period. Capital investments will be represented in terms of annualized or amortized costs over the project period. (See the section on "Cost Analysis Methods" for additional details.)

Cost savings (e.g., fuel savings) will be included, represented as a negative cost. If significant financing costs or split incentives (cases where the benefits are not reaped by the investor) are expected, these will be identified.

Cost-effectiveness

The cost effectiveness—cost or savings per tone—for each quantified policy, represented as dollars per MMt CO_2e (\$/MMtCO_2e), will be calculated by dividing the present value cost by the cumulative (undiscounted) reduction in GHG emissions. When combined with GHG impact assessments, the results of these cost estimates will be aggregated into a sectoral summary table and sector and economy-wide stepwise marginal cost curves.

Direct vs. Indirect Effects

"Direct effects" are those borne by the entities subject to or directly affected by the policy or entities implementing the new policies. For example, direct costs are net of any financial benefits or savings to the entity. Direct effects will be quantified.

"Indirect effects" are those borne by entities other than those defined for "direct effects". Indirect effects will not be quantified.

Non-GHG (External) Impacts and Costs

Environmental co-benefits such as reductions in criteria air pollutants, which in turn would lead to reduced public health impacts from productive activities in New York, will not be quantified. Qualitatively, CCS will document measures that are expected to have other non-GHG impacts, including, but the physical and monetary costs or savings associated with these external impacts will not be included explicitly in this analysis.

Uncertainty / Sensitivity Analysis

Key uncertainties and feasibility issues will be identified and discussed qualitatively.

Calculation of Emissions

Emission reductions will be estimated incremental to baseline emissions based on the change (reduction) in emissions activity (e.g., reduced vehicle miles traveled—VMT), calculated either directly, by using the same factors applied in the baseline inventory (e.g., reduction in fuel consumed and fuel-based emission factors), or as a fraction of the baseline inventory (e.g., fraction of baseline VMT and associated emissions reduced).

Emissions associated with electricity consumption will be calculated based on the procedures outlined for the PSD sector. Electric demand by vehicles may be calculated using the NY-GREET model (see Section 2 below).

Calculation of Costs

Net capital, operating and maintenance (O&M), and fuel costs will be estimated for each of the policies that are determined quantifiable. Costs will be discounted as a multi-year stream of net costs to arrive at the "net present value cost" associated with implementing new technologies and best practices. It is proposed that costs be discounted for all options in constant 2005 dollars using a 5 percent annual real discount rate. The nominal discount rate will be calculated by adding the projected inflation rate over the analysis period.[30] For full details on cost calculation, see the Quantification Memo.

Documentation

Documentation of the work will be completed in a template format that addresses the following items (among others):

Work Group Sector

Name of policy option

Policy Description

Policy Design (Goals and Timing for implementation and parties involved or affected by implementation of the policy.)

Implementation Mechanisms

Quantification: Estimated GHG Savings and Costs per MtCO2e (GHG reduction potential in 2020 and 2030, Cumulative GHG reduction potential, net cost, data sources, and quantification methods)

Key Assumptions and Uncertainties

Co-Benefits and External Costs (qualitative discussion)

POLICY ANALYSIS METHODS AND ASSUMPTIONS SPECIFIC TO TRANSPORTATION AND LAND USE ISSUES

Policy analysis of transportation and land use issues is inherently complex, given the inter-relationships between transportation systems, land use, and other important aspects of societal well-being. Policy analysis methods for transportation and land use as conducted by consultants for CCS is based upon many years of well-established professional practice and methods that are widely accepted in the fields of public policy analysis, urban and transportation planning, transportation engineering, and environmental sciences. The information provided here provides information about analyses relating to the potential changes in GHG emissions in the transportation sector resulting from the combustion of transportation fuels and use of electric power. In addition, GHG emissions associated with the production and transport of standard and alternative fuels ('fuel-cycle emissions') and with construction activity and materials are included where information and methods are readily available.

There are four general categories of factors that impact upon the emission from the transportation sector: vehicles, fuels, systems, and travel activity. These four factors interact in a complex

[30] The inflation rate for the analysis period is assumed to be 2.2%, subject to approval by the Integration Advisory Panel and Climate Action Council. Capital and other costs reported in nominal dollars will be converted to 2005$ using the inflation rate for the NY state region as reported by the Bureau of Labor Statistics (http://www.bls.gov/ro2/news.htm)

fashion to affect GHG emission. In addition, direct and indirect emissions may be associated with construction and infrastructure.

Underlying Premises and Methodology

Simple spreadsheet modeling techniques in which assumptions are transparent will be used for the analyses as much as possible. To ensure consistent results across options, common factors and assumptions will be used for the following items:

Independent and integrated analyses: Each option will first be analyzed individually and then addressed as part of an overall integrated analysis.

Fuel Costs and Projected Escalation: Fuel cost estimates will be based on common sources wherever possible. For example, fossil fuel price escalation will be indexed to the U.S. Department of Energy (DOE) projections as indicated in their most recent Annual Energy Outlook (AEO).

Consumption–Based Approach: The analysis uses a consumption-based approach where emissions are calculated on the basis of the consumption of transportation fuels (represented as direct fuel consumption or as vehicle miles traveled) to provide energy to New York consumers, as opposed to a production-based approach, which considers the emissions from in-state production of transportation fuels.

Life cycle Emissions: Life cycle greenhouse gas emissions are considered on a case-by-case basis. The primary focus of the analysis of Transportation and Land Use issues is upon the direct combustion of transportation fuels to provide energy. Energy cycle of fuels will be included, and construction impacts will be included where practicable.

Overlap with Other Sectors: Where TLU options overlap with options being considered in other Technical Work Groups, the analysis for these options will be conducted in close coordination with the assumptions and other inputs used in other CCS analyses.

Data Sources

TWG members are often in a good position to obtain and provide data sources that are specific to New York, and these will be used as much as possible, including data already provided by NYSDOT, MTA, and others. Where New York-specific information cannot be readily obtained from the Technical Work Group, the analysis relies on other local data available to the consultants, and on published data from the DOE, EPA, national laboratories, other federal agencies, and other state climate change processes.

The analysis of renewable fuels and the use of electricity for vehicles will be based on output from the New York-specific application of the Argonne National Laboratory’s Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model (NYGREET), prepared for this effort (also used in the baseline inventory).

General data sources will include:

Baseline Historical Energy Consumption by Sector

Historical energy consumption in the state, by sector, is from the DOE Energy Information Administration (EIA) State Energy Data available at http://www.eia.doe.gov/emeu/states/seds.html.

Baseline Historical Vehicle Fleet, Fuel Use, and Travel Activity Data

Baseline data on the state vehicle fleet, fuel use, and travel activity data is obtained from the latest inventory and forecast provided by NYSERDA. (Data sources, and methods of analyses for the baseline and forecast are described in the inventory and forecast.)

Baseline Forecast GHG Emissions

Baseline forecasts of future GHG emissions for the transportation and land use sector is obtained from the inventory and forecast report.

Energy Price Projections through 2030

Energy prices by region are from the EIA Supplemental Tables to the AEO 2010, with projections through 2030. Adjustments to the EIA projections are made on a case-by-case basis.

Cost Inclusion

The analytical methods being used can incorporate a wide variety of costs, depending on the availability of cost data. Fuel costs are incorporated into all analyses where relevant. Other types of costs will be explicitly considered in the analysis if they can be readily estimated. Types of costs that may be incorporated include:

Annualized Capital costs levelized (amortized);

Operations and maintenance cost; and

Administrative costs.

Types of costs that will not be incorporated include

External costs, such as the monetized environmental or social benefits and impacts (e.g., the cost of damage by air pollutants on structures and crops), quality-of-life improvements, and health impacts and benefits (e.g., improved road safety);

Energy security benefits; and

Macroeconomic impacts related to reduced or increased consumer spending, and shifting of cost and benefits among different sectors of the economy.

Appendix F
2050 Visioning:
Brookhaven National Laboratory Report

As part of its climate action planning, the state of New York is unique in undertaking a visioning process to assist the long-range goal of reducing greenhouse gas emission 80 percent below the levels emitted in 1990 by the year 2050. To develop a plan capable of setting in motion the radical, long-term changes required to achieve the 80 by 50 goal, the Council and its technical work groups and panel — indeed, decision makers at many levels — must be able to imagine the kind of low-carbon clean energy future toward which they are working.

An initial step in that visioning process was a conference held January 5, 2009, Envisioning a Low-Carbon Clean Energy Economy in New York. The conference, organized by the New York Academy of Sciences, Brookhaven National Laboratory, the New York State Energy Research and Development Authority, and the New York State Department of Environmental Conservation, involved members of the Climate Action Council, the Integration Advisory Panel, and the Technical Work Groups.

Led by subject matter experts, the participants in the workshop explored innovative strategies for meeting the State's energy needs, reducing energy demand, managing greenhouse gas (GHG) emissions, driving technological change, and creating economic opportunities for "green-tech" in New York. The workshop considered specific scenarios that outlined possible pathways to reducing GHG emissions. The purpose was not to validate a particular pathway, but rather to explore possibilities and their implications, as well as to identify obstacles to achieving the goal.

The January conference led to the creation of the report, *Envisioning a Low-Carbon Clean Energy Economy in New York,* produced by Brookhaven National Laboratory and appended here in its entirety and keeping its original pagination.

Envisioning a Low-Carbon 2050 for New York State

A white paper submitted to the
New York State Climate Action Council

by Gerry Stokes and Patrick Looney
Brookhaven National Laboratory
Upton, NY 11973

October 1, 2010

Contents

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Important note to readers:

This is the first complete draft of a paper designed to inform the NYS Climate Action Council's work to develop a State Climate Action Plan.

The Council's mandate is uncommonly broad in scope. It has a planning horizon far longer than what most planners address. It entails large uncertainties. No clear precedent for an enterprise of this scope exists.

Consequently, this draft paper is necessarily provisional. As the planning process proceeds, the paper will be revised, and it will steadily gain in value as fresh insights are acquired and the knowledge base it draws from expands.

One feature of this paper is a description of three scenarios that illustrate different versions of a low-carbon 2050 future for the state. It's important that readers understand that these scenarios are offered for illustrative purposes only. In no sense do they constitute the elements of a plan, and indeed even a casual review of them reveals that there is no way in which they could be fashioned into a plan. Rather, they're intended to facilitate and provoke thinking about the future.

We hope other parties will generate their own 80x50 scenarios and share them. The ability to *imagine* a sustainable future, model it rigorously, and explore it is as vital to achieving that future as the clean-energy technologies, best management practices, and behavioral changes that must be developed, advanced, and adopted.

SUMMARY

The State of New York aims to reduce state greenhouse gas (GHG) emissions to 80% below 1990 levels by 2050. The fact that the state is already more energy efficient than most other states makes this goal particularly ambitious. A State Climate Action Council is charged with developing a draft Climate Action Plan by November, 2010. Toward this end, it has organized technical work groups and an integration advisory panel of stakeholders and experts.

To develop a plan capable of setting in motion the radical, long-term changes required to achieve the 80x50 goal, the Council and its team must be able to imagine the kind of low-carbon future toward which they are working. To facilitate this, the Council also formed a 2050 Visioning Advisory Panel. Comprising experts from many fields, that panel was convened at a workshop held on January 5, 2010.

This draft visioning paper draws from insights and knowledge shared at that workshop, and from other expert sources. It also draws from three GHG mitigation scenarios for 2050 that we developed for the workshop to illuminate how a low-carbon future might be achieved, and what it would mean. Making assumptions about future energy demand, patterns of energy use, the technologies that might be available to supply needed energy with reduced emissions, and what their levels of performance might be, we estimated emissions for each major sector of the state's economy. We found that reaching the 80x50 goal is challenging and that modeling required aggressive assumptions.

Together, the workshop, scenario development, and the crafting of this visioning paper constitute a "visioning process." Its focus has been manifold: an examination of technologies that might prove scalable and those that might be dead ends, of technical issues that require assessment, of policies that favor or constrain GHG reductions, and of management and societal changes needed to reduce emissions.

While the state's energy future cannot be predicted, some points are already clear, among them, these:

- Reducing emissions is imperative because atmospheric levels of GHGs are already perilously high, and emissions are cumulative – and there are real costs associated with inaction.

- The 80x50 goal is ambitious, and achieving it will require investments in new energy systems and infrastructure that have very low or no net carbon emissions. Patterns of energy use will also need to change.

- Energy efficiency is an essential, but not sufficient, strategy that can be aggressively pursued today.

- A broad shift from reliance on burning fossil fuels to electricity generated from low- or no-carbon sources, or widespread use of carbon capture and sequestration, will be needed.

- Transportation and buildings (residential and commercial) will have to move away from reliance on combustion of fossil fuels to alternate sources with significantly lower carbon or no carbon emissions.

- Development and redevelopment based on smart growth principles, as well as the building design practices, building technologies, and construction methods can significantly reduce the energy demand for buildings, as well as transportation.

- Incremental, short-term planning cannot achieve the goal. Near-term decisions – both those taken and not taken – can preclude longer-term options, such as infrastructure projects requiring long lead times. Key climate strategies *must* reflect this inexorable reality.

- The goal must be pursued in part through extensive, long-term partnering among all levels of government and across the region, and between the public and private sectors. It will take sustained effort on the part of all.

THE BROAD CONTEXT FOR THIS PAPER

In the face of climate change, the stakes are so high, the challenge so immense, and the opportunities so richly promising that business as usual and conventional wisdom are themselves risky. Innovation is imperative — not only in technology but in ways of thinking, working, and living.

In fact, what's demanded transcends "innovation": transforming an entire economy from largely carbon-based energy sources to largely carbon-neutral sources in a scant 40 years will be a true revolution, a radical shift that can renew New York's economy, enhance its natural environment, and improve its citizens' quality of life for generations to come.

For this revolution to succeed, institutions must be mobilized, businesses must adapt or fail, and individuals, families, and communities must make better-informed energy choices. And all of this change must be scaled up massively and rapidly.

The 80x50 challenge

Recognizing the benefits of action and the risks of inaction, in August 2009 the Governor signed Executive Order 24, which tasks the State to reduce GHG emissions from all sources within the state to a level 80% below the 1990 level by 2050. It establishes a Climate Action Council that is to develop a Climate Action Plan to achieve that goal, taking into account economic and other considerations. The plan is to be drafted by November, 2010. The Council will hold public comment hearings on the draft and after reviewing comments prepare a final plan.

That plan will be reviewed annually and revised as appropriate. The Executive Order says it "is not intended to be static, but rather a dynamic and continually evolving strategy to assess and achieve the goal of sustained reductions of greenhouse gas emissions."

To advance and inform its work, the Council has convened stakeholders from New York, as well as experts from New York and beyond, and organized them into technical work groups and an integration advisory panel. Working in support of the Council and these groups is the Center for Climate Strategies. The Council's comprehensive web site offers detailed information about its work, and it links to the *New York Greenhouse Gas Emissions Inventory and Forecast*. Readers unfamiliar with the Council are urged to consult the site for essential information that complements this paper.

How visioning contributes to the Council's work

To develop a plan capable of setting in motion the radical, long-term changes required to achieve the 80x50 goal, the Council and its technical work groups and panel must be able to imagine the kind of low-carbon clean energy future toward which they are working. To facilitate this, a 2050 Visioning Advisory Panel comprising experts drawn from many fields was convened at a January 5, 2010, workshop held at the New York Academy of Sciences. At the workshop, the experts made presentations and responded to concerns and questions from the floor. (The link above leads to a link to a webinar of the workshop, the slides speakers showed, and the agenda.)

This draft paper draws from insights and information shared at the January workshop. It also draws from many other expert sources, such as reports from the National Academies of Science. And it draws from three GHG mitigation scenarios for 2050 that we developed for the workshop, described below. Together, the workshop, the development of scenarios, and the crafting of this visioning paper constitute what may be termed a "visioning process."

The focus of the process has been manifold: an examination of technologies that might prove scalable and of those that might be dead ends, of technical issues that must be addressed, of policies that favor or constrain GHG reductions, and of management and societal changes needed to reduce emissions. Of course, policies that favor GHG reductions must be implementable. But for a time horizon so far distant, at this early stage, technical feasibility and cost considerations can be considered only in broad-brush terms. This paper treats them accordingly.

Our scenarios suggest that, in concept, the 80x50 goal is technically possible. The overall visioning process makes clear that incremental, short-term planning alone cannot meet the goal and that even a sophisticated long-term approach must surmount serious challenges. This in turn underscores how important it is that climate change vulnerability analyses and adaptation planning proceed on equal footing with mitigation efforts.

But the scenarios reveal a world of opportunities, too, that hold tremendous potential for the state's economy and its citizens' well being.

THE APPROACH TO ENVISIONING A LOW-CARBON 2050

The technical work groups that are contributing to development of the State's Climate Action Plan process are responsible for recommending specific strategies, policies, and actions for the Council's consideration. The visioning process, defined above, was designed to complement their work. Scenarios are a uniquely valuable tool for this purpose. Scenarios have been widely and routinely used, for many years, in many fields, as a tool for exploring options and contingencies. The three scenarios we developed for the State's January visioning workshop investigated the technical feasibility of the 80x50 goal and identified some technology options and best practices that could achieve the goal. The scenarios also helped us identify some significant technical barriers and policy issues that might facilitate or constrain those options.

To model and gain insight into possible futures, we "worked backward" from an imagined mid-century New York that has far lower GHG emissions. Making assumptions about future energy demand, patterns of energy use, what technologies might be available to supply energy and reduce emissions and what their levels of performance might be, we estimated emissions for each major sector of the economy, considering many interchangeable elements that might be dictated by policy implementation, technology breakthroughs, or market developments in the US and abroad.

The value of the scenarios is in providing a framework for thinking concretely about how energy efficiency, new energy technologies, fuel switching, best practices, and other matters might shape the path to a low-carbon future. Scenario modeling can also provide insight into performance levels for new energy technologies such as plug-in hybrid electric vehicles (PHEVs), or emission-reduction technologies such as carbon capture and storage (CCS).

All three of the 80x50 scenarios share important characteristics:

- An end state is postulated for each major energy-consuming sector of the economy: Transportation, Electricity Production and Distribution, Residential Buildings, Commercial Buildings, and Industrial. These end states are largely characterized by their technological characteristics, such as low carbon-emitting central generation of electricity, electric vehicles, and net-zero carbon emission buildings.

- Next, the ramifications of these technology options are examined. For example, if the state were to depend on hydrogen as a transportation fuel, how would the hydrogen be produced? Similarly, if the goal is low-carbon electricity central generation, what are the technology options for generating that power?

- Finally, the resulting scenario is referenced to a projection of what the energy use may be in absence of carbon abatement policies; that is, in the "business as usual case" (BAU). This comparison illuminates, for example, the magnitude of energy-efficiency gains that might be required, or the extent to which projected transportation needs that light duty vehicles would otherwise meet could be met by expanded mass transit instead.

THREE SCENARIOS FOR 2050

Models, assumptions, and limitations

The three scenarios were designed to answer these basic questions:

- What are possible, illustrative scenarios in which NYS GHG emissions would be ~80% lower than the 1990 level of ~251.4 million metric tons (MMt) of CO_2 equivalent (CO_2e)? (a goal of about 51 MMt)
- What are the implications of such scenarios?

To support the modeling exercise, a macro model of statewide GHG emissions was developed. Data are presented in Table 1, below. Emissions data for 2007 are the most recent available and are considered "current" for the purpose of this paper. NYSERDA projects that 2025 annual GHG emissions will be 266 MMT CO2e, a relatively small increase from current levels. The relative contributions of the various sectors remain unchanged, except that the "Other Source" category (non-fuel combustion) is projected to surpass residential emissions by 2025. ("BAU" is the "business as usual projection.")

Table 1. Sector GHG Emissions for Select Years (in Million Metric Tons CO_2e)

	1990 (actual)	2007 (actual)	2025 (forecast)	2050 (BAU Projection)
Transportation	72.9	88.4	93.4	114.3
Electric	64.5	49.2	42.9	75.5
Electric Imports	1.7	7.4	7.6	-
Residential	34.1	37.6	34.7	40.8
Commercial	26.8	27.3	30.1	35.4
Industrial	25.0	19.2	18.7	21.9
Other	26.5	28.7	38.5	39.0
TOTAL	251.4	257.7	266.0	326.6

Scenario modeling was a rigorous process that began by estimating the total energy demand that might have to be met in 2050 in each sector. This was done by extrapolating current forecasts and assuming modest growth in state GDP and hence energy demand.

These assumptions create the future "business as usual" (BAU) emissions scenario – the case that perpetuates the path we are on. BAU energy demand projection estimates the energy supply needed to support the state's economy in 2050 given our current patterns of transportation, energy use and efficiency.

The foundation of our scenario development is a state-level, coupled-sector macro model of energy supply flows and corresponding (calculated) emissions for each sector of the economy. In addition, possible reductions in non-energy related emissions (the "Other", non-energy related category) were estimated.

Table 2. Estimated Energy Demand by Sector

	2007 (actual)	2025 (forecast)	2050 (BAU Projection)
Transportation			
LDV/HDV VMT	136B Miles	170B Miles	224B Miles
Aviation	210 Mbtu	222 Mbtu	240 Mbtu
Electric	165,000 GWh	187,000 GWh	270,000 GWh
Residential	591Tbtu	629Tbtu	721Tbtu
Commercial	533Tbtu	557Tbtu	587Tbtu
Industrial	191 Tbtu	180 Tbtu	180Tbtu

In the table above "LDV" means 'light duty vehicle; "HDV" means "heavy duty vehicle; "VMT" means "vehicle miles traveled."

We then took the energy demand forecast for each sector, presented in Table 2, above, and traced energy flows through each sector as primary energy (e.g., coal, biomass) and energy carriers (e.g., gasoline, #2 and #6 oil, coal, etc.) would be used for such purposes as creating electricity, heating homes, providing power for businesses and manufacturing sectors, and fueling light duty and heavy duty vehicles. For each of those uses, we calculated corresponding emissions. Fuel energy content and emissions factors for combustion come from US EPA data tables.

Significantly, unlike conventional "wedge" models, which treat sectors as freestanding, the coupled-sector model we employed reflects the fact that switching technologies in one sector may raise or lower demand in another. For example, two scenarios (the "Yellow" and "Ultraviolet") depend on widespread use of PHEVs in the transportation sector, resulting in a decrease in gasoline demand and an increase electricity demand; thus, primary energy demand switches to the electricity sector.

A note of caution: The scenario modeling provides insights into how technologies and patterns of energy use may have to change to meet emissions targets. But there are limitations to using the scenarios. This sort of modeling is not a practical planning tool, as it does not account for the crucial factor of scalability, or for economic, regulatory, and other barriers to the implementation of any given technology, including the availability of the raw material required. Nor does it take into account lifecycle analyses of nuclear power and renewable energy technologies. The models also do not consider the future interaction between a changing climate and energy use and impacts on the performance of different technologies.

The models do include estimates of the performance of new and emerging energy technologies for which the predicted development time scales are commensurate with the State's 40-year planning timeframe. Assumptions about the performance of new, emerging energy technologies are based on credible estimates from available literature, though there can be no guarantee that as-built systems will meet the estimated levels of performance, be economically viable, or penetrate the market at rates needed to meet assumed levels.

A note on methodology and references: For more information on methodology and data sources used in our modeling, please see Appendix A. For more detail on the scenarios, see Appendix B.

Basic strategies for reducing emissions

Developing scenarios that illustrate potential approaches to meeting the 80x50 emissions target of ~50 MMT CO2e requires recognition of the fact that those emissions result from activities that power our society and our economy, providing food, shelter, heating and cooling, communications, transportation, and innumerable other things essential to well-being. Cutting GHG emissions could have real-world consequences if low-carbon or no-carbon energy sources don't adequately replace fossil sources.

The scenarios rely on four key strategies to reduce GHG emissions:

- The simplest and the most cost-effective is energy conservation through energy efficiency.

- Reducing combustion from fossil fuels is another obvious strategy, as that combustion accounts for about 87% of all GHG emissions in New York State, with the largest fraction coming from the transportation sector (38%), followed by on-site combustion in the residential, commercial, and industrial sectors (37%), and then from electricity generation (22%). All scenarios assume that combustion of fossil fuels should only be used when and where necessary, or where controls such as CCS effectively limit emissions. Minimizing point sources of combustion such as vehicles and use of oil and natural gas for heating, and switching to electricity, coupled with simultaneously reducing the GHG footprint of the electricity supply, thus constitutes the second strategy.

- The third strategy is to drive fuel switching where combustion must still be used, as in aviation and cement production, to minimize the GHG footprint.

- Using local, point-of-use renewable energy technologies such as solar to reduce the reliance of homes and businesses on centrally generated electricity is the fourth strategy.

By varying these strategies and devising portfolios of energy technologies and practices that could implement them, we created three scenarios that we named "Yellow," "Deep Blue," and "Ultraviolet." The Yellow scenario falls far short of the 80x50 goal; the other two scenarios meet it, in different ways.

The Yellow scenario

The Yellow scenario does not meet the ~50 MMT CO2e GHG emissions challenge. It is intended to be a "first cut" at reducing GHG emissions through increased efficiency: the adoption of more efficient energy technologies that are largely available today, or will be soon. This scenario assumes a significantly different mix of light-duty vehicles (LDV) in use in 2050, with 30% being conventional internal combustion engines with an average of 37 mpg, 30% being hybrid electric vehicles (HEV) with an average of 50 mpg, and 40% being plug-in hybrid electric vehicles (PHEV) with 95% all-electric miles. This produces a modest increase in demand in the electricity sector of about 20,000 GWh. The use of intermodal freight shipping is assumed to reduce vehicle miles traveled (VMT) for HDV by about 30%.

In the electricity sector, it's assumed that New York State wind and hydro-electric generation will be built out to meet the maximum forecasts developed by NYSERDA, and that there will be a very significant increase (up to 100,000 GWh) of utility-scale solar electric generation or other renewable source such as off-shore wind. Where combustion is used for electricity, a switch to higher-efficiency natural gas combustion turbine (NGCT) and integrated gasification combined cycle (IGCC) power plants with CCS at 90% is assumed. It's also assumed that present levels of nuclear power generation can be maintained. Transmission and distribution losses are reduced by 50% to an average of 4% for the entire system. Residential, commercial, and industrial sectors reduce electricity demand via Energy Star+ efficiency gains.

This scenario includes elimination of 75% of all fossil fuel combustion in the residential and commercial sector, with natural gas and liquid fuels replaced by electricity, some generated on-site via solar (about 10% of the energy demand), and the balance generated at utility plants. Industrial emissions are reduced by curtailing fossil fuel combustion overall by 75% and using only natural gas and #2 oil; coal is eliminated in favor of natural gas.

Reductions in non-energy emissions (the “Other” category) assume elimination of sulfur hexafluoride (SF_6) dielectric from the transmission and distribution grid. Per molecule, SF6 has the highest GHG warming potential, about 23,900 times that of CO2. Reducing natural gas line leaks (by 50%), implementing a broad and aggressive *reduce, reuse, and recycle* policy, and eliminating leaks of alternative refrigerants (hydroflourocarbons [HFCs]) would reduce emissions from these sources significantly.

The Yellow scenario results in about 114 MMT CO2e emissions, a reduction of 55 percent below the 1990 level. It thus falls far short of the 80x50 goal – a sobering fact, given how much it differs from today’s energy patterns.

The Deep Blue scenario

The Deep Blue scenario meets the ~50 MMT CO_2e GHG emissions challenge. It begins with the efficiency savings outlined in the Yellow Scenario and then explores alternatives if fossil fuel combustion in the residential and commercial sectors were to be eliminated, thereby driving an increase in electricity demand. Some of the increased electricity demand is assumed to be met with a larger fraction of point-of-use solar.

The Deep Blue scenario explores the impact of widespread adoption of hydrogen-powered light-duty vehicles for 100% of the LDV VMT with an equivalent of 65 mpg. The scenario assumes that hydrogen is produced through high-temperature steam electrolysis using gas-cooled high-temperature nuclear reactors. Because this approach employs a carbon-free electricity source, emissions are minimized. The calculations suggest the need for ~5 to 7 GW of nuclear capability for electrolysis. Gas-cooled reactors are well known conceptually, but significant technological and regulatory developments are needed. An alternative source of electricity could involve the use of IGCC or natural gas combined cycle (NGCC) with CCS. High-temperature steam electrolysis is an unproven technology at this time. The scenario does not address infrastructure issues associated with the transformation to a hydrogen-based transportation system.

The scenario assumes that 100% of all fossil fuel combustion in the residential and commercial sectors is eliminated and that the use of natural gas and liquid fuels is replaced by electricity, some generated onsite via solar (about 40% of the energy demand), the balance generated at utility plants. Industrial emissions are reduced by curtailing fossil fuel combustion overall by 75% and using only natural gas and #2 oil; coal is eliminated in favor of natural gas. Importantly, 8.4 MMT of the 13 MMT in emissions in the industrial sector are residual emissions from asphalt, petrochemical production, etc. It will be important to devise methods for curbing emissions from asphalt production to make further reductions.

Electricity demand is met from carbon-free sources, including 30% from nuclear (including 2 new plants that would increase nuclear power generation by 25,000 GWh, not counting the additional reactors required for hydrogen generation), 30% from renewables (maximum hydro, wind, and 100,000 GWh of solar), and 40% from NGCC plants with 90% CCS. It is important to note that the emission levels from NGCC limit generation from this source unless CCS is achievable at levels higher than 90%. This would make the future use of natural gas or coal for the electricity sector dependent upon the viability of CCS for locations and geologies within the state, and upon the amount of CO2 that can ultimately be stored.

In addition, the Deep Blue scenario assumes that emissions in aviation and the residential, commercial, and industrial sectors could be significantly reduced through the use of in-state, bio-derived oils for transportation (diesel), aviation (jet fuel), and heating. Given the potential for reduced emissions in the aviation, residential, and commercial sectors – as well as for HDV transportation – these replacement fuels warrant serious consideration, as do studies of the feasibility of supplying bio-derived oils for fuel from within the state. At present, net carbon emissions from these sources are assumed to be zero or close to zero, as carbon emitted by combustion of the biofuel is offset by carbon sequestered by plants grown to supply fuel. (See EPA's 2009 U.S. Greenhouse Gas Emissions Inventory Report.) Further study regarding the total carbon cycle associated with the use of these fuels is warranted to validate the emissions assumptions.

The Deep Blue scenario estimates emissions at 53 MMT. It thus achieves a 79 percent reduction in GHG emissions below the 1990 level.

The Ultraviolet scenario

Another possible future was devised that would also meet an 80 percent reduction by 2050. Like Deep Blue, the Ultraviolet scenario is much more aggressive than the Yellow scenario. It too begins with the efficiency savings outlined in the Yellow scenario and explores alternatives if fossil fuel combustion in the residential and commercial sectors were eliminated, thereby driving an increase in electricity demand. A part of this electricity demand is met through local, point-of-use solar.

The Ultraviolet scenario explores the impact of shifting to widespread use of PHEVs where 95% of VMT are all-electric miles, with 5% of VMT coming from bio-ethanol at 50 mpg. This is an aggressive goal, well beyond current predictions for most studies of PHEV market penetration and performance improvements through 2030. Significant increases in electricity demand are postulated via elimination of fossil fuel combustion in the transportation sector for LDV.

The scenario assumes that 100% of all fossil fuel combustion in the residential and commercial sector is eliminated and that the use of natural gas and liquid fuels is replaced by electricity, some generated onsite via solar (about 40% of the energy demand), the balance being generated at utility plants. Industrial emissions are reduced by curtailing fossil fuel combustion overall by 75% and only using natural gas and #2 oil; coal is eliminated in favor of natural gas. As in the Deep Blue scenario, 8.4 MMT of the 13 MMT in emissions in the industrial sector are residual emissions from asphalt, petrochemical production, etc.

The significant increase in electricity demand is met largely with carbon-free sources: 35% from nuclear (including ~10-12 new plants), 35% from renewables (maximum hydroelectric, maximum on-shore wind, and 100,000 GWh of solar or other utility scale renewable such as offshore wind), and 17% from NGCC plants with 90% CCS. This scenario employs as much NGCC with CCS as is practical to meet overall emissions targets, thereby requiring a larger fraction (and level) of carbon-free sources. They are assumed to be met with new nuclear plants.

As with the Deep Blue scenario, this scenario relies on the use of low carbon-intensity bio-derived fuels (in-state ethanol) to supply the liquid fuel needed for non-electric miles in the LDV category, and on the use of biofuels in the aviation sector.

The Ultraviolet scenario estimates emission at 55MMT, a 78 percent reduction in GHG emissions below the 1990 level.

SERIOUS CHALLENGES POSED BY THE LOW-CARBON GOAL

The scenarios, presentations, and discussion at the January 5 workshop illuminated issues and challenges facing the Council. In particular three sectors – transportation, electricity generation, and buildings – emerged as particularly challenging and significant. At present, the transportation sector produces 34.3% of the state's GHG inventory; electricity generation, 19.1%; residential uses, 14.6%; commercial uses, 10.6%. The "business as usual" (BAU) case for 2050 projects that the transportation sector will produce 35%; electricity generation, 23.1%; residential, 12.5%; commercial, 10.8%; and industrial, 6.7%.

The text below discusses the challenges those sectors present.

Serious Challenge: Transportation

Mobility is essential to social and economic welfare. By all measures, New York is one of the most mobile states in the nation. It has over 11 million licensed drivers, 10.5 million motor vehicles – virtually all of them operating on fossil fuel, and joined by similar vehicles that travel to New York from other states – and 113,000 miles of roads, along with 4,800 miles of railroads, 18 commercial airports, and 495 public use and private airports. Ensuring a safe, secure, reliable, efficient, low-carbon transportation system is vital to the state's future. (See Strategies for a New Age: New York State's Master Transportation Plan for 2030.)

Today's transportation systems are defined by technological, socioeconomic, land use, and public policy factors. Transportation demand is growing, and patterns of travel are changing and increasingly reliant on multiple, interdependent modes of transportation. Congestion in urban areas is growing, and transportation systems in these areas are bounded by the built environment. Over the next 40 years, the transportation system will have to support the same or greater levels of mobility while lowering emissions dramatically. And the importance of transportation security to national and economic security is expected to increase.

Over the past three decades, tremendous growth in the transportation sector and the decline in US oil production have made the US and New York increasingly dependent on foreign supplies of petroleum. Today, about 60% of the oil consumed in the US is imported. In New York, transportation accounts for about half of petroleum consumption, the equivalent of about 300 million barrels per year, or about 4% of the US total. As the potential for disruptions in world oil supply and production of refined petroleum products increases, so does the risk of disruption to the state's transportation system. Given projected growth in demand for oil in emerging markets, notably China and India, the cost of oil and the reliability of supply are important risk factors to consider.

Within the transportation sector, road transport is the largest consumer of energy and the largest source of emissions. The major contributors to emissions are light duty vehicles (LDV), a category that includes automobiles, SUVs, motorcycles, and light trucks, and heavy duty vehicles (HDV), which includes trucks for road freight as well as buses. After road transportation, aviation is the next biggest contributor. Another important factor is the impact of the design and construction of the local built environment on mobility and patterns of use of available modes of transportation.

Addressing transportation requires a holistic look at all the factors that can improve efficiency as well as reduce emissions. In general, approaches to transportation examine (1) society's future mobility needs, (2) the technical efficiency of a given mode of transportation and the potential for improvements, (3) the effects of the operating environment, and (4) the mix of transportation modalities and potential systems performance improvements via changes in the mix of modalities.

Transportation and the built environment

The New York metropolitan area enjoys an extensive public transportation system that is well integrated into the region. Some 4.8 million passengers use public transportation on a daily basis. The high density of housing, proximity to public transportation, and its relative ease of use contribute to this high level. Aspects of the region have attributes of "compact, mixed-use development" – also known as "smart growth."

In all of the mitigation scenarios, a significant reduction in projected VMT level for 2050 (240 billion miles) is assumed. The assumption is that smart growth can promote greater reliance on public transportation and/or increase walking and bicycle travel. At the January 5 visioning workshop, success stories about smart growth in urban and suburban areas were recounted – notably for Arlington, Virginia, and Portland, Oregon. They offer models for New York's suburbs and for cities other than New York City; for example, the corridors in Long Island along the Long Island Railroad and major traffic arteries.

Over the 40-year horizon of the Climate Action Plan, many urban and suburban centers will very likely be rebuilt or redeveloped. This will create opportunities to reshape the state's transportation system and its use – if transportation planning and redevelopment efforts are approached holistically and use smart-growth practices. As redevelopment in urban and suburban areas occurs, more compact, mixed-use development that includes higher population and employment densities, competitive alternatives to automobile use such as pedestrian and bicycle paths, street networks that provide connectivity between destinations, and easy access to public transportation can all reduce residential and commercial energy use, GHG emissions, and VMT.

A recent and comprehensive study by the Transportation Research Board of the National Academies explores the impact of and correlation between driving behavior and the built environment. It concludes that compact, mixed-use development can reduce VMT by differing means and amounts depending on where the development in a region occurs. The study reports that the literature suggests "that doubling residential density across a metropolitan area might reduce VMT by about 5-12%, and perhaps as much as 25% if coupled with higher employment concentrations, significant public transit improvements, mixed uses, and other supportive demand management measures." It also notes that more study is needed to better understand the causal links between specific design elements in land use, transportation pathways, high density housing, employment centers, and other factors and reductions in VMT and increased use of public transportation.

To significantly reduce VMT would require changes in current practices and patterns of development in suburban areas. In home-rule states like New York, land use is largely a function of local governments, which can be reluctant to zone for higher-density housing because local residents often resist it. Statewide change would require that state-level policies be enhanced with incentives that encourage and support compact, mixed-use developments that would result in greater energy efficiency, increased use of public transportation, and reduced VMT and GHG emissions.

These efforts would be facilitated by communitywide design standards (the equivalent of LEED certification); the development of partnerships among State and local governments and private developers; tax incentives; coordinated State, federal, and local infrastructure investments; coordination with regional transportation authorities and operators; and rezoning to support appropriate transit development.

Light duty vehicles

In 2007 New York State residents drove over 140-billion VMT and consumed some 7.6 billion gallons of gasoline [EIA, Energy Consumption 2007], largely through the use of personal vehicles. As our mitigation scenarios reveal, significant emission reductions are possible in the transportation sector. The scenarios explore three alternative future vehicle fleets: one a mix of conventional, hybrid, and plug-in hybrid electric vehicles (PHEVs) (Yellow scenario); one dominated by hydrogen vehicles (Deep Blue); and one dominated by PHEVs (Ultraviolet). The latter two scenarios show that fuel switching will drive increased demand for electricity production, either for vehicle re-charging or electrolysis of steam for hydrogen production. Of course, emissions reductions would only be realized by the use of nearly carbon-free electricity sources such as renewables, nuclear, or natural gas or coal-fired plants with CCS.

What will it take for the US to realize 100% PHEV or 100% all-hydrogen powered cars on the road in 2050? Significant changes to automobile technology, of course. However, replacing New York's entire fleet of automobiles will take time. The lifetime of a car is long; the mean lifetime is about 15 years: half the cars sold today will still be on the road in 15 years, and it will take about 25 years for 95% of the autos sold today to be retired. (See the ORNL Transportation Energy Data Book [2009 ORNL-6984]). Thus, to achieve a fleet composed of 100% PHEV cars in 2050, 100% of the cars sold in 2025 and every year thereafter would have to be PHEVs. The same case applies to hydrogen-fueled cars.

Another reason why changing the entire fleet will take time is that it takes time for transportation equipment and automobile manufacturers to adopt new technology and integrate it into their product lines and manufacturing processes. At present, automobile models undergo a complete redesign approximately once every 8 years, and new designs are locked in about 2 years in advance. Thus, it could take from 5-10 years for a new automobile design to be brought to market, and another 25 years to completely change over the fleet.

For PHEVs, this penetration rate is more aggressive than what experts are predicting. For example, a recent study by the National Academy of Sciences (NAS), Transitions to Alternative Transportation Technologies – Plug-in Hybrid Electric Vehicles, concluded that PHEVs are "unlikely to achieve cost effectiveness before 2040 at gasoline prices below $4.00 per gallon," given the higher costs when compared to conventional vehicles. Further, the NAS PHEV study concluded that "at a maximum practical rate, as many as 40 million PHEVs could be on the road by 2030, but various factors (e.g., high cost of batteries, modest gasoline savings, limited availability of places to plug in, competition from other vehicles, etc.) are likely to keep the number low."

PHEVs are scheduled to enter the US market in the 2011-2013 timeframe. They will have an all-electric range of ~30-60 miles. For mass-market penetration, a greater all-electric range of around 100 miles or more would be needed – underscoring the need to develop higher performance battery technologies. Costs must come down, too. Drivers include electronic controls, drive trains, and batteries. Lithium-ion battery technology has been developing rapidly, though costs are still high and, according to the NAS study, expected to decline only by about 35% by 2020. Further technology development will likely reduce costs below these levels, as well as increase storage density and reliability, possibly by using alternative chemistries to lithium ion batteries.

Other notable barriers include the need for suitable charging stations or battery exchange facilities and consumer acceptance of PHEVs, especially if PHEVs cost more than similar functioning hybrid electric vehicles and require daily (or more frequent) recharging. Adoption of PHEVs by large vehicle fleets, such as federal, state, and local government fleets, may be an appropriate first step to increase adoption, if costs are reasonable.

The Deep Blue scenario explores the potential impact of fuel switching from gasoline to hydrogen for vehicles. Hydrogen vehicle technologies largely follow two paths: direct burning of hydrogen in a suitably modified internal combustion (IC) engine or use of electrochemical fuel cells (proton-membrane exchange fuel cell [PMEFC]) which, in turn, drives an electric motor. Hybrids of electric and combustion processes are also conceivable – PMEFC with batteries, for example. It is important to note that hydrogen-based ICs and PMEFCs have applications in local point-of-use generation of electricity. It's conceivable that ICs and PMEFCs could be used for hot water, lighting, and heating in residential and commercial applications, as well. Studies of the energy efficiency of hydrogen (such as the National Academies of Science's *The Hydrogen Economy*) find that the hydrogen vehicles would not substantially reduce total energy use per mile driven (the "wheels to wheels" energy per mile driven) unless the hydrogen were produced from wind or solar power.

The Deep Blue scenario relies on nuclear power with high temperature electrolysis of water to produce hydrogen, with electricity and heat generated from a nuclear reactor. Alternate approaches include steam reforming of methane using process heat provided by a very-high temperature nuclear reactor, or through a thermochemical cycles, such as the sulfur iodine process. Steam reforming of methane is widely used in industry to make hydrogen today, and this process is well established. Carbon release from steam reforming of methane would compromise emissions gains through the use of nuclear power and is a potential showstopper, though carbon capture is not inconceivable.

Beyond nuclear-based approaches that rely on steam reforming, several technologies are envisioned for large-scale or central generation of hydrogen. Coal and natural gas integrated gasification combined cycle (IGCC) or natural gas combined cycle (NGCC) plants could also serve as a heat source for steam reforming of methane – and for much smaller hydrogen generation scales, solar PV or wind could be used for electrolysis. Of these sources, only nuclear and renewable-based hydrogen production have a zero-carbon footprint, and with the advent of carbon capture and storage (CCS) technologies, central-station hydrogen production from coal or natural gas plants would have a carbon footprint five to ten times smaller than that of gasoline. The price of hydrogen is highly dependent on the way hydrogen would be produced and associated emissions from the generating source. Thus, today, nuclear-based, as well as NGCC or IGCC with CCS, appear to be cost-competitive with gasoline, while the higher cost of electricity generated by renewable sources is two to five times more expensive.

At best, hydrogen represents a long-term option. Significant technological and infrastructure breakthroughs are needed before it's considered viable. Significant improvement in the energy density of hydrogen storage, reductions in fuel cell costs, increased lifetime and reliability, as well as cost reductions in hydrogen production are needed. Safety is also an important factor. Initially, transportation and distribution of hydrogen would entail transport by truck to regional distribution centers, using compressed gas cylinders. Over time, the use of hydrogen to fuel vehicles would require construction of infrastructure such as pipelines and fueling stations.

To overcome some of the barriers to adoption of hydrogen fuel for PHEVs, New York State would have to work with other states and the federal government to develop requirements that drive the market toward new vehicle technologies. In the meantime, fuel efficiencies and carbon reductions will be realized through improvements to conventional vehicle technologies and greater market penetration of hybrid electric vehicles.

Heavy duty vehicles

Trucks carry the bulk of freight transport. In New York State, 90 percent of commodities by weight are moved by truck, while only 3 percent are moved by rail - a more efficient and less GHG-intensive mode. Freight traffic is expected to grow significantly, with a concomitant growth in VMT. More-efficient, less GHG-intensive modes of transport are clearly needed. In general, there are two ways to reduce HDV emissions: directly reducing truck emissions, and shifting freight from trucks to more efficient and less GHG-intensive modes.

The factors that affect truck emissions and efficiency include (1) the nature of the fleet mix (the size of the trucks), (2) the fuel-efficiency of the trucks, (3) the operating environment (built environment, road conditions, traffic and congestion, etc.), (4) how trucks are operated (speed and idling), (5) the nature of the cargo and truck loading (weight, density, containerized vs. open-bed freight, etc.).

The mix of trucks and their patterns of use are extremely heterogeneous. Efforts to reduce emissions should focus on the largest fuel consumers: tractor-trailers and straight trucks. Tractor-trailer efficiency improvements should start with retrofits to reduce truck frame drag. Estimates indicate that truck retrofit packages (such as aero-cab, front flaring, side skirts, rear tail flaring, low rolling-resistance tires) can improve truck efficiency on the order of 5-10%. Retrofit packages can be readily adopted for existing fleeting. (The Union of Concerned Scientists offers information on green trucks. Scroll down that web page for a link to a study by the technology firm TIAX, Heavy-Duty Truck Retrofit Technology: Assessment and Regulatory Approach.)

In addition, future truck fleets will rely on advanced truck engine designs, such as hybrid-electric engines, with an estimated efficiency increase of 7-9%. Adoption of new engine technologies will take time, as the market is conservative and fleet turnover is much slower than for LDVs: the median lifetime of a HDV is well over 20 years. This implies that the penetration of a new technology will take significantly longer in the HDV market than in the LDV market. Consideration should be given to policies that may speed adoption of new technologies.

Biodiesel is the first advanced biofuel in large-scale commercial production. Biodiesel produced from domestic soybean oil is assumed by the EPA to reduce GHG emissions by 57% compared to petroleum diesel fuel, and the EPA's lifecycle analysis recognizes that the GHG reduction could be as high as 85%. (See http://www.epa.gov/otaq/renewablefuels/420f10006.pdf.) In the US, biodiesel production is now expanding rapidly (see http://www.biodiesel.org/pdf_files/fuelfactsheets/Production_Graph_Slide.pdf). In 2005, production was 75 million gallons; in 2007, 450 million gallons; in 2008, approximately 700 million gallons. By 2011, 1 billion gallons of biodiesel will be produced. An assessment of the resource available to produce biodiesel indicates that feedstock available today could produce more than 1.7 billion gallons per year.

Intermodal

Convenience and cost are the key factors that determine the mode of transportation for the shipment and distribution of goods. In New York State, the predominant method for transport of freight is by truck, with up to 90% by weight shipped by truck. Truck transportation is the most energy and GHG intensive modes of the movement of freight. A key challenge to reducing GHG emissions in the transportation sector is then to reduce emissions from truck transport of freight. This can be most readily accomplished by reducing GHG emissions from trucks and/or shifting freight to other modes of transport with lower emissions. New York State will have to investigate policy options to bring about modal shifts. These would include:

- Financial assistance to develop more efficient organization of supply-chains, including advanced logistics capabilities and optimal positioning of trans-shipment points and distribution centers.

- Increasing fuel and economy standards for trucks, speed limit reduction/enforcement, and development of anti-idling policies and electrification of rest-stops.

- The development and adoption of advanced technologies, particularly the development of no or low net-carbon bio-diesel fuels and waste heat recovery systems to power air conditioning/electronics.

- Reducing congestion by increasing non-truck modes of transportation; provide incentives and build infrastructure to encourage switching from truck to rail or water transport.

Aviation

Emissions reductions in the aviation sector can come from advances in three areas: improved efficiency through advances in technology, development, and adoption of suitable bio-derived fuels, and improvements to operations and air traffic management.

Significant emissions reductions in the aviation system will come from new composite materials that result in airframe weight reductions, as well as improvements to engine design. For example, as much as 50% of the primary structure of the new Boeing Dreamliner is made from advanced composite materials. Coupled with advanced engine designs, this will increase fuel efficiency as much as 20% over similar sized aircraft, while permitting air speeds characteristic of the fastest wide-bodies, mach 0.85.

The National Academies' Airports Cooperative Research Program is examining alternatives to fossil fuels, as is a coalition that includes the Federal Aviation Administration. Industry interest in the subject is growing. Currently, new biofuels – "biojet" are being developed for the military. This represents a significant opportunity for reduction of net carbon emissions from the aviation sector if a sufficient supply of biofuels can be developed for wide-scale adoption and use.

Changes to air traffic management are expected to lead to ~10% reductions in fuel use, through better management of holding patterns, more efficient take-off and landing trajectories, and minimization of suboptimal routes. Switching modes of travel can reduce emissions, too. Many short-distance flights could be replaced by inter-city high-speed rail; for example, between New York City and Albany, as well as Buffalo.

Serious Challenge: Electricity Supply

Electricity generation is currently among the largest sources of GHG emissions and is projected to remain so under the BAU case. New York's current electricity generation system is a diverse mix of primary energy sources, with about 53% of net generated electricity coming from fossil fuel-fired electric generating units. With a diverse resource mix and a solid base in renewable energy, the state's electric sector is expected to contribute approximately 75.5 million tons of CO2e to the GHG emissions inventory in 2050

The electricity sector presents a serious challenge for a set of reasons:

- *All mitigation scenarios place increased demand on the electricity sector.*

  All three 80x50 scenarios assume total electricity demand in excess of 400,000 GWh, a 50% increase over the BAU case. This is typical of mitigation strategies – for example, see the results of the Global Technology Strategy Project. The reasons are several. The most important is that it is much easier and more cost effective to manage any residual carbon emissions at a central electric generation facility than in highly distributed sources like vehicles or buildings. In the 80x50 scenarios, energy demand is driven to electricity by the almost complete conversion of the building sector to electricity, the substitution of electricity for liquid fossil fuels as an energy carrier in the transportation sector (most notably in the Yellow and Ultraviolet scenarios), and a general shift from fossil fuels to electricity in the industrial sector.

  The flexibility of electricity as an energy carrier has led to continued growth in its use. The electricity sector has been well studied, and many technological improvements are made every year. These improvements are quite important: efficiency improvements in the conversion of energy stored in fossil fuels to electricity has a direct impact on the capital cost of all electricity generation resources. Even more important, improvements in the efficiency of end-uses of electrical energy reduce total demand for electricity. The scenarios for each of the major end-uses begin with an assumption of large improvements in end-use efficiency, ranging from 20-30%. Generally, it's expected that the electric generation sector could be decarbonized more easily than distributed uses of energy could be.

- *Renewable resources within the state are not adequate to meet the challenge.*

The major renewable sources of electric power that are carbon free are wind, solar, and hydropower. With the exception of large hydroelectric facilities, these resources are distributed: they collect a local resource. Moreover, in comparison with, for example, a large thermal electric facility like coal or nuclear, they generate far less energy per unit of land. The Yellow scenario includes practically all of the available renewable energy resources in the state, and it includes only resources from within the state. The renewables are over and above the renewable sources assumed to be integrated with buildings.

Wind is a relatively mature technology, and it's relatively easy to estimate how much wind energy is available. The current analysis includes both on-shore and off-shore wind resources. On-shore wind deployment is increasing around the world, but every deployment faces challenges. The first is the actual siting of the turbines, which is often resisted locally for aesthetic and environmental reasons. Second, wind is an intermittent resource and places special demands on the grid, as discussed below. The scenarios are fairly optimistic about success in siting turbines, and they assume wind power's straightforward integration into the grid (as estimated in a 2003 study). They also assume that the current 873 GWh of wind can be expanded to 42,000 GWh by 2050, meeting just over 10% of total projected demand.

Solar is a far less mature technology in terms of both efficiency of conversion and experience with actual installation. The Yellow scenario assumes that 100,000 GWh of demand will be met by grid-installed solar (~25% of 2050 demand); currently in New York the value is zero. This makes the Yellow scenario quite aggressive in several regards. First, this amount of solar energy requires a large amount of land, probably far more than is commonly assumed. For the current generation of solar PV sited in New York, it would take about 1% of the area of New York to generate 100,000 GWh of electricity. Second, it requires a massive improvement in the ability to manufacture photovoltaic (PV) devices. Most current solar technology is based on silicon, and despite large increases in PV cell production, global consumption of silicon for solar applications only recently passed consumption of silicon for semiconductor devices such as computers. Without low-cost, mass production of solar cells on the scale of products like paper or steel, large-scale deployment of solar energy is unlikely. Finally, solar, like wind, is an intermittent resource with special requirement for integration with the grid.

New York has significant hydropower resources, thanks to Niagara/Horseshoe Falls and the St. Lawrence Seaway. Further upgrades and expansions, with a small component of new dams, could significantly increase electric output to the grid and reduce GHG emissions. The Yellow scenario assumes that 10,300 GWh of hydropower will be added to the 25,500 GWh, satisfying nearly 10% of projected 2050 electricity demand.

In summary, the relatively aggressive goals included in the Yellow scenario, which are incorporated in the other two scenarios, meet less than 50% of projected 2050 demand, and indeed in the future they may not be met. But other sources of renewable energy might improve the prospects of success. The largest is probably offshore wind. In addition, full-scale testing of kinetic, in-river hydropower applications is under way in the East River and St. Lawrence River. These projects and maximum build-out were not considered in our analysis, but they could add slightly to the total hydropower package of emission reduction technologies and strategies.

- *Low carbon-emitting central generation options all entail serious issues.*

The discussion of renewable electrical energy options above underscores the fact that demand for central generation of electricity will continue. This demand must be met with low-carbon or no-carbon conversion technologies. Currently in New York, large central generation relies on fossil fuel and 42,500 GWh of nuclear power. Options considered in detail in the scenarios are expanded use of nuclear generation and use of fossil fuels with carbon capture and storage (CCS).

The future of nuclear power generation is uncertain, but nuclear power could satisfy a good portion of a future electricity demand or hydrogen production demand (as discussed above). All of the scenarios assume a continuation of the existing level of nuclear power generation; each takes a different approach to nuclear. The Yellow scenario meets the low-carbon generation option without expanding the current nuclear fleet. The Deep Blue scenario assumes expansion of nuclear power generation by 2 new plants that would generate 25,000 GWh, not counting the additional reactors required for hydrogen generation. The Ultraviolet scenario expands the nuclear supply of electric power by 118,000 GWh, meeting a total of 40% of 2050 electric demand with nuclear power, comparable to the amount planned by Japan.

The scenarios do not speak to the resolution of specific issues associated with nuclear power. Expanding nuclear power will require substantial capital investments and federal loan guarantees. It would require investment in scientific research into and technological advances in alternative fuel cycles and nuclear waste management. It would require public acceptance of license renewals for existing nuclear power plants, expansion of current plants, and siting of new plants.

Fossil fuel combustion with CCS is a significant component of all three scenarios, accounting for 190,000 GWh of energy in the Yellow scenario, 170,000 GWh in Deep Blue, and 70,000 GWh in Ultraviolet. Both coal (IGCC) and natural gas are included in differing amounts in the scenarios. While important in implementation, the fuel choice is non-substantive in comparison with other challenges associated with CCS. They include efficiency of capture and storage, establishment of storage reservoirs, and construction of infrastructure to transport CO2 from its point of generation to the point of storage. Notably, CCS is not yet commercially available and in fact has not yet been successfully demonstrated on a commercial scale. Moreover, the regulatory scheme that would govern it remains to be defined, and the capacity for large scale CCS in New York is not presently known.

Probably the most important CCS challenge is efficiency of capture and storage. The scenarios assume a capture efficiency of 90%, with the electricity sector contributing 24, 13, and 10 MMT CO2e for the Yellow, Deep Blue, and Ultraviolet scenarios respectively. For the latter two scenarios, which do meet the 80x50 goal, CCS still produces 20-25% of total emissions. The improvement of CCS technology to, for example, 99% would significantly reduce emissions.

Storage and transport of CO2 present closely related issues. The capacity to store CO2 is not homogeneously distributed throughout the state. Further, little is yet known about the suitability and capacity of those sites to store CO2. There will be a trade-off between siting of generation sources and siting storage facilities. Certainly, concentrating emissions sources near large-capacity storage reservoirs would simplify implementation and reduce costs. But it could also further increase the burden on the grid. NYSERDA's studies of New York's potential for CCS are important to defining the long-term potential.

Finally, it should be noted that as 2050 approaches, nuclear fusion may become a viable zero-carbon source of electricity. The scenarios assume it won't be sufficiently well developed to meet energy demand in 2050, but as the State looks beyond its 2050 target to continuing emissions reductions, this technology may be important. Decisions made between now and 2050 can impact its availability in the long run.

- *Infrastructure for electricity transmission and distribution must evolve to meet demand and other services the grid must provide.*

Fortunately, growing demand for electricity is accompanied by substantial research into and development and deployment of new technologies, which are shaping the grid of the 21st century – and at a time when capital improvements to New York's aging grid infrastructure are needed. The smart grid will deliver substantial benefits: greater reliability, enhanced security, "smarter" use of information technology, integration of renewable power generation, better storage technology, and sophisticated demand-management strategies. The ability to manage demand can yield another benefit: avoidance of the huge costs of building more power-generating plants.

The 80x50 scenarios assume three significant demands on the grid. One is the need for increased capacity to carry energy. The capacity increases can be met in two ways. The most straightforward is to install higher-capacity transmissions lines and to increase capacity through upgrades to substations, transformers, and distribution lines. Since all three scenarios call for a 50% improvement in transmission and distribution (T&D) efficiency (which contributes as much to emission reductions as all of the hydro enhancements), the upgrades will both increase capacity and reduce T&D losses. Another method is changing from conventional T&D lines to high-temperature superconductors. This technology both increases capacity and decreases losses, and it's already employed in two locations in New York State. However, it's complex to manufacture, and manufacturing capabilities must be radically scaled up and costs shrunk before it can be widely deployed.

The second demand on the grid arises from reliance on large amounts of solar and wind: their intermittency must be managed and compensated for. As intermittent loads grow, this becomes a larger and larger problem. In general, the approach been viewed as a question of "what do you do when the sun goes down, or the wind stops blowing?" This implies the availability of a backup energy resource. Because baseload power from thermal resources (nuclear and fossil with CCS) performs best if it operates continuously, increasingly the view is that energy storage might be the best option for intermittent sources.

Hydro resources have some limited storage capacity, allowing their output to be increased when demand grows. However, without "high" dams like those in western US states, this storage is limited. NYSERDA is studying the potential of below- ground compressed air storage potential in New York. The next step is to introduce storage technology, such as batteries, or in the long run, superconducting magnetic energy storage (SMES). This kind of storage has the added value of serving as a convenient means of helping to manage transients in the system, as well. Managing storage to compensate for intermittency will be greatly enhanced by incorporating information technology into the smart grid.

The smart grid also facilitates another strategy for managing intermittency: demand response, in which loss of generation is compensated for by a sophisticated demand-reduction strategy that targets flexible and non-essential loads, shutting them off for a short period of time. These loads can be at the commercial and industrial level, but recent and ongoing demonstrations also show success in the residential sector through use of smart meters and smart appliances.

Finally, the changing mix of end uses on the demand side will alter the temporal demand for electricity on time scales ranging from daily to seasonal. In general, this is a design and load-dispatch problem. What generation resources do you bring on, when, to minimize the cost of generation? To satisfy peaks in demand with the more-expensive generation resources and, through pricing strategies, encourage end-users to not use resources during peak demand periods? Switching of peaks among seasons, from summer peaking to winter peaking, for example, can create resource mismatches for resources that may have a strong seasonal variability, such as hydro and solar.

The scenarios assume the largest new demand will come through vehicle electrification. Studies have shown that smart electronics in, for example, PHEVs can manage that demand to fill in periods of otherwise lower demand. This allows baseload plants to operate more or less continuously, with consequent greater efficiency. Charging the PHEV "appliance" can also become part of the demand-response network used to manage intermittency – another benefit of the emerging smart grid.

Challenge: The Building Sector – Residential & Commercial

A critical challenge to reaching the 80x50 goal is in the performance of residential and commercial buildings. Reaching mid-century GHG reduction goals will require that buildings function with minimal or no net-energy input (input from the electric grid or from onsite use of high-carbon fuels). New residential, commercial and industrial building systems will need to significantly reduce, and eventually eliminate, onsite fossil fuel combustion for space heating, water heating, cooking, and other needs, and supply electricity through onsite generation from low-carbon energy sources.

The strategy suggested in this vision requires that buildings function with minimal or no net-energy input from onsite use of high-carbon fuels and that to the extent possible their energy demand not be shifted to the grid.. These new residential, commercial and industrial building systems will reduce, and eventually eliminate, onsite fossil fuel combustion for space heating, water heating, cooking, and other needs, and will supply electricity through onsite generation from low-carbon energy sources.

The relationship of the building sector to other sectors is a critical aspect of the 80x50 challenge. These relationships fall within four broad areas:

- End uses: Residential and commercial buildings represent a growing sector of energy demand. This demand is a central part of the standard of living we enjoy. An example is the growing use of personal electronics in residences and the development of large datacenters that support the new internet enabled economy, particularly the global financial industry based in New York. The critical first step in any carbon reduction strategy will be increasing the end use efficiency of the equipment and devices within structures. Reductions of 30% in each electricity and natural gas use is rather straightforward through the adoption of more efficient end-use technologies, such as more efficient lighting, space heating/cooling, water heating, computers, and televisions – as well as through the use of modern controls.

- Structures – A substantial component of the energy demand in the buildings sector is for space conditioning. End use efficiency has an important impact on this demand, particularly in the commercial sector where the cooling demand created by waste heat from devices and equipment. In New York the challenge of structures is exacerbated by the fact that much of the building infrastructure already exists. This will lead to important challenges in improvements of the performance of building envelopes and the creation of cost effective retro-fit options for key building systems such as windows and increased sealing and insulation.

- Distributed generation – One real option for building is the promise of distributed generation. The use of both photovoltaics and passive solar heating as well as the exploitation of geothermal resources through such technologies as ground source heat pumps offers real promise. The greater the contribution of these technologies to both efficiency and meeting electric demand the less the buildings sector will contribute demand to the already growing burden on the grid. There are many policies options that can help reduce the capital costs barrier could be strong enablers of broader adoption of distributed generation technologies in residential and commercial sectors.

- Communities and the promise of smart growth – Probably the most important trend will be the increased view of the buildings sector as a component of communities. Many of the elements above are even more valuable when one considers collections of structures and seeks to manage energy for these aggregations. Distributed generation for communities can include wind and local biomass conversion for heat and power. The community can become part of a micro-grid that not only effectively manages the electric demand of the community but also can be the basis of using the community as a dispatchable demand response resource for the wider grid. Finally, if the communities take on the "smart growth" approach both in new construction but also in re-development, the communities themselves can have appositive impact on other sectors, most notably transportation.

There has been extensive work on energy efficiency in buildings, done by the World Business Council on Sustainable Development, the National Academy of Science, the Pew Center on Climate Change, and Lawrence Berkely National Laboratory, which offer key data and insights to the energy savings potential. A difficulty in comparing the energy efficiency potential across studies is the variation in methodologies and measures within each of them. However, there are some common themes worth noting.

BOTTOM-LINE ISSUES AND CONSIDERATIONS

The scenarios that inform the visioning process can be further manipulated to yield more insights into interrelationships among mitigation strategies for various sectors. But even at present, and the benefit of insights and knowledge gained at the January 5 visioning workshop and from yet other sources, it's clear that major decisions are necessary to achieve the 80x50 goal.

Many of those decisions must be made sooner rather than later, as they affect long-lead-time matters such as infrastructure investments and research and development strategies that can help or hinder progress. Moreover, the early adoption of some measures won't preclude later adoption of others. Thus, identifying pivotal future decisions and sequencing them becomes a serious challenge in its own right.

The text below discusses issues that follow from the discussion of serious challenges above, and that emerged from the visioning process and other sources. Some concern single economic sectors; some span two or more. While it can be difficult to differentiate technical issues from policy issues, we've tried: the points immediately below are primarily technical in nature; policy considerations follow.

Technical considerations

- Gains in energy efficiency are critical to achieving a low-carbon future. The scenarios don't specify mechanisms, technologies, or practices necessary to achieve these gains, but their importance is clear.

- Very soon, a risk assessment table for critical technologies, such as CCS, nuclear, and solar, should to be developed. This table would highlight the barriers to and compare the types of uncertainty associated with each technology, facilitating the identification of both policy measures and research investments.

- Electrification is an essential strategy, too, and a move to electrification is consistent with the energy needs of a 21st-century economy based on information technology, biotechnology and nanotechnology. If New York's demand for electricity nearly doubles by 2050, a number of issues arise. For one thing, electrification transcends selecting non-carbon emitting central generation technologies and arranging for their siting and financing. Demand on transmission and distribution systems will increase, too. This means that ongoing planning for the smart grid and associated technologies must be part of the Climate Action Plan strategy.

  And growing demand will alter not only the amount of electricity needed but when demand peaks, on timescales ranging from daily to annually. How the load duration curve, one measure of changing demand, is managed will be an important part of the smart grid. This may include the use of storage to facilitate handling of larger quantities of intermittent renewable resources, and the use of active demand management technologies like demand response.

- Electrification of buildings could create a stranded asset in the gas distribution system. The existing infrastructure for gas and its continued expansion may create a structural barrier to the goal of reducing highly distributed point sources of GHG emissions. On the other hand, pipelines moving CO2 from gas combustion facilities to storage reservoirs may be co-located along rights of way, provided they are appropriately located.

- All scenarios call for the phase-out of fossil fuel generation that free-vents carbon to the atmosphere. The schedule for retiring or converting existing facilities thus becomes an issue.

- Similarly, existing nuclear power plants are on the critical path for a future that continues to rely on nuclear power. These plants would have to be replaced or re-licensed. If relicensed, it would probably be for a maximum of 20 years; they'd then be replaced.

- Nuclear and/or fossil fuel combustion with CCS, which is largely undemonstrated, are important for decarbonization of centrally generated power. Both require long lead times and large capital outlays. CCS also requires significant infrastructure for storage, which will include site selection and certification as well as some pipeline infrastructure. The regulatory scheme that would govern siting and operations of CCS facilities and storage locations remains to be defined.

- The transformation to a hydrogen economy would require a new infrastructure for producing and delivering hydrogen to consumers. The development of gas-cooled, high-temperature nuclear reactors to produce hydrogen would require new plant designs, which would require licensure. Safety regulations for transportation and storage of hydrogen would also be needed.

- In our scenarios we've included some technologies that are emerging but not yet commercial, such as CCS. Others are unproven, such as large energy storage. We omitted nuclear fusion, an unproven technology, and direct air capture of carbon dioxide, which is speculative at this time. These all have theoretical potential to help achieve the 80x50 goal, but the timeline for making changes requires technologies that are in development today, and ready for deployment at scale within approximately a decade. The current international roadmap for fusion would have the first demonstration reactor online in about 2040.

- The scenarios assume complete success; for example, total conversion of the building sector to electricity, or to net-zero carbon emissions. Inevitably, there will be "leakage," which will place further limitations on emissions from other sectors or technologies.

- Renewable resources play a major role in all three scenarios. But even with expected gains in renewable energy technology efficiencies, the state's renewable resources can't meet all of projected future energy needs. And, distributed resources used on a large scale would require large tracts of land for solar arrays, wind farms, and biomass cropping. The scenarios assume all renewable resources would come from within the state. This is consistent with the State's desire to develop its own resource and energy industry. But out-of-state renewable resources could be used, too, and perhaps in some cases more cheaply. Opening the market could take pressure off in-state only resources.

- Sustainable biomass is a limited resource. What's the best allocation for its use? Should it be used for transportation (as in our scenarios), to heat buildings, or for power with CCS, which could create a carbon sink?

- The grid-installed solar electric assumption in the scenarios is quite optimistic and may not be met without significant energy conversion improvements in photovoltaic panels and systems. Distributed solar awaits gains in scalability, reductions in cost, and the creation of large-scale installation capabilities. The scenarios don't include some renewable technologies that may be fungible and that could help reduce emissions, such as geothermal and hydrokinetic energy sources.

- The transportation sector is an extremely large, diffuse source of GHG emissions. All of the scenarios largely call for eliminating gasoline and diesel as energy carriers and replacing them with bio-fuels, hydrogen, or electricity. The sector is diverse, with each of the subsectors – light duty vehicles (LDV), heavy duty vehicles (HDV), mass transit, and aviation – having its own special needs. Key issues include these:

  -- Transportation options create an infrastructure demand that must be accounted for in planning. The current network of fueling stations for LDV and HDV is pervasive, with one or more fueling station in virtually every community and neighborhood in the state. Pushing vehicles to electricity adds demand to the distribution system, while a hydrogen-based vehicle system would necessitate replacement of key components of this extensive refueling network.

  -- The specifics of how to reduce VMT aren't addressed in the scenarios. They're important: e.g., reducing VMT means increased demand on and expansion of mass transit, as well as potential impacts on community design, development, and redevelopment.

  -- Significant improvements in vehicle fuel efficiency are important to the mitigation scenarios. Whether national standards will be sufficient to drive this change is questionable.

  - The state's residential and commercial sectors are a major source of emissions, and the scenarios call for substantial improvements in energy efficiency and the source of energy used for space conditioning, hot water, and cooking. At the January workshop, the point was made that many building professionals have little concept of how much buildings contribute to GHG emissions, and how little it costs to mitigate them. New York City's new Green Codes, a major effort commissioned by the Mayor and City Council Speaker, may offer a useful guide for other cities in the state, for starters.

But even if all building owners, managers, and tenants were committed to greening the existing building stock, the workforce needed to install energy retrofits may not be adequate to the job: training may be required, along with financing schemes that facilitate retrofits.

- All three scenarios assume use of distributed renewable energy in the building sector. This resource is over and above transmission-connected resources accounted for in the electricity sector. The Deep Blue and Ultraviolet scenarios call for the residential sector and commercial sector to be zero emissions, not net-zero. If the strategy evolves to a net-zero standard, other emissions not accounted for in the scenarios will have to be offset.

- Serious methodological questions must be addressed. For example, how well understood are interconnections among complex physical systems—the networks of energy inputs and feedback loops—that drive emissions? That link energy use and water use? Should estimates of GHG emissions include embedded energy, which produces emissions beyond the state's borders? How far should lifecycle analyses go?

- With a goal of 51 MMT CO_2e, even small sources of emissions become important. Emissions reductions strategies for several sources (e.g. asphalt production, SF_6 leakage, etc.) are not immediately clear. Work is needed to develop strategies for management of emissions from all sources.

- *Interdependencies.* The interdependencies, and consequent vulnerabilities, of transportation, water, energy, and communication systems have direct consequences for system performance and thus for climate change adaptation and mitigation. System managers and operators must be helped to understand and manage those interdependencies.

Policy considerations

- *Incipient policy conflicts and synergies*. The Climate Action Plan has pervasive ramifications for the state's economy and social fabric. Many existing State policies may facilitate or hinder achievement of the 80x50 goal. Policies made by other states and the federal government can affect New York's ability to pursue its chosen path. For example interstate commerce (tourism, freight, and aviation) is shaped by federal policy. Large-scale renewable energy involves significant land-use choices, for siting of wind and solar facilities and use of biomass resources; local choices and policies may affect the State's ability to meet its renewables goals.

- *Policy gaps*. What regulatory scheme will be required to cover the siting for CCS facilities, pipelines, and storage sites, and the permitting of CCS operations? For gas-cooled, high-temperature nuclear reactors that would produce hydrogen? For new technologies yet to emerge? Designing and implementing regulatory "infrastructure," so to speak, might be no small undertaking in its own right.

- *The need for partnering.* Related to policy conflicts and synergies is the great need for partnering among all levels of government and between the public and private sectors, with regional collaboration being a point strongly urged at the January 5 workshop. The inclusiveness and openness already demonstrated by the NYS Climate Action Council and the State's many other climate and energy initiatives, including the State's aggressive partnering with local governments through the Climate Smart Community Pledge, augurs well for this. Obviously, close partnering with the business community will remain a long-term necessity.

- *Long-term consequences of near-term decisions, and lack of decisions.* Decisions made, and not made, about matters that require long lead times, such as major infrastructure projects, and that have long-term consequences, such as land-use policy and a commitment to CCS, cast long shadows into the future. Whatever the choice of low-carbon sources of electricity (CCS, nuclear, solar) and of energy carrier for transportation (electricity or hydrogen), the electricity sector *must* plan for the expansion of the grid and improvement of transmission and distribution. Some early actions, such as improving energy efficiency, have value regardless of other choices made; others may have value only in relation to specific choices of technology, such as development of CCS infrastructure. It's important to remember that achieving a low-carbon future requires a portfolio of actions, and that "easy" decisions aren't substitutes for hard ones.

- *The* rate *at which policies drive change matters to success.* But this important factor is difficult to manage. The Climate Action Council is working in a field in motion, as technologies evolve, economic conditions change, and other parties, including the federal government, make decisions that have consequences for New York.

- *Stranded capital investments*. Practically all energy-related technologies require both infrastructure and capital investment from the private sector, and those investments are generally large. If they are foreclosed because of decisions that support the 80x50 goal before they've delivered a full return on investment or reached the end of their useful lifetimes, the result will be stranded capital investments – both a major hidden cost of carbon mitigation and a source of resistance to future change.

- *Investments by the State*. The current performance of many technologies assumed by the mitigation scenarios – such as PV, offshore wind, large-capacity/low-cost batteries, PHEVs, CCS, zero-energy commercial buildings and LEDs – is inadequate to meet the 80x50 goal. Those technologies will require investment to boost performance. Sources like DOE-National Lab Roadmaps and the National Academies' study, America's Energy Future, identify step-function improvements in technology and major investments in infrastructure needed to achieve a low-carbon economy.

- *Motivating change.* The scenarios make no explicit assumptions about individual behavior. How to motivate individuals to modify their energy consumption and patterns of use, drew considerable interest at the January workshop, and warrants the attention the State Climate Action Council.

CODA

Insidiously, carbon emissions are cumulative: they persist in the atmosphere for up to thousands of years. This means that as levels of emissions grow, reducing them to levels deemed acceptable becomes ever harder. And because New York is already more energy-efficient than most states, reducing emissions from what is already a low baseline is harder, still.

Against this physical reality, the momentum of *business as usual* is not to be underestimated: it's one of the most powerful forces in the world. And yet, the nature of *business as usual* continually evolves. The "installed base" of current energy technologies represents trillions of dollars in sunk costs and powerful special interests. Fossil fuels are cheap, abundant, and convenient. Options for scaling up alternatives to them, affordably, are not yet in hand. Yet history tells us that technologies, and markets, continue to change. The brutal realities of fiscal deficits are certain to constrain important efforts to achieve the 80x50 goal. And yet they also make the very real economic opportunities generated by that goal even more compelling.

Notably, the assets and advantages that the State enjoys can be game-changers, too. Executive Order 24 is soundly and sensibly conceived. The Climate Action Council's approach to its task is exemplary. It enjoys the benefit of committed top-down leadership; many motivated state employees who possess technical expertise, policy savvy, and insight into how government and the political system work; a broad-spectrum approach that engages a large number of committed stakeholders in the NGO and private sectors; and a deep commitment to achieving environmental justice.

Crucially, the Council is rapidly gaining insight into the staggering magnitude of the challenge it has been tasked to address and the nature of the strategies it can employ.

Over coming decades, New Yorkers – long celebrated for being tough, resourceful, and creative – may well prove to be the equal of the 80x50 challenge. Every megaton of GHG emissions avoided will be a gain, and the societal and economic transformation achieved in vigorous pursuit of sustainability will create a future for our children and grandchildren and generations beyond that is *better* than the present we inhabit.

APPENDIX A

Supplemental Information on Methodology & Data Sources for the Baseline Forecast of Energy Demand and the "Business as Usual" Case

The input to the macro coupled-sector modeling is the baseline projection for energy demand by sector and fuel type in 2050. These values were estimated by a constant growth (% per year) extension of the modeling conducted in the development of the New York State Greenhouse Gas Emissions Inventory and Forecast for the 2009 State Energy Plan, which estimated the GHG emissions by sector and fuel type to 2025.

Forecasts of petroleum and coal use for residential, commercial, industrial, and non-highway transport sectors were based on U.S. Energy Information Administration (EIA) forecasts for Mid-Atlantic fuel demand, along with natural gas projections provided by Energy and Environmental Analysis, Inc. (ref: Energy Demand and Price Forecast, 2009 State Energy Plan).

Forecasts for fuel use for the electricity sector and net imports of electricity were based on output from ICF International's Integrated Planning Model® (IPM), an electricity sector modeling software used to support the development of the 2009 State Energy Plan. Energy demand by sector and fuel type was modeled to 2025. From 2025 to 2050, a constant annual rate of growth or decline was assumed. In addition, emissions projections for 2025 and 2050 are also estimated and presented in Table 2 above. These projections include estimated emission reductions due to RGGI and partial implementation of New York's 15x15 energy efficiency goal.

Forecasts of NYS vehicle miles of travel (VMT) were estimated from historical NYS Department of Transportation VMT data (https://www.nysdot.gov/divisions/policy-and-strategy/darb/dai-unit/ttss/repository/vmt_0.pdf). NYDOT estimates that VMT will continue to grow at a 1.1% per year growth rate out to 2030, and is assumed to grow at this pace to 2050. The annual rate of growth of VMT was 2.5% between 1975 and 1990, and 1.7% between 1990 and 2005 (See Strategies for a New Age: New York State's Transportation Master Plan for 2030.) On-highway diesel and gasoline fuel use was based on NYS VMT along with the Department of Energy's Energy Information Agency-projected vehicle economy, and was the basis the estimate of emissions from the transportation sector.

Finally, non-fuel combustion GHG emission forecasts for the industrial sector were based on the projected growth of New York industries. These forecasts were created using Policy Insight® version 8.0, macroeconomic modeling software from Regional Economic Models Inc. Estimates for emissions from hydrofluorocarbon (HFC) refrigerant substitutes are scaled from EPA projections for national emissions by New York State's relative use of air conditioning, refrigerators, and freezers. Emissions from electricity transmission and distribution were assumed to continue to decline, following the long-term historical trend.

A more detailed explanation of the forecasting methods can be found in the NYS State Energy Plan Energy Demand and Price Forecast Assessment. GHG emission forecasts are in large part based on these energy-use forecasts. A more detailed explanation of the sources and methodologies for GHG emissions can be found in the New York State Greenhouse Gas Emissions Inventory and Forecast for the 2009 State Energy Plan.

Appendix B

GHG Emissions Scenario Assumptions

Sector	Yellow	Deep Blue	Ultraviolet
Transportation	Smart growth reduces VMT Demand 10% for LDV Fleet mix composed of CV/HEV/PHEV* = 30/30/40 CV reaches 37 mpg; HEV miles at 50mpg 95% of VMT for PHEV are all-electric 50% of HDV miles switch to freight transport by rail 30% efficiency gains in aviation ~51.3 MMT CO2e	Smart growth reduces VMT demand 40% for LDV 100% of VMT for LDV from hydrogen (nuclear-based) @65 mpg equivalent 50% HDV VMT switch to freight transport to rail; 40% of balance of miles from biodiesel 30% efficiency gains in aviation, 50% reduction of aviation emissions from biofuel ~15 MMT CO2e	Smart growth reduces VMT demand 40% for LDV 95% of VMT from LDV are all-electric miles Balance of LDV VMT 50 mpg with in-state E85/biodiesel 50% HDV VMT switch to freight transport to rail 30% efficiency in aviation sector; 50% reduction of aviation emissions from biofuel ~20 MMT CO2e
Electricity	25% electricity efficiency in Residential 25% electricity efficiency in Commercial 10% electricity efficiency in Industrial Minimize combustion; what is left switches to IGCC, NGCC w/ CCS Max hydro, wind No new nuclear NO NEW OUT OF STATE RENEWABLE ELECTRICITY ~24 MMT CO2e	Significant efficiency gains as in Yellow Scenario Eliminate all combustion Maximize hydro 30% from carbon-free (nuclear [+2 new plants producing 25K GWh] + hydro) 30% from renewables (utility-scale solar (100,000 GWh), max wind) 40% from NGCC and CCS (@90%) H2 via electrolysis of high-temperature steam using high-T gas-cooled reactors (5-8 plants) NO NEW OUT OF STATE RENEWABLE ELECTRICITY ~13 MMT CO2e	Significant efficiency gains as in Yellow Scenario Maximize hydro, max wind 35% from carbon-free (nuclear [15 new nuclear plants; 24 total], max hydro) 35% from renewables (utility scale solar (100,000 GWh), wind) 17% from NGCC and CCS (@90%) 35%- 40% energy demand in Res./Comm from local solar NO NEW OUT OF STATE RENEWABLE ELECTRICITY ~10 MMT CO2e
Residential	20% efficiency gains in energy demand for heat/hot water 10% of electricity needs met from local solar Reduce combustion by 70-80% ~7.5 MMT CO2e	30% reduction in energy demand through efficiency 50% delivered gas/liquid fuels from biomass 40% of balance of energy demand left met by local solar generation Balance to energy demand from grid ZERO MMT CO2e	50% reduction in energy demand through efficiency Eliminate all combustion of gas, oil 40% of balance of energy demand met by local solar PV ZERO MMT CO2e
Commercial	Reduce natural gas/oil combustion by 75% 10% of electricity needs met from local solar Balance of energy need shifted to central electricity ~4.5 MMT CO2e	20%-30% efficiency gains 50% delivered liquids fuels from biomass ~30% of electricity demand from local solar Balance of energy need shifted to central electricity ZERO MMT CO2e	20%-30% reduction in energy demand through efficiency Eliminate all combustion of gas, oil ~ 50% of energy demand from local solar Balance of energy need shifted to central electricity ZERO MMT CO2e

Industrial	Eliminate all coke/coal use Reduce natural gas/oil combustion by 50% Switch coke/coal to natural gas Balance of energy need shifted to electricity ~14 MMT CO2e	20%-40% reduction in energy demand through efficiency Eliminate natural gas, oil combustion Eliminate coke at cement/boilers; switch to natural gas Residual of emissions from asphalt, petrochemical, other (8.4 MMT) ~13MMT CO2e EMISSIONS	20%-40% reduction in energy demand through efficiency Eliminate natural gas, oil combustion Eliminate coke at cement/boilers; switch to natural gas Residual of emissions from asphalt, petrochemical, other (8.4 MMT) ~13MMT CO2e EMISSIONS
Other	Eliminate SF6 dielectric from T/D grid 50% reduction in line leaks in natural gas RRR policy Eliminate HFC leaks Reduce process CO2 ~12 MMT CO2e	Eliminate SF6 dielectric from T/D grid Eliminate hydrofluorocarbon emissions Eliminate 90% line leaks in natural gas RRR policy to eliminate 100% municipal methane/waste emissions Eliminate HFC emissions ~12 MMT CO2e EMISSIONS	Eliminate SF6 dielectric from T/D grid Eliminate hydrofluorocarbon emissions Eliminate 90% line leaks in natural gas RRR Policy to eliminate 100% municipal methane/waste emissions Eliminate HFC emissions ~12 MMT CO2e EMISSIONS

CV = Conventional Vehicle; HEV = Hybrid Electric Vehicle; PHEV = Plug-in Electric Hybrid Vehicle; LDV = Light Duty Vehicle; HDV = Heavy Duty Vehicle; VMT = Vehicle Miles Travelled; MMT CO2e = Million Metric Tons CO2 Equivalent

Appendix G
Electric Vehicle Workgroup Report

Background[1]

The transportation sector currently produces 39.5 percent of New York State's combustion-based inventory of greenhouse gases (GHGs). The gasoline-fueled light-duty vehicle sector is responsible for the vast majority of those emissions. Plug-in electric vehicles (EVs), plug-in hybrid electric vehicles (PHEV), and fuel cell vehicles (FCVs) powered by hydrogen derived from electrolysis, offer the potential to displace a significant portion of this petroleum consumption by using electricity for all or portions of vehicle trips. If this electricity has a low- or near-zero carbon intensity, the carbon footprint from this segment could be nearly eliminated.

The New York Climate Action Council established five Technical Working Groups representing key sectors of the economy. Each Technical Work Group was tasked with providing technical analysis and developing policy options for GHG reductions in each sector. The GHG reduction potential of electrically powered vehicles will be influenced by the policies developed in three sectors: Transportation and Land Use; Power Supply and Delivery; and Residential, Commercial/Institutional, and Industrial Buildings and Infrastructure. The cross-sector Electric Vehicle Subgroup[2] was established to identify how transitioning to a high penetration of grid-powered vehicles would affect multiple economic sectors and to establish, where possible, a consensus on a comprehensive transition strategy for all sectors.

The Approach

The Cross-Sector subgroup consisted of members from the Transportation and Land Use, Power Supply and Delivery, and Residential, Commercial/Institutional, and Industrial Technical Work Groups. The approach used was: (1) segment the flow of electricity from source to vehicle into five stages; (2) identify the questions and issues in each segment that need to be addressed to achieve significant market penetration of plug-in vehicles with maximum GHG reductions; and (3) research the issues, establish findings, and describe strategies or approaches that address the issues. Where appropriate, the group made an attempt to identify mid- and long-term issues.

In addition to the individual sector perspective and expertise of the Technical Work Group members, the group invited participation and presentations from several outside sources. These included vehicle manufacturers Ford and Tesla and a manufacturer/supplier of charging station infrastructure.

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[1] This report was developed by representatives from the Climate Action Council's Transportation and Land Use (TLU), Power Supply and Delivery (PSD), and Residential Commercial/Institutional, and Industrial (RCI) Technical Working Groups. The report describes cross–sector issues and policies associated with a transition to electric-grid-powered vehicles.

[2] Subgroup Members: Richard Drake (NYSERDA), Eleanor Stein (NYS DPS), Matt Fronk (RIT), Jamie Van Nostrand (Pace University), Joe Oats (Consolidated Edison), Steve Corneli (NRG Energy), Kerry-Jane King (NYPA), Carol Murphy (ACE NY), John D'Aloia (NYS DPS), Steven Tobias (National Grid), Matt Nielsen (General Electric), Dave Coup (NYSERDA), John Zamurs (NYS DOT), and David Gardner (NYS DEC).

Summary

General: A top priority should be an in-depth analysis of the coincidental overlays of: EV-charging load profiles; future intermittent and non-dispatchable generation growth in New York State; and projected residential, commercial/institutional, and industrial electrical load growth in the state. The findings in this appendix are based on available analysis as referenced in the report.

Power Supply—Generation

- Through the mid-term (2025), New York State has adequate generation capacity to accommodate the maximum (30 percent) anticipated penetration of EVs and PHEVs.
- "Smart charging" to minimize grid impacts will be necessary.
- New York's current off-peak generation mix provides PHEVs significant GHG reductions, as compared to conventional vehicles. However, to maximize GHG reductions, the transmission grid will need to be near carbon-free.
- Through the mid-term (2025), the state's transmission grid has adequate capacity to accommodate the maximum (30 percent) anticipated penetration of EVs and PHEVs with smart charging.

Distribution

- Near to mid-term: Local distribution (transformer) upgrades are likely to be necessary.
- Longer term: The large number of EVs requiring quick charge may require local storage.
- Business models, policies, and regulatory actions encouraging smart charging and allowing third-party sale of electricity may be necessary.

Infrastructure

- Building codes addressing Level II and Level III charging in new residential and commercial garage construction will significantly reduce costs.
- Building codes that address garaging hydrogen-fueled vehicles should be part of the long-term solution.
- Policies and regulations should encourage the development of a variety of business models for charging/refueling (battery swap, etc.).

Vehicles

- PHEVs, EVs, and FCVs demonstrating acceptable performance are a reality.
- Vehicles deriving their fuel from the electric grid are likely to become a cost-effective means of achieving carbon-free mobility.

- Near term: Incentives will likely be necessary to induce adoption. Gas may need to reach $4/gallon and research and development (R&D) will be needed to improve performance and reduce cost before EVs and PHEVs are economically compelling without incentives.[3]
- Near- and mid-term: Battery vehicles will predominate. The advantages of FCVs having greater range, performance, and quick fill together with lower vehicle cost may compel commercial fleets initially and later private vehicles to invest in localized hydrogen infrastructure based on electrolysis from off-peak carbon-free grid power.

Table G-1. Electric Grid Powered Vehicle—Climate Policy Issues by Category

A Generation	B Transmission	C Distribution	D Infrastructure (Buildings and Facilities)	E Vehicle + End-User
A-1: How much generation is needed to meet the new load? **A-2**: What CO_2e intensity is required to achieve 80 by 50? How do we achieve it? **A-3:** What is the desired load shape for EVs to minimize the carbon intensity of required generation?	**B-1:** Do we have sufficient transmission capacity to meet the new load? **B-2:** Does this new load create any major reliability issues (e.g., stability, thermal, voltage)? **B-3:** Are there transmission-level investments that would reduce the carbon intensity of an EV load?	**C-1:** Do we have sufficient distribution capacity to meet the new load? **C-2:** Does this new load create any major reliability or infrastructure cost issues (e.g., stability, thermal, voltage)? **C-3:** Are there legal, regulatory, or policy actions that could reduce transaction obstacles and accelerate a transition to electrified transportation? **C-4:** Who should pay for any required upgrades? The individual beneficiary or the rate base? **C-5:** Will fast-fill fueling require distribution-scale stationary energy storage (hydrogen or electric)?	**D-1:** What charging infrastructure/ strategy is needed? **D-2:** Are changes necessary in retail electricity rate structures? If so, how should they be changed? **D-3:** What kind of advanced metering is needed? **D-4:** What land-use issues need to be addressed? **D-5:** What kind of consumer education is needed? **D-6:** How do we bring upfront costs down for consumers? **D-7:** What codes and standards need to be created/updated?	**E-1:** What charging technologies are needed (e.g., smart charge)? **E-2:** What battery technologies are most suitable for this application? Are they available and cost-effective? **E-3:** What vehicle platform(s) seems the most viable? Can EVs meet driver needs, or will we need fuel cell or bio-PHEVs to meet range requirements? **E-4:** Who will service these vehicles? **E-5:** What is the rate of advanced low carbon vehicle introduction needed to meet 80 by 50? How do we get more cars "in the pipeline"? **E-6:** How do we bring upfront costs down for consumers? Are incentives required to overcome the high cost of electric vehicles?

80 by 50 = 80percent reduction in carbon from 1990 levels by 2050; CO_2 = carbon dioxide; EV = electric vehicle; PHEV = plug-in electric vehicle.

[3] *Transitions to Alternative Transportation Technologies*, National Academy of Sciences, 2010.

Strategies

A. Power Supply: Generation

A-1 How much new generation is needed?[4]

New York's electric supply is sufficient to meet electric vehicle megawatt (MW) requirements in the near-to-mid-term (2025). According to a National Renewable Energy Laboratory study, "a 50 percent penetration of PHEVs would increase the per capita electricity demand by around 5–10 percent, while increasing total electrical energy consumption (but without requiring additional generation capacity)." However, an increased proportion of low- or zero-carbon generation to displace traditional fossil plants must be brought on line to meet the 80 by 50 goal. This assumes that smart charging will be implemented as grid-fueled vehicle penetration grows. It may be necessary for public policy or rate structures to provide incentives and disincentives to implement adoption.

- Strategy: Near-term and long-term continued support of R&D for renewable technologies, as well as methods to reduce carbon from fossil sources; continued financial incentives/rate structure to encourage low-/zero-carbon generation and off-peak, valley filling charging.

A-2 What electric grid carbon dioxide (CO_2) intensity is required to achieve 80 by 50?[5]

The nation has experienced a significant increase in the carbon intensity of the grid over the past 20 years. Therefore, for the United States to achieve an 80 percent reduction in carbon from 1990 levels by 2050, the country must cut its current rate of 5.8 billion tons CO_2/year to 1 billion tons/year. This equates to approximately a 4 percent reduction each year for the next 40 years.

The carbon intensity of the grid varies significantly as a function of grid load, with off-peak power having the lowest carbon footprint. In New York, the electric grid is responsible on average for approximately 800 pounds (lb) of CO_2 for every MW produced. At this level of intensity, an all-electric car typically produces approximately 0.3 lbs. of CO_2 per mile while a conventional vehicle getting 26 miles per gallon (MPG) produces 0.77 lbs. CO_2 per mile. Therefore, with today's generation mix, an electric vehicle provides on average a 61percent reduction in CO_2. With the current generation mix, New York State would be unable to achieve the 80 by 50 goal, even if elective vehicles were used for all travel. While off-peak power is less carbon intense and "smart (off-peak) charging" has the potential to provide some benefit in the near term, a high percentage of grid-powered vehicles and a near-zero carbon footprint from the electric grid will be required in order to achieve the 80 by 50 goal

- Strategy: (1) Develop technologies (energy storage, smart charging) and policies (EV electric rates) that promote vehicle charging at times when the carbon intensity of the grid is lowest

[4] EPRI/NYSERDA, *Grid Impact of PHEVs*, 2010; NREL, *An Evaluation of Utility System Impacts and Benefits of Optimally Dispatched Plug-In Hybrid Electric Vehicles*, Oct. 2006; PNNL, *Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids*, 2007.

[5] International Energy Agency, "CO_2 Emissions from Fuel Combustion - Highlights," 2009; U.S. DOE, *Annual Energy Review*, Table 12.2, 2009; CARB, *2050 Greenhouse Gas Emissions Analysis: Staff Modeling in Support of the Zero Emission Vehicle Regulation*, 2009.

(i.e., off-peak). (2) De-carbonize the grid to the greatest extent possible. Achieving more than a 60 percent reduction in vehicle-mile carbon intensity from EVs will require a grid with a much lower carbon footprint.

A-3 What is the desired load shape for EVs to minimize the carbon intensity of required generation?[6]

EV charging should move to off-peak charging. Conversely, charging immediately upon returning home (4-6 p.m.) should generally be avoided, as this could compete with other electrical loads. Furthermore, moving charging to overnight hours would correlate with the production profile of zero-carbon wind resources in New York (as well as base-loaded hydro and nuclear power).

- Strategy: Create an electricity rate structure with incentives for EV owners to charge during off-peak hours, with the highest incentives during overnight hours.

B. Transmission

B-1 Do we have sufficient transmission capacity to meet the new load?[7]

The transmission system will not require added capacity specifically for EV charging because PHEV vehicle adoption is not anticipated to seriously affect generation (MW of supply).

- Strategy: This assumes smart charging and other strategies to shift demand from peak hours. Otherwise, no specific strategy is required, assuming upgrades to the transmission system due to expected load growth outside of EV.

B-2 Does this new load create any major reliability issues (e.g., stability, thermal, voltage)?[8]

System reliability could be reduced as a result of a high utilization scenario, as less reserve capacity is available. With smart charging, reliability issues are not expected. With further advancements in vehicle-to-grid (V2G) technology, it is possible that vehicle storage may provide benefits to transmission system reliability. While it appears that PHEVs are much better suited to support short-term ancillary services, such as regulation and spinning reserve, a large fleet of PHEVs could replace a moderate percentage (perhaps up to 25 percent) of conventional low-capacity-factor (rarely used) generation used for periods of extreme demand or system emergencies. Overall, the ability to schedule both charging and very limited discharging of PHEVs could significantly increase power system utilization.

[6] NYISO, "Alternate Route: Electrifying the Transportation Sector," June 2009.

[7] KEMA, *Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems*, report for ISO/RTO Council; PNNL, *Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids*, 2007. (Note: KEMA is not an acronym, it is the name of an international testing and certification company.)

[8] PNNL, *Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids*, 2007; NREL, *An Evaluation of Utility System Impacts and Benefits of Optimally Dispatched Plug-In Hybrid Electric Vehicle*s, Oct. 2006

- Strategy: Adopting "smart charging" systems that recognize grid emergencies could mitigate the extent and severity of these events. Continue R&D into V2G technology. Explore financial incentives for providing grid support.

B-3 Are there transmission-level investments that would reduce the carbon intensity of an EV load?

The issues of vehicle range, fueling infrastructure, and cost will be challenging. Quick-charge (Level III) electric charging may require stationary storage or other upgrades. Range issues can be overcome with FCVs; however, quick-fill public hydrogen infrastructure would require a major investment. A third option, hybrid bio-PHEV, may be the easiest pathway on the vehicle side; however, low-carbon cellulosic ethanol is not yet a proven option.

- Strategy: All of the above options should be developed; all may be needed to meet the variety of duty cycles, first cost versus operating cost constraints, and user needs. In all cases, continuous improvements in vehicle technology will be needed, together with significant long-term infrastructure investment. Public policy should be technology-neutral and, in the near term, focus on low-carbon vehicle incentives, such as feebates for low-carbon vehicles and tax credits and buy-downs for fueling infrastructure.

C. Distribution

C-1 Do we have sufficient distribution capacity to meet the new load?[9]

To achieve the penetration rates required by the 80 by 50 target, some distribution system upgrades will undoubtedly be needed. Because of clustering and a slower penetration rate of pure battery versus PHEV, current analysis indicates that upgrades involving distribution transformers and customer service – not primary feeders or transformers – will be needed at a local level. Impacts can vary greatly from system to system. Some distribution systems have a ratio of customers to service transformers as low as 2 to 1, while others, such as Rochester Gas and Electric, have ratios of 9 to 1. This will result in different impacts on the distribution systems in different distribution systems. In systems that are largely underground, there is some potential for underground cables and transformers to have inadequate cool-down periods at night, should significant load be shifted to off-peak nighttime periods on feeders that are highly loaded during the day. So, although the load growth rate is generally expected to be within the normal bounds of planning activities and load growth, there will be situations requiring special consideration and study.

- Strategies: Smart charging, load shifting, and stationary storage all have the potential to mitigate most of the anticipated problems for the next decade.

[9] EPRI/NYSERDA, *Analysis of Grid Impact of PHEVs in New York State,* 2010; Quanta Technology, "Thoughts and Opinions on the Impact of Plug-in Hybrid Electric Vehicles," 2008.

C-2 Does this new load create any major reliability or infrastructure cost issues (e.g., stability, thermal, voltage)?

As noted in B-2, (transmission), distribution reliability issues are not expected with smart charging. With further advancements in V2G technology, it is possible that vehicle storage may actually provide benefits to distribution system reliability.

- Strategies: Financial incentives for desired market transformation and disincentives for unwanted behavior will be necessary to accelerate low-carbon vehicle market penetration. Infrastructure investment will also be a necessary element and may require adjustments in public policy and public investment.

C-3 Are there legal, regulatory, or policy actions that could reduce transaction obstacles and accelerate a transition to electrified transportation?

- Strategy: Consider revised tariffs in New York that would allow charging infrastructure providers to resell the electricity they purchase from utilities.

C-4 Who should pay for any required upgrades? The individual beneficiary or the rate base?

It could be argued that the advent of PHEVs is similar to the widespread adoption of air conditioning in the 1960s. The utilities incorporated this new load as a part of their normal planning process, and the cost was added to the rate base.

- Strategy: Costs should not be borne by individual customers. A preferred alternative is to use revenue derived from a broader base to cover the cost of upgrades specific to the supply of electricity for plug-in vehicle charging.

C-5 Will fast-fill fueling require distribution-scale stationary energy storage (hydrogen or electric)?

- Strategy: Since fast-fill charging is likely to be required by a user at a time other than off-peak hours, purchase of the stationary electrical storage may be necessary to minimize negative grid impacts and allow the utilization of excess renewable electricity generated in off-peak times.

D. Infrastructure (Buildings and Facilities)

D-1 What charging infrastructure/strategy is needed?

It seems generally accepted (and reinforced with surveys, PlaNYC, Electric Power Research Institute, etc.) that the most important locations for charging infrastructure are those facilities where vehicles are parked routinely for extended periods, such as home garages or places of work. New business models together with communication and transaction protocols will need to be standardized to allow smart charging that benefits the grid and consumer.

There are potential legal and regulatory barriers or policy choices related to the introduction of electric vehicle charging facilities on private premises and for public use. Under current New York law, all sellers of electricity to end users are electric corporations subject to Public Service Commission (PSC) regulation over rates and practices. New York has three overall options: (1) New York state could exercise this jurisdiction to set prices for EV charging that encourage electric car consumption and ensure off-peak charging to minimize grid impact (the Michigan approach); (2) the state could lightly regulate or forbear from regulating EV charging, to encourage new entrants and competition (the California approach); or (3) the state could amend its laws to deregulate entirely the sale of electricity as a motor vehicle fuel (to open the EV charging market completely, without any governmental oversight as to price and conditions, while safety and reliability restrictions would remain). Each approach has its own advantages, costs, and risks, and the policy and legal discussion is ongoing.

- Strategies: *First priority:* Standardize physical interconnections (plugs, voltages, etc.) and communications protocols. *Second priority:* Pursue public policy and regulatory actions that support the development of business models that allow the sale of electricity by third parties (non-utility), aggregation of loads for business transactions, private and public investment in publicly accessible vehicle charging, and development and deployment of standardized quick-charge (Level III) technology.

D-2 Are changes necessary in retail electricity rate structures? If so, how should they be changed?[10]

California's Public Utilities Commission has established special rates for EV charging and off-peak use. Remote-controlled charging could also occur by allowing customers to charge their vehicles at any location and be billed for the energy at a rate determined by the location of the vehicle, rather than at a residential rate.

- Strategy: Establish EV electric rates that encourage vehicle charging load growth that is consistent with minimized negative impact on the grid and that provides positive economic incentives to consumers. PHEV-specific dynamic pricing may be one way to introduce dynamic pricing to consumers while minimizing adverse customer reaction with regard to existing retail loads.

D-3 What kind of advanced metering is needed?

Using advanced meters, vehicle charging would be one of several home energy uses that could be managed through automation. Even simple time-of-use residential meters could provide customers with the incentive and the ability to manage their energy use for charging PHEVs.

- Strategy: Advanced metering will be required to enable consumers to benefit from favorable electric rate structures. Utility specifications and business models will determine meter specifications. PSC tariffs allowing rate-base recovery of additional costs specific to EV charging as opposed to unique customer cost may be helpful.

D-4 What land use issues need to be addressed?

- Strategy: Provide preferential parking, high-occupancy vehicle lanes, and lower tolls for low-carbon vehicles.

[10] KEMA, *Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems*, report for ISO/RTO Council.

D-5 What kind of consumer education is needed?

- Strategy: Produce television, newspaper, and web site information for consumers similar to the current New York State Energy Research and Development Authority media campaign promoting change-out of incandescent lighting to compact fluorescent lamps.

D-6 How do we bring upfront costs down for consumers?

- Strategy: See D-2 and D-3.

D-7 What codes and standards need to be created/updated?

Vehicle charging communications has received some support from automakers because it could allow for a single industry standard for recharging mechanisms to meet the needs of the electric utility system. Automakers would prefer to see a single vehicle standard that could be universally implemented, as opposed to a patchwork of standards and technologies across state boundaries or utility service territories.

The addition of Level II charging infrastructure to an existing building can typically cost $3,000, which can be an impediment to sales. When charging infrastructure is incorporated in new construction, the cost is $300.

- Strategy: Develop standards that are compatible with smart-grid/smart-charging Level III and building codes that require conforming circuitry in both residential and commercial new garage construction. This will enable lower-cost market penetration and safer/more reliable service. Policy and regulations should encourage standardization of vehicle charging interfaces at the regulated utility level and with vehicle manufacturers.

E. Vehicle (End User) Strategies[11]

E-1 What charging technologies are needed (e.g., smart charge)?

Smart charging will be needed as grid-fueled vehicle penetration grows. Shifting the vehicle charging load to off-peak time may be the biggest long-term issue. It may be necessary for public policy or rate structures to provide incentives and disincentives to implement adoption. Society of Automotive Engineers and Institute of Electrical and Electronics Engineers standards are under development, and there are several technical approaches that will enable vehicle-grid-building communication and smart charging. Energy storage technology will likely be necessary to mitigate large quantities of on-peak or fast-charging use in the future.

- Strategy: *Near term:* Encourage demonstrations of technical options, monitor performance, and explore behavioral influences of rate structures and public policy. *Long term:* Enact appropriate rate adjustments and incentives to mitigate grid problems, and conduct R&D of

[11] National Academy of Sciences, *Transitions to Alternative Transportation Technologies—Plug-in Hybrid Electric Vehicles*, 2009; The Electrification Coalition, *Electrification Roadmap*, 2009 (200 million EVs by 2050); CARB, *2050 Greenhouse Gas Emissions Analysis: Staff Modeling in Support of the Zero Emission Vehicle Regulation*, 2009; David L. Greene *and* Andreas Schafer, *Reducing Greenhouse Gas Emissions from U.S. Transportation*, prepared for Pew Center on Global Climate Change, 2003.

energy storage technologies that can utilize large quantities of excess power generated from renewable sources and baseload nuclear power (which are difficult to turn down) for on-demand and Level III quick-charge vehicle charging.

E-2 What battery technologies are most suitable for this application? Are they available and cost-effective?

Continued advances are required in battery technology and manufacturing. Significant cost reductions will be required to allow grid-charged vehicles to compete with petroleum at anything less than $4/gallon. This may be difficult with lithium-ion technology, because of the currently low labor costs and as-of-yet undetermined sources of cheaper materials.

- Strategy: Continue R&D into the next generation of battery chemistry and explore innovative business models (battery leasing, battery change out, etc.).

E-3 What vehicle platform(s) seems the most viable? Can EVs meet driver needs, or will we need fuel cell or bio-PHEVs to meet range requirements?

The issues of vehicle range, fueling infrastructure, and cost will be challenging. Quick-charge (Level III) electric charging may require stationary storage or other upgrades. Range issues can be overcome with FCVs. However, quick fill public hydrogen infrastructure would require a major investment. Hydrogen only provides significant GHG benefits over conventional hybrids when the hydrogen is produced through electrolysis or via thermo-nuclear means. Therefore, hydrogen is a long-term option that can provide benefits if and when there is adequate (or an excess of) zero-carbon electricity. A third option, hybrid bio-PHEV, may be the easiest pathway on the vehicle side. However, low-carbon cellulosic ethanol is not a proven option.

- Strategies: None of the above options should be abandoned. All may be needed to meet the variety of duty cycles, first cost versus operating cost constraints, and user needs. In all cases, continuous improvements in vehicle technology will be needed together with significant long-term infrastructure investment. Public policy should be technology-neutral and in the near term should focus on low-carbon vehicle incentives, such as feebates for low-carbon vehicles, a low-carbon fuel standard and tax credits, and buy-downs for fueling infrastructure.

E-4 Who will service these vehicles?

- Strategies: To build the skilled workforce needed, adopt public policy and financial support for educational and workforce development programs at community colleges and the Board of Cooperative Education Services and other publicly supported schools and provide tuition assistance for these programs.

E-5 What is the rate of advanced low-carbon vehicle introduction needed to meet 80 by 50? How do we get more cars "in the pipeline"?

Over 90 percent of vehicle miles are traveled with vehicles less than 15 years old. Therefore, to achieve a near total transition to low-carbon travel by 2050, nearly all vehicles sold after 2030 would need to be low carbon.

- Strategies: Offer financial incentives for desired market transformation and disincentives for unwanted behavior to accelerate low-carbon vehicle market penetration. Fund infrastructure investments, which may require adjustments in public policy and public investment.

E-6 How do we bring upfront costs down for consumers? Are incentives required to overcome the high cost of electric vehicles?

- Strategy: Manufacturer competition may be the most cost-effective way to reduce vehicle cost, with battery manufacturing capacity and supply-demand being dominant factors. A robust market can be encouraged through incentives, adequate charging infrastructure, and education. A low-carbon fuel standard, vehicle purchase feebate, or other carbon pricing mechanism will be needed for EVs/PHEVs to be economically competitive in the near term.

Appendix H
ClimAID Report Summary

Prior to the Governor Paterson's Executive Order 24 creating the Climate Action Council the New York Energy Supply and Development Authority (NYSERDA) was undertaking research on climate change under its Environmental Monitoring, Evaluation, and Protection (EMEP) program. A key project of this program is the *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State,* known as ClimAID.

ClimAID was undertaken to provide decision-makers with cutting-edge information on the state's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge. Involving the work of scientists from universities throughout New York state and key stakeholders, the assessment identifies critical vulnerabilities, climate risks, and adaptation strategies specific to New York State, for a range of key sectors: agriculture, coastal zones, ecosystems, energy, public health, telecommunications, transportation, and water resources.

A draft summary of the ClimAid project's work, *Responding to Climate Change in New York,* is appended here in its entirety keeping its original pagination. The larger materials on which this summary is based were critical to the Council's Adaptation Technical Work Group. Several of the ClimAID report authors served on this group.

RESPONDING TO CLIMATE CHANGE IN NEW YORK STATE

New York State Energy Research and Development Authority

2010

DRAFT

Authorship

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Full report may be found at www.nyserda.org/programs/environment/emep/home.asp

Citations

Synthesis Report
NYSERDA ClimAID Team. 2010. *Responding to Climate Change in New York State*, the Synthesis Report of the *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State*. C. Rosenzweig, W. Solecki, A. DeGaetano, S. Hassol, P. Grabhorn, M. O'Grady, Eds. New York State Energy Research and Development Authority (NYSERDA), 17 Columbia Circle, Albany, New York, 12203.

Foundation Report
NYSERDA ClimAID Team. 2010. *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State*. C. Rosenzweig, W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, P. Grabhorn, Eds. New York State Energy Research and Development Authority (NYSERDA), 17 Columbia Circle, Albany, New York, 12203.

All the figures and tables in this document are drawn from the ClimAID Foundation Report: *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State.*

Columbia University in the City of New York
CUNY The City University of New York
Cornell University

Responding to Climate Change in New York State

Climate change is already beginning to affect the people and resources of New York State, and these impacts are projected to grow. At the same time, the state has the potential capacity to address many climate-related risks, thereby reducing negative impacts and taking advantage of possible opportunities.

ClimAID: the Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State was undertaken to provide decision-makers with cutting-edge information on the state's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge.

This state-level assessment of climate change impacts is specifically geared to assist in the development of adaptation strategies. It acknowledges the need to plan for and adapt to climate change impacts in a range of sectors: Water Resources, Coastal Zones, Ecosystems, Agriculture, Energy, Transportation, Telecommunications, and Public Health.

The author team for this report is composed of university and research scientists who are specialists in climate change science, impacts, and adaptation. To ensure that the information provided would be relevant to decisions made by public and private sector practitioners, stakeholders from state and local agencies, non-profit organizations, and the business community participated in the process as well.

This document provides a general synthesis of highlights from a larger technical report that includes much more detail, case studies, and references. The larger report provides useful information to decision-makers, such as state officials, city planners, water and energy managers, farmers, business owners, and others as they begin responding to climate change in New York State.

Contents

Temperatures are increasing, precipitation patterns are changing, and sea level is rising. These climatic changes are projected to occur at much faster than natural rates because of increased amounts of greenhouse gases in the atmosphere. Some types of extreme weather and climate events have already increased in frequency and intensity and these changes are projected to continue.

These climate changes are already having impacts in some aspects of society, the economy, and natural ecosystems and these impacts are expected to increase. Not all of these changes will be gradual. When certain tipping points are crossed, impacts can increase dramatically. Past climate is no longer a reliable guide to the future. This affects planning for water, energy, and all other social and economic systems.

Interactions

Interactions between climate change and other stresses such as pollution and increasing demand for resources will create new challenges.

Heat Waves

Heat waves will become more frequent and intense, increasing heat-related illness and death and posing new challenges to the energy system, air quality, and agriculture.

Summer Drought

Summer drought is projected to increase, affecting water supply, agriculture, ecosystems, and energy production.

Heavy Downpours

Heavy downpours are increasing and are projected to increase further. These can lead to flooding and related impacts on water quality, infrastructure, and agriculture.

Wide Ranging Impacts

Major changes to ecosystems including species range shifts, population crashes, and other sudden transformations could have wide ranging impacts, not only for natural systems but also for health, agriculture, and other sectors.

Coastal Flooding

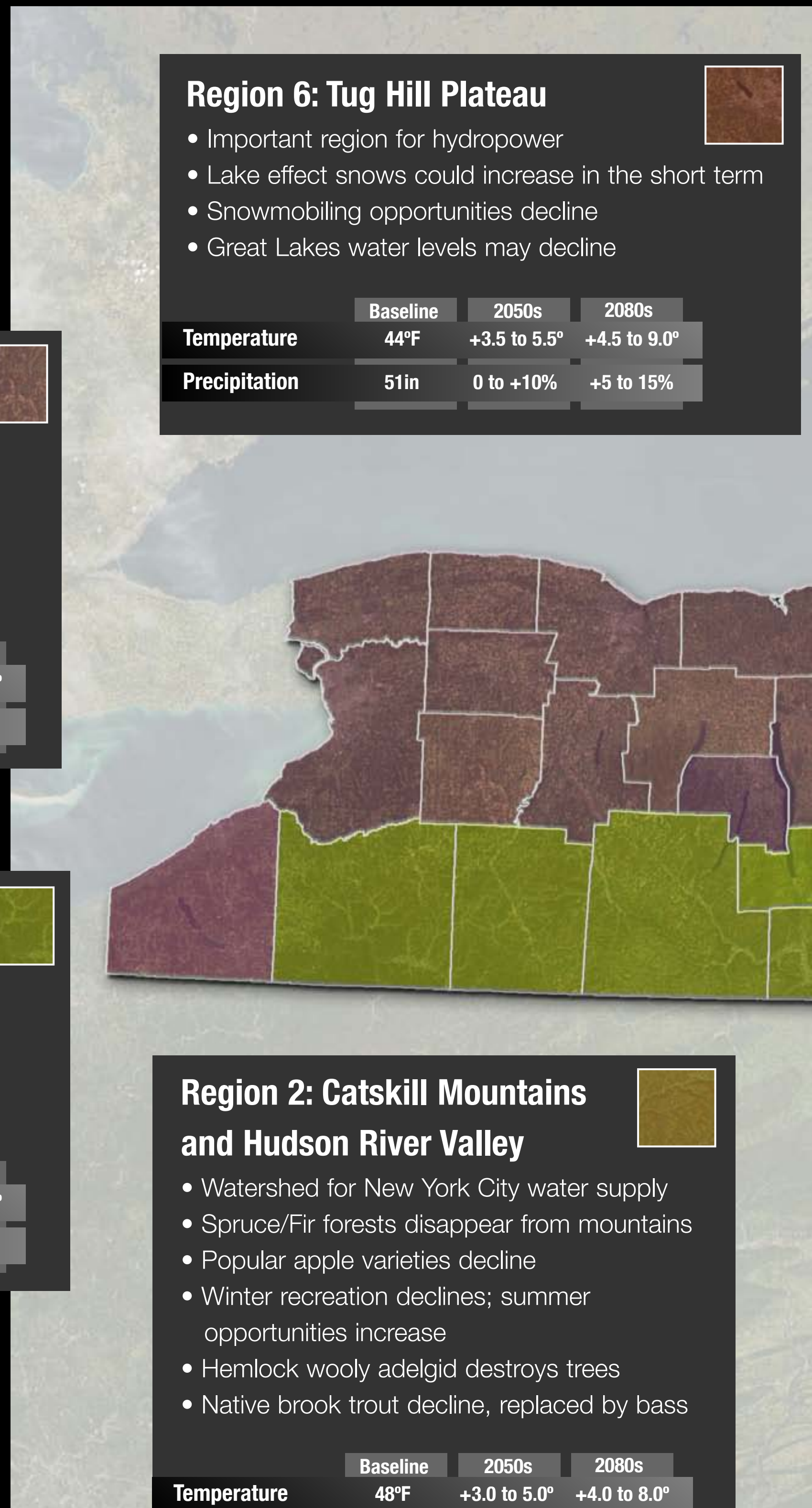
Coastal flooding due to sea level rise and storm surge will increasingly put lives and property at risk. Health, water quality, energy, infrastructure, and coastal ecosystems are all affected.

Opportunities

Climate change may create new opportunities related to a longer, warmer growing season for agriculture, and the potential for abundant water resources.

CLIMATE ISSUES IN NEW YORK STATE'S REGIONS

Each region of New York State (as defined by ClimAID) has unique attributes that will be affected by climate change. Many of the issues highlighted below are described in more detail in the sector discussions that follow.



Region 6: Tug Hill Plateau

- Important region for hydropower
- Lake effect snows could increase in the short term
- Snowmobiling opportunities decline
- Great Lakes water levels may decline

	Baseline	2050s	2080s
Temperature	44ºF	+3.5 to 5.5º	+4.5 to 9.0º
Precipitation	51in	0 to +10%	+5 to 15%

Region 1: Western New York Great Lakes Plain

- Agricultural revenue highest in state
- Relatively low rainfall, increased summer drought risk
- High value crops could need irrigation
- Improved conditions for grapes projected

	Baseline	2050s	2080s
Temperature	48ºF	+3.0 to 5.5º	+4.5 to 8.5º
Precipitation	37in	0 to +10%	0 to +15%

Region 3: Southern Tier

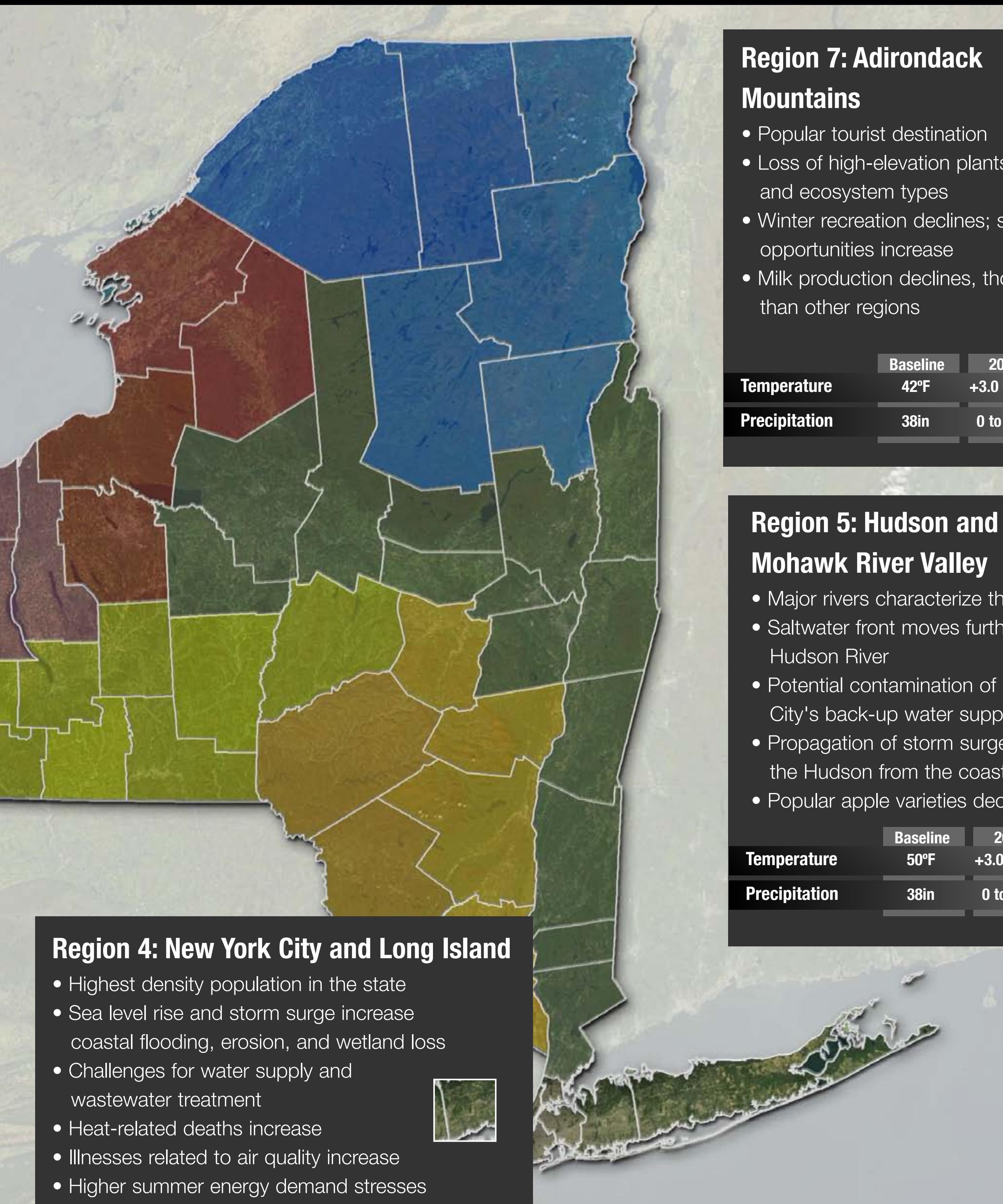
- Dairy dominates agricultural economy
- Milk production losses projected
- Susquehanna River flooding increases
- One of the first parts of the state hit by invasive insects, weeds, and other pests moving north

	Baseline	2050s	2080s
Temperature	46ºF	+3.5 to 5.5º	+4.5 to 8.5º
Precipitation	38in	0 to +10%	+5 to 10%

Region 2: Catskill Mountains and Hudson River Valley

- Watershed for New York City water supply
- Spruce/Fir forests disappear from mountains
- Popular apple varieties decline
- Winter recreation declines; summer opportunities increase
- Hemlock wooly adelgid destroys trees
- Native brook trout decline, replaced by bass

	Baseline	2050s	2080s
Temperature	48ºF	+3.0 to 5.0º	+4.0 to 8.0º
Precipitation	48in	0 to +10%	+5 to 10%



Region 7: Adirondack Mountains

- Popular tourist destination
- Loss of high-elevation plants, animals, and ecosystem types
- Winter recreation declines; summer opportunities increase
- Milk production declines, though less than other regions

	Baseline	2050s	2080s
Temperature	42ºF	+3.0 to 5.5º	+4.0 to 9.0º
Precipitation	38in	0 to +5%	+5 to 15%

Region 5: Hudson and Mohawk River Valley

- Major rivers characterize this region
- Saltwater front moves further up the Hudson River
- Potential contamination of New York City's back-up water supply
- Propagation of storm surge up the Hudson from the coast
- Popular apple varieties decline

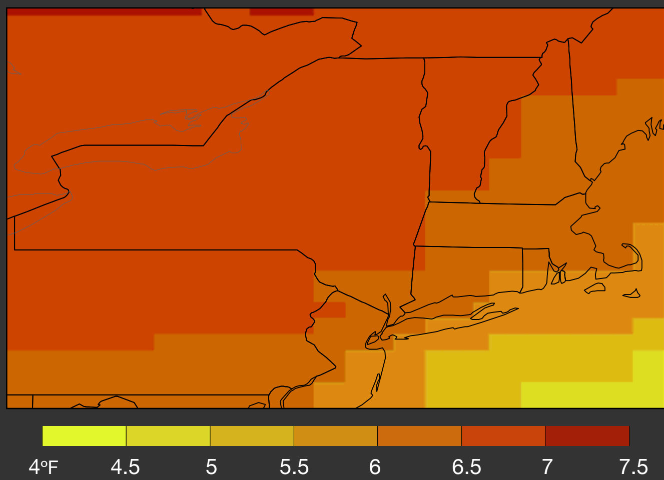
	Baseline	2050s	2080s
Temperature	50ºF	+3.0 to 5.5º	+4.0 to 8.0º
Precipitation	38in	0 to +5%	+5 to 10%

Region 4: New York City and Long Island

- Highest density population in the state
- Sea level rise and storm surge increase coastal flooding, erosion, and wetland loss
- Challenges for water supply and wastewater treatment
- Heat-related deaths increase
- Illnesses related to air quality increase
- Higher summer energy demand stresses the energy system

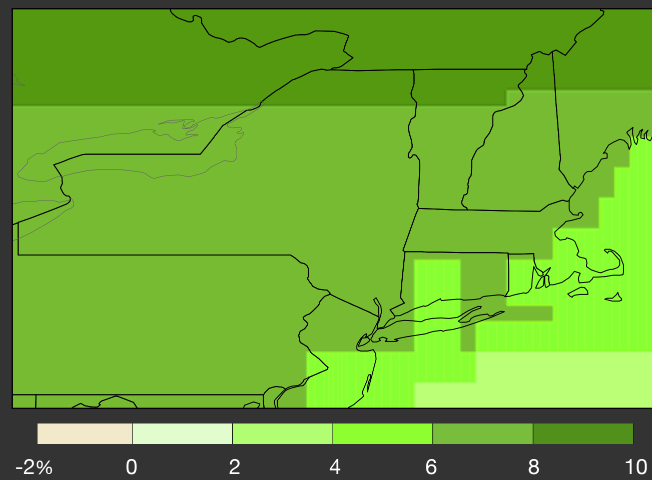
	Baseline	2050s	2080s
Temperature	53ºF	+3.0 to 5.0º	+4.0 to 7.5º
Precipitation	47in	0 to +10%	+5 to 10%

Projected Annual Temperature Change - 2080s (°F)



Average annual temperatures are projected to increase by 4.0 to 9.0°F by the 2080s, with the lower end of this range projected under lower greenhouse gas emissions scenarios and the higher end under higher emissions scenarios. A mid-range emissions scenario, A1B, was used for the maps above, yielding temperature increases of about 7°F for most of the state. The A1B trajectory is associated with relatively rapid increases in emissions for the first half of this century, followed by a gradual decrease in emissions after 2050.

Projected Annual Precipitation Change - 2080s (%)



Precipitation across New York State may increase by approximately 5 to 15 percent by the 2080s, with the greatest increases in the northern parts of the state. Much of this additional precipitation may occur during the winter months as rain, while late summer and early fall precipitation could decline slightly. Both maps show the average across 16 global climate models.

Temperatures are expected to rise across the state, by 1.5 to 3°F by the 2020s, 3 to 5.5°F by the 2050s, and 4 to 9°F by the 2080s. The lower ends of these ranges are for lower greenhouse gas emissions scenarios (in which society reduces heat-trapping gas emissions) and the higher ends for higher emissions scenarios (in which emissions continue to increase). These are not the best and worst cases, however. Sharp cuts in global emissions could result in temperature increases lower than the bottoms of these ranges, while a continuation of business-as-usual could result in increases higher than the high ends.

Annual average precipitation is projected to increase by up to 5 percent by the 2020s, up to 10 percent by the 2050s and up to 15 percent by the 2080s. This will not be distributed evenly over the course of the year. Much of this additional precipitation is likely to occur during the winter months, with the possibility of slightly reduced precipitation projected for the late summer and early fall.

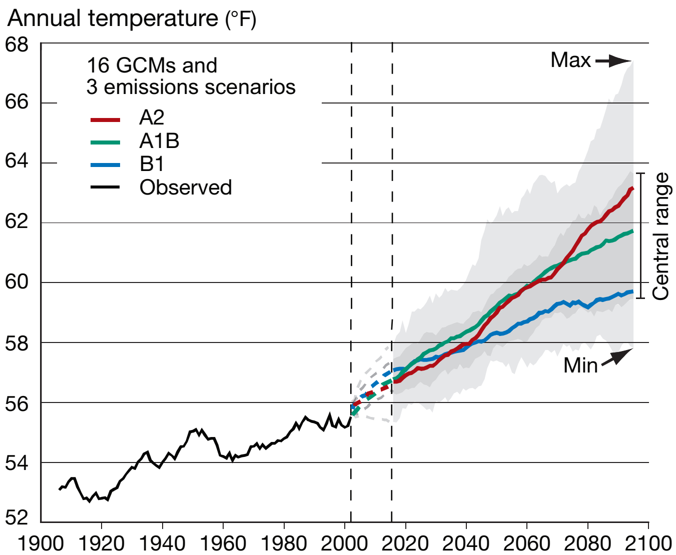
Continuing the observed trend, more precipitation is expected to fall in heavy downpours and less in light rains.

Sea level rise projections that do not include significant melting of the polar ice sheets (which is already observed to be occurring) suggest 1 to 5 inches of rise by the 2020s, 5 to 12 inches by the 2050s and 8 to 23 inches by the 2080s. Scenarios that include rapid melting of polar ice project 4 to 10 inches of sea level rise by the 2020s, 17 to 29 inches by the 2050s and 37 to 55 inches by the 2080s.

Projected Seasonal Precipitation Change - 2050s (% change)

ClimAID Region	Winter	Spring	Summer	Fall
1. Western New York Great Lakes Plain	+5 to +15	0 to +15	-10 to +10	-5 to +10
2. Catskill Mountains and Hudson River Valley	0 to +15	0 to +10	-5 to +10	-5 to +10
3. Southern Tier	+5 to +15	0 to +10	-5 to +5	-10 to +5
4. New York City and Long Island	0 to +15	0 to +10	-5 to +10	-5 to +10
5. Hudson and Mohawk River Valley	+5 to +15	-5 to +10	-5 to +5	-5 to +10
6. Tug Hill Plateau	+5 to +15	0 to +10	-5 to +10	-5 to +10
7. Adirondack Mountains	+5 to +15	-5 to +10	-5 to +5	-5 to +10

Observed and Projected Annual Temperature Change (°F)



These climate-related risks will affect the state's economy and environment. Some of the most serious vulnerabilities and potential adaptation strategies are highlighted in this report.

Higher temperatures and increased heat waves have the potential to

- increase fatigue of materials in water, energy, transportation and telecommunications infrastructure;
- affect drinking water supply;
- cause a greater frequency of summer heat stress on people, plants and animals;
- alter pest populations and habits, affecting agriculture and ecosystems;
- change the distribution of key crops such as apples, cabbage, and potatoes;
- cause reductions in dairy milk production;
- increase electricity demand for cooling;
- lead to declines in air quality that cause respiratory illness; and
- cause more heat-related deaths.

Increased frequency of heavy downpours has the potential to

- affect drinking water supply;
- heighten risk of river flooding;
- flood key rail lines, roadways and transportation hubs; and
- increase delays and hazards related to extreme weather events.

Sea level rise and coastal flooding have the potential to

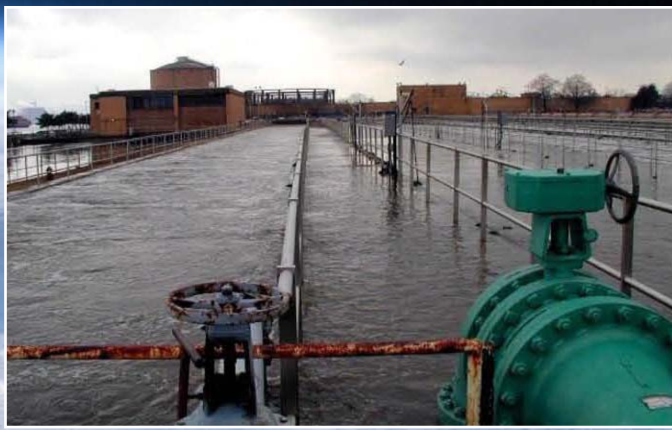
- increase risk of storm surge-related flooding along coast;
- expand areas at risk of coastal flooding;
- increase vulnerability of energy facilities located in coastal areas;
- flood transportation and communication facilities; and
- cause saltwater intrusion into some freshwater supplies near the coasts.

Projected Sea Level Rise for New York State (inches)

Modeled Sea Level Rise	2020s	2050s	2080s
GCM-based	+1 to +5	+5 to +12	+8 to +23
Rapid ice melt scenario	+4 to +10	+17 to +29	+37 to +55

The central range of sea level rise projections is shown, rounded to the nearest inch, based on the average of the ClimAID Global Climate Model-based (GCM) for a range of greenhouse gas emissions scenarios as reported by IPCC 2007 and the ClimAID rapid ice melt scenario (based on accelerated melting of the Greenland and West Antarctic Ice Sheets).

ADAPTATION CAN REDUCE IMPACTS



Adaptation refers to actions taken to prepare for climate change, helping to reduce adverse impacts or take advantage of beneficial ones.

Strategies can include changes in operations, management, infrastructure, and/or policies that reduce risk and/or capitalize on potential opportunities associated with climate change. Adaptations can take place at the individual, household, community, organization, and institutional level. Adaptation can be thought of as just better planning, incorporating the most current information about climate into a variety of decisions. Adaptation should be woven into the everyday practices of organizations and agencies.

Adaptive capacity refers to the ability of a system to adjust to actual or expected climate stresses or to cope with their consequences.

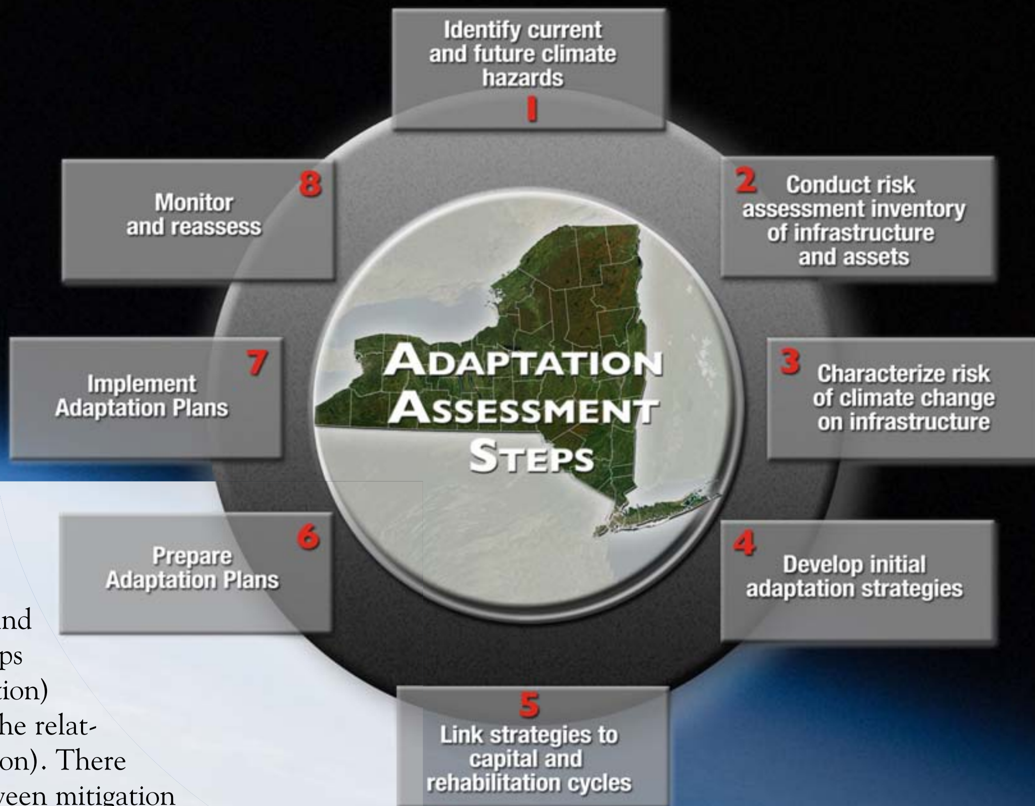
New York State as a whole is generally considered to have significant resources and capacity for effective adaptation responses. However, the costs and benefits of adaptation will not be evenly distributed throughout the state. There can also be a variety of unintended consequences of adaptation options. For example, building sea walls to protect coastal property from rising sea levels can exacerbate the loss of coastal wetlands that serve to protect coastlines from storm surge damage.

Adaptations undertaken in one sector often have implications for other sectors.

For example, increased use of air conditioning is an adaptation to reduce heat-related illness and death in the health sector as well as to reduce heat stress on livestock in the agriculture sector. However, such a strategy would increase peak summer energy use, increasing demands on both energy and water resources. If increased tree planting is used to reduce urban heat, it will be important to plant low-pollen tree species because allergenic pollen is on the rise in a warmer, higher-CO_2 world. These examples point to the need for integrated thinking about adaptation strategies to avoid creating new problems. In addition, climate change and some adaptation options can worsen social and economic inequalities that are already present and create new inequalities. This raises equity issues that are discussed on the following pages.

Adaptation strategies do not directly include actions aimed at reducing the speed and amount of climate change.

Actions to reduce climate change, often called "mitigation," involve lowering emissions of heat-trapping gases or increasing their removal from the atmosphere. Mitigation measures would reduce climate change impacts in the longer term.



There are interactions between adaptation and mitigation.

For example, improving insulation and using reflective roofing material keeps buildings cooler in summer (adaptation) as well as reducing energy use and the related heat-trapping emissions (mitigation). There can be a variety of interactions between mitigation and adaptation measures. Some measures, such as green roofs, reduce emissions by decreasing the need for air conditioning as well as lessen impacts by keeping buildings cooler and reducing stormwater flooding. On the other hand, increasing use of air conditioning to adapt to rising temperatures results in increased emissions. Thus, mitigation and adaptation measures should be considered in concert. Both are necessary elements of an effective response strategy. These two types of responses are also linked in that more effective mitigation measures would reduce the amount of climate change, and therefore affect the need for adaptation.

Our choices can make us more or less vulnerable to climate change.

For example, building in coastal zones and river flood plains and paving over large amounts of land make us more vulnerable to flooding and inundation due to sea level rise and increasing heavy downpours. In contrast, decisions made taking into account the adaptation principles described here can make us less vulnerable, that is, better able to withstand the impacts of climate change. However, even the best efforts to reduce vulnerability will not be sufficient to eliminate all damages associated with climate change in the long-term.
The goal is to create a more climate-resilient New York State.

Reduce other stresses to help improve the adaptive capacity of any system, making it more resilient to climate change. This is true for water and energy supply systems, natural ecosystems, and other sectors.

- For ecosystems, options include reducing human transport of invasive species, controlling sprawl and other habitat destruction, and providing dispersal corridors to allow species range shifts in response to climate change.
- For water and energy systems, options include lowering demand through efficiency measures and consumer education.
- For coasts, reducing development and preserving wetlands through various policies can help.
- For human health, pollution reduction and better management of chronic disease would increase resilience.

Take advantage of normal capital repair and replacement cycles of infrastructure to build in climate change adaptations that are flexible to future conditions.

- When building long-lived infrastructure, such as power plants, tunnels, and bridges, consider projected increases in temperature and sea level, and changes in precipitation patterns.
- Designing a 1-foot floodwall with a strong enough foundation to support an added foot or two of height if needed is an example of flexible adaptation.
- When building new dairy barns, design for better ventilation and possibly the ability to add other cooling technologies.
- Incorporate climate change projections such as the increase in heavy downpours and sea level rise in capital investment decisions currently being made in storm water and wastewater systems.

Examine and revise regulatory mechanisms and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account.

- Regulations concerning infrastructure such as those that govern bridge height and clearance, dam height and strength, materials used, dimensions of drainage culverts for roads, roof strength, and foundation depth should be reconsidered.
- Definitions of flood zones should be revisited and how they may change in the future should be considered.
- Regulations that affect adaptive capacity should be assessed. For example, stronger regulations to control invasive species can help make ecosystems more resilient, and stronger efficiency standards can make water and energy systems more resilient.
- Changes in treaties such as those governing water rights might be appropriate if the amounts and distributions of the resources change. Risk sharing mechanisms including various types of insurance and regional planning approaches should also be examined.

Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt as climate change proceeds.

- Monitor climate change science for the latest developments.
- A central repository for information on new norms for climate, species, etc. would help to reduce uncertainty and better inform policy.
- Monitoring the effectiveness of various adaptation strategies is important.
- There is a need to better monitor hazards and events, and to archive and make this information widely available. This might include air quality monitoring, citizen watches for invasive species, and real-time data gathering on the impacts of extreme weather events (such as, crop and timber value lost, reduction in dairy production, cost of property damaged, and numbers of heat-related illnesses and deaths).
- In addition to monitoring hazards, events, and adaptation strategies, combine the tracking of these indicators to improve understanding of what impacts will result from various climate events and what adaptation strategies are effective.

ENVIRONMENTAL EQUITY

Climate change risks, vulnerabilities, and capacities to adapt are uneven across regions, sectors, households, individuals, and social groups.

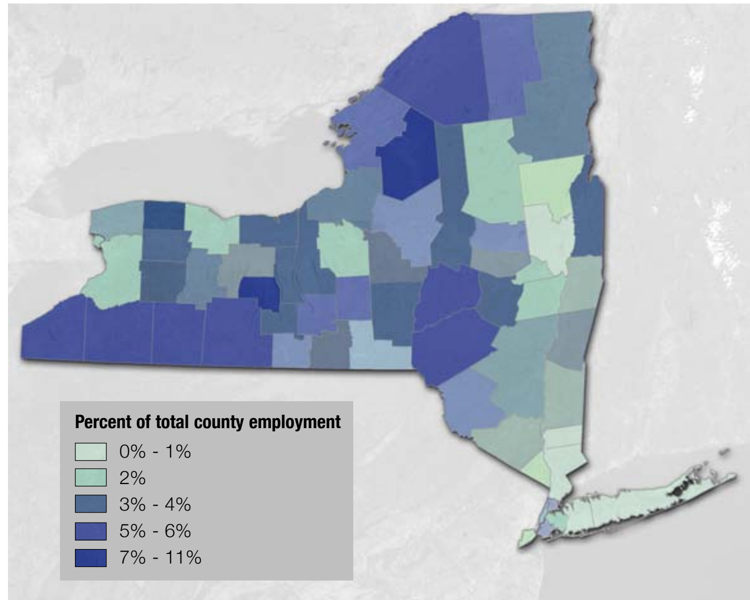
Certain groups will be disproportionately affected by the impacts of climate change.

Equity issues emerge because climate change impacts and adaptation policies can worsen existing inequalities and can also create new patterns of winners and losers.

Intergenerational equity issues arise from the fact that future generations will suffer the consequences of past and current generations' actions.

The same groups, such as the elderly, tend to be at risk for adverse impacts of climate change across multiple sectors.

Employment in Agriculture, Forestry, Fishing and Related Activities



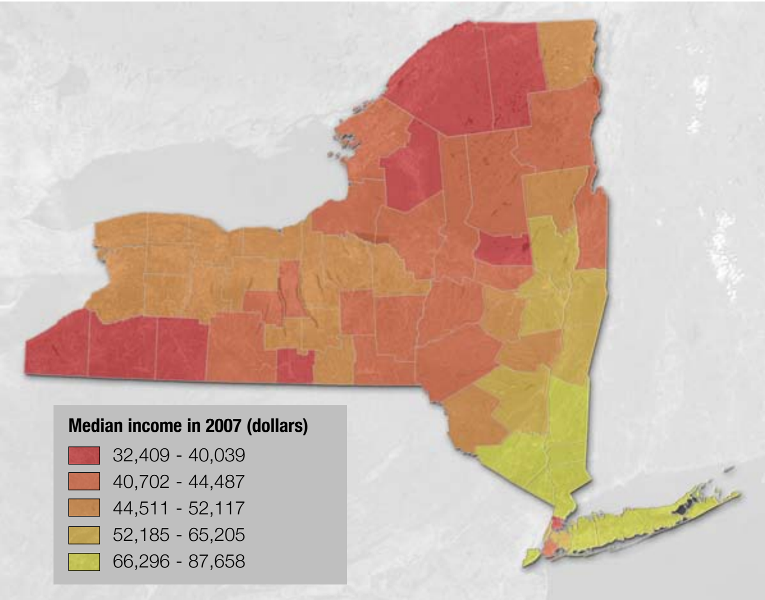
Areas/Locations

- Rural areas, especially small towns, are more vulnerable to, and have less capacity to cope with, extreme events such as floods, droughts, ice storms and other climate-related stressors.
- Regions that depend on agriculture and tourism (such as fishing, skiing, and snowmobiling) may be especially in need of adaptation assistance.
- Low-income urban neighborhoods, especially those within flood zones, are less able to cope with climate impacts such as heat waves, flooding, and coastal storms.
- Coastal zones are vulnerable to sea level rise and storm surge. There are already numerous properties in coastal zones that cannot get insurance, for example.

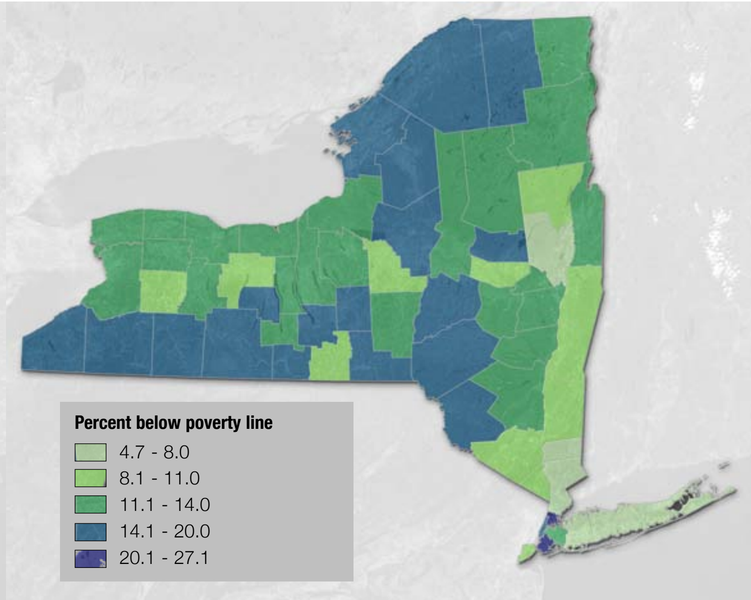
Groups

- Elderly, disabled and health-compromised individuals are more vulnerable to climate hazards, including floods and heat waves.
- Low-income groups have limited ability to meet higher energy costs, making them more vulnerable to the effects of heat waves.
- Those who lack affordable health care are more vulnerable to climate-related illnesses such as asthma.
- Those who depend on public transportation to get to work, and lack private cars for evacuating during emergencies, are vulnerable.
- Farm workers may be exposed to more chemicals if pesticide use increases in response to climate change.
- Asthma sufferers will be more vulnerable to the decline in air quality during heat waves.

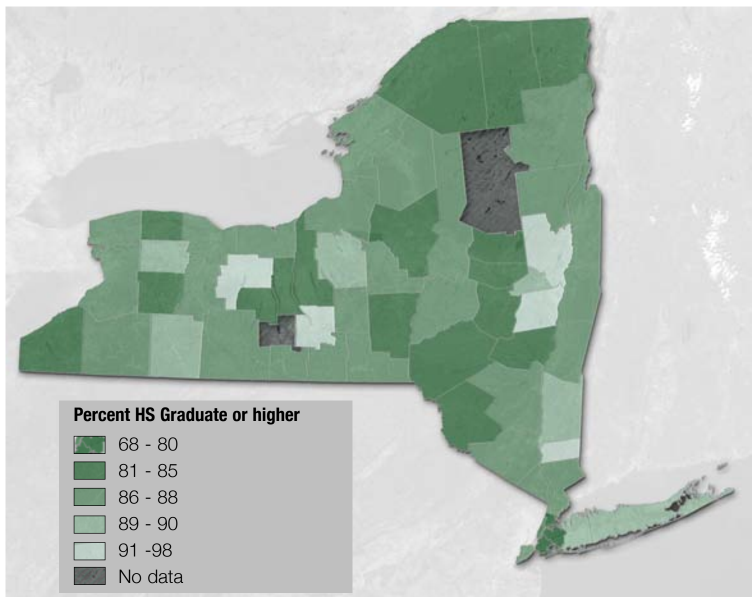
Income Disparities



Poverty Rates



Educational Attainment



Firms and Industries

- Smaller businesses are less able to cope with climate-related interruptions and stresses than larger businesses.
- With often more limited capital reserves, smaller firms are less able to withstand revenue loss associated with power and communication service disruptions.
- Small businesses tend to have less capital available to make investments to promote adaptation, such as the use of snowmaking in ski areas, or adoption of new crops or techniques on small farms.

There is a need for more attention to how the impacts of climate change adaptation policies affect different populations, areas, and industries. Affected communities and populations should have a voice in the adaptation policy process.

New York State's climate has already begun to change and impacts related to increasing temperatures and sea level rise are already being felt in the state, with associated costs. Future climate change has the potential to cause even more significant economic costs for New York State. Additional economic costs are likely to be tens of billions of dollars per year by the middle of this century. However, many costs of climate change are still not known and are difficult to estimate. Climate-change related economic impacts will be experienced in all sectors, types of communities and regions across the state.

Regions

All regions of the state will incur economic costs associated with climate change. Specific economic impacts will affect particular regions. For example, the negative impact on the state's winter recreation industry will adversely affect the Catskill and Adirondack regions.

The coastal zone, because of its relative exposure and vulnerability to storms and the concentration of residences, businesses, and infrastructure on the shore, will experience the greatest economic impact of any single region. The urbanized areas of the state with high population density will incur higher public health costs because of existing and projected urban heat island conditions.

Sectors

All sectors will incur costs associated with climate change; however, the costs will be highly uneven across and within sectors.

- All sectors are likely to experience significant economic impacts that may alter the overall structure and function of the sector.
- Water and flooding related management costs will affect almost all sectors.
- The highest direct economic costs of climate change are connected to large scale capital investment, housing, and commercial activity in the coastal zone.
- Sectors such as agriculture and telecommunications are inherently dynamic, changing annually, seasonally, and in some cases even daily. The economic consequences of climate change will be woven into the risk management and operations of the sector.

Types of Climate Impact Costs

Direct costs include costs that are incurred as the direct economic outcomes of a specific climate event or aspect of climate change. Direct costs can be measured by standard methods of national income accounting, including lost production and loss of value to consumers.

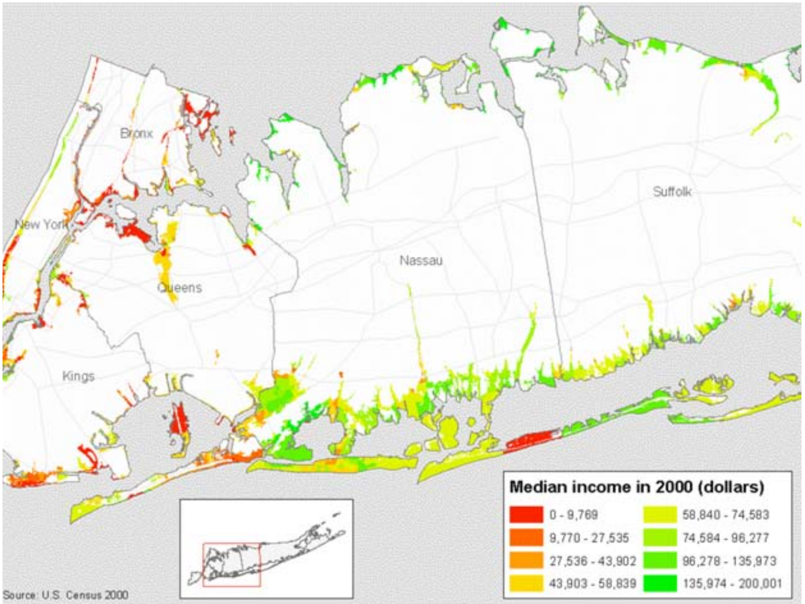
Indirect costs are costs incurred as secondary outcomes of the direct costs of a specific event or facet of climate change. Examples include jobs lost in firms that provide inputs to firms directly harmed by climate change.

Impact costs are direct costs associated with the impacts of climate change, for example the reduction in milk produced by dairy cows due to heat stress.

Adaptation costs include direct costs associated with adapting to the impacts of climate change, such as the cost of cooling dairy barns to reduce heat stress on dairy cows.

Costs of residual damage are direct costs of impacts that cannot be adapted to, for example, reductions in milk production due to heat stress that may occur if cooling capacity is exceeded.

Economic Diversity of Coastal Populations



New York City and Long Island are among the areas most at risk from climate change. The areas in color on this map are already at risk from coastal flooding during storms, and much more land will be at risk as sea level rise accelerates. The impacts and costs of climate change and adaptation options in this heavily developed coastal zone will be large and diverse. There is a great deal of property in harm's way, including long-lived, high-value infrastructure such as roads, airports, bridges, and power plants. As shown on the map, the population of this region is very diverse, from low income inner-city neighborhoods to very high income communities.

Timing

Economic costs of climate change impacts will generally increase throughout the century as the rate of climate change accelerates. Some of the largest costs will be associated with extreme events such as large scale floods and heat waves. Costs associated with average climate changes are expected to increase more slowly over time.

The timing of impacts could be more mixed for sectors that are expected to experience both potential benefits and costs. For example, in the agricultural sector, short term costs could eventually be overwhelmed by the emergence of longer term benefits, or vice versa.

Climate Change Adaptation Costs and Benefits

The implementation of adaptation strategies will bring economic benefits to the state. For each sector, a wide variety of adaptation options at varying costs are available.

- Transportation, the coastal zone, and water resources will have the most significant climate change impact costs and will require the most adaptations.
- Energy, telecommunications, and agriculture sectors have costs that could be large if there is no adaptation; but adaptation to climate could be seen as a regular part of moderate re-investment.
- The benefit-cost ratio comparing avoided impacts to costs of adaptation is highest for the public health and coastal zones sectors, moderate for the water resources, agriculture, energy, and transportation sectors, and low for the telecommunications sector.

WATER RESOURCES

Context

New York State has an abundance of water resources, including large freshwater lakes, high-yielding groundwater aquifers and major rivers.

Water resources are managed by a diverse array of large and small agencies, governments and institutions, with little statewide coordination.

Water resources are already subject to numerous human-induced stresses, such as increasing demand for water and insufficient water supply coordination; these pressures are likely to increase over the next several decades.

Water quality is already at risk from aging wastewater treatment plants, continued combined sewage overflow events, and excess pollution from agricultural and urban areas.

Key Climate Impacts

Rising air temperatures intensify the water cycle by driving increased evaporation and precipitation. The resulting altered patterns of precipitation include more rain falling in heavy events, often with longer dry periods in between. Such changes can have a variety of effects on water resources.

Heavy downpours have increased over the past 50 years and this trend is projected to continue, causing an increase in localized flash flooding in urban areas and hilly regions.

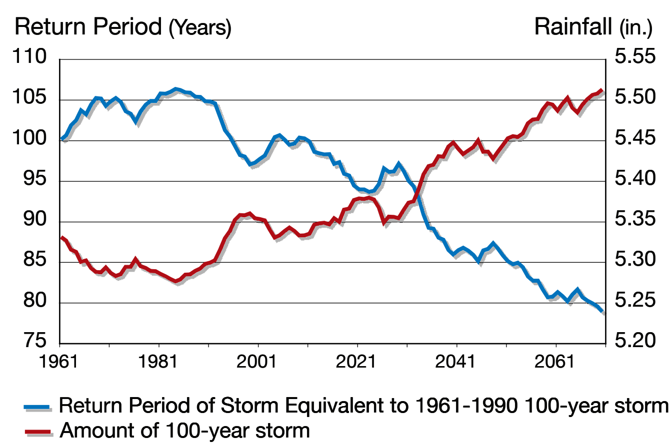
Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable development within floodplains.

Less frequent summer rainfall is expected to result in additional, and possibly longer, summer dry periods, potentially impacting the ability of water supply systems to meet demands.

Reduced summer flows on large rivers and lowered groundwater tables could lead to conflicts among competing water users.

Increasing water temperatures in rivers and streams will affect aquatic heath and reduce the capacity of streams to assimilate effluent from wastewater treatment plants.

Projected rainfall and frequency of extreme storms



The amount of rain falling in a "100-year" storm is projected to increase (red line), while the number of years between such storms ("return period") is projected to decrease (blue line). Thus, rainstorms will become both more severe and more frequent. These results, from the UK Met Office Hadley Centre Climate Model Version 3 (HadCM3), are broadly consistent with those of the other 15 GCMs used by ClimAID.

Adaptation Options

Adaptation can build on water managers' existing capacity to handle large variability. Strategies can be designed to be flexible to a range of future conditions. New York's relative wealth of water resources, if properly managed, can contribute to resilience and new economic opportunities.

Operations, Management, and Infrastructure Strategies

- Relocate infrastructure such as wastewater treatment plants and high-density housing to higher elevations and outside of high risk floodplains. For infrastructure that must remain in the floodplain, elevate structures, construct berms or levees to reduce flood damage.
- Adopt stormwater infrastructure and management practices and upgrade combined sewer and stormwater systems to reduce pollution.

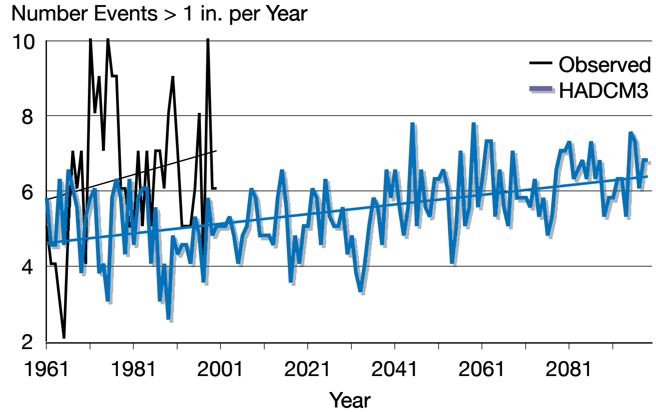
Larger-scale Strategies

- Use multiple strategies to increase water use efficiency. Conserve water through leak detection programs; use of low-flow showerheads, toilets, and washing machines; and rain barrels for garden watering. Research equitable water pricing programs.
- Establish stream flow regulations that mimic natural seasonal flow patterns, including minimum flow requirements, to protect aquatic ecosystem health.
- Expand basin-level commissions to provide better oversight, address water quality issues, and take leadership on monitoring, conservation, coordination of emergency response, and new infrastructure.
- Develop more comprehensive drought management programs that include improved monitoring of water supply storage levels and that institute specific conservation measures when supplies decline below set thresholds. Update and enlarge stockpiles of emergency equipment to help small water supply systems and to assist during emergencies.

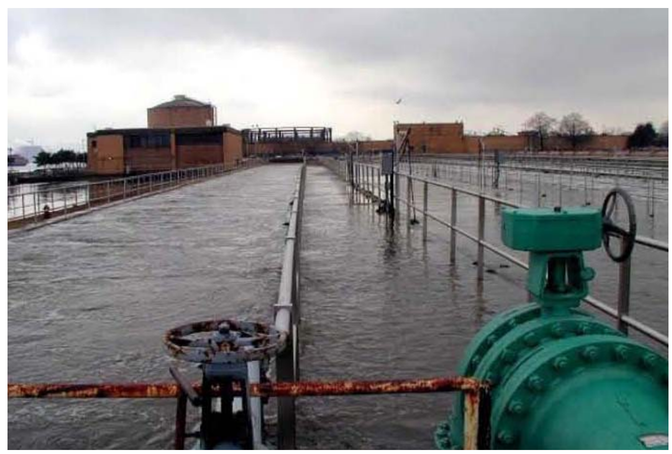
Co-Benefits

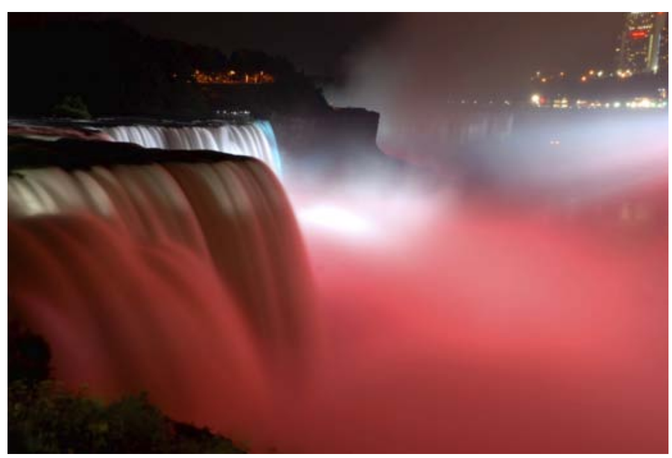
Continuing and expanding current water resource management practices, such as reducing stormwater runoff into water bodies, will benefit pollution control as well as climate adaptation. Encouraging water conservation strategies and minimum flow criteria to prepare for potential summer droughts will help to guarantee water sufficiency.

The number of rainfall events over one inch from 1960-2100

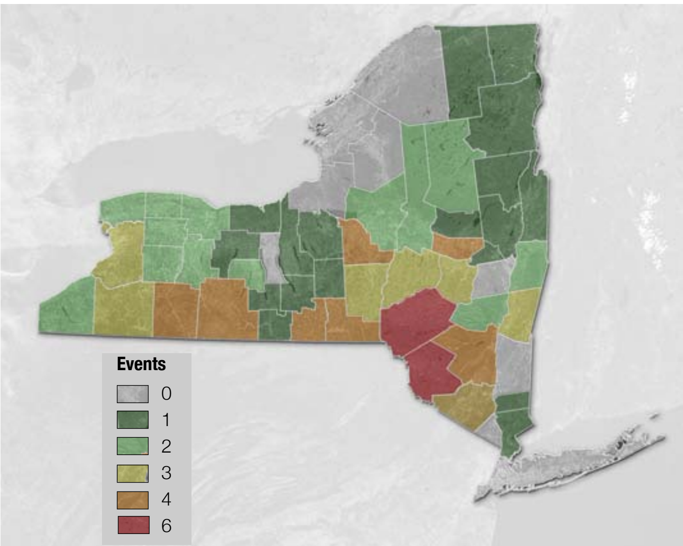


The observed number of rainfall events exceeding one inch from 1960 to 2000 is shown by the black line, and the projected number of such events, using the HadCM3 model, is show by blue line. These results are broadly consistent with those of the other 15 GCMs used by ClimAID.





Flood Events Per County from 1994-2006



Number of FEMA-declared flood disasters in New York state counties. (FEMA)

Particularly Vulnerable Groups

Smaller water systems are more vulnerable to drought and other types of water supply disruptions than larger systems, since large systems tend to be more closely managed and often have more resources for dealing with drought.

The elderly and people with disabilities tend to be more vulnerable to immediate flood hazards due to limited mobility.

Rapidly developing, higher-income exurban communities may experience water scarcity as demand increases in these areas and overwhelms local supplies.

Lower-income or non-English speaking populations may be particularly vulnerable to increasing levels of disease-causing agents in the water supply or contaminants in well water as they may be less aware of government programs and warnings and have less access to health care.

Susquehanna River Flooding, June 2006

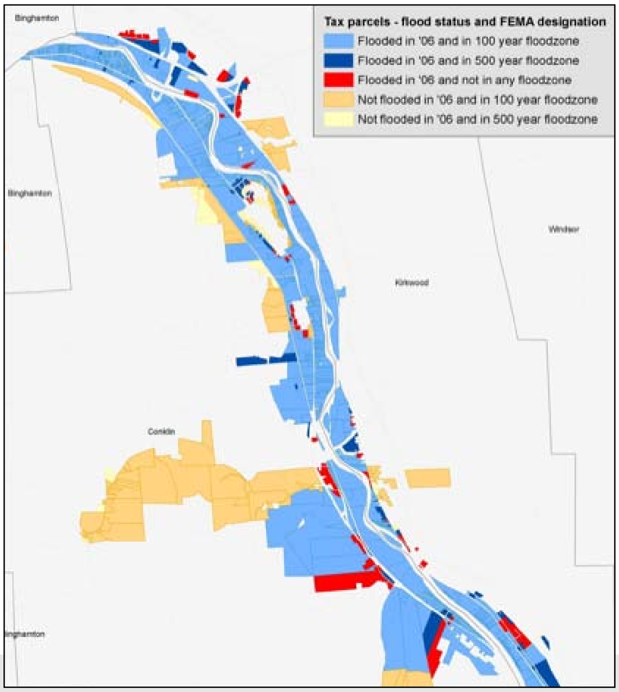
The value of preparedness

Flooding is already a major problem across New York State with damages costing an average of $50 million each year. There are several flood management strategies that can help solve current problems while addressing possible future ones.

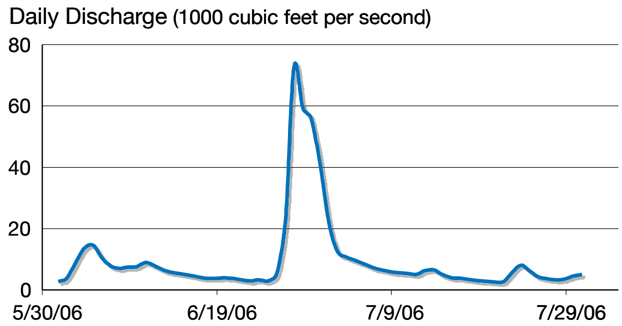
The June 2006 Susquehanna River flood-the largest on record since gauging began on the river in 1912-provides insights into strategies that can be used to reduce flood risks and impacts. Record precipitation from June 25 to 28, totaling 3 to 11 inches, culminated in significant flooding in the basin. Twelve counties in New York and 30 in Pennsylvania were declared disaster areas. Rainfall coupled with runoff from steep hillsides contributed to river water levels rising from less than 5 feet to nearly 21 feet in nine hours. Broome County, N.Y., incurred the most damages.

In Broome County, about 3,350 properties were flooded. Fifty-eight percent of the flooded properties were residential and 10 percent were commercial. Nearly 30 percent of the shopping area, two sewage treatment plants, a public works facility, a hospital, and several hundred miles of roads were also flooded. The town of Conklin was the hardest hit, with 30 percent of its properties flooded, followed by 13 percent in Kirkwood, and 10 percent in Port Dickinson. In total, 1,020 of the properties that were flooded were not within FEMA's Special Flood Hazard Area, including 723 residential properties. These properties were valued at more than $46.3 million and were exempt from having federally mandated insurance.

Distribution of flood risks in a select area in Broome County
Properties flooded in 2006 relative to FEMA floodzone designation



Water level of the Susquehanna River at Conklin, N.Y. during the June 2006 flood.



Days of very heavy rain on top of already saturated soils from weeks of rain, caused a huge spike in the level of the Susquehanna River (chart above), flooding thousands of properties, including Lourdes Hospital (photo below).

Despite the very rapid onset of the flood and the thousands of properties that were inundated, there were only four deaths, thanks to the Susquehanna River Basin's well-developed flood-response system. The area has an excellent warning-and-response system that links NOAA-based weather forecasts to real-time USGS streamflow data and coordinates with regional and local emergency response teams. The June 2006 response included pre-flood community-wide warnings and evacuations, water pumping and sand bag efforts, and emergency evacuations and medical services during the flood. Such a system is not inexpensive to operate; a single USGS gauge can cost nearly $20,000 per year to maintain and the system has nearly 10 such gauges. However, the value of such an early warning system is apparent when large floods do occur, and remains important for the future.

While the area has extensive levees and dams, some are outdated and the current system is not adequate to deal with potential higher-magnitude floods. Development within the floodplains behind these barriers has intensified, making communities more vulnerable and damages greater when floods occur. Strategies to help further reduce flood risk include moving out of the highest risk areas with homeowner buyouts following floods, and relocating infrastructure, such as wastewater treatment plants, out of floodplains. This strategy was used successfully in Conklin, and elsewhere. It reduces subsequent flood risk, both to lives and buildings, and monetary costs can be comparable to or less than costs to expand levees. It also expands natural flood-control processes by expanding the undeveloped areas so that floodwaters can spread out and dissipate instead of being forced downstream. In some areas, downstream flooding can also be lessened by reducing stormwater runoff through improving soil infiltration capacity, expanding vegetated surfaces, and decreasing impervious surfaces such as roads.

COASTAL ZONES

Key Climate Impacts

High water levels, strong winds, and heavy precipitation resulting from strong coastal storms already cause billions of dollars in damages and disrupt transportation and power distribution systems. Sea level rise will lead to more frequent and extensive coastal flooding. Warming ocean waters raise sea level through thermal expansion and have the potential to strengthen the most powerful storms.

Barrier islands are being dramatically altered by strong coastal storms as ocean waters overwash dunes, create new inlets, and erode beaches.

Sea level rise will greatly amplify risks to coastal populations and will lead to permanent inundation of low-lying areas, more frequent flooding by storm surges, and increased beach erosion.

Loss of coastal wetlands reduces species diversity, including fish and shellfish populations.

Some marine species, such as lobsters, are moving north out of New York State, while other species, such as the blue claw crab, are increasing in the warmer waters.

Saltwater could reach farther up the Hudson River and in estuaries, contaminating water supplies. Tides and storm surges may propagate farther, increasing flood risk both near and far from the coast.

Sea level rise may become the dominant stressor acting on vulnerable salt marshes.

Context

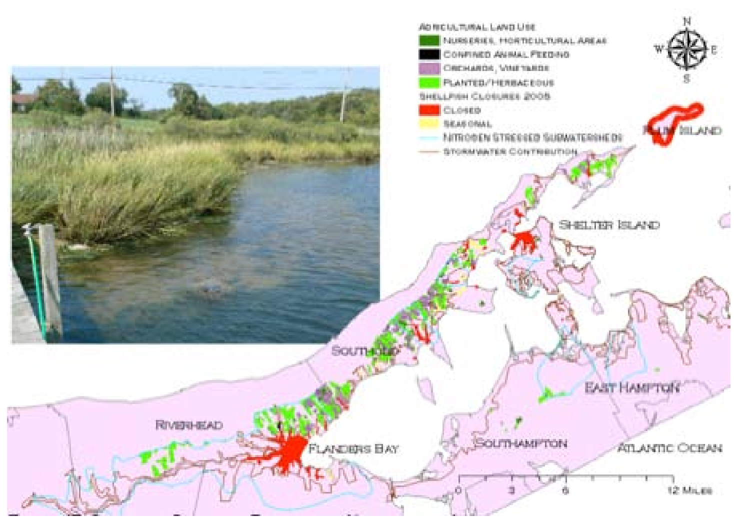
New York's coastal zones are becoming more developed, further increasing the consequences of flooding, coastal erosion, and sea level rise.

More than a half million people live within the 100-year coastal floodplain in New York State.

Coastal marshes and wetlands are highly sensitive and must maintain a delicate balance as they are affected by rapid sea level rise, wave erosion, sediment deposition and other forces. These important ecosystems provide wildlife habitat, protect coastlines against storms, and absorb pollution.

Coastal impacts propagate into inland areas, such as up the Hudson River, all the way to the Troy Dam.

Closures of Shellfish Harvesting Related to Agricultural Practices



The impacts of climate change occur in the context of numerous other stresses, many of which are also caused by human activities. While climate change increases air and water temperatures and alters precipitation and runoff patterns, nitrogen from agricultural areas is an additional stress that harms fish and shellfish in the coastal zone. The map shows shellfish closures for the Peconic River Estuary in 2005 and the agricultural land use practices that contribute to such closures.

Adaptation Options

New York's highly developed and populated coastlines are vulnerable to severe coastal storms, such as hurricanes.

Implementation of adaptation strategies in coastal zones is complicated by the complex interactions of natural and human systems and competing demands for resources.

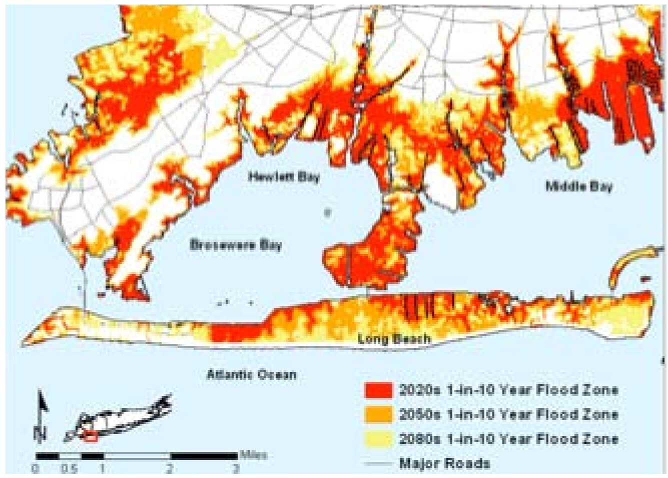
Operations, Management, and Infrastructure Strategies

- Move sand onto beaches, although doing so can lead to habitat disruption and erosion in the area of removal, and is only a temporary solution. Add sediment from shipping channels to marshes, although this may not keep up with the rate of loss.
- Consider use of engineering-based strategies such as constructing or raising sea walls, and bio-engineered strategies including restoring or creating wetlands.
- Site new infrastructure and developments outside of future floodplains, taking into consideration the effects of sea level rise, erosion of barrier islands and coastlines, and wetland inundation.

Larger-scale Strategies

- Buy out land or perform land swaps to encourage people to move out of flood-prone areas and allow for wetlands to shift inland. Enact rolling easements to help protect coastal wetlands by prohibiting seawall construction while still allowing some near-shore development.
- Improve building codes to promote storm-resistant structures and increase shoreline setbacks.

Projected Flooding



Projected flood map for 1-in-10 year storm event for Long Beach and surrounding bay communities for ClimAID rapid ice melt scenario.

Co-benefits

Protecting wetland areas has mitigation and other ecosystem service co-benefits because they provide critical functions such as capturing carbon, providing habitat for fish and other species, and serving as a buffer for storm surge.

Particularly Vulnerable Groups

Within the coastal zone, elderly and disabled residents and households without cars are particularly vulnerable to flood hazards as they have more difficultly evacuating in a timely manner.

Low-income populations living in coastal and near-coastal zones will be less able to recover from damages resulting from extreme weather events than will wealthier populations.

Racial and ethnic minorities are more vulnerable to extreme events than nonminority populations; African Americans and Latinos represent a significant portion of the people living in the New York City flood zone.

Coldwater marine species, such as lobsters, are vulnerable to increases in sea surface temperature and some are already beginning to move north out of New York State waters.

Freshwater ecosystems in estuaries are vulnerable to saltwater intrusion as sea level rises.

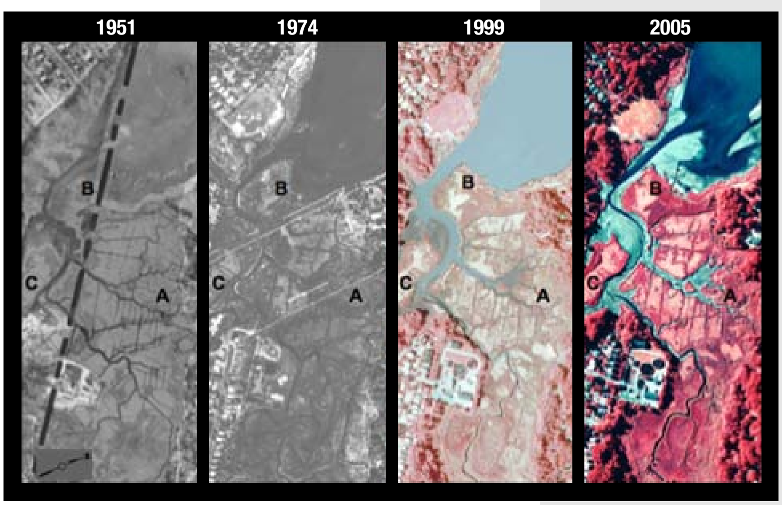
Effects of sea level rise on vital coastal wetlands

Salt marshes are essential ecosystems in New York State that provide a number of services including protection against coastal storm damage, habitat for migratory birds, nurseries for local fisheries, and recreation opportunities for residents. Over the past several decades, the area of these essential ecosystems has declined dramatically.

While sea level rise is currently a relatively minor component among several human-induced stressors (including draining of marshes, building seawalls, and dredging navigation channels) that may be contributing to the submergence and loss of vulnerable marshes, sea level rise may become the dominant factor in future decades.

At Jamaica Bay in New York City, island salt marsh area declined by 20 to 35 percent between the mid-1920s and mid-1970s. Since the mid 1970s, despite the implementation of regulations limiting dredging and filling activity, the rate of loss has accelerated; by 2008 close to 70 percent of the mid-1920s marsh area had been lost. In a 2003 pilot project at Big Egg Marsh, sediment was sprayed to a thickness of up to 3 feet and plugs of *Spartina alterniflora*, a marsh plant, were planted. In 2006 at Elder's Point East, a large-scale, $12 million restoration project used sand from maintenance dredging to artificially elevate the marsh. At both sites, the elevated stands of marsh plants are currently thriving. The successes of these two projects led to initiation of the 2010 restoration at Elder's Point West with plans underway for Yellow Bar Hassock.

Salt Marsh Loss Comparisons



Udalls Cove Park Preserve, Queens, NY

Udalls Cove Park in Queens and Pelham Bay Park in the Bronx have also experienced significant marsh loss. At Udalls Cove Park, marsh area has declined by 38 percent since 1974 and by 33 and 45 percent at two locations in Pelham Bay Park. Monitoring stations have been established in these parks to track the changes. The data are being used in combination with projected rates of sea level rise and aerial photographs to assist park managers, scientists and public advocates in managing and thereby perhaps minimizing salt marsh loss in the coming decades.

Sea level rise and severe coastal storms

Vulnerability of urban and suburban communities

Sea level rise will lead to more frequent and extensive coastal flooding.

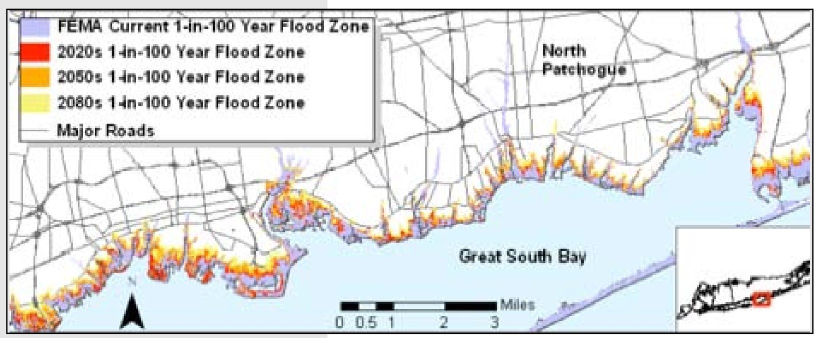
New York's highly developed and populated coastlines are vulnerable to severe coastal storms, such as hurricanes. The urban and suburban regions of Long Beach and the communities along the mainland coastline of Great South Bay are two examples of areas at risk. Flood adaptation strategies for such areas require a holistic approach that promotes resiliency across communities.

Sea level rise in combination with a coastal storm that currently occurs about once every 100 years on average is expected to place a growing population and more property at risk from flood and storm damage. In 2020, nearly 96,000 people in the Long Beach area alone may be at risk from sea level rise under the rapid ice melt scenario; by 2080, that number may rise to more than 114,500 people. The value of property at risk in the Long Beach area under this scenario ranges from about $6.4 billion in 2020 to about $7.2 billion in 2080.

To help protect against the effects of sea level rise and coastal storm flooding, a number of adaptation strategies could be undertaken. In terms of financial cost, relocating agricultural and low-density residential development further away from the coast is an appropriate adaptation strategy. Engineering-based strategies, such as constructing levees and sea walls, can be appropriate for moderate- and high-density development, although they involve tradeoffs.

Each adaptation measure may create new patterns of winners and losers. For example, sea walls may protect some people within a community while others are left vulnerable to flooding. Seawalls also prevent wetlands from migrating inland, resulting in the loss of wetlands that are important nurseries for marine species and that also help protect the coastline from damage during storms. Relocating infrastructure to higher elevation areas may result in gentrification in the upland community, making low-income populations more vulnerable. Such patterns of vulnerability need to be considered when planning for adaptation to reduce climate change impacts.

Flood Zone for a 1-in-100 Year Storm in Great South Bay



The map shows areas projected to be flooded in three future time periods based on projections from 7 global climate models, 3 emissions scenarios, and the rapid ice melt scenario used in ClimAID.

Context

The vast majority of New York's forests and other natural landscapes are privately owned (more than 90 percent of the state's 15.8 million acres of potential timberland), with implications for land-use planning and policies.

Urbanization and other land-use changes have fragmented large, connected habitats important for species dispersal and migration.

Increasing deer populations cause economic losses to agricultural crops and urban landscapes, and their selective feeding in natural landscapes alters plant community structure with cascading effects on other species.

Many non-climate stressors currently have negative effects on New York's ecosystems. These stressors include invasive species, air pollution, acid precipitation, and excess nitrogen and phosphorus in the state's waterways.

Key Climate Impacts

Within the next several decades New York State is likely to see widespread shifts in species composition in the state's forests and other natural landscapes, with the loss of spruce-fir forests, alpine tundra and boreal plant communities.

Climate change will favor the expansion of some invasive species into New York, such as the aggressive weed, kudzu, and the insect pest, hemlock woolly adelgid. Some habitat and food generalists (such as white-tailed deer) may also benefit.

A longer growing season and the potential fertilization effect of increasing carbon dioxide could increase the productivity of some hardwood tree species, provided growth is not limited by other factors such as drought or nutrient deficiency.

Carbon dioxide fertilization tends to preferentially increase the growth rate of fast growing species, which are often weeds and other invasive species.

Lakes, streams, inland wetlands and associated aquatic species will be highly vulnerable to changes in the timing, supply, and intensity of rainfall and snowmelt, groundwater recharge and duration of ice cover.

Increasing water temperatures will negatively affect brook trout and other native coldwater fish.

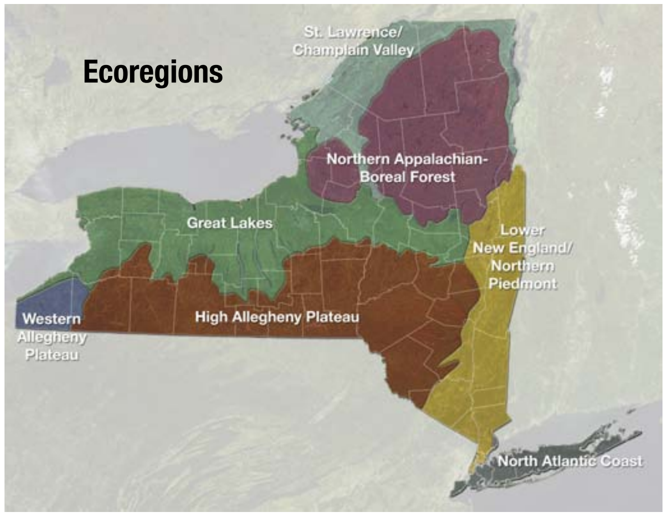
Adaptation Options

New York's state fish, the brook trout, is at particular risk from hemlock loss and is already at risk from increasing temperatures.

When considering adaptation strategies for ecosystems, it is important to manage primarily for important ecosystem services and biodiversity rather than attempting to maintain the current mix of species.

Operations, Management, and Infrastructure Strategies

- Develop management interventions to reduce vulnerability of high-priority species and communities, and determine minimum area needed to maintain boreal or other threatened ecosystems.



Larger-scale Strategies

- Maintain healthy ecosystems so they are more tolerant or better able to adapt to climate change by minimizing other stressors such as pollution, invasive species, and sprawl and other habitat-destroying forces.
- Facilitate natural adaptation by protecting riparian zones and migration corridors for species adjusting to climate changes.
- Institutionalize a comprehensive and coordinated monitoring effort and accessible database to track species range shifts and other indicators of habitat and ecosystem response to climate change. Identifying and prioritizing what to monitor and, in some cases, developing new indicators will be required.

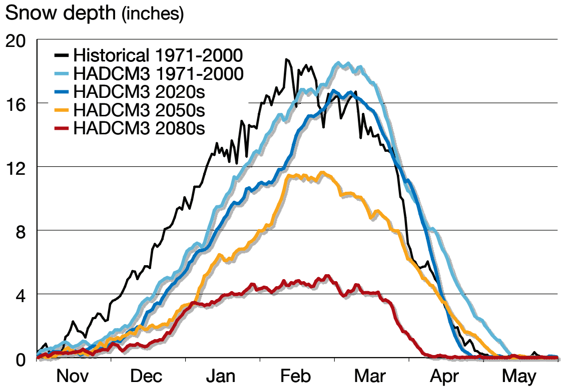
Co-benefits

Maintaining healthy ecosystems in a changing climate will allow them to continue to provide services such as provision of water resources, maintenance of biodiversity, and recreation.

Ecosystem Services

Healthy ecosystems are our life support system, providing us with essential goods and services that would be extremely expensive or impossible to replace. Ecosystems purify air and water, and provide flood control. They supply us with products like food and timber, and sequester carbon and build soils. They provide recreation, hunting, and fishing, and wild places in which to enjoy nature. Human disruption of ecosystems, through climate change and other factors such as habitat destruction and pollution, can reduce ecosystems' ability to provide us with these valuable services.

Seasonal Snow Depth at Wanakena, N.Y. (Adirondacks)



Snowpack is projected to decline sharply due to future warming. The black line shows historical snowpack, and the colored lines show projected snowpack over the months with snow for three future time periods under one relatively high emissions scenario (A2) using one global climate model, UK Met Office Hadley Centre Model version 3 (HadCM3). These projections are broadly consistent with those of other models used in ClimAID.

Particularly Vulnerable Groups

Communities whose economies depend on skiing and snowmobiling will be negatively affected by higher temperatures and reduced snowpack.

Communities that depend on tourism associated with coldwater fisheries such as trout could be particularly vulnerable, although there could be increases in warmer water fish species that could help offset these losses.

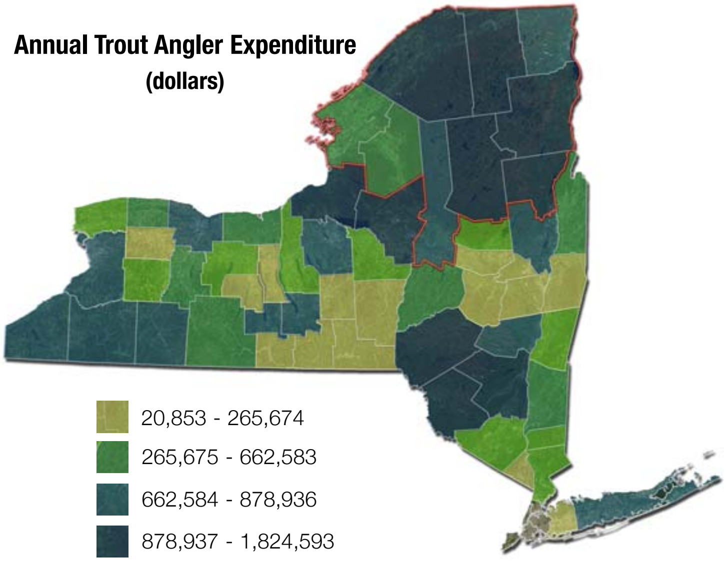
Characteristics that make species and communities highly vulnerable to climate change include: being adapted to cold or high-elevation conditions; being near the southern boundary of their ranges; having a narrow range of temperature tolerance; having specialized habitat or food requirements; being susceptible to new competitors, invasive species, or pests; having poor dispersal ability; having low genetic diversity; and having low population levels.

Vulnerable species and ecosystems include: spruce-fir forests of the Adirondack and Catskill mountains; boreal and alpine tundra communities of the Adirondack mountains; hemlock forests; brook trout, Atlantic salmon, and other coldwater fish; snow-dependent species such as snowshoe hare, voles and other rodents, and their winter predators such as fox and bobcat; moose; bird species such as Baltimore oriole and rose-breasted grosbeak; amphibians and other wetland species.

Bobcat

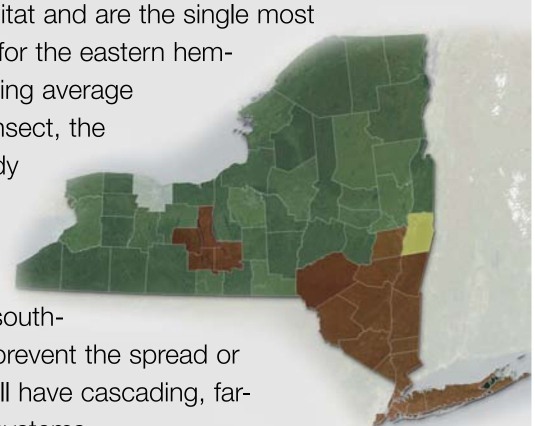
Snowshoe Hare

Annual Trout Angler Expenditure (dollars)



Cascading effects of climate change on animals, plants, and the economy

Shaded and cool hemlock forests provide unique wildlife habitat and are the single most prevalent conifer species in New York state. Suitable habitat for the eastern hemlock is expected to decline in New York as a result of increasing average summer temperatures as well as the spread of the invasive insect, the hemlock woolly adelgid. The hemlock woolly adelgid is already well established in New York and recently has spread to the central part of the state, in part due to rising winter temperatures that are allowing the insect to survive the winter. Hemlocks already are dying from infestations in New York's southern and Hudson Valley regions. Currently there is no way to prevent the spread or the effects of the insect. Extensive loss of hemlock forests will have cascading, far-reaching effects on a variety of wildlife species and their ecosystems.



New York's state fish, the brook trout, is at particular risk from hemlock loss and is already at risk from increasing temperatures. The southern extent of the habitable range for brook trout is in New York and the historical abundance of the fish is likely to be severely reduced by warming. Brook trout depend on coldwater refuges in streams and lakes to survive. Lakes that are unstratified lack coldwater refuges and are likely to lose all of their trout. These represent about 41 percent of brook trout lakes in the Adirondack Mountains, for example. Brook trout in streams and rivers will also be vulnerable as water temperatures rise along with air temperatures. Their vulnerability will be complicated by the extensive loss of hemlock forests, which shade and maintain lower water temperatures in streams.

The loss of brook trout will cause changes in New York's fishing economy and may have disproportionate effects on small, fishing-dependent communities in which millions of dollars are spent by tourists who come to fish for trout. Possible adaptation strategies for keeping steams cool enough for brook trout include maintaining or increasing vegetation that provides shade along rivers, streams, and lake shorelines, and minimizing disturbances that would impede water flows and groundwater inputs.

Even more important from an economic perspective are the broader impacts of climate change on mountain forests. The local economies of the Adirondacks, Catskills, and Finger Lakes are dominated by tourism and recreation. Two-thirds of the current tree species in mountainous areas of the Adirondacks will be outside of their sustainable climate zone and in severe decline by the end of this century if current emissions trends continue.

Hunting, fishing and wildlife viewing make significant contributions to New York State's economy. More than 4.6 million people fish, hunt, or wildlife watch in the state, spending $3.5 billion annually on equipment, trip-related expenditures, licenses, contributions, land ownership and leasing and other items. The loss of spruce-fir forests and alpine meadows will negatively affect these experiences and their economic contributions to the state.

Winter recreation is another major component of the economic value of the state's natural ecosystems. New York has more ski areas than any other state, hosting an average of 4 million visitors each year, contributing $1 billion to the state's economy and employing 10,000 people. New York is also part of a six-state network of snowmobile trails that totals 40,500 miles and contributes $3 billion each year to the Northeast regional economy. Shorter, warmer winters and reduced snowpack will have significant negative impacts on winter recreation in the state and the region.

Context

The agriculture sector in New York State encompasses more than 34,000 farms that occupy about one-quarter of the state's land area (more than 7.5 million acres) and contribute $4.5 billion annually to the state's economy.

A large majority of New York agriculture is currently rain-fed without irrigation, but summer precipitation is currently not sufficient to fully meet crop water needs most years.

Economic pressures have led to consolidation into fewer, larger farms, particularly in the dairy industry. The costs of adapting to climate change may exacerbate this trend.

Agriculture is sensitive to the volatile and rising costs of energy, a challenge that climate change is likely to exacerbate.

Key Climate Impacts

Increased summer heat stress will negatively affect cool-season crops and livestock unless farmers take adaptive measures such as shifting to more heat-tolerant crop varieties and improving cooling capacity of livestock facilities.

Increased weed and pest pressure associated with longer growing seasons and warmer winters will be an increasingly important challenge.

Water management will be a more serious challenge for New York farmers in the future due to increased frequency of heavy rainfall events, and more frequent and intense summer water deficits by mid to late century.

Opportunities to explore new crops, new varieties, and new markets will come with higher temperatures and a longer growing season.

Early season produce can provide a large fraction of a farmer's income. Heavy downpours can delay spring planting and/or damage crops, greatly reducing this important source of revenue.

Adaptation Options

A changing climate presents challenges and potential opportunities for New York state farmers. Responding will necessitate both on-farm and state-level strategies.

Operations, Management, and Infrastructure Strategies

- Change planting dates, varieties or crops grown. Increase farm diversification.
- Improve cooling capacity, including the use of fans and sprinklers in dairy barns.
- Increase use of chemical and non-chemical techniques for controlling pests, pathogens, and weeds.
- Develop new crop varieties for projected New York climate and market opportunities.
- Invest in irrigation and/or drainage systems.

Larger-scale Strategies

- Develop decision tools to assist farmers in determining the optimum timing and magnitude of investments to cope with climate change.

Co-benefits

There are several opportunities for reducing greenhouse gas emissions with agriculture adaptation options including improved manure management, generation of on-site energy, increasing the use of soil organic matter, and using nitrogen fertilizer more efficiently.

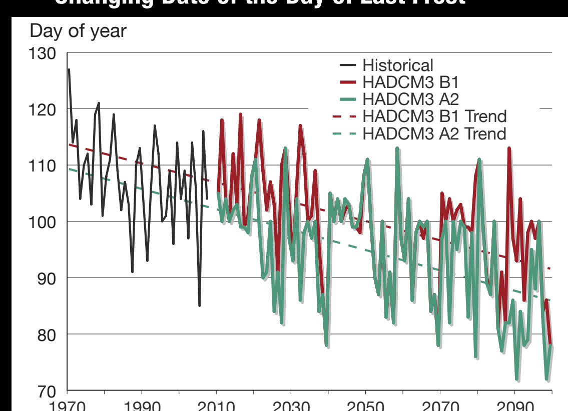
Changes for the grape industry

New York's grape harvest ranked third in the nation in 2007, with the crop valued at nearly 50 million dollars. In recent years, however, challenges associated with cold injury to crops have cost the states agriculture industry millions of dollars. Increasing temperatures at the beginning of winter reduce cold hardiness and can raise the probability of midwinter damage. In late winter or early spring (after the winter-chilling requirement has been met), an earlier arrival of spring or a prolonged warm period may lead to premature budding and increased vulnerability to spring frost. Projections indicate a slight increase in the potential for spring frost injury in Concord grapes.

In the long term, warmer winters and a longer growing season may bring opportunities to introduce a wider range of high value, less cold-tolerant European red wine grape varieties such as Cabernet Sauvignon and Zinfandel, that currently are constrained by the state's climate.

Adaptation strategies to avoid damage from spring frost events (such as using wind machines that pull warmer air down from high above ground during temperature inversions, and changing pruning and mulching strategies) are well established. New research will be required to integrate weather forecasts into early-warning systems for extreme events such as hard freeze and spring frost events. Linking these warning systems to the susceptibility of crops to damage could help reduce losses.

Changing Date of the Day of Last Frost



As climate warms, the date of last frost comes ever earlier in the year. The chart shows the date of last frost as the number of days after January 1. The black line shows observations. The red line shows a model projection (HadCM3) based on a lower emissions scenario (B1) while the green line shows that model's projection based on a higher emissions scenario (A2). Higher emissions mean more warming and hence cause the last frost day to occur even earlier in the year. This model's projections are broadly consistent with those of the other models used in ClimAID.

Particularly Vulnerable Groups

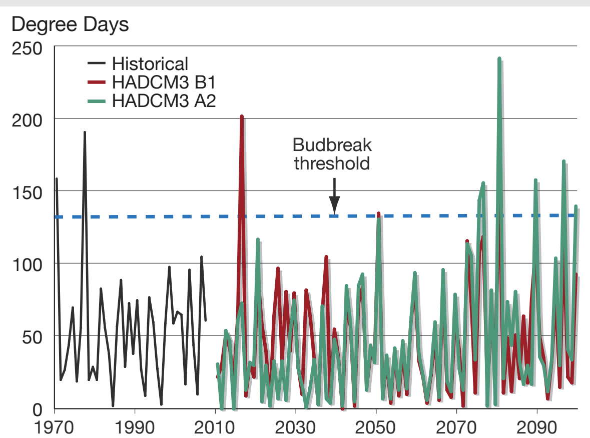
Dairy milk production and the productivity and/or quality of some cool-season crops such as apples, potatoes, and cabbage will be particularly vulnerable to increases in summer heat stress. Adaptations such as improving cooling capacity of dairy barns or changing varieties or crops are straightforward but will not be cost-free or risk-free. For example, the state could lose some favorite varieties of apples, such as McIntosh and Empire, for which it currently has national recognition, and have to replace them with more heat-tolerant varieties.

Smaller farms may have less information and training and less capital to invest in adaptation strategies such as stress-tolerant plant varieties, increased chemical and water inputs, and enhanced livestock cooling. By adding to already severe competitive pressure, climate change is likely to exacerbate current trends towards consolidation into fewer, larger farms, especially in the dairy sector.

Farms specializing in cool-season crops may have challenges finding appropriate new varieties that meet both production demands and market expectations.

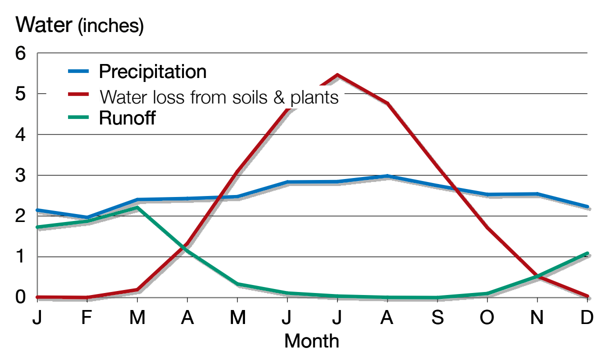
Without pro-active development of non-chemical approaches, increased pesticide and fertilizer use could harm sensitive environments, such as streams and rivers.

Projected Degree Days above 60ºF Prior to Last Frost



As temperatures rise, plants flower earlier in the spring. This can make them more vulnerable to damage from late spring frost. Climate change has the potential to exacerbate this vulnerability in Concord grapes grown in New York state. The dotted blue line represents a cumulative degree-day threshold that would lead to bud break prior to the last spring frost for Concord grapes in the Fredonia region. Years exceeding the threshold would have a high risk of frost damage. As the chart shows, under a higher emissions scenarios (A2, green line), this is projected happen much more frequently in the later part of this century. These results are broadly consistent with the other global climate models used in ClimAID.

Seasonal Differences in Soil-Water Balance



The chart shows historical averages for each month of the year for precipitation, evaporative water loss from soils and plants, and runoff. Runoff is the fraction of precipitation that is not evaporated and exceeds the soil-holding capacity and thus passes into deep groundwater or into streams. The red line shows that there is a moisture deficit in summertime as evaporative losses increase due to higher temperatures, resulting in virtually no runoff during the warmest months. ClimAID projections show that both the summer deficit and winter excess are expected to increase in a warming climate.

Dairy Heat Stress

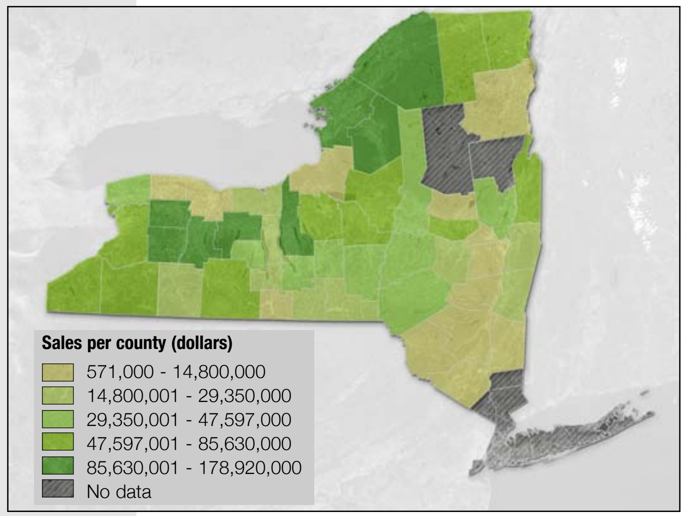
Heat stress has both short- and long-term effects on the health and performance of dairy cattle depending on severity and timing of the stress. Short-term impacts include decreases in feed intake and milk production. Under heat stress cows spend less time resting and more time standing and walking. A decrease of 1 hour of resting time is associated with a decrease of 2 to 3 pounds of milk produced per cow. Severe heat stress can cause lameness and poor reproductive performance (calving), with subsequent long-term negative effects on milk production. While short-term responses can be partially reversed after a heat wave, long-term effects are less easily reversed.

By the 2080s, the magnitude of annual N.Y. milk production decline associated with heat stress is projected to increase six-fold compared to current heat stress-related declines. Economic losses associated with the projected increase in heat stress range from $37 to $66 per cow per year. These ClimAID estimates took into account only short-term heat stress effects. They did not consider the potential long-term effects of severe stress on milk production, so they may underestimate losses.

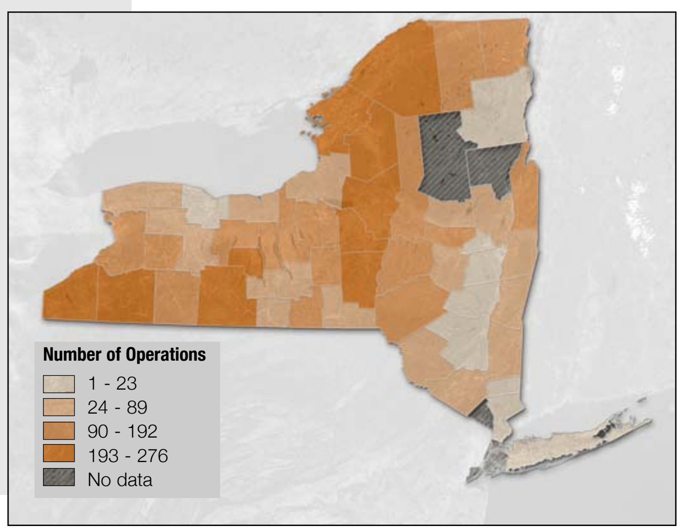
Modifying feeding and providing adequate water can help ameliorate heat stress in cows, but cannot substitute for improving cooling capacity in dairy barns (for example, through improved ventilation, high airspeeds directly over the cows, and sprinkler systems). Many ventilation systems are inherently more cost-effective when deployed for larger barns. Small farms that cannot afford these kinds of adaptation measures will be most vulnerable to the impacts of warming.

By the 2080s, the magnitude of annual N.Y. milk production decline associated with heat stress is projected to increase six-fold compared to current heat stress-related declines.

Variations in Dairy Sales



Distribution of Dairy Operations



Context

The energy system in New York State is designed to cope with a wide range of climate variability.

Climate change is likely to exacerbate existing risks rather than create new ones.

Extreme, short-term weather events and changes in demand are particularly important to the energy industry.

The state's annual electricity load has increased by about 4.3 percent per year. New York City and Long Island account for about half of the total demand.

New York State's electricity sources vary regionally. For example, about half the fossil fuel-fired plants are in New York City and Long Island while most of the state's hydropower is in central and northern New York.

Wind power deployment is expected to increase across the state.

Natural gas is the most commonly used source of heating energy in buildings, although there are strong regional differences, which reflect the lack of gas service in many parts of the state.

Energy prices vary widely, with higher prices in eastern New York than in western parts of the state.

Key Climate Impacts

Impacts of climate change on energy demand are likely to be more significant than impacts on supply. Climate change will adversely affect system operations, increase the difficulty of ensuring adequate supply during peak demand periods, and exacerbate problematic conditions, such as the urban heat island effect.

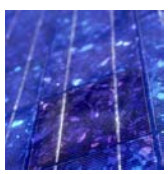
More frequent heat waves will cause an increase in the use of air conditioning, stressing power supplies and increasing peak demand loads.

Increased air and water temperatures will decrease the efficiency of power plants, as they decrease cooling capacity.

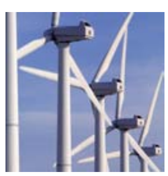
Coastal infrastructure is vulnerable to flooding as a result of sea level rise and coastal storms.

Hydropower is vulnerable to projected increases in summer drought.

The availability and reliability of solar power systems are vulnerable to changes in cloud cover although this may be offset by advances in technology; wind power systems are similarly vulnerable to changes in wind speed and direction.

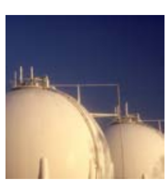


Biomass energy availability depends on weather conditions during the growing season, which will be affected by a changing climate.



Transformers and distribution lines for both electric and gas supply are vulnerable to extreme weather events, such as heat waves and flooding.

Higher winter temperatures are expected to decrease winter heating demand, which will primarily affect natural gas markets, while increases in cooling demand will affect electricity markets; such changes will vary regionally.



The indirect financial impacts of climate change may be greater than the direct impacts of climate change. These indirect impacts include those to investors and insurance companies as infrastructure becomes more vulnerable and those borne by consumers due to changing energy prices and the need to use more energy.

Adaptation Options

Planning for climate change must balance the need to make energy systems more resilient with the cost of such investments and changes. One way to do this is to incorporate adaptation planning into the replacement cycles of system assets, which have a long but relatively fixed lifespan. As temperatures rise, it will be even more important to encourage the use of energy efficient cooling methods such as shading buildings and windows, or using highly reflective roof paints to reduce buildings' temperatures. Although demand-side management, which encourages consumers to use energy more efficiently, is already a key state policy, it could be made an even greater priority.

Operations, Management, and Infrastructure Strategies

- Use transformers and wiring that function efficiently at higher temperatures.
- Construct berms and levees to protect infrastructure from flooding; install saltwater-resistant transformers to protect against sea level rise and saltwater intrusion.
- Review and revise tree trimming practices to account for changes in vegetation due to climate change.

Larger-scale Strategies

- Adjust reservoir release policies to ensure sufficient summer hydropower capacity.
- Improve energy efficiency in areas that are likely to have the largest increases in demand.

Co-benefits

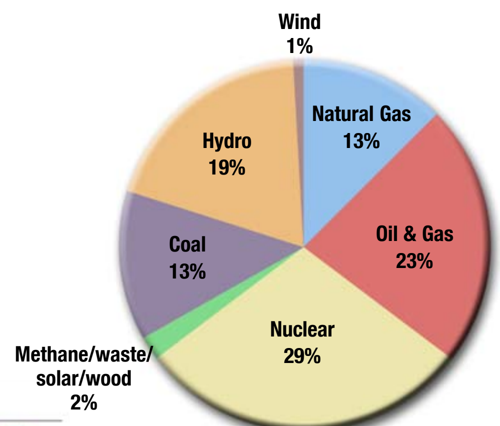
Increasing energy efficiency can help people to adapt to higher temperatures while reducing greenhouse gas emissions in order to mitigate climate change.

Projected changes in peak electricity demand for heating and cooling - 2020s (compared to current peak demand)

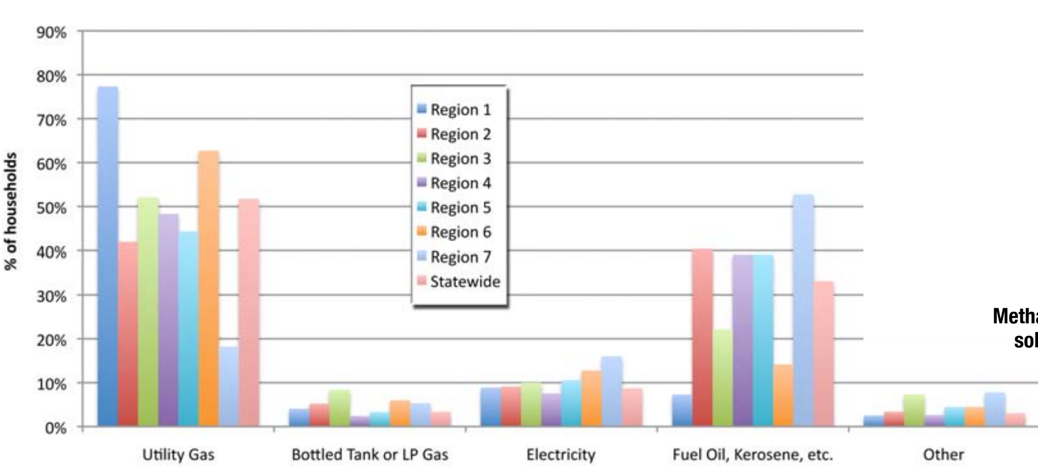
Weather Station	Heating Season **Decrease** in MWp Electricity Demand in 2020s	Cooling Season **Increase** in MWp Electricity Demand in 2020s
Buffalo	14 - 27	55 - 111
Rochester	9 - 18	53 - 105
Syracuse	19 - 37	61 - 122
Massena	5 - 10	7 - 15
Watertown	11 - 21	29 - 57
Albany	15 - 29	63 - 126
Poughkeepsie	12 - 25	72 - 145
NY City (LGA)	40 - 80	249 - 497
Islip	27 - 58	194 - 387

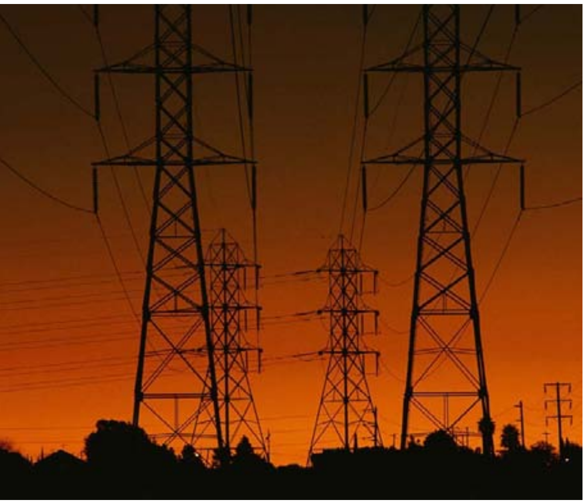
ClimAID global climate models project that average annual temperature will rise by 1.5 to 3.0°F in the 2020s compared to the 1970-1999 baseline period. An analysis of the sensitivity of energy demand to these changes shows that while heating energy use will decrease slightly, cooling energy use will increase much more.

New York State Electricity Generation by Fuel Type (2008)



Fuels used for residential heating in New York State by ClimAID Region





Particularly Vulnerable Groups

For lower-income residents, increased energy costs associated with air conditioning may be difficult to afford.

Low-income residents living in urban areas, which are already subject to urban heat island effects, may be especially vulnerable to higher energy costs.

New energy facilities to power the increased demand for air conditioning may place burdens on communities located nearby.

Elderly, disabled, and health-compromised residents are especially vulnerable to energy outages associated with extreme climate events.

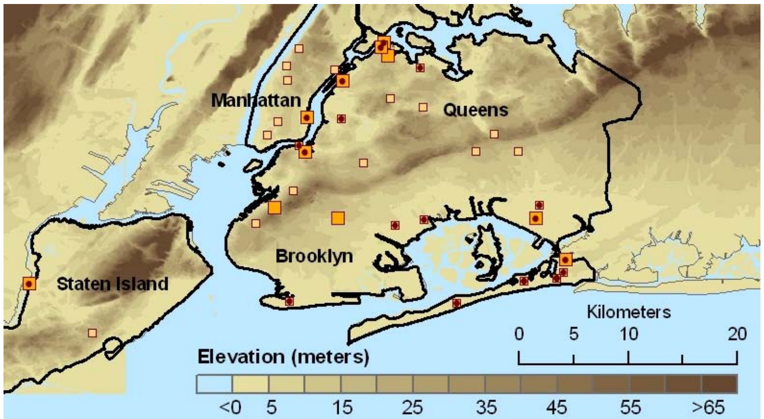
Impacts of Extreme Heat in Cities

Sustained high temperatures contribute to increased energy usage during heat waves, primarily for cooling indoor space and industrial equipment. When high temperatures persist overnight during these extended heat events, the likelihood of outages increases. While the network design of local grids tends to isolate outages geographically, limiting the number of customers affected, prolonged heat waves can cause multiple outages across a city. The impacts of power outages can extend well beyond the energy sector, affecting health, transportation, and telecommunication.

In New York City, urban heat island effects already contribute to an increase in energy demand during hot summer periods. Worsening heat waves under climate change pose a challenge for the city's energy sector. Existing urban heat island patterns will become more intense, such that areas that are already warmer due to heat island effects will become relatively hotter during a heat wave. The effects of heat islands are especially prominent in many lower income neighborhoods, such as Fordham in the Bronx and Crown Heights in Brooklyn. These neighborhoods often have fewer trees on the street and higher building density, both of which contribute to hotter conditions.

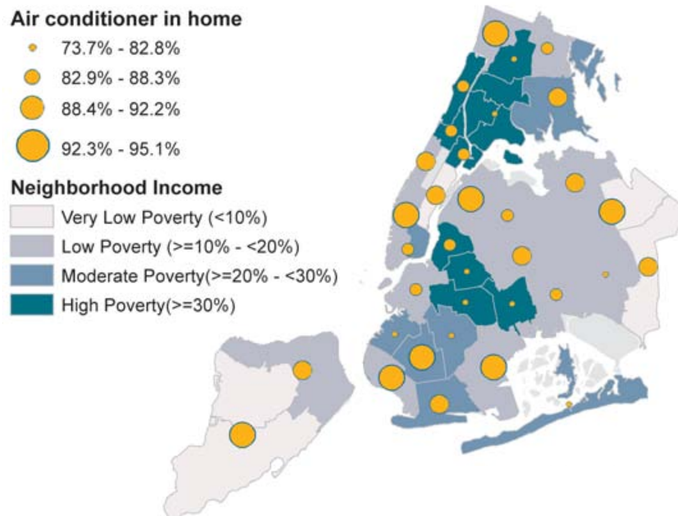
Higher poverty areas of New York City, particularly in northern Manhattan, the South Bronx, and parts of Brooklyn, have lower rates of home air conditioning than other areas, putting them at greater risk for heat-related health problems. But even households that have air conditioning in these areas may be reluctant to use it because of the high cost of energy, which represents a large portion of their household income.

Location and elevation of power plants in New York City



The majority of New York City's power plants are located at low elevations on the coast and are thus vulnerable to sea level rise and storm surge.

Air conditioning distribution and neighborhood level poverty



Neighborhoods with higher poverty rates, including Central Harlem, Washington Heights, Fordham, the South Bronx, Greenpoint, Williamsburg, Bedford-Stuyvesant and others, have lower rates of in-home air conditioning than more affluent parts of the city.

To provide enough power during heat waves to meet the increase in peak demand, less efficient and more highly polluting sources of power may be used. High ozone levels due to the combination of high temperatures and air pollution are particularly harmful for the elderly and ill.

Power outages and other disruptions to supply have significant financial impacts, with costs to U.S. consumers ranging from $119 billion to $188 billion per year. The workforce-especially those living farther from their jobs or who are more dependent on forms of transportation that become inoperable during power outages-are likely to bear these losses. During the 2003 Northeast blackout, loss of wages was estimated to account for two-thirds of the total financial losses.

Those providing emergency services, including emergency health professionals, also may have difficulty getting to work during a power outage, thereby increasing risks to individuals in need of assistance. During the 2003 Northeast blackout, the health services sector had the second highest workforce losses as a result of business closures. Demand for emergency services during the outage increased significantly as did the rate of respiratory device failure.

To protect against severe power outages, smart grid technology can be used to help avoid them altogether by providing network operators with clearer metrics of the potential risk. Reducing demand and distributed generation (which generates electricity from many small sources) can also help lessen the risk of power outages. During heat waves and in advance of peak demand, voluntary and mandatory load-reduction programs that call for customers to reduce usage also can be employed.

Context

New York State is home to a 113,000-mile network of Interstate and State Highways including 16,000 bridges, a 4,600-mile rail network including the largest mass transit system in the U.S., some 500 public and private aviation facilities, more than 130 public transit operators, four port authorities, and numerous private ports. Transportation contributes about 10 percent, or $100 billion annually, to the state's economy.

The highest concentration of transportation infrastructure is generally located in regions that are population centers and vital drivers of the global, national and state economy. Threats to these dense metropolitan transportation systems (especially New York City) would have far-reaching impacts.

Ground transportation systems (roads and rails) in coastal population centers are often placed underground in tunnels very close to or below sea level.

Since transportation is a networked system, delays and failures in one system can affect other systems.

Key Climate Impacts

Over the next few decades, heat waves and heavy precipitation events are likely to dominate the causes for moderate, more frequent transportation problems such as flooded streets and delays in mass transit.

By later this century, it is very likely that coastal flooding will be more frequent and intense due to sea level rise. Major adaptations are likely to be needed, not only in the coastal zones, but also in Troy and Albany as sea level rise and storm surge propagate up the tide-controlled Hudson River.

Materials used in transportation infrastructure, such as asphalt and train rails, are vulnerable to increased temperatures and frequency of extreme heat events.

Air conditioning requirements in buses, trucks, and trains, and ventilation requirements for tunnels will increase.

Low-lying transportation systems such as subways and tunnels, especially in coastal and near-coastal areas, are at particular risk of flooding as a result of sea level rise, storm surge, and heavy precipitation events.

Transportation systems are vulnerable to ice and snowstorms, although requirements for salting and snow removal may decrease as precipitation tends to occur more often as rain than snow. Freeze/thaw cycles that disturb roadbeds may increase in some regions as winter temperatures rise.

Runways may need to be lengthened in some locations since hotter air provides less lift and hence requires higher speeds for take off. Newer, more powerful aircraft can reduce this potential impact.

The Great Lakes may see a shorter season of winter ice cover, leading to a longer shipping season. However, reduced ice cover may result in an increase in "lake effect" snow events, which cause various transportation-related problems.

New York State has the most days per year of freezing rain in the nation. This affects air and ground transportation directly and also indirectly through electric and communication outages. It is unknown how climate change will influence the frequency of freezing rain in the future.

Adaptation Options

Disaster management studies have shown that every $1 invested in preventative measures saves $4 in losses not incurred.

Operations, Management, and Infrastructure Strategies

- Perform engineering-based risk assessments of assets and operations and complete adaptation plans based on these assessments, including financing.
- Protect coastal transportation infrastructure with levees, sea walls and pumping facilities; elevate bridge landings, roads, railroads, airports, and collision fenders on bridge foundations; design innovative gates at subway, rail and road tunnel entrances and ventilation openings.
- Relocate critical systems to higher ground out of future flood zones.
- Lengthen airport runways and expansion joints on bridges; upgrade to energy-efficient air conditioning on trains, subways, and buses; use heat-resistant construction materials for pavements and rail tracks.

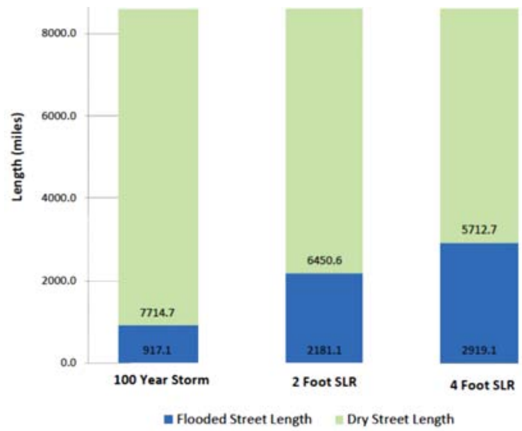
Larger-scale Strategies

- Change standards for engineering specifications related to climate such as for heat-resistant materials and the capacity of drainage systems.
- Form alliances to set performance standards to reduce climate risks; form mutual insurance pools that spread risks.

Co-benefits

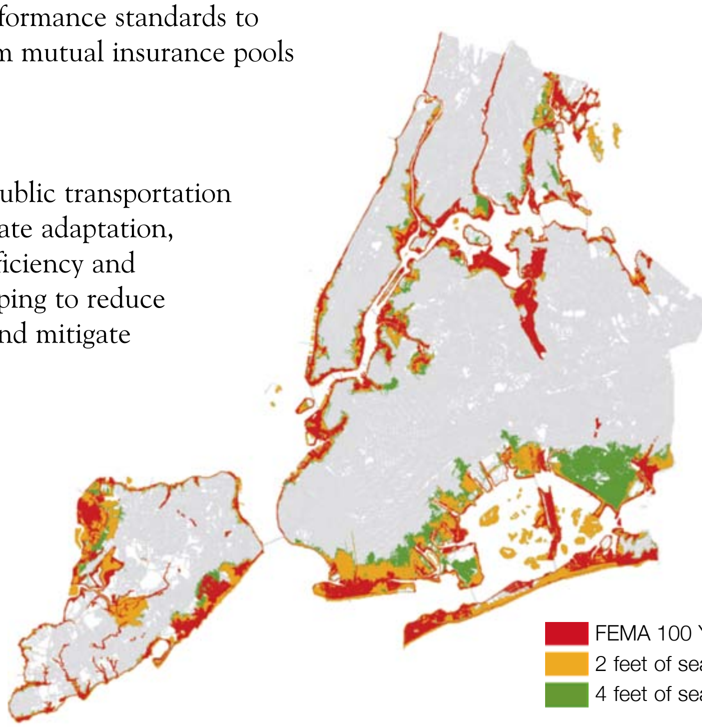
Making improvements to public transportation systems will not only facilitate adaptation, but also enhance energy efficiency and increase ridership, thus helping to reduce greenhouse gas emissions and mitigate climate change.

NY City Streets at Risk of Flooding



As sea level rises, many more New York City streets will be at risk of flooding. The chart shows the total length in miles of NY City streets at risk of flooding under current sea level with a 100-year storm, and with 2 feet and 4 feet of sea level rise (consistent with the ClimAid projections). Under current conditions, about 11 percent of city streets are at risk. With 2 feet of sea level rise, that increases to about 25 percent. And with 4 feet of sea level rise, about 34 percent of NY City streets are at risk.

New York City's Expanding Flood Zones



100-year flood zones for the New York City area under observed conditions (red, from FEMA), with 2 feet of sea level rise (yellow), and 4 feet of sea level rise (green), as projected by the ClimAID rapid ice melt sea level rise scenario for the 2080s.

FEMA 100 Year flood zone
2 feet of sea level rise
4 feet of sea level rise

Particularly Vulnerable Groups

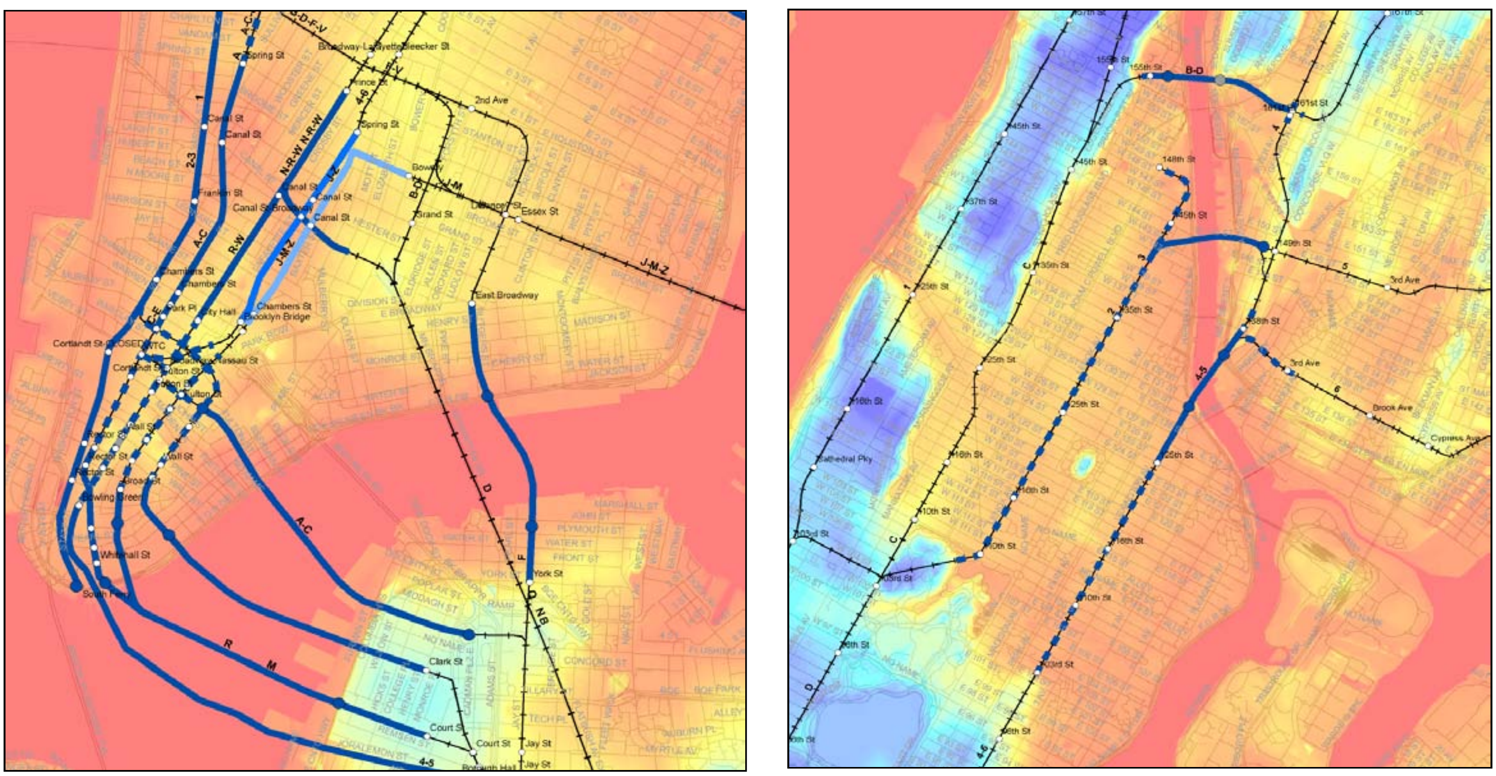
Low-income and elderly populations, especially in urban areas, are particularly vulnerable to disruption to transportation services, limiting their ability to get to work or evacuate during emergencies and extreme weather events.

Transport interruptions take a particular toll on working women, who tend to have less spare time because of child and family care and on average earn less than men.

Workers on hourly payrolls can less afford transportation-related work loss or delays compared to more affluent, salaried employees whose pay does not depend on the number of hours worked.

Lower income neighborhoods, whether rural, suburban, or urban, generally have already poor transportation options and little or no redundancy. Increases in extreme events will worsen their situation.

100-year flood with 4-foot Sea Level Rise



Stations
Ventilation openings (data provided)
100 Year Flood + 2' SLR
0% Enters
3% Enters
8% Enters
17% Enters
72% Enters
100% Enters
Under River Tunnels (data provided)
100 Year Flood + 2' SLR
0%
3%
100%
Subway tunnels below Houston St (data provided)
100 Year Flood + 2' SLR
0%
6%
18%
100%
Added length for volume overflow

A 100-year flood with a 4-foot rise in sea level (consistent with the ClimAID rapid ice melt scenario projections in the 2080s) would flood a large fraction of Manhattan subways, including virtually all of the tunnels crossing into the Bronx beneath the Harlem River and the tunnels under the East River. Blue lines on the maps show flooded subway lines and tunnels. Background colors indicate topography, with areas greater than 30 feet in elevation in yellow. Since subway tracks are typically 20 feet below the street level, areas in yellow could avoid flooding given the ClimAID storm surge and sea level rise pro-

Sea level rise and a 100-year coastal storm

Impacts on New York City metropolitan area

Sea level rise in combination with coastal storm surge has the ability to severely damage transportation systems in New York-particularly those in New York City and the surrounding metropolitan region since much of the systems are located at low elevations, and some in tunnels below sea level. By the end of this century, the ClimAID projections show that sea level is expected to rise by 2 to 4 feet with significant implications for the transportation sector.

Damages from a coastal storm in the New York City metropolitan area that currently occurs on average once every 100 years would be significant. At current sea level, economic losses from such a storm would amount to about $58 billion. Losses under a 2-foot sea level rise scenario increase to $70 billion and to $84 billion under a 4-foot sea level rise scenario. All sectors of the transportation system would be affected, including roads, railways, subways, airports, and seaports.

The effects of such a flooding scenario would occur rapidly. For example, many of the tunnels lying below flood heights (including subway, highway, and rail) would fill up with water in less than 1 hour. At the low-lying La Guardia airport, sea level rise would wipe out the effectiveness of existing levees, even for less severe storms. The outage times estimated for the various transportation systems range from 1 to 29 days, depending on the infrastructure and sea level rise scenario. More detailed engineering-based vulnerability assessments are needed to improve these preliminary estimates.

The social and economic effects of a 100-year storm would not be distributed evenly. People with limited mobility and transportation options would be affected the most, including low-income households, the disabled, and the elderly. These populations also may be less likely to access relief from centralized facilities located beyond walking distance.

To protect against the impacts of a 100-year storm, sea walls, floodgates, and pumping stations could be constructed in the short term. In the long term, transportation infrastructure could be relocated to higher elevation areas, outside of the future floodplain, and some tunnel structures could be outfitted with engineered flood protection. The sustainability of a proposed barrier system to protect the entire New York harbor has not been established and requires careful cost/benefit assessments of long-term risks and of exit strategies when prolonged sea level rise combined with coastal storm surge begins to exceed the finite design elevations of any such barrier system.

Annualized losses from the expected climate hazards for the entire metropolitan transportation systems are estimated in the hundreds of millions of dollars per year now, increasing to billions of dollars per year by mid-century. Required annual capital costs to make the transportation systems resilient to climate hazards in this coastal setting are on the order of one quarter of the expected losses that are estimated to occur if no protective adaptation measures were undertaken. Therefore preventive measures are likely to be highly cost-effective, but require engineering assessments, and must be in place before irreparable flood damage occurs. This will require capital investments.

TELECOMMUNICATIONS

Key Climate Impacts

Communication service delivery is vulnerable to hurricanes, lightning, ice, snow, and wind storms, and other extreme weather events, some of which are projected to change in frequency and/or intensity.

The delivery of telecommunication services is sensitive to power outages, such as those resulting from the increased demand associated with heat waves, which are expected to increase with climate change.

Communication lines and other infrastructure are vulnerable to heavy precipitation events, flooding, and/or freezing rain.

In coastal and near-coastal areas, sea level rise in combination with coastal storm surge flooding will be a considerable threat later this century.

Context

Telecommunications infrastructure is vital to New York State's economy and welfare; its capacity and reliability are essential to the effective functioning of emergency services as well as global commerce and the state's economy.

The sector is largely privately operated, but it has important public functions.

Because of rapidly changing telecommunications technology and deregulated, fiercely competitive markets, some operators often focus on short-term market share and profitability rather than pursuing long-term strategies to achieve reliability and redundancy.

Under current climate conditions and severe weather events, there are already serious vulnerabilities that in many instances prevent the telecommunications sector from delivering services to the public. If the sector could be made more resilient to the current climate, then the incremental threat from climate change is likely to be more manageable.

The sector is tightly coupled to the energy sector, with power outages affecting the reliability of communication services; many of its communication lines also are located on the same poles as power lines.

Modern digital technologies, including telecommunication services based on fiber optics, broadband, and the Internet, can be more vulnerable to power outages than traditional landline technology that was - or in some places still is - self-powered.

Wireless mobile phone services and landlines often share the same backbone network. In these instances, redundancy is essential to avoid simultaneous breakdowns.

Reports of service outages to federal or state regulators are not accessible to the public and are not uniformly mandatory across the different types of services.

Adaptation Options

Changes to telecommunications infrastructure to make it more robust, resilient, and redundant will reduce future climate-related outages.

Operations, Management, and Infrastructure Strategies

- Trim trees near communication lines; place communication cables underground where technically and economically feasible.
- Provide backup power at cell towers with generators, solar-powered battery banks, and "cells on wheels" that can replace disabled towers. Extend the fuel storage capacity to run back-up generators for extended times.
- Relocate central communications offices out of future floodplains.
- Improve backup cell phone charging options by standardizing charging interfaces, including for car chargers, which allow any phone to be recharged by any charger.
- Assess, develop, and expand alternative communication technologies to increase redundancy and/or reliability.

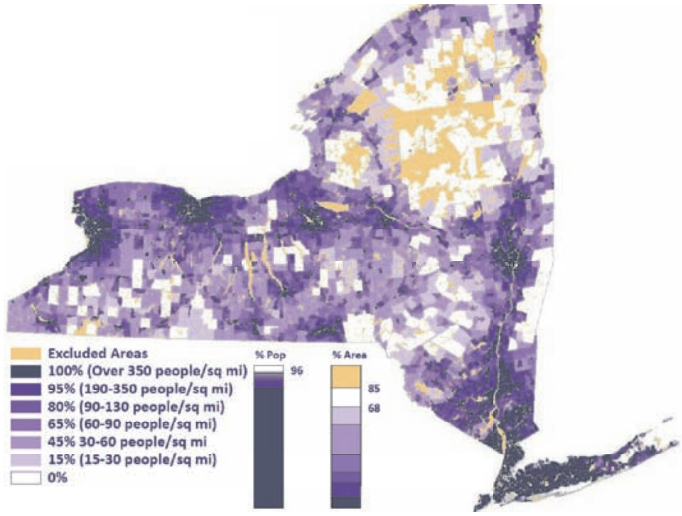
Larger-scale Strategies

- Reassess industry performance standards combined with appropriate, more uniform regulation across all types of telecommunication services. Provide better enforcement of regulations, including uniform mandatory reporting of outages.
- Develop high-speed broadband and wireless services in low population-density rural areas.
- Diversify communication media by separating cable and phone services and increasing the use of internet-based telephone services.
- Decouple telecommunications infrastructure from electric grid infrastructure to the extent possible.

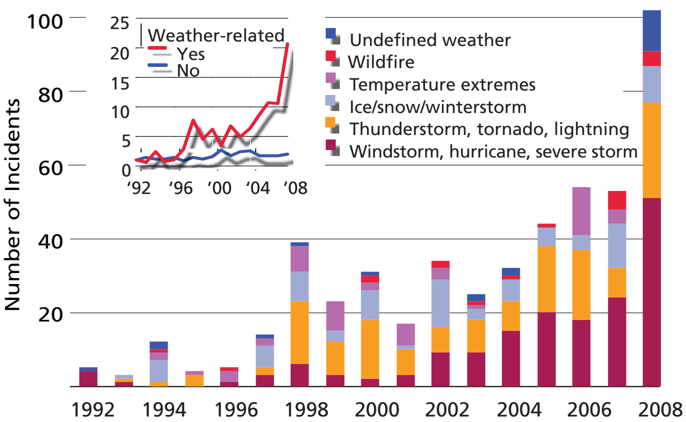
Co-benefits

Increasing redundancy and reliability in the telecommunications sector will reduce outages not only from a changing climate, but also from other non-climate related risks. Improving telecommunications technology reliability will also help to reduce greenhouse gas emissions from travel.

Cable Modem Broadband Availability - 2009



Significant weather-related U.S. electric grid disturbances



Telecommunication technologies are dependent on reliable and consistent electric power. The number of electric grid disruptions caused by extreme weather has increased tenfold since 1992. The fraction of all grid disturbances caused by weather-related phenomena has more than tripled from about 20 percent in the early 1990s to about 65 percent in recent years. While the figure does not demonstrate a cause and effect relationship between climate change and grid disruptions, it does suggest that weather and climate extremes have important effects on grid disruptions. Projections of future increases in extreme events suggest increased risks for the electric grid and the telecommunications that depend on it.

Particularly Vulnerable Groups

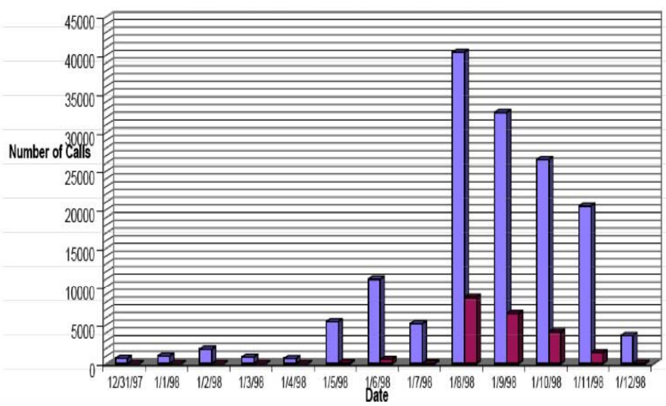
Customers in rural, remote areas are more vulnerable to service disruptions than customers in urban areas, because they have fewer backup service options and often lack wireless and broadband services.

Restoration of communication services following a storm typically happens first in urban areas and then in rural areas, with smaller, remote communities likely to be restored last; this places people in rural areas at increased risk during emergencies.

Within remote, rural areas, elderly, disabled, and health-compromised populations are especially vulnerable to communication service disruptions associated with storm events due to their more limited mobility.

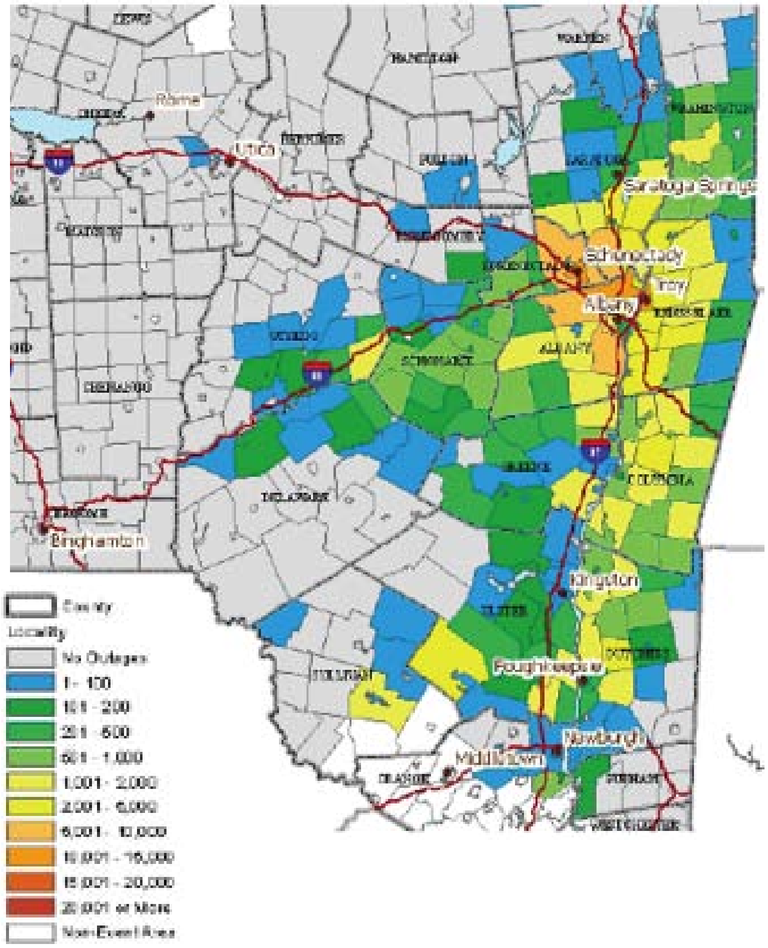
Lower-income populations are more likely to drop landline services; this increases their risk during emergency situations, as a result of their more limited communication options.

Emergency Radio Calls - 1998 Ice Storm



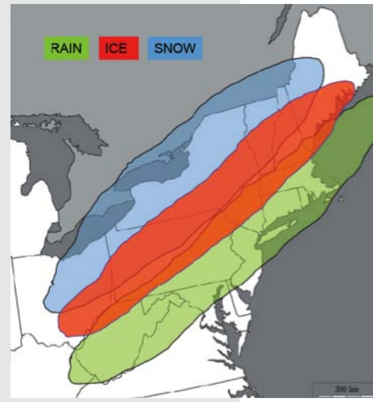
The chart shows the number of emergency radio calls per day (blue) and blocked radio calls (red) because of overload, in one New York state county during the 1998 ice storm. The graph covers 13 days, with a peak number of over 40,000 calls in one day. The first five days show normal background call traffic before the storm hit.

Customers Without Power by Locality - December 2008 Ice Storm



Winter Storm in Central, Western and Northern New York

Vulnerability of telecommunication services



Severe winter storms in New York generally follow this pattern: a low-pressure system moves up the Atlantic Coast bringing warm moist air that encounters cold dry air in a high-pressure system over Canada and extends into the northern parts of New York. The northward movement of the counterclockwise-rotating storm system causes warm air to overrun the cold air mass. This typically forms three moving bands of precipitation as illustrated on the map to the right.

It is uncertain how climate change will influence extreme winter storms. A hypothetical composite of historical extreme winter storms is described. While the three types of precipitation (rain, freezing rain, and snow) would not necessarily be expected to occur concurrently in these proportions, each of these types of extreme winter precipitation is currently expected to occur on average at least once per century.

- Up to 8 inches of rain fall in the rain band in near-coastal New York over a period of 36 hours.
- Up to 4 inches of freezing rain falls in the ice band in central New York, of which between 1 and 2 inches accumulates as ice, over a period of 24 hours.
- Up to 2 feet of snow accumulates in the snow band in northern and western New York over a period of 48 hours.

A storm of this magnitude could result in widespread power and communication outages, with most people who lose electricity also losing communication services. In the Central New York ice storm area, about a half million people would be without power. It would take up to 10 days to restore power to half of these customers living in the larger cities such as Albany, Binghamton, and Schenectady, and up to five weeks to fully restore services to those living in remote, rural areas. Fewer people would be affected in the western and northern New York snow accumulation area. There services may be restored more quickly, first in cities and progressing to rural areas.

Economic damages from productivity losses alone would amount to about 900 million dollars. Costs associated with direct damages - such as spoiled food, damaged orchards, replacement of downed poles and electric and phone wires, medical costs and emergency shelter expenses - would be of a similar magnitude. In total, productivity and direct damage costs would amount to about $2 billion. These numbers, however, likely underestimate the total costs, given that a 1998 ice storm resulted in losses of about $5.4 billion in Canada alone.

Those most vulnerable to power and communication service disruptions are those that are unable to leave their homes (those with limited transportation options) and those who lack access to cell phones, including elderly, low-income, disabled, and rural populations.

To protect against communication and power outages, trees near power and communication lines can be trimmed, backup poles and wires can be stocked to replace those that are damaged, and readiness of emergency crews to assist with restoration can be arranged in advance of storms. Increasing the fuel supply to extend the duration of emergency backup power at mobile phone cell towers with difficult road access is especially important in areas with low landline, broadband, and internet penetration.

Context

New York State relies primarily on a county-based system for public health service delivery, resulting in a decentralized system in which core services are not provided uniformly.

Information and the capacity to integrate climate change into public health planning remains limited at the local level.

Cardiovascular disease is the leading cause of death in the state and is made worse by extreme heat and poor air quality.

Childhood asthma is an important current health challenge in many parts of New York State, especially in the five counties that comprise New York City, and is made worse by poor air quality.

New York State has experienced the emergence of several vector-borne diseases (those spread by carriers such as mosquitoes and ticks) in the past few decades.

Key Climate Impacts

Demand for health services and the need for public health surveillance and monitoring will increase as climate continues to change.

Heat-related illness and death are projected to increase, while cold-related death is projected to decrease. Increases in heat-related death are projected to outweigh reductions in cold-related death.

More intense precipitation and flooding along the coasts and rivers could lead to increased stress and mental health impacts, impaired ability to deliver public health and medical services, increased respiratory diseases such as asthma, and increased outbreaks of gastrointestinal diseases.

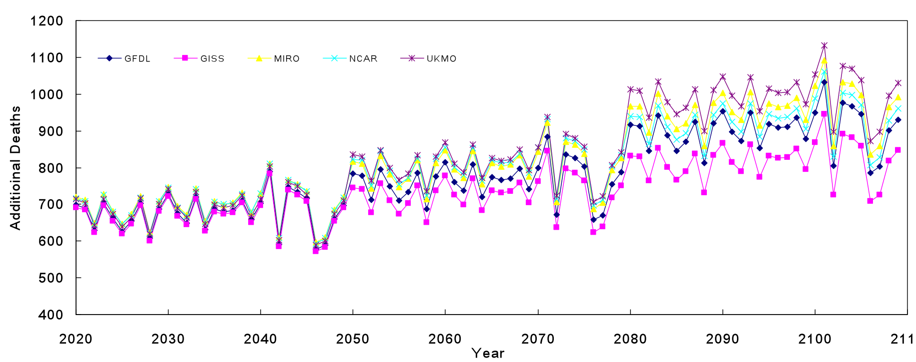
Cardiovascular and respiratory-related illness and death will be affected by worsening air quality, including more smog, wildfires, pollens, and molds.

Vector-borne diseases, such as those spread by mosquitoes and ticks (like West Nile virus), may expand or their distribution patterns may change.

Water supply, recreational water quality, and food production will be at increased risk due to increased temperatures and changing precipitation patterns.

Water- and food-borne diseases are likely to increase without adaptation intervention.

Projected Temperature-related Deaths in NY County



As climate continues to warm, heat-related deaths are expected to increase, while cold-related deaths are expected to decrease. A preliminary study of all of these temperature-related deaths from 2010 to 2100 in New York County was undertaken using 5 climate models from the set of ClimAID models under lower (B1) and higher (A2) emissions scenarios. The results suggest that increases in heat-related deaths will outweigh reductions in cold-related deaths, resulting in a net increase in deaths due to climate change. The lower-emission scenario (B1) is projected to result in substantially fewer deaths by the 2080s. The chart shows the results from 5 models for the higher (A2) emissions scenario. These results are broadly consistent with the other global climate models used in ClimAID.

Adaptation Options

Enhanced capacity will be needed to integrate climate adaptation strategies into existing health programs.

Operations, Management, and Infrastructure Strategies

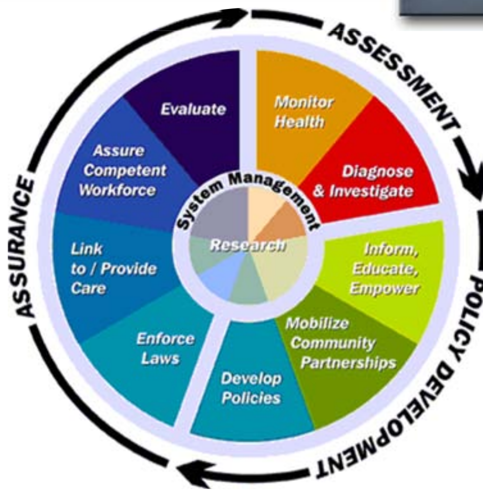
- Extend surveillance of climate and health indicators, including a statewide network of publicly available data monitoring airborne pollen and mold.
- Evaluate extreme heat response plans, focusing particularly on expanding access to cooling services during heat events. Build on this knowledge to develop similar systems for other climate health risks. Target strategies and messages for the most vulnerable populations.
- Plant low-pollen trees in cities to reduce heat without increasing allergenic pollen.

Larger-scale Strategies

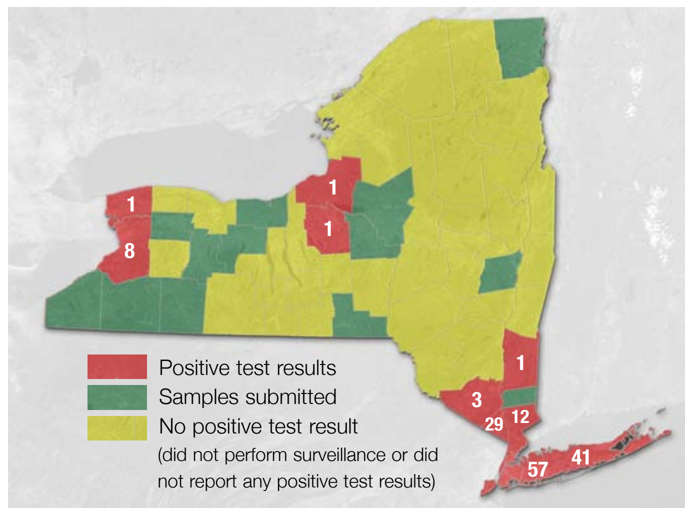
- Environment and health initiatives should be better integrated so that they address both human and ecosystem health and avoid the divide that often exists between them.

Co-benefits

Adaptation strategies which maximize co-benefits, such as cleaner air, improved nutrition or increased physical activity, should be given priority. Investing in structural adaptations to reduce heat vulnerability, including tree planting, green roofs, and high-reflectivity building materials, will help to reduce energy demand and expense while reducing heat-related risks.



West Nile virus in mosquitoes, New York State, 2008



While West Nile virus infections in humans and birds have only been reported in a limited part of the state, the prevalence of West Nile virus in mosquitoes is more widespread throughout the state.

Particularly Vulnerable Groups

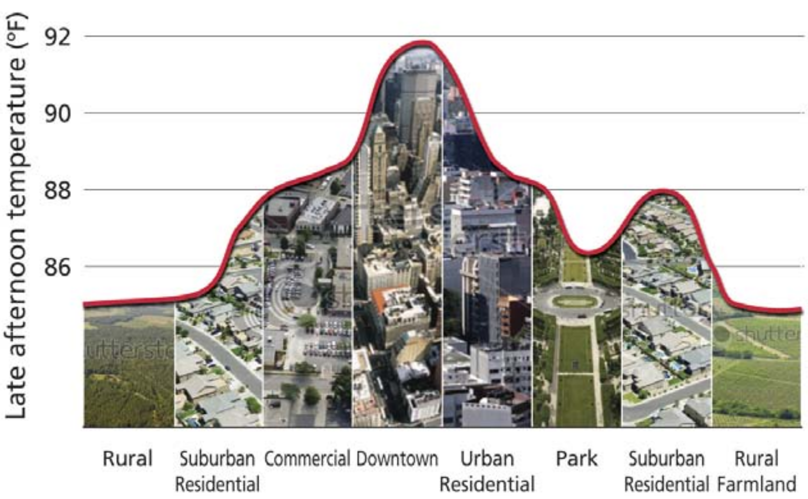
- Without intervention, existing health disparities are likely to be exacerbated by climate change.
- Age, preexisting illness, neighborhood infrastructure and/or poverty put people at elevated risk.
- In urban areas, the elderly, persons with impaired immune systems, children, and poor are at particular risk for heat-related illness and death.
- People in northern parts of the state who are not accustomed to extreme heat are at particular risk for heat-related death.
- People with asthma are particularly vulnerable to ozone and fine-particle air pollution, which could lead to increased illness and death.
- Low-income individuals are more likely to go to the hospital for asthma attacks than wealthier individuals with health insurance who are under doctor supervision and have access to asthma control medications.
- Children, outdoor laborers, and athletes also may be at greater risk for respiratory diseases than those who spend more time indoors and are less active.
- Residents of coastal areas are vulnerable to direct impacts of storm surge flooding, mental health stressors related to evacuation, and mold and toxic exposures when they return home.

Heat and respiratory problems affect those most vulnerable

Certain groups-including the elderly, low-income populations, and minorities-are more vulnerable than others to climate change-related health risks including heat-related illness and death, and decreased respiratory function.

Summer heat waves have caused increased death in cities across the United States-including in New York City. Climate change will increase the frequency and intensity of heat waves. Urban areas are especially vulnerable because of the high concentrations of susceptible populations and the influence of the urban heat island effect, which makes cities hotter than surrounding areas. Health-relevant increases in heat waves are likely to occur within 20 to 30 years, with much larger increases 50 to 100 years from now. Heat related deaths are projected to increase significantly as a result.

Urban Heat Island Effect



Large amounts of concrete and asphalt in cities absorb and hold heat. Tall buildings prevent heat from dissipating and reduce air flow. At the same time, there is generally little vegetation to provide shade and evaporative cooling. As a result, parts of cities can be up to 10ºF warmer than the surrounding rural areas, compounding the temperature increases that people experience as a result of human induced warming.

Home air conditioning is a critical factor for preventing heat-related illness and death. Air conditioning is especially important for elderly, very young, and health-compromised individuals, all of whom have a lower internal capacity to regulate body temperature. In New York City, about 84 percent of households had air conditioning in 2003. But, such resources are not distributed evenly across the city. Many residents living in lower income neighborhoods lack air conditioning and are thus more vulnerable to extreme heat events. Others, including low-income elderly residents-particularly those living alone-may be reluctant to use air conditioning even if they have it due to concerns about energy costs, even during periods of extreme heat. However, air conditioning is highly vulnerable to power outages, pointing to the need for longer-term strategies to reduce heat vulnerability.

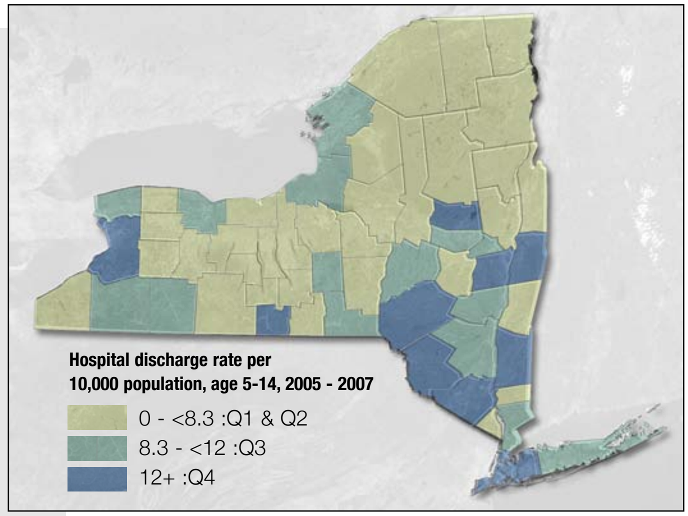
The health effects of extreme heat events can be reduced through adaptation measures. Warning systems and outreach can be used in conjunction with providing more access to public places with air conditioning, such as offering longer hours at community centers for seniors and reducing fares on public transportation. Long-term, engineering-based strategies also can be undertaken, including tree planting, installing green or reflective roofing and insulation in public housing to reduce indoor air temperatures.

Respiratory illness and death also are likely to increase with climate change. Rising temperatures and increasing emissions will result in more air pollution, with summer ozone levels likely to increase significantly. Ozone can increase the risk of asthma-related hospital visits and death. Already, many New Yorkers live in areas in which ozone levels do not meet health standards.

African Americans and Hispanics are particularly vulnerable to decreased air quality because they tend to live in urban centers where they are more exposed to air pollutants. As a group, they are significantly more likely to be hospitalized and die from asthma than other population groups. Children, outdoor laborers, and athletes also may be at greater risk of air pollution exposure than those who spend more time indoors and are less active.

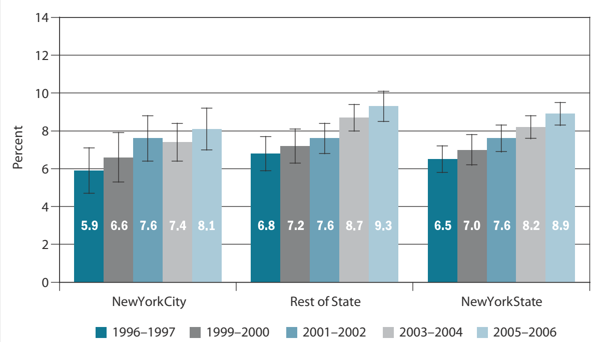
Another probable impact of climate change is increased levels of mold and other allergens that contribute to respiratory health problems. Dampness of households, a key variable for mold growth, is associated with socioeconomic status, and could intensify with projected precipitation increases. Mold may contribute to the high rates of hospitalization for asthma among African Americans in cities such as New York.

Hospital Discharge Rate for Children with Asthma



Asthma is climate-sensitive as it is exacerbated by allergies and air pollution, both of which are related to climate. Childhood asthma is an important current health challenge in many parts of New York State, with many asthma events severe enough to require hospitalization. Children from lower-income families who often lack health insurance, regular doctor visits, and medications that can control attacks are more likely to have to seek hospital treatment.

Prevalence of Current Asthma among Adults, 1996-2006



The number of adults with physician-diagnosed asthma increased between 1996 and 2006. This trend is expected to continue given ClimAID projections of rising temperatures and carbon dioxide because asthma is exacerbated by pollen and ground-level ozone. Pollen production increases under high atmospheric carbon dioxide levels, and ozone tends to increase with higher temperatures.

Conclusions

New York State is highly diverse, with simultaneous and intersecting challenges and opportunities. Among them, climate change will affect the people, sectors and regions of the state in the coming decades. Those that are already facing significant stress will likely be most at risk from future climate change. The success of the state's response will depend on developing effective adaptation strategies by connecting climate change with ongoing proactive policy and management initiatives. Climate change will bring opportunities as well as constraints, and interactions of climate change with other stresses, such as increased resource demand, will create new challenges.

The risks associated with sea level rise and coastal flooding are among the greatest climate-related challenges faced by New York State, affecting public health and ecosystems as well as critical infrastructure across many sectors including water, energy, transportation, and communication. Heat waves and heavy downpours will also affect many people and sectors. These and other drivers of climate change impacts will have a wide variety of effects that will require a range of adaptation strategies that can help reduce these impacts in the future. Such adaptation strategies are also likely to produce benefits today, since they will help to lessen impacts of climate extremes that currently cause damages. Examples of adaptation strategies in each sector have appeared throughout this report.

There is a range of adaptation needs, many of which can be undertaken in the near-term at relatively modest cost. And there are some infrastructure investments – especially relating to transportation and coastal zones – that are likely to be needed in the long-term and that would be expensive (though less expensive than the costs incurred in the absence of such measures). This suggests the need for increased and on-going interaction between scientists and policy-makers to ensure that science better informs policy, as well as the need for increased scientific and technical capabilities to be brought to bear on adaptations that involve the developing infrastructure of New York State.

Observed Climate Changes

- Annual average temperatures in New York State have risen about 2.4ºF since 1970, with winter warming exceeding 4.4ºF.
- Sea level along New York's coastline has risen about one foot since 1900.
- Since 1900, there has been no discernible trend in annual average precipitation for the state as a whole.
- Intense precipitation events (heavy downpours) have increased in recent decades.

Projected Changes

- Climate models with a range of greenhouse gas emissions scenarios suggest temperature increases across New York State of between 1.5 to 3ºF in the 2020s, 3 to 5.5ºF in the 2050s, and 4 to 9ºF in the 2080s.
- Most climate models project a small increase in annual precipitation. Variability is expected to continue to be large. Projected precipitation increases are largest in winter, mainly as rain, and small decreases may occur in late summer/early fall.
- Sea level rise projections for the coast and tidal Hudson River based on IPCC methods (which do not include increased melting of polar ice sheets), are 1-5 inches by the 2020s, 5-12 inches by the 2050s, and 8-23 inches by the 2080s.
- If the melting of the Greenland and West Antarctic Ice Sheets continues to accelerate, sea level rise would exceed projections based on IPCC methods. A rapid ice melt scenario, based on observed rates of melting and paleoclimate records, yields sea level rise of 37-55 inches by the 2080s.
- Extreme heat events are very likely to increase, and extreme cold events are very likely to decrease throughout New York State.
- Intense precipitation events (heavy downpours) are likely to increase. Short-duration warm season droughts are projected to become more common.
- Coastal flooding associated with sea level rise is very likely to increase. Areas not subject to coastal flooding now could become so in the future.

Recommendations

The ClimAID process has yielded some general recommendations for potential actions that can be taken by policy makers, managers, and researchers. These recommendations can help make New York State more resilient to current and future climate risk by bringing cutting-edge knowledge and data to groups of empowered and collaborating decision makers.

Recommendations aimed at statewide decision makers

- Promote adaptation strategies that enable incremental and flexible adaptations in sectors, amongst communities, and across time.

- Identify synergies between mitigation and adaptation. Taking steps to mitigate climate change now will reduce vulnerabilities, increase resilience, and enhance opportunities across all sectors. At the same time, some potential adaptation strategies present significant mitigation opportunities while others work against mitigation.

- Improve public and private stakeholder and general public education and awareness about all aspects of climate change. This could encourage the formation of new partnerships for developing climate change adaptations, especially given limited financial and human resources, and advantage of shared knowledge.

- Analyze and address environmental justice issues related to climate change and adaptation on a regular basis.

- Consider regional, federal and international climate-related approaches when exploring climate adaptation options. This is crucial because it is clear that New York State adaptation potential (and mitigation potential as well) will be affected by national and international policies and regulations as well as state-level policies.

Management recommendations associated with everyday operations within stakeholder agencies and organizations

- Integrate adaptation responses into the everyday practices of organizations and agencies, with the potential for complimentary effects or unintended consequences of adaptation strategies taken into account.

• Evaluate design and performance standards and policy regulations based on up-to-date climate projections.

• Take climate change into account within organizational planning and development efforts.

• Identify opportunities for partnerships among organizations and agencies within the state and region.

• Create standardized, statewide climate change mitigation and adaptation decision tools for decision makers, including a central database of climate risk and adaptation information for the state that is the result of an ongoing partnership between scientists and stakeholders.

Recommendations for science and research

• Refine climate change scenarios for New York State on an on-going basis as new climate models and downscaled products become available.

• Conduct targeted impacts research in conjunction with local, state, and regional stakeholders.

• Implement and institutionalize an indicators and monitoring program focused on climate, impacts, and adaptation strategies.

• Improve mapping and spatial analysis to help present new impact data and adaptation strategies.

• Focus studies on specific systems that may be subject to nonlinearities or “tipping points.” Work should be encouraged to understand the potential for tipping points associated with climate change impacts on natural and social systems.

• Research climate variability, extreme events, and other stakeholder-identified variables of interest including ice storms, extreme precipitation events, and wind patterns.

• Build on economic cost and benefit work to create a better understanding of the costs of climate change and benefits of adaptations on a sector by sector basis.

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