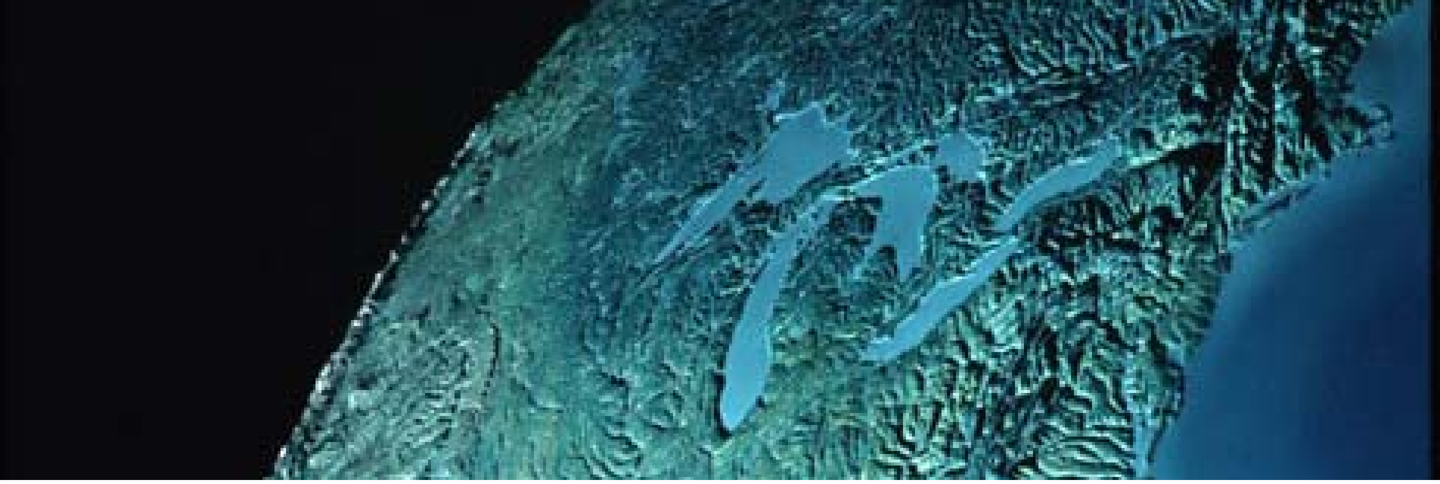
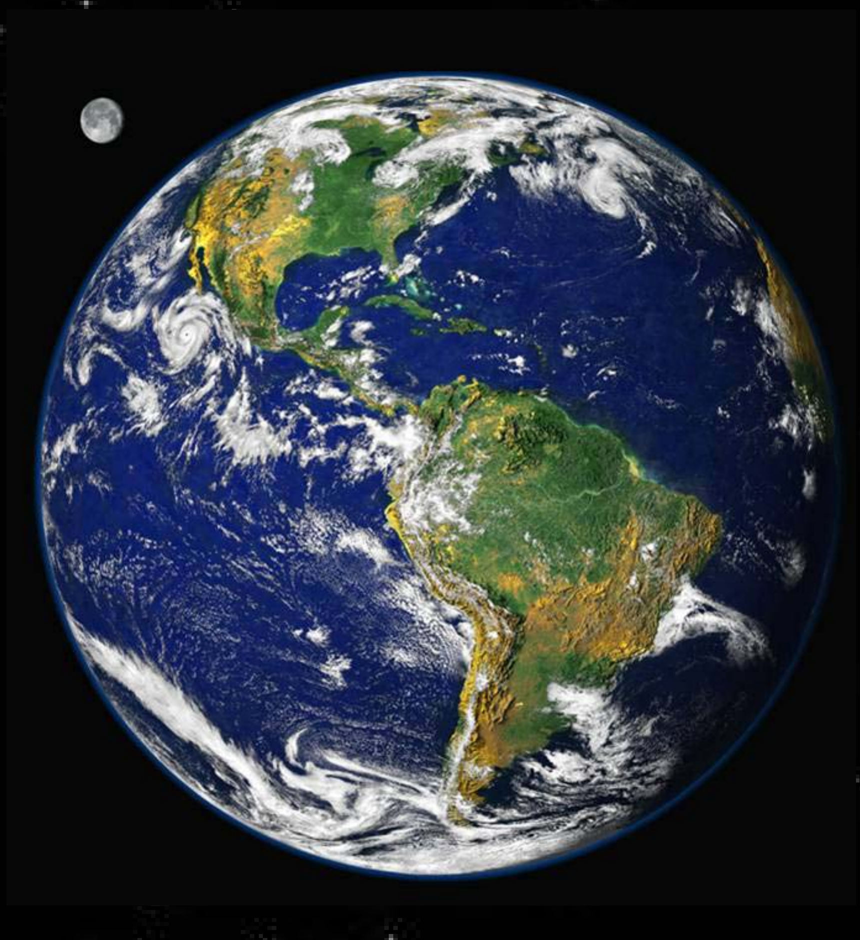


Michigan Climate Action Council

Climate Action Plan



Michigan Department of Environmental Quality
Steven E. Chester, Director

March 2009
Jennifer M. Granholm, Governor

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Members of the Michigan Climate Action Council

The Michigan Climate Action Council (MCAC) comprises 35 representatives from public interest groups, environmental organizations, utilities, the manufacturing sector and other key industries, universities, and state, local, and tribal government. Governor Granholm appointed the following individuals to the MCAC:

Jon Allan, Manager, Next Generation, Consumers Energy
Jeff Andresen, Ph.D., State of Michigan Climatologist**,** Department of Geography, Michigan State University
Guy Bazzani, President, Bazzani & Associates
Dr. Rosina Bierbaum, Ph.D., Dean, School of Natural Resources and Environment, University of Michigan; (**Duncan Callaway**, alternate)
Skiles Boyd, Vice President, Environmental Management and Resources, DTE Energy
Dwight Brady, Ph.D., Department of Communication, Northern Michigan University
Jim Byrum, President, Michigan Agri-Business Association
Steve Chester, Director, Department of Environmental Quality
Norman Christopher, Director of Sustainability, Grand Valley State University
Keith Cooley, Chief Executive Officer, NextEnergy
Dana Debel, Delta Air Lines
Doug Parks, representing **Jim Epolito,** President and CEO, Michigan Economic Development Corporation
Frank Ettawageshik, Tribal Chairman, Little Traverse Bay Bands of Odawa Indians
Michael Garfield, The Ecology Center of Ann Arbor
George Heartwell, Mayor, City of Grand Rapids
Chuck Hersey, Manager of Environmental Programs, Southeast Michigan Council of Governments
John Hiefje, Mayor, City of Ann Arbor
Rebecca Humphries, Director, Department of Natural Resources
Dana Kirk, Wilcox Inc.
Don Koivisto, Director, Michigan Department of Agriculture
Curt Magleby, Director of State and Local Governmental Affairs, Ford Motor Company
Brad Markell, United Auto Workers
Monica Martinez, Commissioner, Michigan Public Service Commission
Reginald Modlin, Director of Environmental and Energy Planning, Chrysler, LLC
Dennis Muchmore, Executive Director, Michigan United Conservation Clubs
Leonard Parker, Safety and Environmental Manager, Cliffs Natural Resources, Inc.
Lana Pollack, Former President, Michigan Environmental Council
Stanley Pruss, Director, Department of Energy, Labor and Economic Growth
Kirk Steudle, Director, Michigan Department of Transportation
Lisa Webb Sharpe, Director, Department of Management and Budget
Jim Weeks, Michigan Municipal Electric Association
Rich Wells, Vice President, Energy, The Dow Chemical Company

Al Weverstad, Executive Director, Environment and Energy Public Policy Center, General Motors Corporation
Willa Williams, Interim Director, Department of Environmental Affairs, City of Detroit
Dr. Gregg Zank, Vice President, Chief Technology Officer and Executive Director of Science and Technology, Dow Corning

The following individuals were appointed by Governor Granholm and served on the MCAC for a portion of its tenure:

Karen Cooper-Boyer, Denso Manufacturing
Pete Madden, Senior Resources Manager, Michigan Operations, Plum Creek Timber Company
Dr. Vincent Nathan, Ph.D., M.P.H., Director, Department of Environmental Affairs, City of Detroit

Acronyms and Abbreviations

\$/kWh	dollars per kilowatt-hour
\$MM	millions of dollars
\$/MWh	dollars per megawatt-hour
\$/t	dollars per metric ton
\$/tCO_2e	dollars per metric ton of carbon dioxide equivalent
ACEEE	American Council for an Energy Efficient Economy
AEO 2007	*Annual Energy Outlook 2007*
AEO 2008	*Annual Energy Outlook 2008*
AES	alternative energy supplier
AEZ	alternative energy zone
AFV	alternative-fuel vehicle
AFW	Agriculture, Forestry, and Waste Management
AII	Athena Institute International
AIS	aquatic invasive species
AMI	advanced metering infrastructure
ANL	Argonne National Laboratory
APU	auxiliary power unit
ASAs	Agricultural Security Areas
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ATRI	American Transportation Research Institute
BACT	best available control technology
BAU	business as usual
Btu	British thermal unit
C	Carbon
C&D	construction and demolition
C&T	cap and trade
CCI	Cross-Cutting Issues
CCS	Center for Climate Strategies
CCSR	carbon capture and storage/sequestration or reuse
CCX	Chicago Climate Exchange
CH_4	Methane
CHP	combined heat and power
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COD	commercial operation date
COEE	Centers of Energy Excellence
COLA	combined operating and licensing application
CREP	Conservation Reserve Enhancement Program [USDA]
CRP	Conservation Reserve Program [USDA]
CTIC	Conservation Technology Information Center

DG	distributed generation
DOE	[United States] Department of Energy
DSM	demand-side management
Dth	decatherms
E10	fuel blend of 10% ethanol and 90% gasoline
E85	fuel blend of 85% ethanol and 15% gasoline
EE	energy efficiency
EERE	[Office of] Energy Efficiency and Renewable Energy [US DOE]
eGRID	Emissions & Generation Resource Integrated Database [US EPA]
EIA	Energy Information Administration [US DOE]
EISA	Energy Independence and Security Act of 2007
EO	energy optimization
EOR	enhanced oil recovery
EOS	energy optimization standard
EPA	[United States] Environmental Protection Agency
ES	Energy Supply
ESCO	energy service company
FACTA	Food, Agriculture, Conservation, and Trade Act of 1990
FEED	front-end engineering and design
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FIA	Forest Inventory and Analysis [USFS]
FJD	First Jurisdiction Deliverer
FRPP	Farm and Ranch Lands Protection Program
g	gram
gal	gallon
GHG	greenhouse gas
GIS	geographic information system
GPO	[United States] Government Printing Office
GREET	Greenhouse [gases] Regulated Emissions and Energy [use in] Transportation [model]
Gt	gigatons
GWh	gigawatt-hour [one million kilowatt-hours]
HB	House Bill
HDPE	high-density polyethylene
HFC	hydrofluorocarbon
I&F	inventory and forecast
IECC	International Energy Conservation Code
IGCC	integrated gasification combined cycle
IOGCC	Interstate Oil and Gas Compact Commission
IOU	investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power provider
IRP	integrated resource planning

ISO	International Standard Organization
ITS	intelligent transportation system
kg	kilogram
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
lb	pound
LCA	life-cycle analysis
LDPE	low-density polyethylene
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design [Green Building Rating System™]
LFG	landfill gas
LFGcost	landfill gas cost model
LFGTE	landfill gas-to-energy
LIEEF	Low-Income and Energy Efficiency Fund
LMOP	Landfill Methane Outreach Program [US EPA]
LPG	liquefied petroleum gas
LRR	low-rolling-resistance [tires]
MAC	[California] Market Advisory Committee
MAEAP	Michigan Agriculture Environmental Assurance Program
MAHB	Michigan Association of Home Builders
MAREC	Michigan Alternative and Renewable Energy Center
MBP	Market-Based Policies
MCAC	Michigan Climate Action Council
MCF	thousand cubic feet
MCCI	Michigan Conservation and Climate Initiative
MCCP	Michigan Climate Challenge Program
MCLs	Michigan Compiled Laws
MDA	Michigan Department of Agriculture
MDEQ	Michigan Department of Environmental Quality
MDELEG	Michigan Department of Energy, Labor and Economic Growth
MDMB	Michigan Department of Management and Budget
MDNR	Michigan Department of Natural Resources
MDOT	Michigan Department of Transportation
MEDC	Michigan Economic Development Corporation
metric ton	1,000 kilograms or 22,051 pounds
MGA	Midwestern Governors Association
MIFFS	Michigan Food & Farming Systems
MISO	Midwest Independent Transmission System Operator
MM	million
MMBtu	million British thermal units
MMtC	million metric tons of carbon

$MMtCO_2$	million metric tons of carbon dioxide
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MPO	metropolitan planning organization
MPSC	Michigan Public Service Commission
MRCSP	Midwest Regional Carbon Sequestration Partnership
MSU	Michigan State University
MSW	municipal solid waste
MUEC	Michigan Uniform Energy Code
MW	megawatt [one thousand kilowatts]
MWh	megawatt-hour [one thousand kilowatt-hours]
N	nitrogen
N_2O	nitrous oxide
N/A	not applicable
NASS	National Agricultural Statistics Service [USDA]
NGO	nongovernmental organization
NO_x	oxides of nitrogen
NPV	net present value
NQ	not quantified
NRC	[United States] Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service [USDA]
NREL	National Renewable Energy Laboratory [US DOE]
NREPA	Natural Resources and Environmental Protection Act
NRI	National Resources Inventory [USDA]
NSR	New Source Review
O&M	operation and maintenance
OEM	original equipment manufacturer
ORNL	Oak Ridge National Laboratory
P2 Loans	[Small Business] Pollution Prevention Loan Program
PA	Public Act
PCORP	Plains CO_2 Reduction Partnership
PET	polyethylene terephthalate
PFC	perfluororocarbon
PHEV	plug-in hybrid electric vehicle
PLA	polylactic acid
PM	particulate matter
PSD	Prevention of Significant Deterioration
psi	pounds per square inch
PTC	production tax credit
PV	photovoltaic
R&D	research and development
RBEG	Rural Business Enterprise Grant

RCDG	Rural Cooperative Development Grant
RBOG	Rural Business Opportunity Grant
RCI	Residential, Commercial, and Industrial
REC	renewable energy credit
REP	renewable energy payment
RFP	request for proposal
REFIT	renewable energy feed-in tariff
RETAP	Retired Engineers Technical Assistance Program
RFC	[Michigan] Renewable Fuels Commission
RGGI	Northeast Regional Greenhouse Gas Initiative
ROI	return on investment
RPS	renewable portfolio standard
SB	Senate Bill
SO_2	sulfur dioxide
SRWC	short-rotation woody crop
t	metric ton
TBD	to be determined
tC	metric tons of carbon
tCO_2e	metric tons of carbon dioxide equivalent
tCO_2e/MWh	metric tons of carbon dioxide equivalent per megawatt-hour
TCR	The Climate Registry
TDR	transfer of development rights
TLU	Transportation and Land Use
TSE	truck-stop electrifications
TTI	Texas Transportation Institute
TWG	Technical Work Group
TWh	terawatt-hours
UIC	underground injection control
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USFS	United States Forest Service [USDA]
VMT	vehicle miles traveled
WARM	WAste Reduction Model [US EPA]
WCI	Western Climate Initiative
WTO	World Trade Organization
yr	year

Michigan Climate Action Council's Recommended Policy Positions on Michigan Climate Action Strategy

Michigan is in a period of extraordinary transition and faces unprecedented challenges. Among the most compelling of these challenges is the urgent need to reduce greenhouse gas (GHG) emissions to address climate change and its impact on our health, our natural resources and our way of life. As part of this challenge, the economic core of our prosperity, the automobile industry, is undergoing tumultuous change as we move from a high carbon to a low carbon economy and a new energy future. Revenues to address government services are declining and are expected to do so in the foreseeable future. In addressing these issues, in response to climate change, we have the unique opportunity to also encourage deployment of new investment and technologies, save energy and money, create new jobs and income, promote energy independence and sustainability, and diversify and grow our economy. The magnitude of the challenge will require a remarkable level of cooperation among all levels of government.

The policy direction is clear. Michigan should seize this moment and take a leadership role in formulating and promoting efficient, effective national, regional and state polices to address climate change. These policies should holistically address the economy, renewable energy, climate change, energy efficiency and independence.

There are two integrated parts to Michigan's Climate Action Strategy. The first is based on state-based advocacy for strong national and international action on climate change. A framework describing the key elements of a national climate policy is summarized in Part One below.

The second part requires integration of national climate action policies and efforts with those that the Michigan Climate Action Council (MCAC) recommends for implementation in Michigan to achieve significant reductions in GHG emissions. This represents a call to action by State government, business, and the general public to confront the issue of climate change. It contains actions that we can take now within our state to simultaneously address climate change while transitioning our economy by, promoting new technology development, improving energy efficiency, conserving natural resources, and developing clean and renewable energy sources. These two policy trajectories are essential, coequal and intertwined.

Part One: Michigan Platform on Climate Change

The purpose of this platform is to assist Governor Granholm and other Michigan leaders as they represent Michigan in various forums on the topic of climate change. This includes the New Administration, U.S. Congress as well as the existing and emerging industry-based, non-governmental, and multi-state alliances on global warming.

- Michigan should take action now to address climate change. That action should take two forms: 1) specific actions to reduce GHG emissions in the state and region, and 2) active engagement in the development of a national climate policy.
- Governor Granholm is already taking steps to diversify Michigan's economy using alternative energy to create and retain jobs. Michigan should pursue policies and programs that leverage the State's existing knowledge and expertise to strengthen the auto and other manufacturing sectors and to further diversify the economic base of the State in the renewable energy, energy efficiency and natural resource conservation sectors.
- A national commitment to make significant reductions in GHG emissions will require a transformation of our energy, manufacturing and transportation systems. There will be economic costs and benefits associated with this transformation. Therefore, it is critical that a national climate policy optimizes economic efficiency, equity, and cost effectiveness. Michigan should advocate for the development of such a policy within the framework of a federal-state partnership. While the design, implementation and integration of federal, state and local GHG reduction policies present important issues to be resolved by federal and state policymakers, there is broad agreement that, in our system of government, all levels of government must work together in partnership if the nation is to effectively address this challenge.
- Although national climate policy could be based on alternatives to or additions to "cap and trade" (such as tax, subsidy, standards, and technical assistance policies), federal legislation is most likely to focus on a cap and trade and sector based programs.[1] Michigan therefore should advocate for a national cap and trade program that is efficient, equitable, economy wide, and based on a federal-state partnership. This should include sector based policies and measures that reduce market and institutional barriers to GHG reduction. The state should press for enactment of this legislation by 2010.
- Federal legislation should include national emission reduction targets.
- Federal legislation must be structured in a manner that drives immediate GHG reductions.

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[1]Although the New Administration and Congress are likely to pursue a nationwide cap and trade policy, other options remain available. The alternative most often mentioned is a carbon tax. If this alternative becomes the preferred approach, the comments and recommendations made herein also largely apply to a carbon tax, i.e., it must be fair from a revenue standpoint, efficient, equitable and effective, and not place Michigan residents and businesses at a disadvantage.

- Federal legislation should ensure GHG emissions are truly reduced and not just shifted from one state or region to another nor from one sector to another.
- The national program should encourage rapid technology development and deployment through the adoption of technology supporting and inducing policies. Cost efficiency and co-benefits should also be considered in achieving reductions of GHG emissions to assure that the timing of reductions coincides with the successful commercialization of emerging technologies. Major reductions from certain sectors may most effectively be accomplished if based on aggressive yet appropriate lead times that allow the necessary infrastructure to be put in place. Examples include carbon sequestration, low-carbon fuels, and commercial viability of high-density energy storage systems.
- While the need for action is now, there are remaining uncertainties regarding the pace at which technologies and markets will develop. Instead of waiting to act, the federal legislation should provide for periodic review so that adjustments can be made based on evolving knowledge of technologies, markets, emission reduction needs and other circumstances.
- Recognizing that effective measures to address climate change depend on international action, the United States should take the lead in facilitating global participation.
- Market forces and current federal legislation already are increasing vehicle fuel economy. Any federal policies adopted should not put the domestic auto industry at a competitive disadvantage**.**
- To the extent reasonably practical and feasible, the costs and benefits of achieving varying degrees of GHG reductions should be fully disclosed and discussed as part of a deliberative process in the State and nationally, including health, environment, energy and economic impacts, as well as recognition of both monetized and non-monetized impacts.
- A national cap-and-trade program should include appropriate measures to provide a degree of long-term cost certainty and temper wide fluctuations in the price of allowances that would be economically harmful to the U.S. while guarding against any negative impact on GHG emission reductions targets and timetables. Without approving any particular measure, the MCAC notes that examples of such potential measures are identified in Market Based Policy -1.
- Care should be taken to avoid unintended consequences. For example, the national program should not result in actions that make it more difficult to protect human health and the environment through attaining national air quality standards or is hampered by inconsistent policies in other areas.
- Revenue derived from the regulation of GHGs should be used to assist with the transformation to a low carbon economy through appropriate incentives and subsidies for the development and deployment of GHG-reducing technologies and to mitigate increased costs to the consumers. The revenues that exit the state should return at the same proportion, with the exception of that percentage dedicated to technology research, development, and deployment at the national level.

Part Two: Michigan Emission Reduction Proposals

1. The Michigan Climate Action Council (MCAC) has developed a comprehensive list of policy recommendations to reduce GHG emissions in Michigan. Michigan should take immediate steps to implement the policy recommendations of the MCAC establishing priorities to significantly reduce GHG emissions in the State. To begin this, the State should immediately calculate and publish the expected GHG reductions expected from the recent comprehensive energy legislation related to the Renewable Portfolio Standard (RPS) and Energy Efficiency programs as well as other recent and planned actions.
2. The MCAC also recommends that public education be a top priority in the State's climate action plan. A number of the MCAC recommendations are achievable in the short run. However, success is predicated on the will of the public to change its behavior. Michigan should aggressively move to inform the public of its choices for achieving GHG reductions and the cost of those choices. The public should be encouraged to participate in order to reduce costs. The success or failure of this effort should be tracked as part of evolving implementation of the State's climate change efforts, and the results should be disclosed to the public.
3. The MCAC further suggests that Michigan leverage the resources of its outstanding higher education system to promote international cooperative research pacts for the development of alternative energy sources and energy efficiency technologies.
4. Additionally, the MCAC recommends a multi-year strategy for inventorying, tracking and verifying GHG emissions and progress against state goals and targets must be developed and implemented so that progress towards state goals and targets can be accurately assessed.

Executive Summary

Background

Governor Jennifer Granholm signed Executive Order 2007-42 creating the Michigan Climate Action Council (MCAC) on November 14, 2007. The MCAC was charged with producing a Greenhouse Gas (GHG) emissions inventory and forecast, compiling a comprehensive Climate Action Plan with recommended GHG reduction goals and potential actions to mitigate climate change in various sectors of the economy, and advising state and local governments on measures to address climate change.

The MCAC began its deliberations in December 2007. The MCAC held eight meetings leading to this Final Report which constitutes the Michigan Climate Action Plan (Climate Action Plan).

In order to provide a broad range of technical expertise and stakeholder involvement in development of the Climate Action Plan, the MCAC formed six Technical Work Groups (TWGs) to assist in the process. The six TWGs considered information and potential options in the following sectors:

- Energy Supply (ES);
- Market Based Policies (MBP);
- Residential, Commercial and Industrial (RCI);
- Transportation and Land Use (TLU);
- Agriculture, Forestry, and Waste Management (AFW); and
- Cross-Cutting Issues (CCI) (i.e., issues that cut across the above sectors).

The Center for Climate Strategies (CCS) provided facilitation and technical assistance to the MCAC and each of the TWGs. The TWGs served as advisors to the MCAC and consisted of MCAC members and additional individuals with interest and expertise. Members of the public were invited to observe and provide input at all meetings of the MCAC and TWGs. The TWGs assisted the MCAC by generating initial Michigan-specific policy options to be added to the catalog of existing states actions; developing priority policy options for analysis; drafting proposals on the design characteristics and quantification of the proposed policy options; reviewing specifications for analysis of draft policy options (including best available data sources, methods and assumptions); and evaluating the other key elements of policy option proposals, including related policies and programs, key uncertainties, co-benefits and costs, feasibility issues, and potential barriers to consensus.

Key Elements and Recommendations

The MCAC developed this Climate Action Plan as an initial step in establishing a basis for moving forward on the implementation of climate change policies in Michigan. Evaluation of key factors such as cost effectiveness, economic impacts, and harmonization with other Michigan programs and policies will be critical to the next stage of climate policy implementation.

The following key elements and recommendations were identified by the MCAC during this initial process:

- The MCAC's proposed GHG reduction goals for Michigan are to achieve a 20% reduction of GHGs below 2005 levels by 2020 and an 80% reduction below 2005 levels by 2050. These goals are consistent with goals being considered by the Midwestern Governors Regional Greenhouse Gas Reduction Accord process. The MCAC recommends that they be officially established as the states' GHG reduction goals.
- MCAC reviewed over 330 multi-sector policy options and approved for inclusion in this report a package of 54 policy recommendations to reduce GHG emissions and address related energy and commerce issues in Michigan. 52 of these 54 recommendations were approved unanimously and only one option was rejected. The recommended policy options cover a wide range of costs and GHG reduction potentials.
- In moving towards implementation to achieve these goals, Michigan must prioritize these 54 policy recommendations during 2009 in order to set the stage for strategic implementation of the most promising options. The prioritization should take into account the GHG reduction potential, costs and savings, feasibility, co-benefits, and a macro-economic analysis of selected recommendations, and consistency with other Michigan programs and policies.
- The MCAC approved policy recommendations are estimated to generate a net cumulative savings of about $10 billion between 2009 and 2025. The weighted-average cost-effectiveness of these policies is estimated to be approximately a $10.2/ tCO_2e cost savings. Those policy options that show negative costs[1] (i.e. benefits) should be evaluated as quickly as possible. All policy options, particularly those that show a net cost, should be evaluated thoroughly, using tools such as regional economic modeling, before being implemented.
- The MCAC recommends periodic review of Michigan's progress with appropriate adjustments made in the Climate Action Plan to assure the approaches taken and GHG reductions are on target. Michigan's GHG Inventory and Forecast has been prepared which outlines historical conditions for 1990-2005 and projected emissions through 2025

[1] Policy options that are "negative cost" are not necessarily better than other potential investments. In capital constrained situations only a limited number of investments can be made. There may be structural or policy barriers to the adoption of options identified as negative cost.

based upon a business as usual scenario. These documents were completed prior to the severe downturn in the global economy. To account for fluctuations such as changes in the economy, updates to this inventory should be performed annually with the projections evaluated every three years.

- The MCAC recommends that Michigan further analyze actions needed for adaptation. The MCAC was unable to examine the impacts of climate change on Michigan's natural resources and the Great Lakes due to time and resource constraints. Therefore, the MCAC recommends that Michigan conduct additional analyses of the state's vulnerability to the impacts of climate change and develop specific adaptation plans for key sectors.

- MCAC recommends that Michigan position itself as a leader in the national and regional dialogue on climate change policy as described in the MCAC's Recommended Policy Positions Section of this report.

Michigan GHG Emissions Inventory and Reference Case Projections

The Center for Climate Strategies (CCS) prepared the Michigan Inventory and Forecast Report for the Michigan Department of Environmental Quality (MDEQ). The report presents an assessment of Michigan's greenhouse gas (GHG) emissions and anthropogenic sinks (carbon storage) from 1990 to 2025. The preliminary draft inventory and forecast estimates in January 2008 served as a starting point for the Michigan Climate Action Council (MCAC) and Technical Work Groups (TWGs). The inventory and forecast were revised to address the comments received. The final Inventory and Forecast Report was approved by the MCAC at the November 2008 meeting and is available at:
http://www.miclimatechange.us/Inventory_Forecast_Report.cfm .

The inventory and projections cover the six types of gases included in the United States (US) Greenhouse Gas Inventory: 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 equivalence (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential- (GWP-) weighted basis[2].

As illustrated in Figure ExS-1, below, activities in Michigan accounted for approximately 248 million metric tons (MMt) of gross[3] CO_2e emissions (consumption basis) in 2005, an amount

[2] 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 (IPCC, 2001). 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.

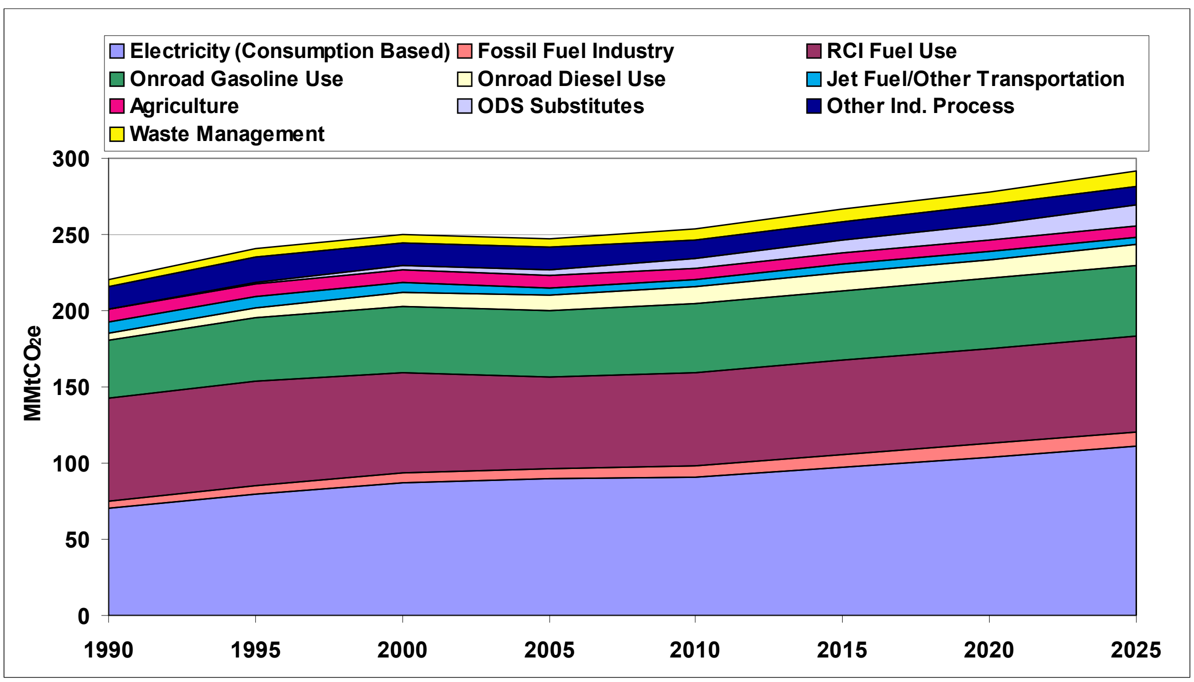
[3] Excluding GHG emissions removed due to forestry and other land uses and excluding GHG emissions associated with exported electricity.

equal to about 3.5% of total US gross GHG emissions (based on 2005 US data).[4] Gross emissions exclude carbon sinks, such as forests. Michigan's gross GHG emissions are rising slower than those of the nation as a whole. From 1990 to 2005, Michigan's gross GHG emissions increased by about 12%, while national emissions rose by 16%. The growth in Michigan's emissions was primarily associated with electricity consumption and the transportation sector.

The principal sources of Michigan's GHG emissions are electricity consumption; residential, commercial, and industrial (RCI) fuel use; and transportation accounting for 36, 24, and 24% of Michigan's gross GHG emissions in 2005, respectively.

Also illustrated in Figure ExS-1 under the reference case projections, Michigan's gross GHG emissions are projected to continue growing, to approximately 292 MMtCO$_2$e by 2025, 32% above 1990 levels. While these projections are made over the long term (e.g. to 2025), they do not account for the current severe global economic downturn and how this will impact future growth projections.

Figure ExS-1. Gross GHG emissions by sector, 1990–2025: historical and projected (consumption-based approach) business as usual / base case

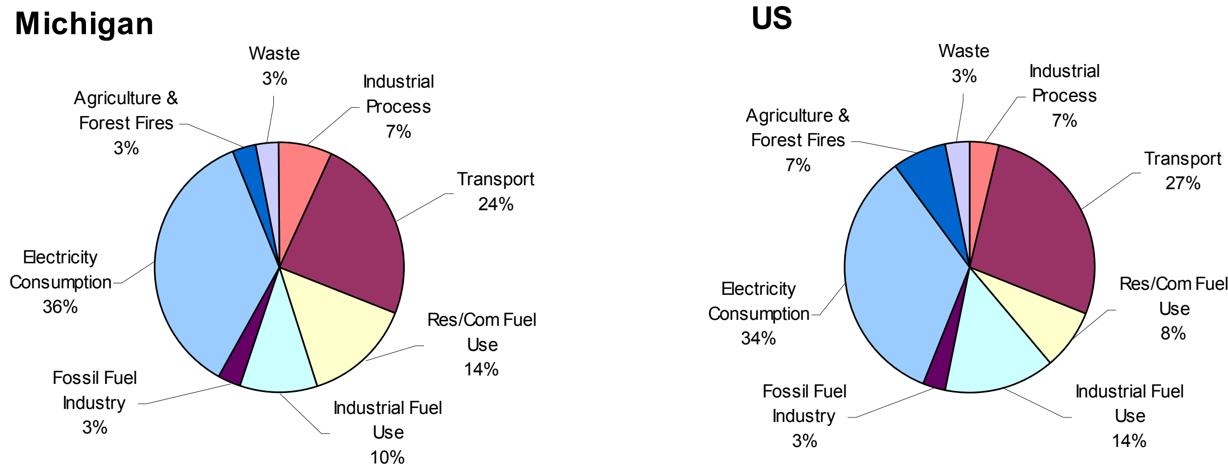


MMtCO$_2$e = million metric tons of carbon dioxide equivalent; RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone-depleting substance; Ind. = industrial.

Figure ExS-2 depicts the 2005 distribution of sources in Michigan and the United States (U.S.)

[4] The national emissions used for these comparisons are based on 2005 emissions from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2006*, April 15, 2008, US EPA #430-R-08-005, (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).

Figure ExS-2. Gross GHG emissions by sector, 2005: Michigan and U.S.



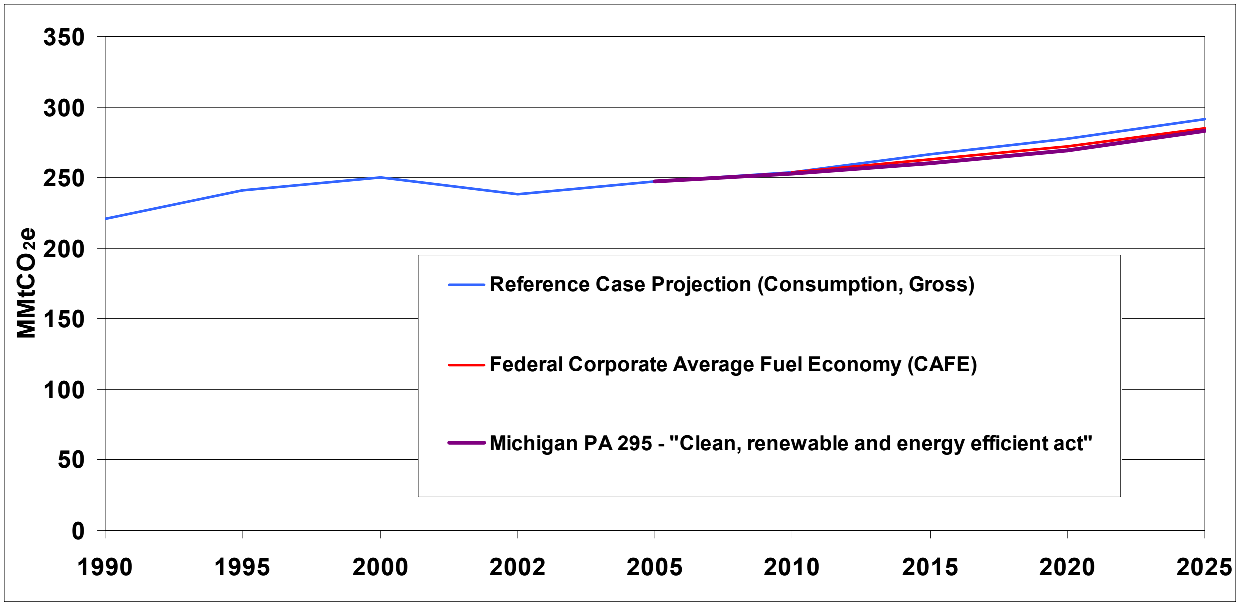
Recent Actions

GHG Reductions Associated With Recent Federal and State Actions

The MCAC identified recent actions undertaken in Michigan that will reduce GHG emissions while conserving energy and promoting the development and use of renewable energy sources. One such action was the adoption of PA 295[5]. The resultant emission reductions were estimated. Reductions associated with federal actions, such as the federal Energy Independence and Security Act (EISA) of 2007 and the implementation of the Act's Corporate Average Fuel Economy (CAFE) requirements, were also estimated. A total reduction of about 8.9 $MMtCO_2e$ (3.1%) in 2025 from the business-as-usual reference case emissions is projected. These GHG emission reductions are summarized in Figure ExS-3.

[5] PA 295 The Clean Renewable and Energy Efficient Act of 2008

Figure ExS-3. Estimated emission reductions associated with the effect of recent federal and state actions in Michigan (consumption-basis, gross emissions)



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

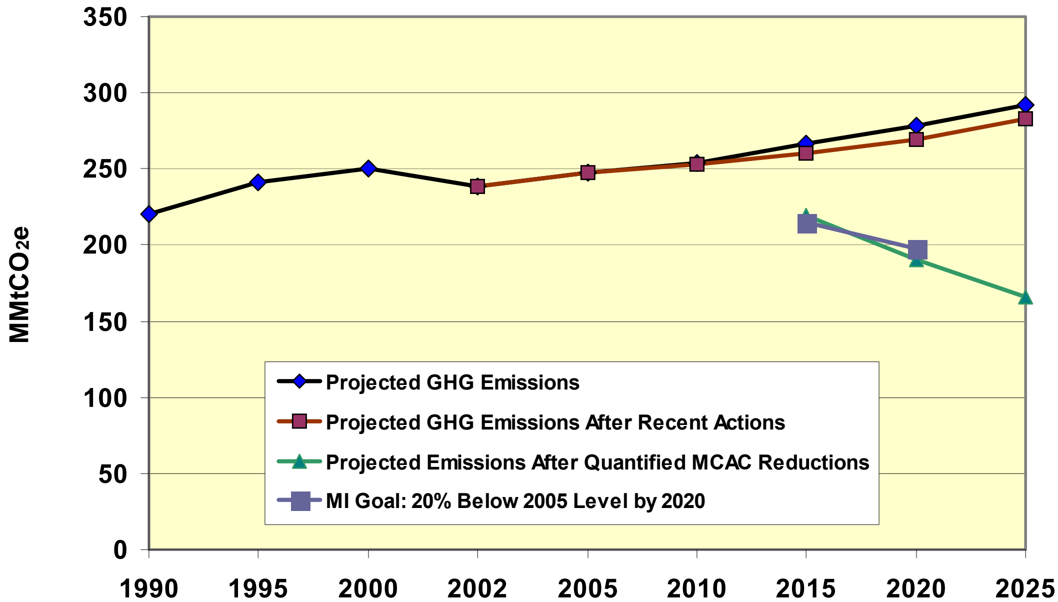
MCAC Policy Recommendations (Beyond Recent Actions)

The MCAC approved 54 policy recommendations for action in Michigan. Of these, 33 were analyzed quantitatively to calculate both emission reductions and either costs or savings. Based on this analysis, the 33 quantified policies have the cumulative effect of reducing annual GHG emissions by approximately 41 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2015 and by 117 $MMtCO_2e$ in 2025. The additional policy recommendations were not readily quantifiable but are considered valuable recommendations to support the overall Climate Action Plan. Several of the non-quantified policy recommendations may have the potential to achieve GHG emission reductions.

Figure ExS-4 presents a graphical summary of the potential cumulative emission reductions associated with the 33 quantified policy options and federal actions relative to the business-as-usual reference case projections.

- The blue line shows actual (for 1990, 1995, 2000, and 2005) and projected (for 2010, 2015, 2020 and 2025) levels of Michigan's gross GHG emissions on a business as usual basis.
- The red line shows the projected emissions adjusted for the recent state and federal actions described in Figure ExS-3.
- The green line shows the projected emissions if all of the MCAC's 33 recommended options are implemented and the estimated reductions are fully achieved. It is important to note, to yield these emission reductions from the 33 MCAC recommended options, implementation must be timely, aggressive, and thorough.

Figure ExS-4. Annual GHG emissions: reference case projections and MCAC recommendations (consumption basis, gross emissions)



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; MCAC = Michigan Climate Action Council.

Table ExS-1, below, provides the numeric estimates underlying Figure ES-4. In summary, if all of the Policy Recommendations are fully implemented and successful in achieving all of the GHG reductions projected then MI should over-achieve its GHG reduction goals by 7.3 $MMtCO_2e$ in 2020. Another way to look at this is that the MCAC package of policy recommendations entails a surplus of GHG reductions of about 7.3$MMTCO_2e$.

Table ExS-1. Annual emissions: reference case projections and impact of MCAC options (consumption basis, gross emissions)

Consumption Basis - Gross Emissions							
	1990	2000	2005	2010	2015	2020	2025
Projected GHG Emissions	220.7	250.0	247.5	253.8	266.4	278.0	291.6
Reductions from Recent Actions			0.0	0.7	6.2	8.3	8.9
Projected GHG Emissions After Recent Actions			247.5	253.1	260.2	269.6	282.7
GHG Reduction Goal Recommended by MCAC					NA	198.0	NA
Total GHG Reductions from MCAC Policies					41.2	78.9	116.6
Difference Between MCAC 2020 Goal & Remaining Emissions after Reductions					NA	7.3	NA
Projected Emissions After Quantified MCAC Reductions					219.0	190.7	166.1

GHG = greenhouse gas; MCAC = Michigan Climate Action Council; N/A = not applicable.

Reductions from recent actions include the EISA of 2007, Title III. GHG reductions from Titles IV and V of this Act have not been quantified because of the implementation uncertainties.

Table ExS-2 depicts the final policy recommendations of the Council and their associated GHG reductions and costs or savings for each sector.

What do the numbers mean? In Table ExS-2 and throughout the Climate Action Plan, positive cost figures ($) indicate costs; negative cost (- $) figures indicate cost savings. For example, in Table ExS-2 the column totals for the Net Present Value (NPV) of (-$10,093 million) portrays a cost savings of $10,093,000,000 over the 2009- 2025 period of analysis.

Table ExS-2. Summary by sector of estimated impacts of implementing all of the MCAC recommended options (cumulative reductions and costs/savings)

Sector	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
	2015	2025	Total 2009–2025		
Residential, Commercial and Industrial	21.9	65.1	524.6	–$13,014	–$25
Energy Supply	8.1	23.6	220.3	$7,980	$36
Transportation and Land Use	4.8	10.5	95.1	–$3,425	–$36
Agriculture, Forestry, and Waste Management	6.4	17.4	147.0	-$1,634	-$11.1
Cross-Cutting Issues	Non-quantified, enabling options				
TOTAL (includes all adjustments for overlaps)	**41.2**	**116.6**	**987.0**	**-$10,093**	**-$10.2**

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

Notes for Table ExS-2 are continued on the next page.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the policy options.

Within each sector, values have been adjusted to eliminate double counting for policies or elements of policies that overlap. In addition, values associated with policies or elements of policies within a sector that overlap with policies or elements of policies in another sector have been adjusted to eliminate double counting. Appendix F (for the ES sectors), Appendix H (for the RCI sectors), Appendix I (for the TLU sectors), and Appendix J (for the AFW sectors) of this report provide documentation of how sector-level emission reductions and costs (or cost savings) were adjusted to eliminate double counting associated with overlaps between policies.

Table ExS-3, which begins below and continues through page ES-14, depicts the MCAC policy recommendations and the associated GHG reductions and costs/savings for each sector.

Note: The numbering used to denote the policy recommendation in Table ExS-3 and in other parts of this report is for reference purposes only; it does not reflect prioritization among these important recommendations. Negative numbers indicate cost savings.

Table ExS-3 Summary List of MCAC Policy Recommendations for all Sectors

Energy Supply (ES) Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effectiveness ($/t$CO_2$e)	Level of Support
		2015	2025	Total 2009–2025			
RECENT ACTION	PA 295, Clean, Renewable, and Efficient Energy Act	2.7	2.0	30.8	$1,024	$33	N/A
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	5.0	14.6	137.5	$6,600	$48.00	Unanimous
	Renewable Portfolio Standard (RPS)	4.6	13.7	129.5	$5,546	$42.83	
	Wind	3.7	10.3	100.4	$4,748	$47.31	
	Biomass	0.9	2.7	25.2	$376	$15	
	Solar Photovoltaic (PV)	0.0	0.4	2.6	$392	$152	
	Plasma Gasification	0.0	0.3	1.3	$29	$22	
	Distributed Generation "Carve-Out"	0.4	0.9	8.0	$1,054	$131.51	
	Solar Hot Water	0.0	0.2	1.2	$26	$22.27	
	Geothermal	0.1	0.2	1.5	$82	$55	
	Wind (distributed)	0.1	0.3	2.7	$503	$186	
	Solar PV (distributed)	0.1	0.2	1.84	$508	$276	
	Biogas	0.1	0.2	2.3	$17	$7	
ES-3	Energy Optimization Standard	0.0	13.6	86.3	–$1,632	–$19	Unanimous
ES-5	Advanced Fossil Fuel Technology (e.g., IGCC, CCSR) Incentives, Support, or Requirements	*Not Quantifiable*					Unanimous
ES-6	New Nuclear Power	0.0	6.3	38.5	$1,001	$25.98	Majority[6]
ES-7	Integrated Resource Planning (IRP), Including Combined Heat & Power (CHP)	*Not Quantifiable*					Unanimous
ES-8	Smart Grid, Including Advanced Metering	*Not Quantifiable*					Unanimous
ES-9	CCSR Incentives, Requirements, R&D, and/or Enabling Policies	*Not Quantifiable*					Unanimous
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration						Majority[7]
	Co-firing at 5%	0.2	0.2	3.3	$34.48	$10.6	
	Co-firing at 10%	0.5	0.5	6.5	$69.43	$10.7	
	Co-firing at 20%	0.9	0.9	13.0	$134.09	$10.3	

[6] 6 opposing votes [Pollack, Ettawageshik, Garfield, Heifje, Bazzani, Overmeyer] and 2 abstentions [Martinez and Calloway for Bierbaum]

[7] 3 opposing votes [Garfield, Pollack and Heifje]

Policy No.	Policy Recommendation	GHG Reductions (MMtCO$_2$e)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
		2015	2025	Total 2009–2025			
ES-11	Power Plant Replacement, Energy Efficiency, and Repowering	2.5	2.0	33.2	$313	$9.4	Unanimous
ES-12	Distributed Renewable Energy Incentives, Barrier Removal, and Development Issues, Including Grid Access	*ES-12 Fully incorporated in distributed generation "carve-out" under ES-1.*					Unanimous
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.4	0.5	7.8	$31.91	$4.09	Unanimous
ES-15	Transmission Access and Upgrades	*Not Quantifiable*					Unanimous
	Sector Totals	**8.1**	**37.2**	**306.6**	**$6,348**	**$22**	
	Sector Total After Adjusting for Overlaps	**8.1**	**23.6**	**220.3**	**$7,980**	**$36**	
	Reductions From Recent Actions	**2.7**	**1.9**	**30.1**	**$1,025**	**$34**	
	Sector Total Plus Recent Actions	**10.8**	**25.5**	**250.4**	**$9,005**	**$36**	

MMtCO$_2$e = millions of metric tons of carbon dioxide equivalent; $/tCO$_2$e = dollars per metric tons of carbon dioxide equivalent; CCI = Cross-Cutting Issues; CCSR = carbon capture and storage or reuse; GHG = greenhouse gas; IGCC = integrated gasification combined cycle; MCAC = Michigan Climate Action Council; N/A = not applicable; PA = Public Act; R&D = research and development.

Market Based Policy (MBP) Recommendations

No.	Policy Recommendations		GHG Reductions (MMtCO$_2$e)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
			2020	2025	Total 2009–2025			
MBP-1	Cap and Trade	20% below 2005 by 2020 (*Free-Granting Allowances*)[8]	92.48				–$25.83	Unanimous
		20% Below 2005 by 2020 (*Auctioning Allowances*)[9]	92.48				–$19.33	
MBP-3	Michigan Joins Chicago Climate Exchange		*Not Quantified*					Unanimous
MBP-6	Market Advisory Group		*Not Quantifiable*					Unanimous

[8] These results include the direct cost of reducing emissions, plus costs associated with purchase of emissions allowances from entities outside of Michigan, minus revenues from the sale of allowances to entities outside Michigan.

[9] These results include the direct cost of reducing emissions, but do not include payments by Michigan to entities for the purchase of allowances at auction, nor do they include revenues to the state from the sale of those allowances. The full cost and revenue implications of allowance distribution by auction can be found in Table G-1-2 and Annex G-1.

Transportation and Land Use (TLU) Policy Recommendations

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)	Level of Support
		2015	2025	Total 2009–2025			
TLU-1[10]	Promote Low-Carbon Fuel Use in Transportation	2.6	5.9	53	$820	$16	Unanimous
TLU-2	Eco-Driver Program	1.1	2.2	22	–$3,921	–$176	Unanimous
TLU-3	Truck Idling Policies	0.36	0.76	7.0	–$596	–$85	Unanimous
TLU-4	Advanced Vehicle Technology	0.01	0.03	0.19	$281	$1,458	Unanimous
TLU-5	Congestion Mitigation	0.08	0.18	1.7	–$135	–$81	Unanimous
TLU-6	Land Use Planning and Incentives	0.14	0.43	3.2	–$598	–$189	Unanimous
TLU-7	Transit and Travel Options	0.13	0.54	3.5	$655	$185	Unanimous
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.10	0.19	2.0	$69	$35	Unanimous
TLU-9	Great Lakes Shipping	0.24	0.27	2.5	NQ	NQ	Unanimous
	Sector Totals	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**
	Sector Total After Adjusting for Overlaps	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**
	Reductions From Recent Actions	**0**	**0**	**0**	**$0**	**$0**	**N/A**
	Sector Total Plus Recent Actions	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**

[10] TLU-1 addresses the consumption of biofuels in Michigan. The quantification results for AFW-2 (biofuel production volumes and costs), were used as inputs to the estimates for low-carbon fuel use in TLU-1.

Residential, Commercial and Industrial (RCI) Policy Recommendations

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009-2025			
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0.0	13.6	86.3	–1,632	–19	Unanimous
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	17.6	53.8	428.6	–12,107	–28	Unanimous
RCI-3	Regulatory (PSC) Changes to Remove Disincentives and Encourage Energy Efficiency Investments by IOUs	*Not Quantifiable*					Unanimous
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	3.6	9.8	82	–2,865	–35	Unanimous
RCI-5	MI Climate Challenge & Related Consumer Education Programs	*Not Quantifiable*					Unanimous
RCI-6	Incentives to Promote Renewable Energy Systems Implementation	0.7	1.5	14.0	1,958	140	Unanimous
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	15.6	47.6	380	–11,693	–31	Unanimous
RCI-8	Net Metering for Distributed Generation	Fully incorporated into RCI-6					Unanimous
RCI-9	Training & Education for Bldg. Design, Construction, and Operation	*Not Quantifiable*					Unanimous
RCI-10	Water Use and Management	*Not Quantifiable*					Unanimous
	Sector Total After Adjusting for Overlaps*	**21.8**	**64.9**	**523.9**	***–13,014***	***–24.8***	
	Reductions From Recent Actions	**Figures adjusted include recent actions**					
	Sector Total Plus Recent Actions	**21.8**	***64.9***	***523.9***	***–13,014***	***–24.8***	

PSC = Public Service Commission; IOU = investor-owned utility.

*The figures listed show totals for the options net of recent legislation. Negative numbers indicate cost savings.

Agriculture, Forestry and Waste (AFW) Management Policy Recommendations

Policy No.	Policy Recommendation		GHG Reductions ($MMtCO_2e$) 2015	2025	Total 2009–2025	Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
AFW-1	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production		3.3	10	79	$1,649	$21	Unanimous
AFW-2*	In-State Liquid Biofuels Production		*Included in the Results of TLU-1*					Unanimous
AFW-3	Methane Capture and Utilization From Manure and Other Biological Waste		0.09	0.14	1.5	$4.7	$3	Unanimous
AFW-4	Expanded Use of Bio-based Materials	A. Use of Bio-based Products	.08	.21	1.7	–$108	–$62	Unanimous
		B. Utilization of Solid Wood Residues	*Not Quantified*					Unanimous
AFW-5	Land Use Management That Promotes Permanent Cover	A. Increase in Permanent Cover Area	0.08	0.21	1.8	$63	$34	Unanimous
		B. Retention of Lands in Conservation Programs†	0.05	0.11	1.1	$24	$23	Unanimous
		C. Retention/ Enhancement of Wetlands	*Not Quantified*					Unanimous
AFW-6	Forestry and Agricultural Land Protection	A. Agricultural Land Protection	0.46	1.1	10	$864	$85	Unanimous
		B. Forested Land Protection	*Not Quantified*					Unanimous
		C. Peatlands/ Wetlands Protection	*Not Quantified*					Unanimous
AFW-7**	Promotion of Farming Practices That Achieve GHG Benefits	A. Soil Carbon Management	0.7	1.7	15	–$200	–$13	Unanimous
		B. Nutrient Efficiency	0.05	0.12	1.1	–$27	–$26	Unanimous
		C. Energy Efficiency	0.13	0.32	2.9	–$102	–$35	Unanimous
		D. Local Food	*Not Quantified*					Unanimous
AFW-8	Forest Management for Carbon Sequestration and Biodiversity	A. Enhanced Forestland Management	0.53	1.42	12.05	$800	$66	Unanimous
		B. Urban Forest Canopy	1.2	2.9	26	–$346	–$13	Unanimous
		C. Reduce Wildfire	*Not Quantified*					Unanimous
AFW-9**	Source Reduction, Advanced Recycling, and Organics Management							Unanimous

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
	In-State GHG Reductions	1.4	3.0	28	–$3,136	–$112	
	Full Life-Cycle Reductions	14.5	35.3	314	–$3,136	–$10	
AFW-10	Landfill Methane Energy Programs	0.91	2.7	22	–$35	–$2	Unanimous
	Sector Totals†	**9**	**23**	**201**	**–$548**	**–$3**	
	Sector Total After Adjusting for Overlaps††	**6**	**17**	**147**	**–$1,634**	**–$11**	
	Reductions From Recent Actions	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
	Sector Total Plus Recent Actions	6	17	147	-$1,634	-$11	

N/A = not applicable. Note that negative costs represent a monetary savings.

* The quantification results for AFW-2 (biofuel production volumes and costs) were used as inputs to the quantification of the results of TLU-1, which covers consumption of biofuels in Michigan.

** The analyses for AFW-5, AFW-7, and AFW-9 include the full life-cycle costs of the policies. In the case of AFW-9, it is estimated that a significant fraction of the reductions will occur out of state. In-state reductions refer only to those occurring from reduced landfilling and waste combustion (these are broken out separately in the table above).

† The reductions from AFW-5B (Retention of Lands in Conservation Programs) have been left out of the sector totals, since they relate to a soil carbon protection measure where the estimated emissions (from conservation acres being returned to active cultivation) are not included in the business as usual (BAU) inventory and forecast (I&F). The costs have been included in the sector totals, since these will be incurred in order to retain the level of emissions in the BAU I&F. For AFW-5, AFW-7, and AFW-9, these include the reductions that are expected to occur within the state.

†† See the section below for discussion of overlap adjustments.

Cross Cutting Issues (CCI) Policy Recommendations

No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
CCI-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not Quantified*					Unanimous
CCI-2	Statewide GHG Reduction Goals and Targets	*Not Quantified*					Unanimous
CCI-3	State, Local, and Tribal Government GHG Emission Reductions (Lead-by-Example)	*Not Quantified*					Unanimous
CCI-4	Comprehensive Local Government Climate Action Plans (Counties, Cities, Etc.)	*Not Quantified*					Unanimous
CCI-5	Public Education and Outreach	*Not Quantified*					Unanimous
CCI-6	Tax and Cap/ Cap and Trade	*MCAC approved creation of a new Market-Based Policies Technical Work Group as the lead for this policy* recommendation.					Transferred to MBP TWG
CCI-7	Seek Funding for Implementation of MCAC Recommendations	*Not Quantified*					Unanimous
CCI-8	Adaptation and Vulnerability	*Not Quantified*					Unanimous
CCI-9	Participate in Regional, Multi-State, and National GHG Reduction Efforts	*Not Quantified*					Unanimous
CCI-10	Enhance and Encourage Economic Growth and Job Creation Opportunities Through Climate Change Mitigation	*Not Quantified*					Unanimous
CCI-11	Enhance and Encourage Community Development Through Climate Change Mitigation: Address Environmental Justice	*Not Quantified*					Unanimous

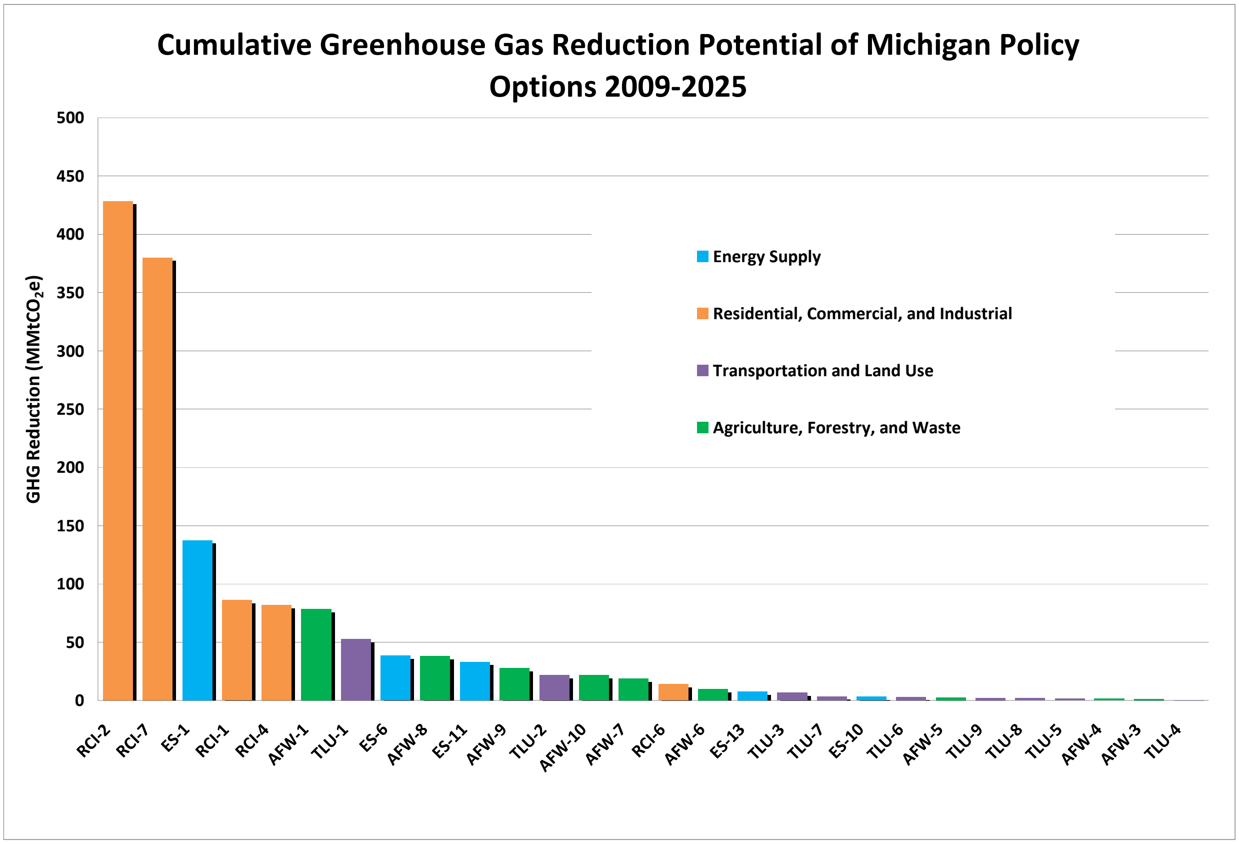
GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent

As explained previously, the MCAC considered the estimates of the GHG reductions that could be achieved and the costs (or cost savings) for the 33 options that were quantifiable. Figure ExS-5, below, presents the estimated tons of GHG emission reductions for each of these policy recommendations, expressed as a cumulative figure for the period 2009–2025.

Figure ExS-6 presents the estimated dollars-per-ton cost (or cost savings, depicted as a negative number) for each quantified policy recommendation. The dollars per ton value is calculated by dividing the net present value of the cost of the policy recommendation by the cumulative GHG reductions, all for the period 2009–2025.

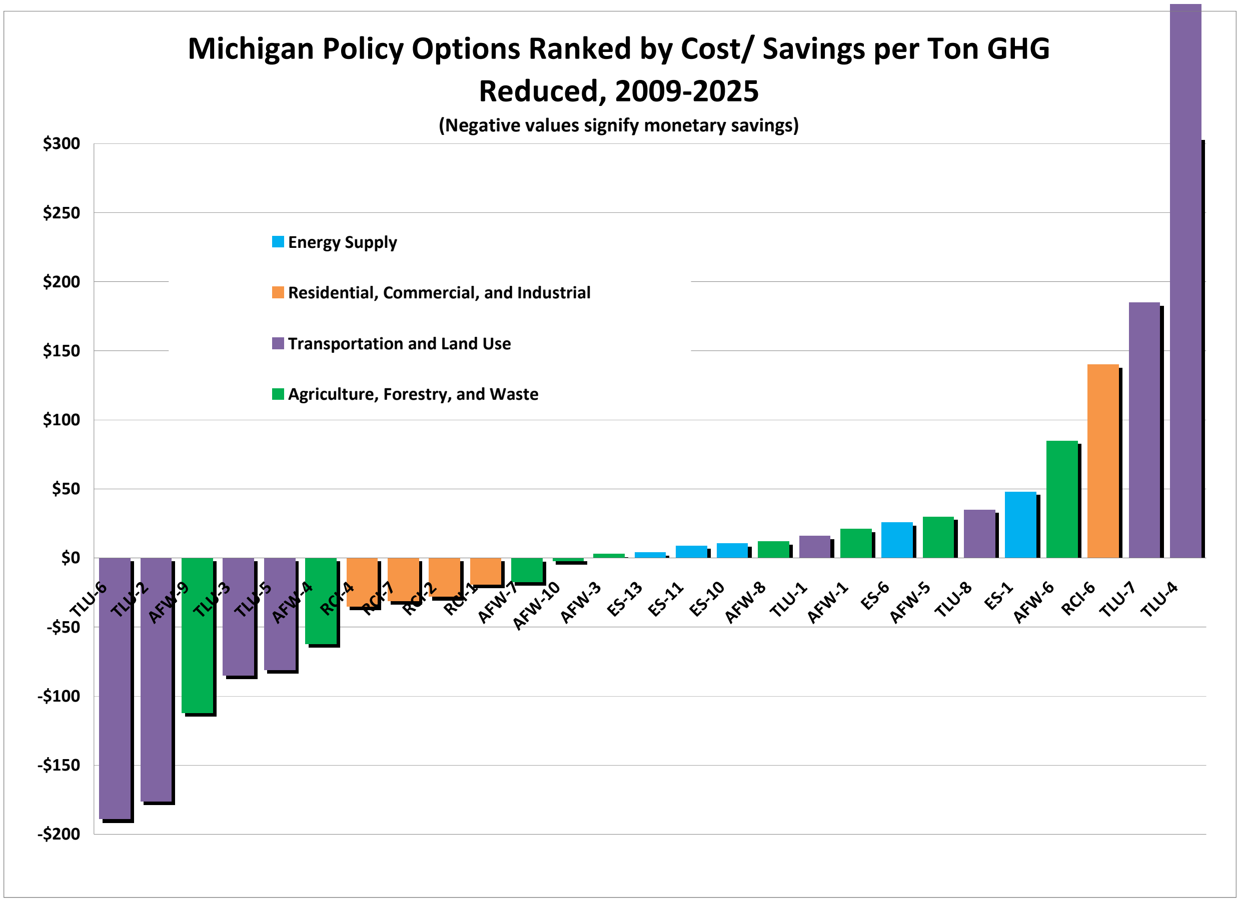
It is important to note that there is some level of uncertainty in projecting GHG reductions and estimating exact costs (or cost savings) per ton of reductions achieved for the time periods of this analysis.

Figure ExS-5. MCAC policy recommendations ranked by cumulative (2009–2025) GHG reduction potential



GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; TLU = Transportation and Land Use; RCI = Residential, Commercial and Industrial

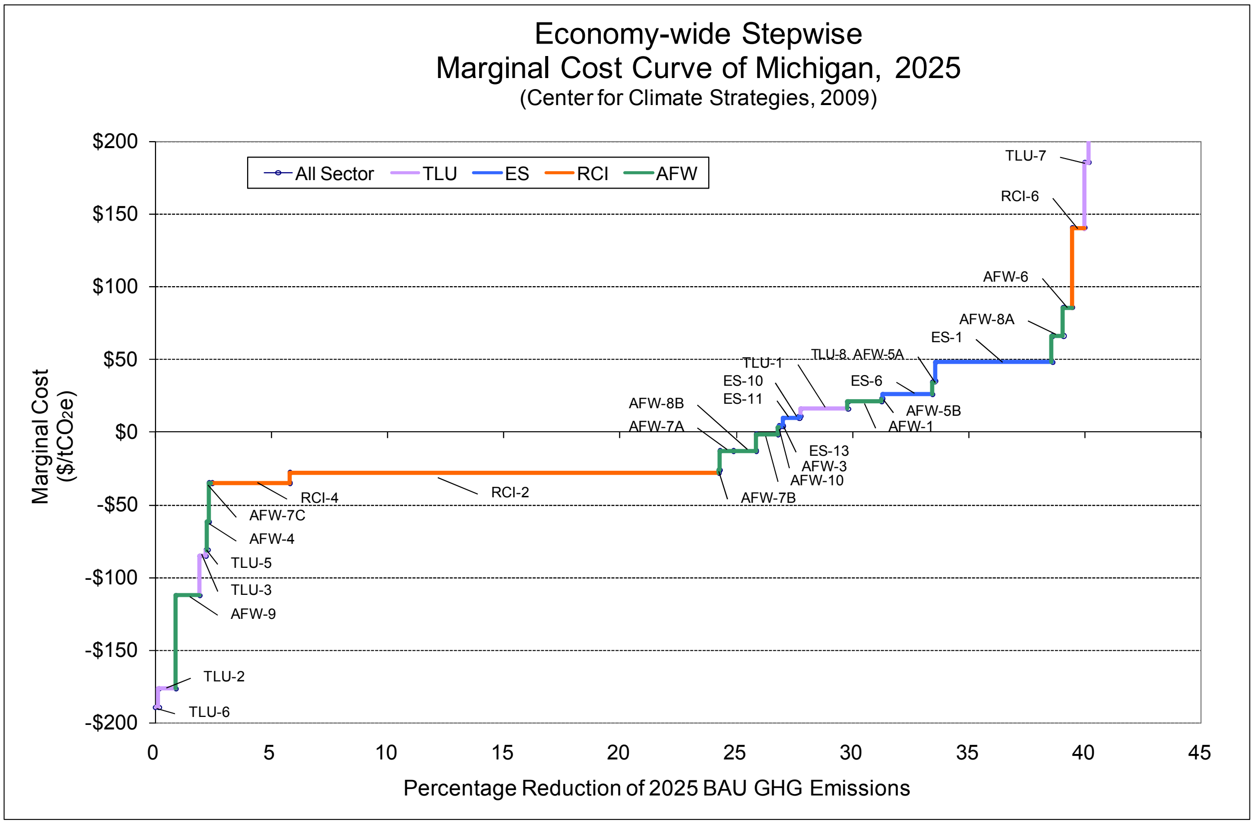
Figure ExS-6. MCAC policy recommendations ranked by cumulative (2009–2025) net cost/cost savings per ton of GHG removed



GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply,; TLU = Transportation and Land Use; RCI = Residential, Commercial and Commercial, Industrial

Figure ExS-7, below, presents a stepwise marginal cost curve for Michigan. The horizontal axis represents the percentage of GHG emissions reduction in 2025 for each option relative to the business as usual (BAU) forecast. The vertical axis represents the marginal cost of mitigation (expressed as the cost-effectiveness of each policy option on a cumulative basis, 2009-2025). In the figure, each horizontal segment represents an individual policy. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the horizontal x-axis shows the average cost (saving) of reducing one $MMtCO_2e$ of GHG emissions through implementation of the option. For instance, for RCI-2-Energy Efficiency- this policy recommendation should result in approximately a 54 $MMTCO_2e$ (19%) reduction of GHG emissions in 2025 below the BAU reference case with an average cost savings of approximately $28/ton.

Figure ExS-7. Stepwise marginal cost curve for Michigan, 2025



BAU = business as usual; GHG = greenhouse gas; tCO_2e = metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; TLU = Transportation and Land Use; RCI = Residential, Commercial and Industrial

Negative values represent net cost savings and positive values represent net costs associated with the policy option.

Note: Results have been adjusted to remove overlaps between policies. For example, RCI-7 reductions overlap with both RCI-2 and RCI-4 assuming all three policies are implemented. The curve, therefore, includes RCI-2 and RCI-4 but not RCI-7 to avoid overstating the combined benefits of the recommendations.

Chapter 1
Background and Overview

Creation of the Michigan Climate Action Council (MCAC)

On November 14, 2007, Governor Jennifer M. Granholm signed Executive Order 2007-42 establishing the Michigan Climate Action Council (MCAC). The purpose of the MCAC is to assist Michigan in identifying the best opportunities to mitigate and adapt to climate change, reduce costs associated with climate change activities, and foster economic growth in Michigan. Governor Granholm charged the advisory group to:

- Produce an inventory and forecast of Greenhouse Gas (GHG) sources and emissions from 1990-2020.
- Consider potential state and multi-state actions to mitigate and adapt to climate change in various sectors including energy supply, residential, commercial and industrial, transportation, land use, agriculture, forestry, and waste management.
- Compile a comprehensive climate action plan with specific goals and recommendations for reducing GHG emissions in Michigan by state and local units of government, businesses, and Michigan residents to minimize climate change and better prepare for the effects of climate change in Michigan.
- Advise state and local government on measures to address climate change.

MCAC's Response

In fulfillment of the requirements of this Executive Order, the MCAC held eight meetings over the last fifteen months. Additionally, the Council formed six Technical Work Groups (TWGs) to assist the MCAC in formulating options. These TWGs met numerous times between the MCAC meetings. The MCAC developed this Climate Action Plan as an initial step in establishing a basis for moving forward on the implementation of climate change policies in Michigan. Evaluation of key factors such as cost effectiveness, economic impacts, and harmonization with other Michigan programs and policies will be critical to the next stage of climate policy implementation.

The following key elements and recommendations were identified by the MCAC during this initial process:

- MCAC reviewed over 330 multi-sector policy options and approved for inclusion in this report a package of 54 policy recommendations to reduce GHG emissions and address related energy and commerce issues in Michigan. 52 of these 54 recommendations were approved unanimously and only one option was rejected. The recommended policy options cover a wide range of costs and GHG reduction potentials.

- In moving towards implementation to achieve these goals, Michigan should prioritize these 54 policy recommendations during 2009 in order to set the stage for strategic implementation of the most promising options. The prioritization should take into account the GHG reduction potential, costs and savings, feasibility, co-benefits, a macro-economic analysis of the selected recommendations, public health and safety and consistency with other Michigan programs and policies.

- The MCAC approved policy recommendations are estimated to generate a net cumulative savings of about $10 billion between 2009 and 2025. The weighted-average cost-effectiveness of these policies is estimated to be approximately a $10.2/ t$CO_2$e cost savings. Those policy options that show negative costs[1] (i.e. benefits) should be evaluated as quickly as possible, for implementation. All policy options, particularly those that show a net cost, should be evaluated thoroughly, using tools such as regional economic modeling, before being implemented.

- The MCAC recommends periodic review of Michigan's progress with appropriate adjustments made in the Climate Action Plan to assure the approaches taken and GHG reductions are on target. Michigan's GHG Inventory and Forecast has been prepared which outlines historical conditions for 1990-2005 and projected emissions through 2025 based upon a business as usual scenario. These documents were completed prior to the severe downturn in the global economy. To account for fluctuations such as changes in the economy, updates to this inventory should be performed annually with the projections evaluated every three years.

- The MCAC recommends that Michigan further analyze actions needed for adaptation. The MCAC was unable to examine the impacts of climate change on Michigan's natural resources and the Great Lakes due to time and resource constraints. Therefore, the MCAC recommends that Michigan conduct additional analyses of the state's vulnerability to the impacts of climate change and develop specific adaptation plans for key sectors.

- MCAC recommends that Michigan position itself as a leader in the national and regional dialogue on climate change policy as described in the MCAC Recommended Policy Positions section.

Recent Actions

GHG Reductions Associated With Recent Federal and State Actions

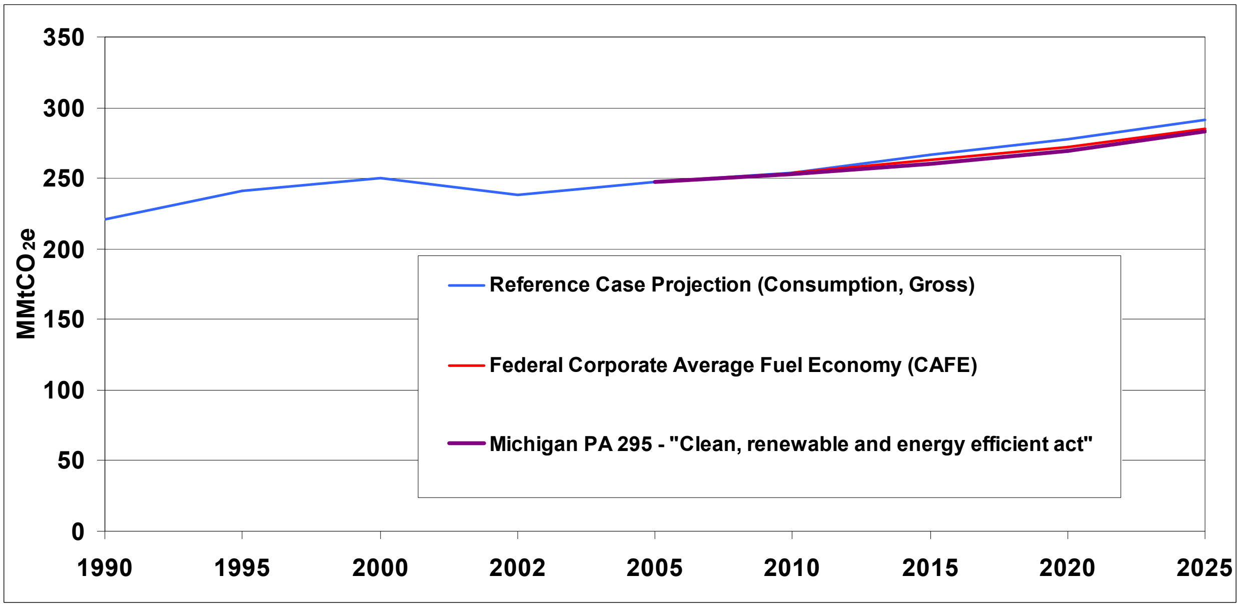
The MCAC identified recent actions undertaken in Michigan that will reduce GHG emissions while conserving energy and promoting the development and use of renewable energy sources. One such action was the adoption of Public Act (PA) 295[2]. The resultant emission reductions were estimated. Reductions associated with federal actions, such as the federal Energy Independence and Security Act (EISA) of 2007 and the implementation of the Act's Corporate Average Fuel Economy (CAFE) requirements, were also estimated. A total reduction of about

[1] Policy options that are "negative cost" are not necessarily better than other potential investments. In capital constrained situations only a limited number of investments can be made. There may be structural or policy barriers to the adoption of options identified as negative cost.

[2] Public Act 295 is The Clean Renewable and Energy Efficient Act of 2008

8.9 MMtCO_2e (3.1%) in 2025 from the business-as-usual reference case emissions is projected. These GHG emission reductions are summarized in Figure 1-1.

Figure 1-1. Estimated emission reductions associated with the effect of recent federal and state actions in Michigan (consumption-basis, gross emissions)



MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table 1-1. Estimated GHG emission reductions associated with the effect of recent federal and state actions in Michigan (consumption-basis, gross emissions)

Reductions from Existing Action **Recent Actions**	1990	2005	2010	2015	2020	2025
Federal CAFÉ	0.00	0.00	0.18	3.55	6.22	6.92
Michigan PA 295 - "Clean, renewable and energy efficient act"	0.00	0.00	0.51	2.65	2.13	2.01
Totals	**0.00**	**0.00**	**0.69**	**6.20**	**8.34**	**8.92**

	1990	2005	2010	2015	2020	2025
Reference Case Projection (Consumption, Gross)	220.7	247.5	253.8	266.4	278.0	291.6
Federal Corporate Average Fuel Economy (CAFE)			253.6	262.9	271.7	284.7
Federal Improved Standards for Appliances and Lighting			253.6	262.9	271.7	284.7
Michigan PA 295 - "Clean, renewable and energy efficient act"		247.5	253.1	260.2	269.6	282.7

The MCAC Process

The MCAC began its deliberative process at its first meeting on December 12, 2007. MCAC met in person a total of seven times, with the final decisional meeting held on January 28, 2009. A teleconference meeting was held on February 26, 2009 exclusively for the review of this report. An additional 74 teleconference meetings of MCAC's six supporting Technical Work Groups were also held to identify and analyze various potential policy actions in advance of the MCAC's January 28, 2009 final decisional meeting.

The six TWGs considered information and potential options in the following sectors:

- Energy Supply(ES);
- Market Based Policies (MBP);
- Residential, Commercial and Industrial (RCI);
- Transportation and Land Use (TLU);
- Agriculture, Forestry, and Waste Management (AFW); and
- Cross-Cutting Issues (CCI) (i.e., issues that cut across the above sectors).

The Center for Climate Strategies (CCS) provided facilitation and technical assistance to the MCAC and each of the TWGs, based on a detailed proposal approved by the MDEQ. The TWGs served as advisors to the MCAC and consisted of MCAC members and additional individuals with interest and expertise. Members of the public were invited to observe and provide input at all meetings of the MCAC and TWGs. The TWGs assisted the MCAC by generating initial options on Michigan-specific policy options to be added to the catalog of existing states actions; Where members of a TWG did not fully agree on the recommendations to the MCAC, the summary of their efforts was reported to the MCAC as a part of its consideration and actions. The MCAC reviewed the TWGs' proposals, modified the proposals, if necessary, and made final decisions on the items before them.

The MCAC process employed a model of informed self-determination through a facilitated, stepwise, fact-based, and consensus-building approach. As noted, the process was facilitated by the Center for Climate Strategies (CCS), an independent, expert facilitation and technical analysis team. It was based on procedures that CCS has used in a number of other state climate change planning initiatives since 2000, but was adapted specifically for Michigan. The MCAC process sought but did not mandate consensus, and it explicitly documented the level of MCAC support for policies and key findings through a voting process established in advance, including barriers to full consensus where they existed on final consideration of proposed actions.

The 54 policy recommendations (out of more than 330 potential options considered) adopted by the MCAC and presented in this report were developed through a stepwise approach that included: (1) expanding a list of existing states actions to include additional Michigan-specific actions; (2) developing a set of "priority for analysis" options for further development; (3) fleshing these proposals out for full analysis by development of "straw proposals" for level of effort, timing and parties involved in implementation; (4) developing and applying a common framework of analysis for options, including sector-specific guidance and detailed specifications for options that include data sources, methods and key assumptions; (5) reviewing results of analysis and modifying proposals as needed to address potential barriers to consensus; (6) finalizing design and analysis of options to remove barriers to final agreement; and (7) developing other key elements of policy proposals such as implementation mechanisms, co-benefits, and feasibility considerations. At Meetings # 6 and 7, policy recommendations receiving unanimous support, a super majority or majority support (defined as less than half of those present objecting) from the MCAC members present were adopted by the MCAC and included in this report. The TWGs' options to the MCAC were documented and presented at each MCAC meeting. All of the MCAC and TWG meetings were open to the public and all materials for and summaries of the MCAC and TWG meetings were posted on the MCAC Web site (www.miclimatechange.us). A detailed description of the deliberative process is included in Appendix B.

Analysis of Policy Recommendations

With CCS providing facilitation and technical analysis, the six TWGs submitted policy recommendations for MCAC consideration using a "policy option template" conveying the following key information:

Policy Description
Policy Design (Goals, Timing, Parties Involved)
Implementation Mechanisms
Related Policies/Programs in Place
Type(s) of GHG Reductions
Estimated GHG Reductions and Net Costs or Cost Savings
Key Uncertainties
Additional Benefits and Costs
Feasibility Issues
Status of Group Approval
Level of Group Support
Barriers to Consensus

In its deliberations, the MCAC reviewed, modified, and reached group agreement on various policy recommendations. The final versions for each sector, conforming to the policy recommendation templates, appear in Appendices F through K and constitute the most detailed record of decisions of the MCAC. Appendix E describes the methods used for quantification of the 33 policy options that were analyzed quantitatively. The quantitative analysis produced estimates of the GHG emission reductions and direct net costs (or cost savings) of implementation of various policies, in terms of both a net present value from 2009 to 2025 and a dollars-per-ton cost (i.e., cost-effectiveness). The key methods are summarized below.

Estimates of GHG Reductions: Using the projection of future GHG emissions (see below) as a starting point, 33 policy options were analyzed by CCS to estimate GHG reductions attributable to each policy in the individual years of 2015 and 2025 and cumulative reductions over the period 2009–2025. The years 2015 and 2025 were chosen as the target years for quantification and analysis as part of the *MCAC Interim Report to the Governor,* in April 2008.[3] The estimates were prepared in accordance with guidance by the appropriate TWG and the MCAC, which later reviewed the estimates and, in some cases, directed that they be revised with respect to such elements as goals, data sources, assumptions, sensitivity analysis, and methodology. Some policies were estimated to affect the quantity or type of fossil fuel combusted. Other policies affected methane or carbon dioxide (CO_2) being sequestered. Sequestered means the gas is stored in plant materials or geologic formations so it is not contributing to global warming. Among the many assumptions involved in this task was identification of the appropriate GHG accounting framework—namely, the choice between taking a "production-based" approach versus a "consumption-based" approach to various sectors of the economy.[4]

Estimates of Costs/Cost Savings: The analyses of 33 policy recommendations included estimates of the direct cost of those policies, in terms of both net costs or cost savings during 2009–2025 and a dollars-per-ton cost (i.e., cost-effectiveness). Following is a brief summary of the approach used to estimate the costs or cost savings associated with the policy recommendations:

- *Discounted and annualized costs or cost savings*—Standard approaches were taken here. The net present value of costs or cost savings was calculated by applying a real discount rate of 5%. Dollars-per-ton estimates were derived as an annualized cost per ton, dividing the present value cost or savings by the cumulative GHG reduction measured in tons. As was the case with GHG reductions, the period 2009–2025 was analyzed.
- *Cost savings*— Total net costs or savings were estimated through comparison of monetized costs and savings of policy implementation over time, using discounting. These net costs could be positive or negative. Negative costs indicated that the policy saved money or produced "cost savings." Many policies were estimated to create net financial cost savings (typically through fuel savings and electricity savings associated with new policy actions).
- *Direct vs. indirect effects*—Estimates of costs and cost savings were based on "direct effects" (i.e., those borne by the entities implementing the policy).[5] Implementing entities could be individuals, companies, and/or government agencies. In contrast, conventional cost-benefit analysis takes the "societal perspective" and tallies every conceivable impact on every entity in society (and quantifies these wherever possible).

Additional Costs and Benefits: The MCAC options were guided by four decision criteria that included GHG reductions and monetized costs and cost savings of various policies, as well as other potential co-benefits and costs (e.g., social, economic, and environmental) and feasibility

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[2] *"MCAC Interim Report to the Governor," April 30, 2008*

[3] A production-based approach estimates GHG emissions associated with goods and services produced within the state, and a consumption-based approach estimates GHG emissions associated with goods and services consumed within the state. In some sectors of the economy, these two approaches may not result in significantly different numbers. However, the power sector is notable, in that it is responsible for large quantities of GHG emissions, and states often produce more or less electricity than they consume (with the remainder attributable to power exports or imports).

[4] "Additional benefits and costs" were defined as those borne by entities other than those implementing the policy option. These indirect effects were quantified on a case-by-case basis, depending on magnitude, importance, need, and availability of data.

considerations. The TWGs were asked to examine the latter two in qualitative terms where deemed important and quantify them on a case-by-case basis, as needed, depending on need and where data were readily available. It should be noted that some of these un-quantified co-benefits and costs could be quite significant and merit further investigation.

Implementation Mechanisms: The analysis for each option (see Appendices F through K) of the MCAC includes guidance on the policy instruments or "mechanisms" that were prescribed or assumed for the policy action. This includes a range of potential mechanisms including, for instance, funding incentives, codes and standards, voluntary and negotiated agreements, market based instruments, information and education, reporting and disclosure, and other instruments. In some cases, the recommended instruments are precise. In other cases, they are more general and envision further work to develop concrete programs and steps to achieve the goals recommended by the MCAC.

Michigan GHG Emissions Inventory and Reference Case Projections

The Center for Climate Strategies (CCS) prepared the Michigan Inventory and Forecast Report[6] for the Michigan Department of Environmental Quality (MDEQ). The report presents an assessment of the State's greenhouse gas (GHG) emissions and anthropogenic sinks (carbon storage) from 1990 to 2025. The preliminary draft inventory and forecast estimates in January 2008 served as a starting point for the Michigan Climate Action Council (MCAC) and Technical Work Groups (TWGs). The MCAC and TWGs reviewed, discussed, and evaluated the draft inventory and methodologies and offered alternative data and approaches for improving the draft GHG inventory and forecast. The inventory and forecast were revised to address the comments received. The final Inventory and Forecast Report was approved by the MCAC at the November 2008 meeting and is available at:
http://www.miclimatechange.us/Inventory_Forecast_Report.cfm .

The inventory and projections cover the six types of gases included in the United States (US) Greenhouse Gas Inventory: 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 equivalence (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential- (GWP-) weighted basis.[7]

The inventory and reference case projections included detailed coverage of all economic sectors and GHGs in Michigan, including future emission trends and assessment issues related to energy, the economy, and population growth. It is important to note that the emission estimates

[6] "*Final Michigan Greenhouse Gas Inventory and Reference Case Projections, 1990- 2025,*" Center for Climate Strategies, November 2008.

[7] 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 (IPCC, 2001). 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.

reflect the GHG emissions associated with the electricity sources used to meet Michigan's demands, corresponding to a consumption-based approach to emissions accounting. 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.

As illustrated in Figure 1-2, activities in Michigan accounted for approximately 248 million metric tons (MMt) of *gross*[8] CO_2e emissions (consumption basis) in 2005, an amount equal to about 3.5% of total US gross GHG emissions (based on 2005 US data).[9] Gross emissions exclude carbon sinks, such as forests. Michigan's gross GHG emissions are rising slower than those of the nation as a whole. From 1990 to 2005, Michigan's gross GHG emissions increased by about 12%, while national emissions rose by 16%. The growth in Michigan's emissions from 1990 to 2005 is primarily associated with the electricity consumption and transportation sectors.

The principal sources of Michigan's GHG emissions are electricity consumption; residential, commercial, and industrial (RCI) fuel use; and transportation accounting for 36, 24, and 24% of Michigan's gross GHG emissions in 2005, respectively.

As illustrated in Figure 1-2, below, under the reference case projections, Michigan's gross GHG emissions continue to grow, and are projected to climb to about 292 $MMtCO_2$e by 2025, reaching 32% above 1990 levels. While these projections are made over the long term (e.g. to 2025), they do not account for the current severe global economic downturn and how this will impact future growth projections.

Emissions associated with electricity consumption are projected to be the largest contributor to future GHG emissions growth, followed by emissions associated with the transportation sector. Other sources of emissions growth include the RCI fuel use sector and the increasing use of HFCs and PFCs as substitutes for ozone-depleting substances in refrigeration, air conditioning, and other applications. The agriculture sector is the only sector in which emissions are projected to decrease from 2005 to 2025. Figure 1-3 depicts the 2005 distribution of sources in Michigan compared to the US.

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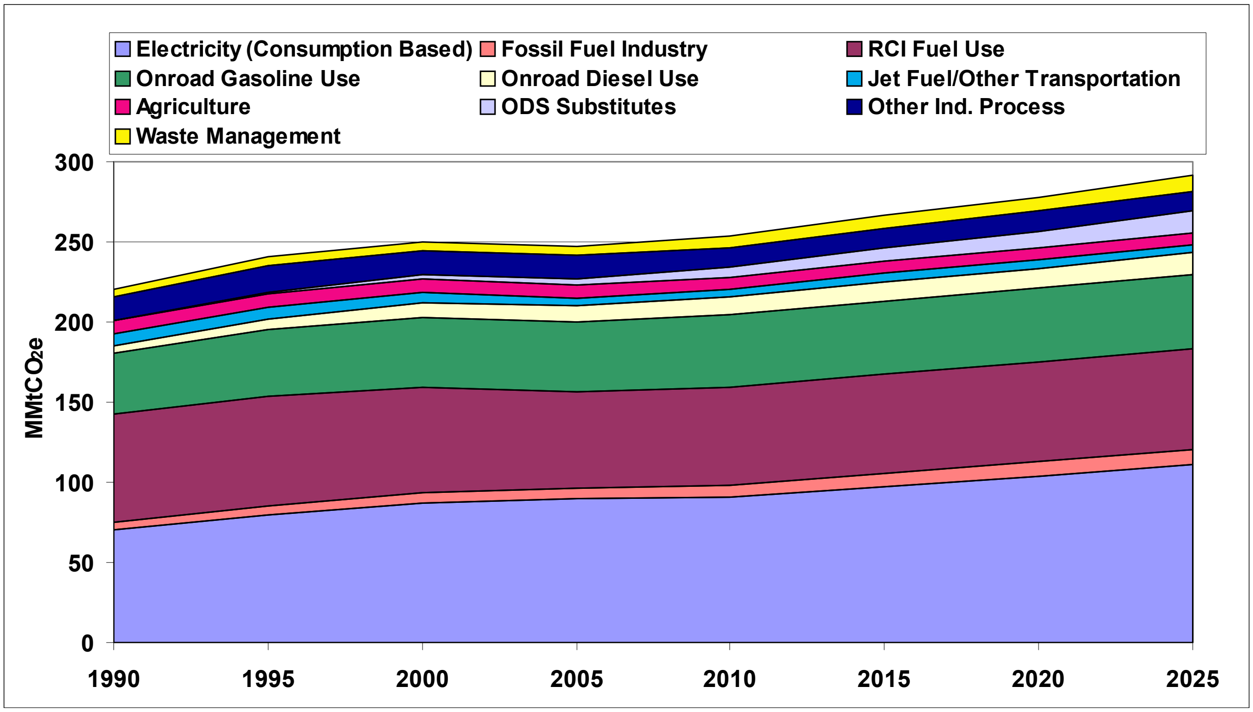
[8] Excluding GHG emissions removed due to forestry and other land uses and excluding GHG emissions associated with exported electricity.

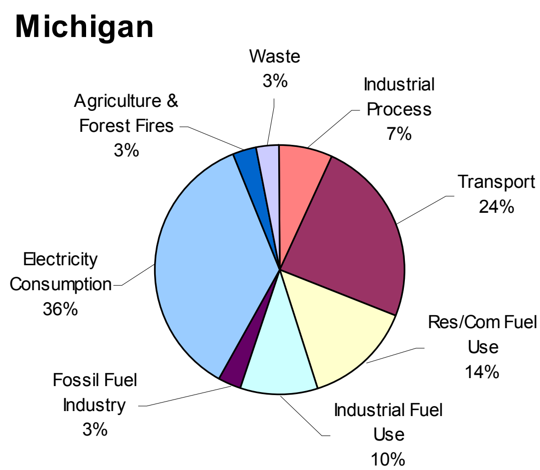
[9] The national emissions used for these comparisons are based on 2005 emissions from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2006*, April 15, 2008, US EPA #430-R-08-005, (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).

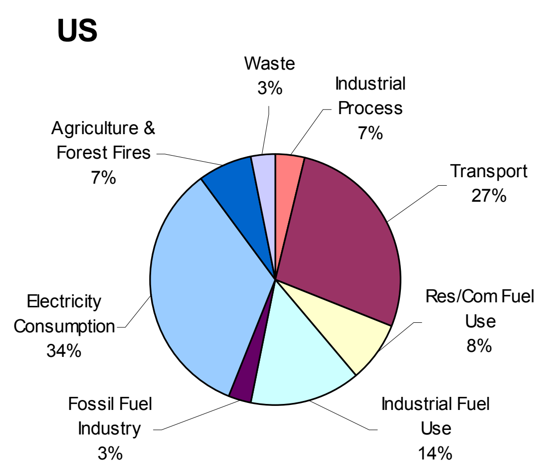
Figure 1-2. Gross GHG emissions by sector, 1990–2025: historical and projected (consumption-based approach) business as usual / base case



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone-depleting substance; Ind. = industrial.

Figure 1-3. Gross GHG emissions by sector, 2005: Michigan and U.S.





MCAC Policy Recommendations (Beyond Recent Actions)

The MCAC approved 54 policy recommendations for consideration of further action in Michigan. Of these, 33 were analyzed quantitatively to calculate both emission reductions and costs or savings. Based on this analysis, the 33 quantified policies have the cumulative effect of reducing annual GHG emissions by approximately 41 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2015 and by 117 $MMtCO_2e$ in 2025. The additional policy recommendations were not quantifiable but are considered valuable recommendations to support the overall Climate Action Plan. Several of the non-quantified policy recommendations may have the potential to achieve GHG emission reductions.

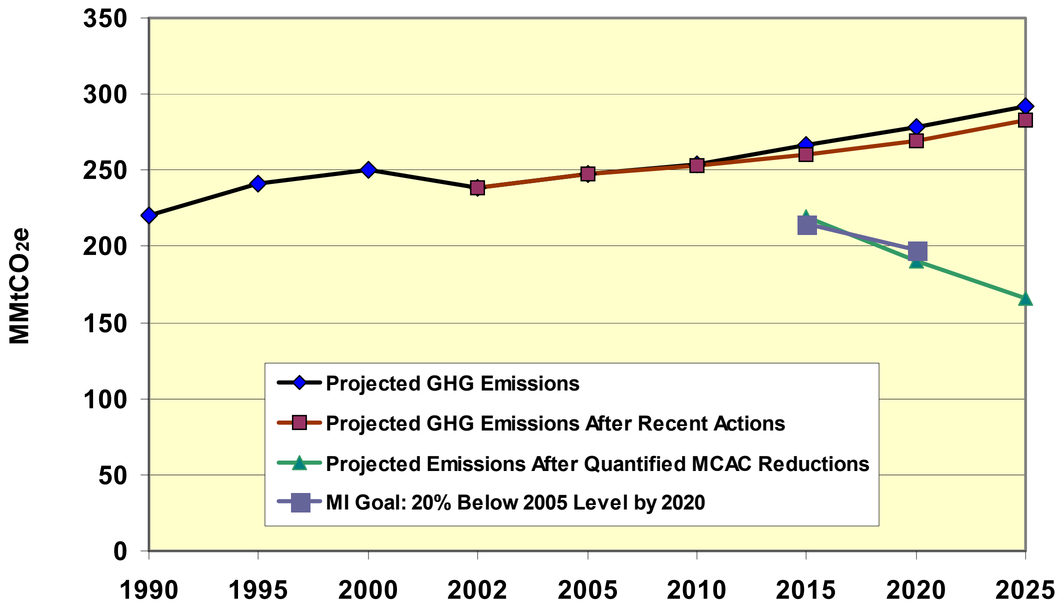
Figure 1-4 presents a graphical summary of the potential cumulative emission reductions associated with the 33 policy options and federal actions relative to the business-as-usual reference case projections.

- The blue line shows actual (for 1990, 1995, 2000, and 2005) and projected (for 2010, 2015, 2020 and 2025) levels of Michigan's gross GHG emissions on a business as usual basis. This consumption-based approach accounts for emissions associated with the generation of electricity in Michigan to meet the state's demand for electricity.

- The red line shows the projected emissions adjusted for the recent state and federal actions described in Table 1.1.
- The green line shows the projected emissions if all of the MCAC's 33 recommended options are implemented and the estimated reductions are fully achieved. While the other MCAC options have the effect of reducing emissions, those reductions were not quantified and are not reflected in the green line.

It is important to note, to yield these emission reductions from the 33 MCAC recommended options, implementation must be timely, aggressive, and thorough. Evaluation of key factors such as cost effectiveness, economic impacts, and harmonization with other Michigan programs and policies will be critical to the next stage of climate policy implementation.

Figure 1-4. Annual GHG emissions: reference case projections and MCAC recommendations (consumption basis, gross emissions)



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; MCAC = Michigan Climate Action Council.

Table 1-2 provides the numeric estimates underlying Figure 1-4. In summary, if all of the Policy recommendations are fully implemented and successful in achieving all of the GHG reductions projected then MI should over-achieve its GHG reduction goals by 7.3 MMtCO2e in 2020. Another way to look at this is that the MCAC package of policy recommendations entails a surplus of GHG reductions of about 7.3MMTCO2e.

Table 1-2. Annual emissions: reference case projections and impact of MCAC recommended options (consumption basis, gross emissions)

Consumption Basis - Gross Emissions							
	1990	2000	2005	2010	2015	2020	2025
Projected GHG Emissions	220.7	250.0	247.5	253.8	266.4	278.0	291.6
Reductions from Recent Actions			0.0	0.7	6.2	8.3	8.9
Projected GHG Emissions After Recent Actions			247.5	253.1	260.2	269.6	282.7
GHG Reduction Goal Recommended by MCAC					NA	198.0	NA
Total GHG Reductions from MCAC Policies					41.2	78.9	116.6
Difference Between MCAC 2020 Goal & Remaining Emissions after Reductions					NA	7.3	NA
Projected Emissions After Quantified MCAC Reductions					219.0	190.7	166.1

GHG = greenhouse gas; MCAC = Michigan Climate Action Council; N/A = not applicable.
Notes continued next page.

Reductions from recent actions include the Energy Independence and Security Act of 2007, Title III. GHG reductions from Titles IV and V of this Act have not been quantified because of the uncertainties in how they will be implemented.

Table 1-3 depicts the final policy recommendations of the Council and their associated GHG reductions and costs or savings for each sector.

In Table 1-3 and throughout the Climate Action Plan, negative cost (- $) figures indicate cost savings. For example, in Table 1-3 the column totals for the Net Present Value (NPV) of (-$10,093 million) portrays a cost savings of $10,093,000,000 over the 2009- 2025 period of analysis.

Table 1-3. Summary by sector of estimated impacts of implementing all of the MCAC recommended options (cumulative reductions and costs/savings)

Sector	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
	2015	2025	Total 2009–2025		
Residential, Commercial and Industrial	21.9	65.1	524.6	–$13,014	–$25
Energy Supply	8.1	23.6	220.3	$7,980	$36
Transportation and Land Use	4.8	10.5	95.1	–$3,425	–$36
Agriculture, Forestry, and Waste Management	6.4	17.4	147.0	-$1,634	-$11.1
Cross-Cutting Issues	Non-quantified, enabling options				
TOTAL (includes all adjustments for overlaps)	**41.2**	**116.6**	**987.0**	**-$10,093**	**-$10.2**

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the policy options.

Within each sector, values have been adjusted to eliminate double counting for policies or elements of policies that overlap. In addition, values associated with policies or elements of policies within a sector that overlap with policies or elements of policies in another sector have been adjusted to eliminate double counting. Appendix F (for the ES sectors), Appendix H (for the RCI sectors), Appendix I (for the TLU sectors), and Appendix J (for the AFW sectors) of this report provide documentation of how sector-level emission reductions and costs (or cost savings) were adjusted to eliminate double counting associated with overlaps between policies.

Table 1-4 Summary List Policy Recommendations for all Sectors

Energy Supply (ES) Policy Recommendation

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
RECENT ACTION	PA 295, Clean, Renewable, and Efficient Energy Act	2.7	2.0	30.8	$1,024	$33	N/A
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	5.0	14.6	137.5	$6,600	$48.00	Unanimous
	Renewable Portfolio Standard (RPS)	4.6	13.7	129.5	$5,546	$42.83	
	Wind	3.7	10.3	100.4	$4,748	$47.31	
	Biomass	0.9	2.7	25.2	$376	$15	
	Solar Photovoltaic (PV)	0.0	0.4	2.6	$392	$152	
	Plasma Gasification	0.0	0.3	1.3	$29	$22	
	Distributed Generation "Carve-Out"	0.4	0.9	8.0	$1,054	$131.51	
	Solar Hot Water	0.0	0.2	1.2	$26	$22.27	
	Geothermal	0.1	0.2	1.5	$82	$55	
	Wind (distributed)	0.1	0.3	2.7	$503	$186	
	Solar PV (distributed)	0.1	0.2	1.84	$508	$276	
	Biogas	0.1	0.2	2.3	$17	$7	
ES-3	Energy Optimization Standard	0.0	13.6	86.3	–$1,632	–$19	Unanimous
ES-5	Advanced Fossil Fuel Technology (e.g., IGCC, CCSR) Incentives, Support, or Requirements	*Not Quantifiable*					Unanimous
ES-6	New Nuclear Power	0.0	6.3	38.5	$1,001	$25.98	Majority[10]
ES-7	Integrated Resource Planning (IRP), Including combined heat & power.	*Not Quantifiable*					Unanimous
ES-8	Smart Grid, Including Advanced Metering	*Not Quantifiable*					Unanimous
ES-9	CCSR Incentives, Requirements, R&D, and/or Enabling Policies	*Not Quantifiable*					Unanimous
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration						Majority[11]
	Co-firing at 5%	0.2	0.2	3.3	$34.48	$10.6	
	Co-firing at 10%	0.5	0.5	6.5	$69.43	$10.7	
	Co-firing at 20%	0.9	0.9	13.0	$134.09	$10.3	

[10] 6 opposing votes [Pollack, Ettawageshik, Garfield, Heifje, Bazzani, Overmeyer] and 2 abstentions [Martinez and Calloway for Bierbaum]

[11] 3 opposing votes [Garfield, Pollack and Heifje]

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
ES-11	Power Plant Replacement, Energy Efficiency, and Repowering	2.5	2.0	33.2	$313	$9.4	Unanimous
ES-12	Distributed Renewable Energy Incentives, Barrier Removal, and Development Issues, Including Grid Access	*ES-12 Fully incorporated in distributed generation "carve-out" under ES-1.*					Unanimous
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.4	0.5	7.8	$31.91	$4.09	Unanimous
ES-15	Transmission Access and Upgrades	*Not Quantifiable*					Unanimous
	Sector Totals	**8.1**	**37.2**	**306.6**	**$6,348**	**$22**	
	Sector Total After Adjusting for Overlaps	**8.1**	**23.6**	**220.3**	**$7,980**	**$36**	
	Reductions From Recent Actions	**2.7**	**1.9**	**30.1**	**$1,025**	**$34**	
	Sector Total Plus Recent Actions	**10.8**	**25.5**	**250.4**	**$9,005**	**$36**	

$/t$CO_2e$ = dollars per metric tons of carbon dioxide equivalent; CCI = Cross-Cutting Issues; CCSR = carbon capture and storage or reuse; CHP = combined heat and power; GHG = greenhouse gas; IGCC = integrated gasification combined cycle; IRP = integrated resource planning; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = millions of metric tons of carbon dioxide equivalent; N/A = not applicable; PA = Public Act; R&D = research and development.

Note: The numbering used to denote all the policy recommendations in Table 1-4 and in other parts of this report is for reference purposes only; it does not reflect prioritization among these important recommendations.

Table 1-4 (cont'd.) Market Based Policy (MBP) Recommendations

No.	Policy Recommendations		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2e$)	Level of Support
			2020	2025	Total 2009–2025			
MBP-1	Cap and Trade	20% below 2005 by 2020 (*Free-Granting Allowances*)[12]	92.48				–$25.83	Unanimous
		20% Below 2005 by 2020 (*Auctioning Allowances*)[13]	92.48				–$19.33	
MBP-3	MI Joins Chicago Climate Exchange		*Not Quantified*					Unanimous
MBP-6	Market Advisory Group		*Not Quantifiable*					Unanimous

[12] These results include the direct cost of reducing emissions, plus costs associated with purchase of emissions allowances from entities outside of Michigan, minus revenues from the sale of allowances to entities outside Michigan.

[13] These results include the direct cost of reducing emissions but do not include payments by Michigan entities for the purchase of allowances at auction, nor do they include revenues to the state from the sale of those allowances. The full cost and revenue implications of allowance distribution by auction can be found in Table G-1-2 and Annex G-1.

Table 1-4 (cont'd.) Transportation and Land Use (TLU) Policy Recommendations

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)	Level of Support
		2015	2025	Total 2009–2025			
TLU-1	Promote Low-Carbon Fuel Use	2.6	5.9	53	$820	$16	Unanimous
TLU-2	Eco-Driver Program	1.1	2.2	22	–$3,921	–$176	Unanimous
TLU-3	Truck Idling Policies	0.36	0.76	7.0	–$596	–$85	Unanimous
TLU-4	Advanced Vehicle Technology	0.01	0.03	0.19	$281	$1,458	Unanimous
TLU-5	Congestion Mitigation	0.08	0.18	1.7	–$135	–$81	Unanimous
TLU-6	Land Use Planning and Incentives	0.14	0.43	3.2	–$598	–$189	Unanimous
TLU-7	Transit and Travel Options	0.13	0.54	3.5	$655	$185	Unanimous
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.10	0.19	2.0	$69	$35	Unanimous
TLU-9	Great Lakes Shipping	0.24	0.27	2.5	NQ	NQ	Unanimous
	Sector Totals	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**
	Sector Total After Adjusting for Overlaps	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**
	Reductions From Recent Actions	**0**	**0**	**0**	**$0**	**$0**	**N/A**
	Sector Total Plus Recent Actions	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent. Note: Negative numbers indicate cost savings.

Table 1-4 (cont'd.) Residential, Commercial and Industrial (RCI) Policy Recommendations

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009-2025			
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0.0	13.6	86.3	–1,632	–19	Unanimous
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	17.6	53.8	428.6	–12,107	–28	Unanimous
RCI-3	Regulatory (PSC) Changes to Remove Disincentives and Encourage Energy Efficiency Investments by IOUs	*Not Quantifiable*					Unanimous
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	3.6	9.8	82	–2,865	–35	Unanimous
RCI-5	MI Climate Challenge & Related Consumer Education Programs	*Not Quantifiable*					Unanimous
RCI-6	Incentives to Promote Renewable Energy Systems Implementation	0.7	1.5	14.0	1,958	140	Unanimous
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	15.6	47.6	380	–11,693	–31	Unanimous
RCI-8	Net Metering for Distributed Generation	Fully incorporated into RCI-6					Unanimous
RCI-9	Training & Education for Bldg. Design, Construction, and Operation	*Not Quantifiable*					Unanimous
RCI-10	Water Use and Management	*Not Quantifiable*					Unanimous
	Sector Total After Adjusting for Overlaps*	**21.8**	**64.9**	**523.9**	***–13,014***	***–24.8***	
	Reductions From Recent Actions	**Figures adjusted include recent actions**					
	Sector Total Plus Recent Actions	**21.8**	***64.9***	***523.9***	***–13,014***	***–24.8***	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; PSC = Public Service Commission; IOU = investor-owned utility.

Note: The numbering is for reference purposes only; it does not reflect prioritization among these policy options. Negative net present values and cost effectiveness numbers above reflect "negative costs" or net savings.

*The figures listed show totals for the options net of recent legislation.

Table 1-4 (cont'd.) Agriculture, Forestry and Waste (AFW) Management Policy Recommendations

Policy No.	Policy Recommendation		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
			2015	2025	Total 2009–2025			
AFW-1	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production		3.3	10	79	$1,649	$21	Unanimous
AFW-2*	In-State Liquid Biofuels Production		*Included in the Results of TLU-1*					Unanimous
AFW-3	Methane Capture and Utilization From Manure and Other Biological Waste		0.09	0.14	1.5	$4.7	$3	Unanimous
AFW-4	Expanded Use of Bio-based Materials	A. Use of Bio-based Products	.08	.21	1.7	–$108	–$62	Unanimous
		B. Utilization of Solid Wood Residues	*Not Quantified*					Unanimous
AFW-5	Land Use Management That Promotes Permanent Cover	A. Increase in Permanent Cover Area	0.08	0.21	1.8	$63	$34	Unanimous
		B. Retention of Lands in Conservation Programs†	0.05	0.11	1.1	$24	$23	Unanimous
		C. Retention/ Enhancement of Wetlands	*Not Quantified*					Unanimous
AFW-6	Forestry and Agricultural Land Protection	A. Agricultural Land Protection	0.46	1.1	10	$864	$85	Unanimous
		B. Forested Land Protection	*Not Quantified*					Unanimous
		C. Peatlands/ Wetlands Protection	*Not Quantified*					Unanimous
AFW-7**	Promotion of Farming Practices That Achieve GHG Benefits	A. Soil Carbon Management	0.7	1.7	15	–$200	–$13	Unanimous
		B. Nutrient Efficiency	0.05	0.12	1.1	–$27	–$26	Unanimous
		C. Energy Efficiency	0.13	0.32	2.9	–$102	–$35	Unanimous
		D. Local Food	*Not Quantified*					Unanimous
AFW-8	Forest Management for Carbon Sequestration and Biodiversity	A. Enhanced Forestland Management	0.53	1.42	12.05	$800	$66	Unanimous
		B. Urban Forest Canopy	1.2	2.9	26	–$346	–$13	Unanimous

Policy No.	Policy Recommendation		GHG Reductions (MMtCO_2e)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effectiveness ($/t$CO_2$e)	Level of Support
			2015	2025	Total 2009–2025			
		C. Reduce Wildfire	*Not Quantified*					Unanimous
AFW-9**	Source Reduction, Advanced Recycling, and Organics Management							Unanimous
	In-State GHG Reductions		1.4	3.0	28	–$3,136	–$112	
	Full Life-Cycle Reductions		14.5	35.3	314	–$3,136	–$10	
AFW-10	Landfill Methane Energy Programs		0.91	2.7	22	–$35	–$2	Unanimous
	Sector Totals†		**9**	**23**	**201**	**–$548**	**–$3**	
	Sector Total After Adjusting for Overlaps††		**6**	**17**	**147**	**–$1,634**	**–$11**	
	Reductions From Recent Actions		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
	Sector Total Plus Recent Actions		6	17	147	-$1,634	-$11	

GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent; $/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; TLU = Transportation and Land Use; N/A = not applicable.

Note that negative costs represent a monetary savings.

* The quantification results for AFW-2 (biofuel production volumes and costs) were used as inputs to the quantification of the results of TLU-1, which covers consumption of biofuels in Michigan.

** The analyses for AFW-5, AFW-7, and AFW-9 include the full life-cycle costs of the policies. In the case of AFW-9, it is estimated that a significant fraction of the reductions will occur out of state. In-state reductions refer only to those occurring from reduced landfilling and waste combustion (these are broken out separately in the table above).

† The reductions from AFW-5B (Retention of Lands in Conservation Programs) have been left out of the sector totals, since they relate to a soil carbon protection measure where the estimated emissions (from conservation acres being returned to active cultivation) are not included in the business as usual (BAU) inventory and forecast (I&F). The costs have been included in the sector totals, since these will be incurred in order to retain the level of emissions in the BAU I&F. For AFW-5, AFW-7, and AFW-9, these include the reductions that are expected to occur within the state.

†† See the section below for discussion of overlap adjustments.

Table 1-4 (cont'd.) Cross Cutting Issues (CCI) Policy Recommendations

No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
CCI-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not Quantified*					Unanimous
CCI-2	Statewide GHG Reduction Goals and Targets	*Not Quantified*					Unanimous
CCI-3	State, Local, and Tribal Government GHG Emission Reductions (Lead-by-Example)	*Not Quantified*					Unanimous
CCI-4	Comprehensive Local Government Climate Action Plans (Counties, Cities, Etc.)	*Not Quantified*					Unanimous
CCI-5	Public Education and Outreach	*Not Quantified*					Unanimous
CCI-6	Tax and Cap/ Cap and Trade	*MCAC approved creation of a new Market-Based Policies Technical Work Group as the lead for this policy* recommendation.					Transferred
CCI-7	Seek Funding for Implementation of MCAC Recommendations	*Not Quantified*					Unanimous
CCI-8	Adaptation and Vulnerability	*Not Quantified*					Unanimous
CCI-9	Participate in Regional, Multi-State, and National GHG Reduction Efforts	*Not Quantified*					Unanimous
CCI-10	Enhance and Encourage Economic Growth and Job Creation Opportunities Through Climate Change Mitigation	*Not Quantified*					Unanimous
CCI-11	Enhance and Encourage Community Development Through Climate Change Mitigation: Address Environmental Justice	*Not Quantified*					Unanimous

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

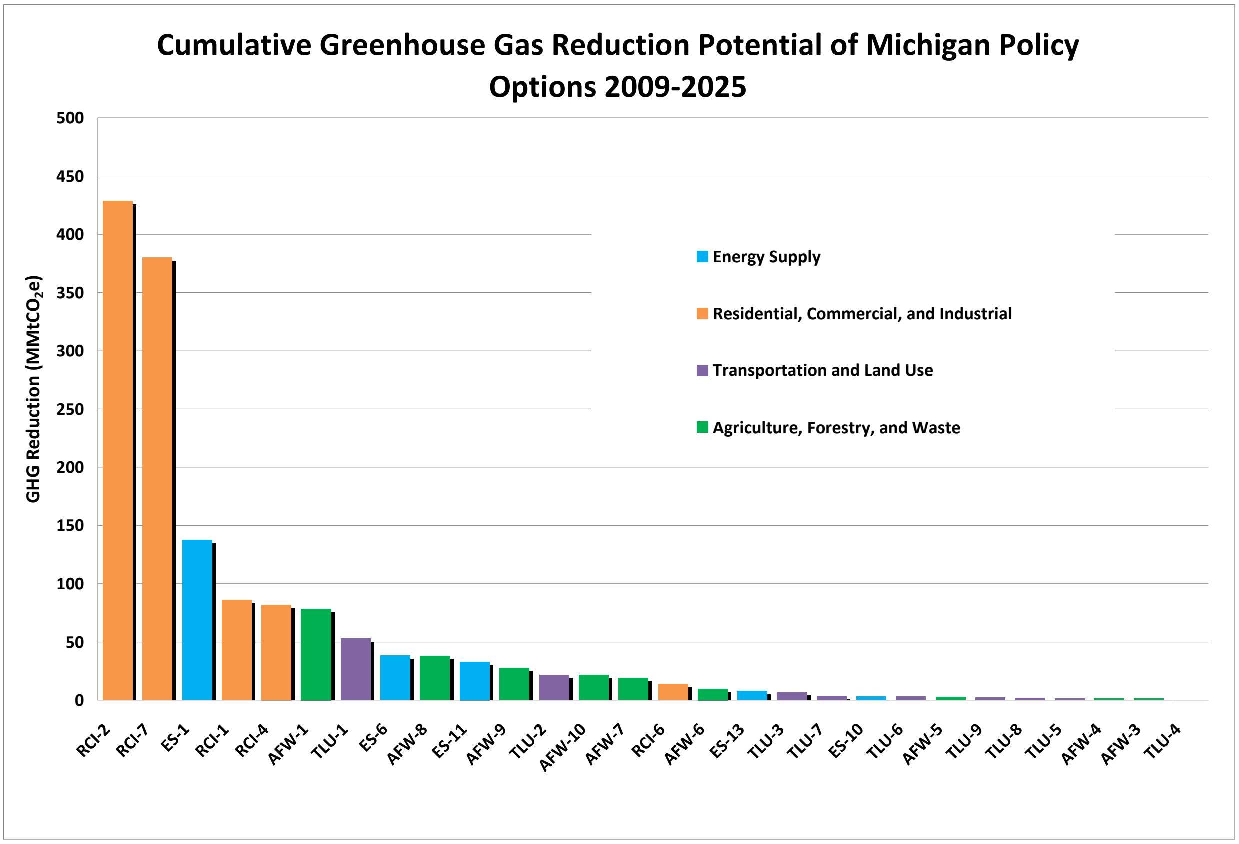
Perspectives on Policy Options

As explained previously, the MCAC considered the estimates of the GHG reductions that could be achieved and the costs (or cost savings) for the 33 options that were quantifiable. Figure 1-5, below, presents the estimated tons of GHG emission reductions for each of these policy recommendations, expressed as a cumulative figure for the period 2009–2025.

Figure 1-6 presents the estimated dollars-per-ton cost (or cost savings, depicted as a negative number) for each quantified policy recommendation. The dollars per ton value is calculated by dividing the net present value of the cost of the policy recommendation by the cumulative GHG reductions, all for the period 2009–2025.

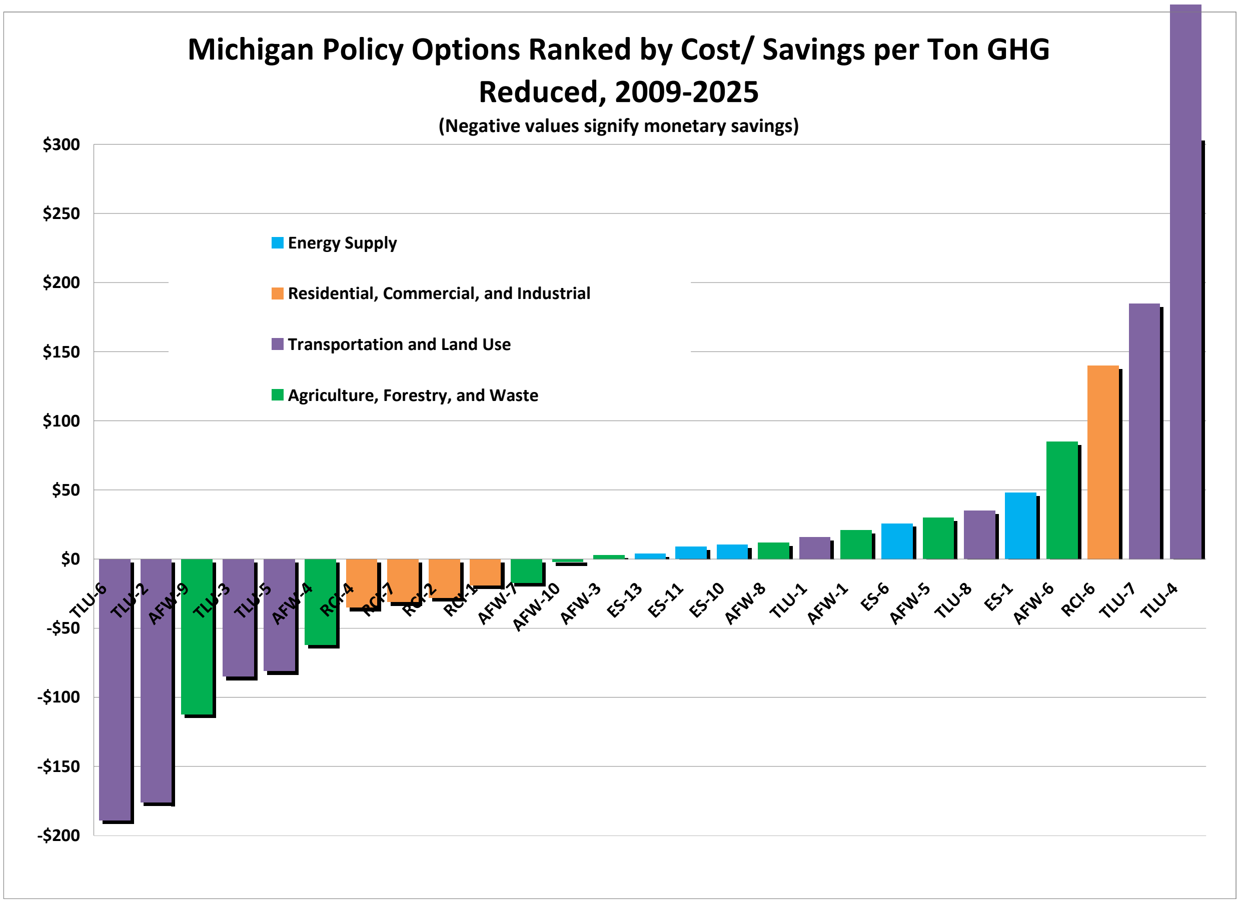
It is important to note that there is some level of uncertainty in projecting GHG reductions and estimating exact costs (or cost savings) per ton of reductions achieved for the time periods of this analysis.

Figure 1-5. MCAC policy recommendations ranked by cumulative (2009–2025) GHG reduction potential



GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; TLU = Transportation and Land Use; RCI = Residential, Commercial, Industrial

Figure 1-6. MCAC policy recommendations ranked by cumulative (2009–2025) net cost/cost savings per ton of GHG removed

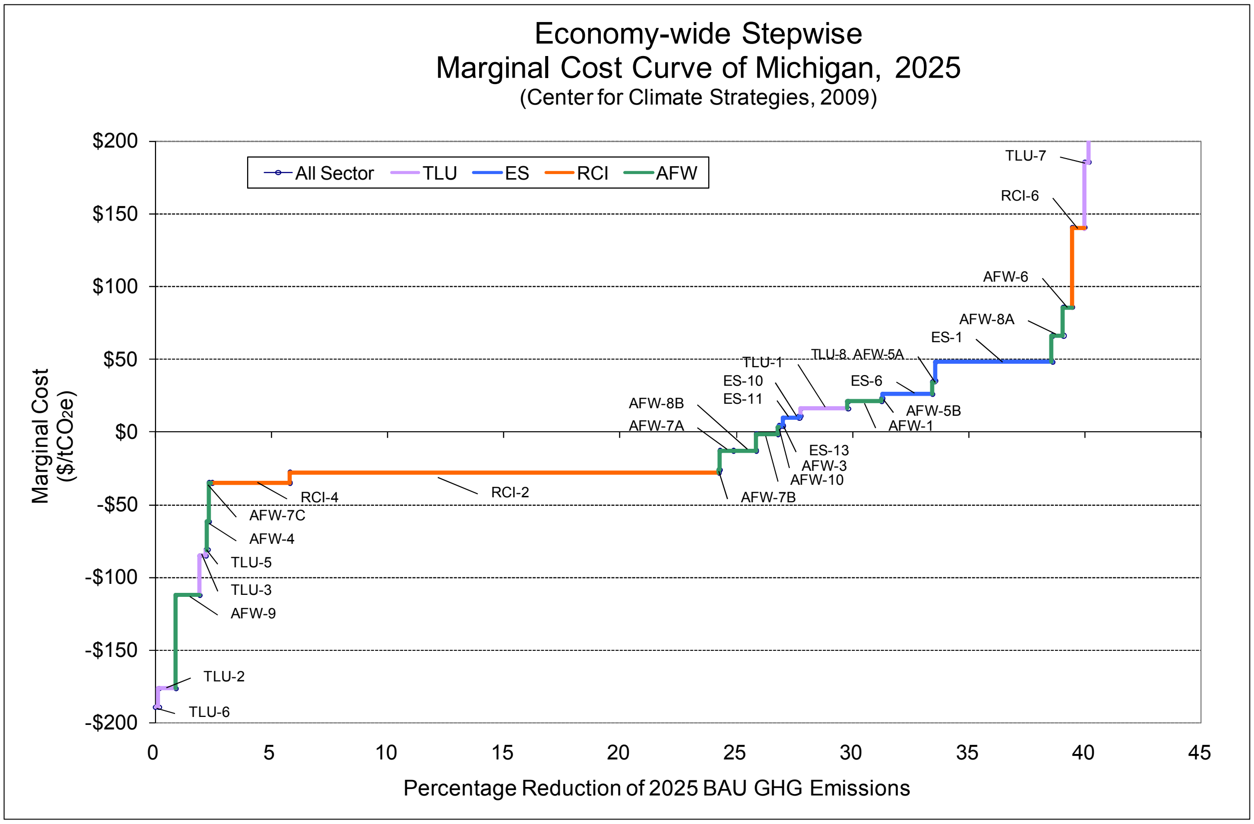


GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; TLU = Transportation and Land Use; RCI = Residential, Commercial, Industrial.

TLU 4 cost effectiveness is $1458 per ton.

Figure 1-7, below, presents a stepwise marginal cost curve for Michigan. The horizontal axis represents the percentage of GHG emissions reduction in 2025 for each option relative to the business as usual (BAU) forecast. The vertical axis represents the marginal cost of mitigation (expressed as the cost-effectiveness of each policy option on a cumulative basis, 2009-2025). In the figure, each horizontal segment represents an individual policy. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost (saving) of reducing one $MMtCO_2e$ of GHG emissions with the application of the option. For instance, for RCI-2-Energy Efficiency- this policy recommendation should result in approximately a 54 MMTCO2e (19%) reduction of GHG emissions in 2025 below the BAU reference case with an average cost savings of approximately $28/ton.

Figure 1-7. Stepwise marginal cost curve for Michigan, 2025



BAU = business as usual; GHG = greenhouse gas; tCO_2e = metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; TLU = Transportation and Land Use;

Negative values represent net cost savings and positive values represent net costs associated with the policy option.

Note: Results have been adjusted to remove overlaps between policies. For example, RCI-7 reductions overlap with both RCI-2 and RCI-4 assuming all three policies are implemented. The curve, therefore, includes RCI-2 and RCI-4 but not RCI-7 to avoid overstating the combined benefits of the recommendations.

Chapter 2
Inventory and Projections of Michigan's GHG Emissions

Introduction

This chapter summarizes Michigan's greenhouse gas (GHG) emissions and sinks (carbon storage) from 1990 to 2025. The Center for Climate Strategies (CCS) prepared a draft of Michigan's GHG emissions inventory and reference case projections for the Michigan Department of Environmental Quality (MDEQ). The draft inventory and reference case projections, completed in January 2008, provided the MDEQ with an initial, comprehensive understanding of current and possible future GHG emissions. The draft report was provided to the Michigan Climate Action Council (MCAC) and its Technical Work Groups (TWGs) to assist them in understanding past, current, and possible future GHG emissions in Michigan, and thereby inform the policy recommendation development process. The MCAC and TWGs have reviewed, discussed, and evaluated the draft inventory and methodologies, as well as alternative data and approaches for improving the draft GHG inventory and forecast. The inventory and forecast have since been revised to address the comments provided by the MCAC. The information in this chapter reflects the information presented in the final *Michigan Greenhouse Gas Inventory and Reference Case Projections* report (hereafter referred to as the Inventory and Projections report).[1]

Historical GHG emission estimates (1990 through 2005)[2] were developed using a set of generally accepted principles and guidelines for state GHG emission inventories, relying to the extent possible on Michigan-specific data and inputs. The reference case projections (2006-2025) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the final Inventory and Projections report.

The Inventory and Projections report covers the six types of gases included in the U.S. GHG inventory: 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 equivalence (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential-weighted basis.[3]

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[1] Center for Climate Strategies. *Final Michigan Greenhouse Gas Inventory and Reference Case Projections: 1990–2025*. Prepared for the Michigan Climate Action Council. November 2008.

[2] The last year of available historical data for each sector varies between 2000 and 2005. The University of Michigan also prepared an inventory and forecast of GHG emissions in conjunction with the MDEQ in 2005.

[3] 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

It is important to note that the emission estimates reflect the GHG emissions associated with the electricity sources used to meet Michigan's demands, corresponding to a consumption-based approach to emissions accounting. 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.

Michigan GHG Emissions: Sources and Trends

Table 2-1 provides a summary of GHG emissions estimated for Michigan by sector for 1990, 2000, 2005, 2010, 2020, and 2025. As shown in this table, Michigan is estimated to be a net source of GHG emissions (positive, or gross, emissions). Michigan's forests serve as sinks of GHG emissions (removal of emissions, or negative emissions). Michigan's net emissions subtract the equivalent GHG reduction from emission sinks from the gross GHG emission totals. The following sections discuss GHG emission sources and sinks, trends, projections, and uncertainties.

Historical Emissions

Overview

In 2005, on a gross emissions consumption basis (i.e., excluding carbon sinks), Michigan accounted for approximately 248 million metric tons (MMt) of CO_2e emissions, an amount equal to 3.5% of total U.S. gross GHG emissions. On a net emissions basis (i.e., including carbon sinks), Michigan residents accounted for approximately 235 MMtCO_2e of emissions in 2005, an amount equal to 3.8% of total U.S. net GHG emissions.[4] Michigan's GHG emissions are rising slower than those of the nation as a whole. From 1990 to 2005, Michigan's gross GHG emissions increased by 12%, while national gross emissions rose by 16%.[5]

On a per-capita basis, Michigan residents emitted about 24 metric tons (t) of gross CO_2e in 2005, similar to the national average of about 24 tCO_2e. Figure 2-1 illustrates the state's emissions per capita and per unit of economic output. Both Michigan and national per-capita emissions remained nearly constant from 1990 to 2005. This consistency in per-capita emission rates in Michigan results from growth in emissions from the electricity supply and transportation sectors, and decline in emissions from the industrial fuel use and industrial processes sectors. In both Michigan and the nation as a whole, economic growth exceeded emissions growth throughout the 1990 – 2005 period. From 1990 to 2005, emissions per unit of gross product dropped by 26% nationally, and by 23% in Michigan.[6]

Climate Change, Cambridge University Press, Cambridge, United Kingdom. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

[4] The national emissions used for these comparisons are based on 2005 emissions from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*, April 15, 2008, EPA430-R-08-005. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[5] During this period, population grew by 10% in Michigan and by 19% nationally. However, Michigan's economy grew at the same rate as the nation on a per-capita basis (up 32%).

[6] Based on real gross domestic product (millions of 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/.

Table 2-1. Michigan GHG emissions, historical and reference case projection, by sector*

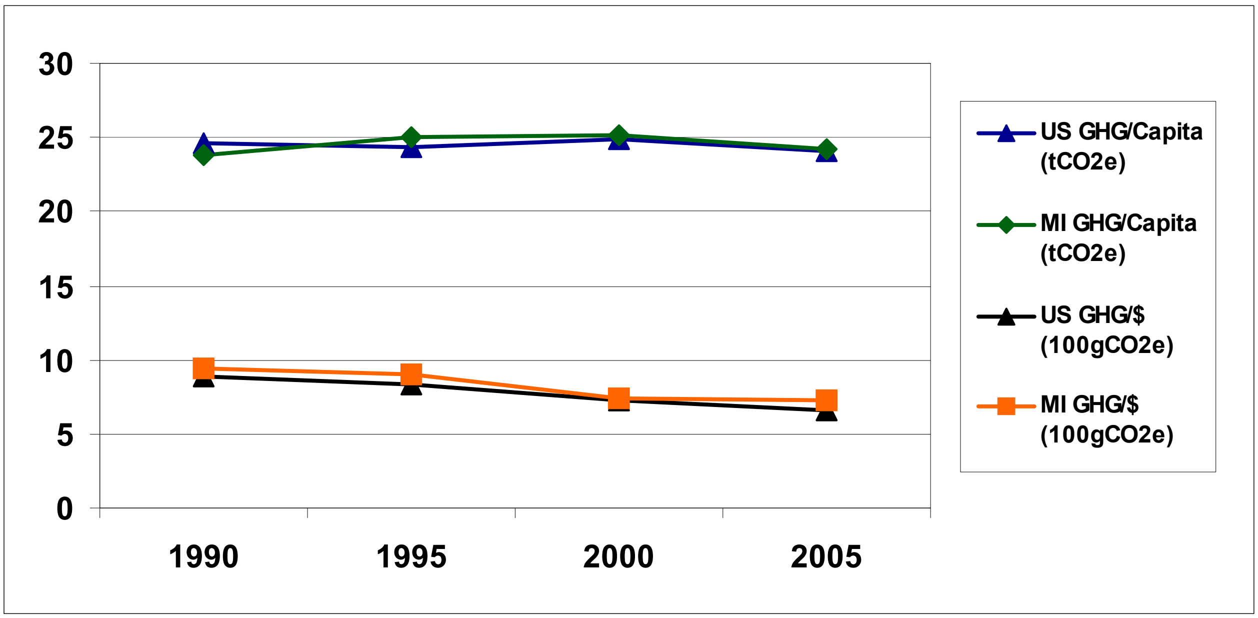
Sector	1990	2000	2005	2010	2020	2025
	MMtCO_2e					
Energy (Consumption Based)	**192.5**	**218.6**	**214.7**	**220.2**	**238.7**	**248.5**
Electricity Use (Consumption)	**70.3**	**86.9**	**90.0**	**91.0**	**103.9**	**111.1**
Electricity Production (in-state)	64.0	68.1	71.4	72.3	85.3	92.6
Coal	*62.8*	*64.9*	*67.7*	*67.6*	*78.8*	*85.3*
Natural Gas	*0.46*	*1.77*	*2.38*	*3.67*	*5.40*	*6.06*
Oil	*0.66*	*0.99*	*0.71*	*0.48*	*0.48*	*0.57*
MSW/Landfill Gas	*0.12*	*0.38*	*0.34*	*0.39*	*0.44*	*0.46*
Biomass	*0.010*	*0.031*	*0.030*	*0.025*	*0.027*	*0.029*
Other Wastes	*0.009*	*0.029*	*0.16*	*0.19*	*0.21*	*0.22*
Imported/Exported Electricity	6.22	18.8	18.7	18.7	18.6	18.5
Residential/Commercial/Industrial (RCI) Fuel Use	**67.5**	**66.1**	**59.9**	**60.5**	**62.1**	**62.4**
Coal	*11.7*	*9.34*	*7.32*	*6.12*	*5.67*	*5.56*
Natural Gas	*42.8*	*43.7*	*40.4*	*42.6*	*44.4*	*44.8*
Petroleum	*12.8*	*12.9*	*12.0*	*11.6*	*11.9*	*11.8*
Wood (CH_4 and N_2O)	*0.28*	*0.17*	*0.19*	*0.20*	*0.20*	*0.20*
Transportation	**49.7**	**59.4**	**58.2**	**61.4**	**64.0**	**65.3**
On-road Gasoline	*37.4*	*43.7*	*43.3*	*45.5*	*46.2*	*46.4*
On-road Diesel	*5.21*	*8.90*	*10.2*	*11.3*	*12.9*	*13.7*
Rail, Natural Gas, LPG, Other	*1.10*	*1.16*	*0.90*	*0.93*	*0.95*	*0.95*
Marine Vessels	*1.87*	*2.61*	*2.25*	*2.18*	*2.52*	*2.70*
Jet Fuel and Aviation Gasoline	*4.15*	*3.00*	*1.52*	*1.45*	*1.50*	*1.51*
Fossil Fuel Industry	**4.94**	**6.13**	**6.64**	**7.25**	**8.70**	**9.66**
Natural Gas Industry	4.69	6.03	6.55	7.19	8.67	9.64
Oil Industry	0.25	0.10	0.086	0.061	0.032	0.024
Industrial Processes	**15.3**	**18.1**	**18.4**	**18.9**	**23.3**	**26.4**
Cement Manufacture (CO_2)	2.27	2.26	2.13	2.12	2.10	2.09
Lime Manufacture (CO_2)	0.43	0.48	0.41	0.41	0.41	0.41
Limestone and Dolomite Use (CO_2)	0.24	0.25	0.31	0.31	0.31	0.31
Soda Ash (CO_2)	0.10	0.094	0.088	0.084	0.076	0.072
Iron & Steel (CO_2)	11.2	11.0	10.2	8.47	8.12	7.95
Taconite Production (CO_2)	0.037	0.28	0.25	0.20	0.14	0.11
Magnesium Production (SF_6)	0.18	0.45	0.45	0.70	1.16	1.50
ODS Substitutes (HFC, PFC)	0.012	2.84	4.16	6.18	10.6	13.6
Electric Power T&D (SF_6)	0.82	0.47	0.40	0.37	0.34	0.33
Semiconductor Manufacturing (HFC, PFC, and SF_6)	0.001	0.004	0.004	0.004	0.003	0.003
Waste Management	**4.67**	**5.30**	**6.28**	**6.98**	**8.70**	**9.74**
Waste Combustion	0.33	1.14	1.20	1.26	1.38	1.45
Landfills	3.16	2.86	3.75	4.34	5.82	6.73
Wastewater Management	1.17	1.30	1.33	1.38	1.50	1.56
Agriculture	**8.33**	**7.99**	**8.07**	**7.71**	**7.25**	**7.03**
Enteric Fermentation	1.53	1.36	1.40	1.38	1.33	1.31
Manure Management	0.92	0.97	1.09	1.07	1.01	0.99
Agricultural Soils	3.71	3.49	3.42	3.09	2.73	2.55
Agricultural Burning	0.022	0.026	0.029	0.030	0.034	0.036
Agricultural Soils (cultivation practices)	2.14	2.14	2.14	2.14	2.14	2.14

Sector	1990	2000	2005	2010	2020	2025
	MMtCO_2e					
Forest Wildfires and Prescribed Burning	**0.020**	**0.020**	**0.020**	**0.020**	**0.020**	**0.020**
Gross Emissions (Consumption Basis)	**220.7**	**250.0**	**247.5**	**253.8**	**278.0**	**291.6**
Increase relative to 1990		*13%*	*12%*	*15%*	*26%*	*32%*
Emissions Sinks	**–37.9**	**–12.5**	**–12.7**	**–12.7**	**–12.7**	**–12.7**
Forestry and Land Use	**–37.9**	**–12.5**	**–12.7**	**–12.7**	**–12.7**	**–12.7**
Forested Landscape	–27.8	–8.77	–8.77	–8.77	–8.77	–8.77
Urban Forestry and Land Use	–10.1	–3.69	–3.91	–3.91	–3.91	–3.91
Net Emissions (Consumption Basis) (including forestry and land use sinks)	**182.9**	**237.5**	**234.8**	**241.1**	**265.3**	**278.9**

MMtCO_2e = million metric tons of carbon dioxide equivalent; CH_4 = methane; N_2O = nitrous oxide; MSW = municipal solid waste; LPG = liquefied petroleum gas; ODS = ozone-depleting substance; HFC = hydrofluorocarbon; PFC = perfluorocarbon; SF_6 = sulfur hexafluoride; T&D = transmission and distribution.

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

Figure 2-1. Michigan and U.S. gross GHG emissions, per-capita and per-unit gross product



GHG = greenhouse gas; tCO_2e = metric tons of carbon dioxide equivalent; g = grams.

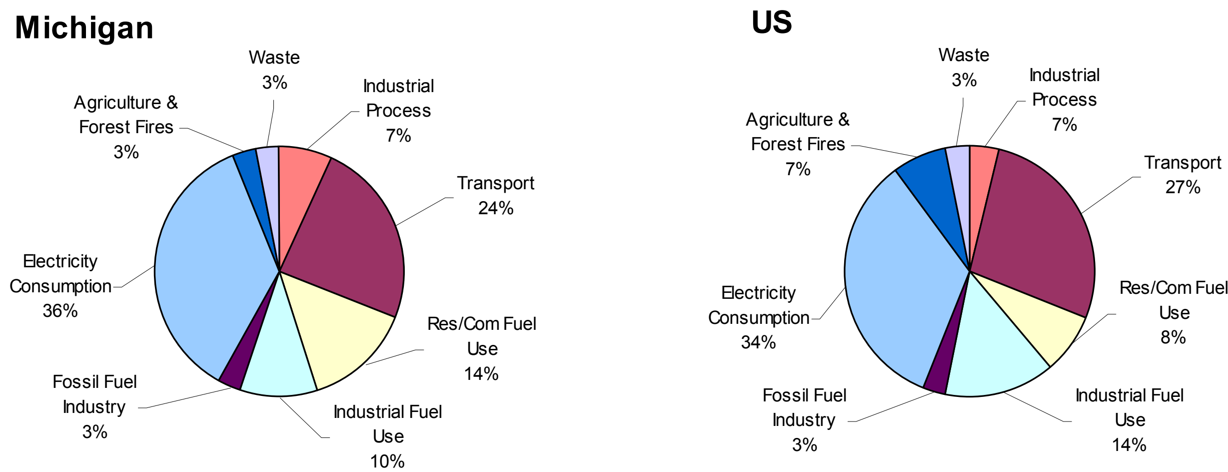
The principal sources of Michigan's GHG emissions in 2005 are electricity consumption, residential, commercial, and industrial (RCI) fuel use, and transportation, accounting for 36%, 24%, and 24% of Michigan's gross GHG emissions, respectively, as shown in Figure 2-2. The next largest contributor is the industrial processes sector, accounting for 7% of gross GHG emissions in 2005; these emissions are rising due to the increasing use of HFCs and PFCs as substitutes for ozone-depleting chlorofluorocarbons.[7] Other industrial process emissions include

[7] Chlorofluorocarbons are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol on Substances That Affect the Ozone Layer. See Appendix I in the Final Inventory and Projections report for Michigan (http://www.miclimatechange.us/stakeholder.cfm).

CO_2 released by cement and lime manufacturing; CO_2 released during soda ash, limestone, and dolomite use; CO_2 released during taconite production and iron and steel production; SF_6 released during magnesium production and from transformers used in electricity transmission and distribution systems; and HFCs, PFCs, and SF_6 released during semiconductor manufacturing.

Figure 2-2 also shows that the agricultural and forest wildfire sectors together accounted for 3% of the gross GHG emissions in Michigan in 2005. These CH_4 and N_2O emissions primarily come from agricultural soils, enteric fermentation, manure management, and agricultural soil cultivation practices. Also, landfills and wastewater management facilities produce CH_4 and N_2O emissions that accounted for 3% of total gross GHG emissions in Michigan in 2005. Similarly, emissions associated with the production, processing, transmission, and distribution of fossil fuels accounted for 3% of the gross GHG emissions in 2005.

Figure 2-2. Gross GHG emissions by sector, 2005: Michigan and U.S.



Notes: Res/Com = Residential and commercial fuel use sectors. 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. The commercial sector accounts for emissions associated with the direct use of fuels by, for example, hospitals, schools, government buildings (local, county, and state) and other commercial establishments. The industrial processes sector accounts for emissions associated with manufacturing and excludes emissions included in the industrial fuel use sector. 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 industrial sector. Electricity = Electricity generation sector emissions on a consumption basis, including emissions associated with electricity imported from outside of Michigan and excluding emissions associated with electricity exported from Michigan to other states.

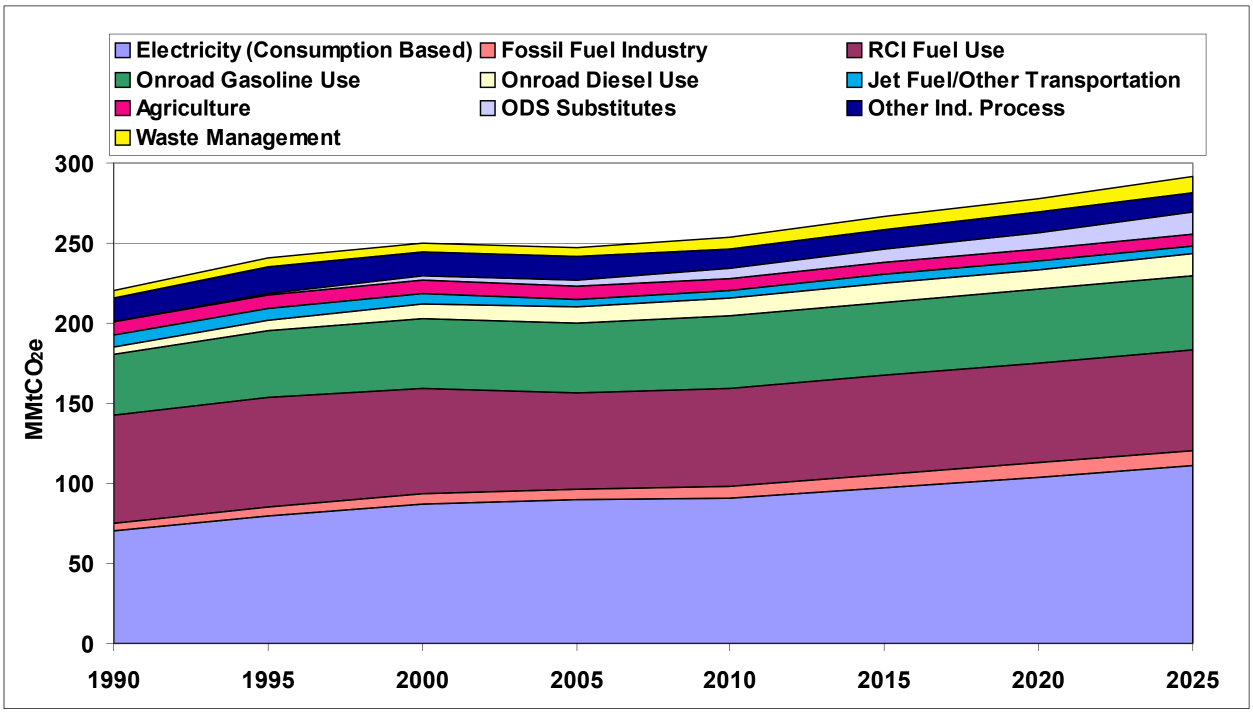
Forestry emissions refer to the net CO_2 flux[8] from forested lands in Michigan, which account for about 53% of the state's land area.[9] Michigan's forests are estimated to be net sinks of CO_2 emissions in the state, reducing net GHG emissions by 13 $MMtCO_2e$ in 2005.

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

Reference Case Projections

Relying on a variety of sources for projections, as noted in the Inventory and Projections report, a simple reference case projection of GHG emissions through 2025 was developed. As illustrated in Figure 2-3 and shown numerically in Table 2-1, under the reference case projections, Michigan's gross GHG emissions continue to grow steadily, climbing to about 292 $MMtCO_2e$ by 2025, or 32% above 1990 levels. This equates to a 0.8% annual rate of growth from 1990 to 2025. Relative to 2005, the share of emissions associated with electricity consumption and industrial processes both increase slightly to 38% and 9%, respectively, by 2025. The share of emissions from the transportation, RCI fuel use, and agriculture sectors all decrease slightly to 22%, 21%, and 2%, respectively. The emissions from the fossil fuel industries and the waste sector remain the same in 2025 as their shares in 2005.

Figure 2-3. Michigan gross GHG emissions by sector, 1990–2025: historical and projected



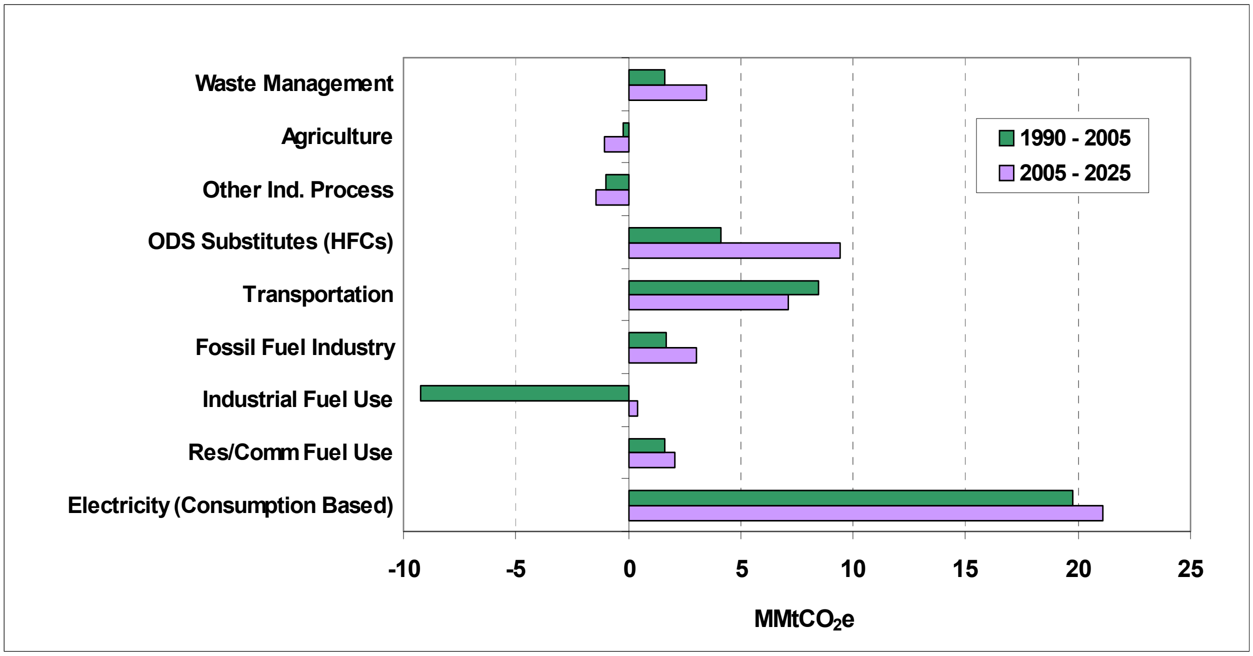
$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone-depleting substance; Ind. = industrial.

Emissions associated with electricity consumption are projected to be the largest contributor to future GHG emissions growth, followed by emissions from ozone-depleting substance substitutes (HFCs), and then emissions associated with the transportation sector, as shown in Figure 2-4. Other sources of emissions growth include the fossil fuel industry, the RCI fuel use

[9] Total forested acreage in Michigan is 19.3 million acres. For acreage by forest type, see: Richard A. Birdsey and George M. Lewis. "Carbon in United States Forests and Wood Products, 1987–1997: State-by-State Estimates." Michigan Estimate for 1987–1997. Available from the U.S. Department of Agriculture, Forest Service, Northern Global Change Research Program, at: http://www.fs.fed.us/ne/global/pubs/books/epa/states/MI.htm. The total land area in Michigan is 36 million acres (http://www.50states.com/michigan.htm).

sector, and the waste management sector. Table 2-2 summarizes the growth rates that drive the growth in the Michigan reference case projections, as well as the sources of these data.

Figure 2-4. Sector contributions to gross emissions growth in Michigan, 1990–2025: reference case projections



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; ODS = ozone-depleting substance; HFCs = hydrofluorocarbons; Res/Comm = direct fuel use in the residential and commercial sectors.

Table 2-2. Key annual growth rates for Michigan, historical and projected

Annual Growth Rate	1990–2005	2005–2025	Sources
Population	0.63%	0.24%	Michigan population statistics for 1990 and 2000, compiled by Michigan Information Center from US Census Bureau, are available at http://www.michigan.gov/documents/PopByCty_26001_7.pdf. Population data for 2000 to 2004 are available from Michigan Department of History, Arts, and Libraries at http://www.michigan.gov/hal/0,1607,7-160-17451_28388_28392-106981--,00.html. Michigan projections (2005–2030) available from Michigan Department of History, Arts, and Libraries at http://www.michigan.gov/hal/0,1607,7-160-17451_28388_28392-116118--,00.html.
Electricity Sales			For 1990–2005, annual growth rate in total electricity sales for all sectors combined in Michigan calculated from EIA State Electricity Profiles (Table 8) http://www.eia.doe.gov/cneaf/electricity/st_profiles/michigan.html and sales by Michigan generators calculated by subtracting T&D losses from net generations collected from EIA Annual Electric Utility Data - 906/920 database. For 2005–2025, annual growth rates are based on data that Michigan utilities provided for gross electricity sales for 2006–2025 (see Appendix II, Table 15, page 101 of *Michigan's 21st Century Electric Energy Plan*).
Total Sales[a]	1.97%	0.99%	
Michigan Sales[b]	1.05%	1.27%	
Vehicle Miles Traveled	1.6%	0.37%	Based on historical VMT and projected VMT growth rates provided by Michigan Department of Transportation and the Southeast Michigan Council of Governments.

[a] Represents annual growth in total sales of electricity by generators in Michigan to RCI sectors located within and outside of Michigan.

[b] Represents annual growth in total sales of electricity by generators in Michigan to RCI sectors located within Michigan.

EIA = Energy Information Administration; SIT = State (GHG) Inventory Tool; T&D = transmission and distribution; VMT = vehicle miles traveled.

A Closer Look at the Three Major Sources: Electricity Supply, RCI Fuel Use, and Transportation

As shown in Figure 2-2, electricity use in 2005 accounted for 36% of Michigan's gross GHG emissions (about 90 $MMtCO_2e$), which was higher than the national average share of emissions from electricity consumption (32%).[10] On a per-capita basis, Michigan's GHG emissions from electricity consumption are higher than the national average (in 2005, 8.8 tCO_2e per capita in Michigan, versus 8.1 tCO_2e per capita nationally). Electricity generation in Michigan is dominated by steam units, which are primarily powered by coal and nuclear fuel.

In 2005, emissions associated with Michigan's electricity consumption (90 $MMtCO_2e$) were about 19 $MMtCO_2e$ higher than those associated with electricity production (71 $MMtCO_2e$). The higher level for consumption-based emissions reflects GHG emissions associated with net imports of electricity from other states to meet electricity demand.[11] Projections of electricity sales for 2005–2025 indicate that Michigan will remain a net importer of electricity. Emissions from electricity imports are projected to be constant (19 $MMtCO_2e$/yr) during the 2006–2025 period. The reference case projection indicates that production-based emissions (associated with electricity generated in-state) will increase by about 21 $MMtCO_2e$, and consumption-based emissions (associated with electricity consumed in-state) will also increase by about 21 $MMtCO_2e$ from 2005 to 2025.

While estimates are provided for emissions from both electricity production and consumption, unless otherwise indicated, tables, figures, and totals in this report reflect electricity consumption emissions. The consumption-based approach can better reflect the emissions (and emission reductions) associated with activities occurring in the state, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for decision making. Under this approach, emissions associated with electricity exported to other states would need to be covered in those states' inventories in order to avoid double counting or exclusions.

Activities in the RCI[12] sectors produce GHG emissions when fuels are combusted to provide space heating, process heating, and other applications. From 1990 to 2005, emissions from RCI decreased at an annual rate of 0.8%, largely due to the decrease in industrial fuel use. In 2005, combustion of oil, natural gas, coal, and wood in the RCI sectors contributed about 24% (about 60 $MMtCO_2e$) of Michigan's gross GHG emissions, slightly higher than the RCI sector contribution for the nation (22%).

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[10] For the United States as a whole, there is relatively little difference between the emissions from electricity use and emissions from electricity production, as the US imports only about 1% of its electricity, and exports even less.

[11] 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 Projections report.

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

In 2005, the residential sector's share of total RCI emissions from direct fuel use was 39% (23.6 $MMtCO_2e$), the commercial sector accounted for 18% (11 $MMtCO_2e$), and the industrial sector's share of total RCI emissions from direct fuel use was 42% (25 $MMtCO_2e$). Overall, emissions for the RCI sectors (excluding those associated with electricity consumption) are expected to increase by 4.1% between 2005 and 2025. Emissions from the commercial sector are projected to increase more rapidly than the residential or industrial sectors, with an 18% increase from 2005 to 2025. In contrast, emissions from the residential and industrial sectors are expected to increase by only 0.5% and 1.6%, respectively, during the same period.

Like electricity emissions, GHG emissions from transportation fuel use rose steadily from 1990 to 2005, at an average annual growth rate of 1.1%. In 2005, gasoline-powered on-road vehicles accounted for about 74% of transportation GHG emissions; on-road diesel vehicles for 18%; marine vessels for 4%; aviation fuels, rail and other sources (natural gas- and liquefied petroleum gas-fueled vehicles used in transport applications) for the remaining 4%. As a result of Michigan's population and economic growth and an increase in total vehicle miles traveled, emissions from on-road gasoline use grew at a rate of 0.98% annually between 1990 and 2005. Meanwhile, emissions from on-road diesel use rose by 4.6% per year from 1990 to 2005, suggesting an even more rapid growth in freight movement within or across the state. Emissions from on-road gasoline vehicles in 2025 are projected to increase by 0.35% annually from 2005 levels, and emissions from on-road diesel vehicles are projected to increase by 1.5% annually from 2005 to 2025, with total transportation emissions expected to reach 65 $MMtCO_2e$ by 2025.

MCAC Revisions

The following identifies the revisions that the MCAC made to the inventory and reference case projections, thus explaining the differences between the final Inventory and Projections report and the initial assessment completed in January 2008:

All Sectors: The initial assessment included GHG emission projections to 2020. This was revised to extend the GHG projections to 2025 for all sectors.

Electric Supply:

- Production-based (in-state) and consumption-based generation and emissions:
  - Excluded electricity that Donald Cook nuclear plant exports to other states.
  - Replaced this nuclear generation with electricity imports from outside the state.

- Emissions from pumped storage:
  - Set emissions to zero to avoid double counting of emissions (pumps are operated by electricity purchased from grid),

- Landfill gas (LFG)/municipal solid waste (MSW) and biomass emissions:
  - Added emissions for 1990–2000 (data for non-utilities inadvertently not included in the draft inventory and forecast).
  - For 1990–2000, only the aggregated non-utility generation (generation from independent power producers) can be obtained from the Energy Information Administration (EIA)

Web site (EIA Electric Power Annual 2006). To get the disaggregated generation of LFG, MSW, and biomass for 1990–2000 from the aggregated Other Renewable Generation number in Electric Power Annual (this number excludes hydro electricity), we applied the proportions by fuel and by plant type in 2001 to the aggregated renewable numbers of 1990–2000.

- Transmission & distribution (T&D) line losses of Michigan:
  - The T&D line losses used in the draft analysis were revised based on the data provided by the Michigan Public Service Commission. The T&D loss rate of Consumers Energy/METC, Detroit Edison/ITC, and Upper Peninsula were collected. The weighted-average T&D loss rate of Michigan was computed based on the 2007 peak load on the system in each of the three regions

- Forecast for biomass net generation:
  - The forecast of biomass in the draft inventory and forecast used EIA regional projections, which show big increases in biomass generation in the forecast years. The EIA regional projections could be influenced by the existing renewable portfolio standard (RPS) in other states of the region. The electricity generation from biomass has been flat over the past 10 years or so in Michigan, about 1% of the total generation of the state. Biomass generation would be unlikely to significantly increase in Michigan in the forecast years unless there are strong policy regulations, such as an RPS. Therefore, in this report, for the business-as-usual condition in the forecast years, we assumed the same generation capacity from biomass as the existing capacity indicates (an average level of 2001–2005).

<u>Transportation</u>: MCAC approved the use of a new set of vehicle miles traveled (VMT) growth rates (for 2005–2010, 2010–2015, 2015–2020, and 2020–2025), provided by the Michigan Department of Transportation; this replaces the previous VMT growth rates used in the draft inventory and forecast.

<u>Industrial Process</u>: The MCAC revised iron and steel emissions by replacing the default State Inventory Tool (SIT) steel production data with crude steel production data provided by MDEQ for 1990–2005.

<u>Fossil Fuel Industry</u>: The MCAC added new estimates of the CO_2, CH_4, and N_2O emissions from the combustion of natural gas by internal combustion engines used to operate pipeline compressor stations. These emissions were not included in the initial assessment. These pipeline natural gas fuel use emissions were estimated using SIT emission factors and Michigan 1990–2005 natural gas data from EIA.

<u>Agriculture</u>: Projections for livestock populations were revised based on feedback from the Agriculture, Forestry, and Waste TWG. Projections for beef cattle, swine, sheep, goats, and horses were estimated based on logarithmic forecasts of the historical 1990–2005 populations. Poultry populations were held at 2005 levels based on input from the poultry industry.[13]

[13] C. Vollmer-Sanders, MI Farm Bureau, communicated to R. Anderson, CCS, via telephone, May 2008.

Waste Sector: In the initial assessment, CH_4 captured for flaring and use in landfill gas to energy (LFGTE) plants were estimated with SIT defaults. The revised estimates are based on waste emplacement data for controlled landfills and date of emission capture equipment installation. Information on controlled landfills was obtained from MDEQ and a database of LFGTE projects compiled by the U.S. Environmental Protection Agency (EPA).

Open burning of MSW at residential sites was not estimated in the initial assessment. The revised report includes these emissions, which were obtained from EPA's 2002 National Emissions Inventory for estimates of the quantity of waste burned at residential sites in Michigan.[14]

Forestry: CO_2 flux estimates for 1994–2005 were revised to be based on the average calculated flux during this period using the Carbon Calculation Tool. This was done to minimize the influence of estimates in individual years and shifts between U.S. Forest Service Forest Inventory and Analysis (FIA) measurements.

Key Uncertainties

Some data gaps exist in this inventory, particularly in the reference case projections. Key tasks for future refinement of this inventory and forecast include review and revision of key drivers, such as the transportation, electricity demand, and RCI fuel use growth rates that will be major determinants of Michigan's future GHG emissions (see Table 2-2 and Figure 2-4). 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.

[14] EPA, ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/nonpoint/2002nei_final_nonpoint_documentation0206version.pdf.

Chapter 3
Energy Supply Sector

Overview of GHG Emissions

The energy supply (ES) sector includes greenhouse gas (GHG) emissions from the production, processing, transmission, and storage of electricity and fossil fuels. Electricity generation accounts for the vast majority of these emissions, representing 93% of Michigan's total ES sector emissions in 2005. Nearly all of the remainder comes from the production, processing, transmission, and distribution of natural gas. GHG emissions from the ES sector represented 45% of Michigan's total consumption-based emissions in 2005.

Michigan has historically been a net importer of electricity. Electricity imports increased from about 8,500 gigawatt-hours (GWh) in 1990 to about 25,000 GWh in 2000, which is comparable to total imports in 2005, or 21% of all electricity consumed in Michigan[1]. GHG emissions from imported electricity represented the same percentage (21%) of total consumption in 2005.

In the absence of any mitigation efforts, GHG emissions from Michigan's ES sector are expected to increase from 2005 base year levels of 90 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) to 111 $MMtCO_2e$ in 2025, or about a 23.3% increase. Compared with estimated current (2009) emissions of 89.5 $MMtCO_2e$, a 26% increase is expected.[2] Projections of future electricity generation requirements are taken from *Michigan's 21st Century Electric Energy Plan,* prepared by the Michigan Public Service Commission (MPSC). Projections assume electricity imports throughout the forecast period will remain at 2005 levels, and that in-state and imported generation fuel mix will also remain unchanged. Figure 3-1 shows historical and projected GHG emissions from power generation by fuel source.

Key Challenges and Opportunities

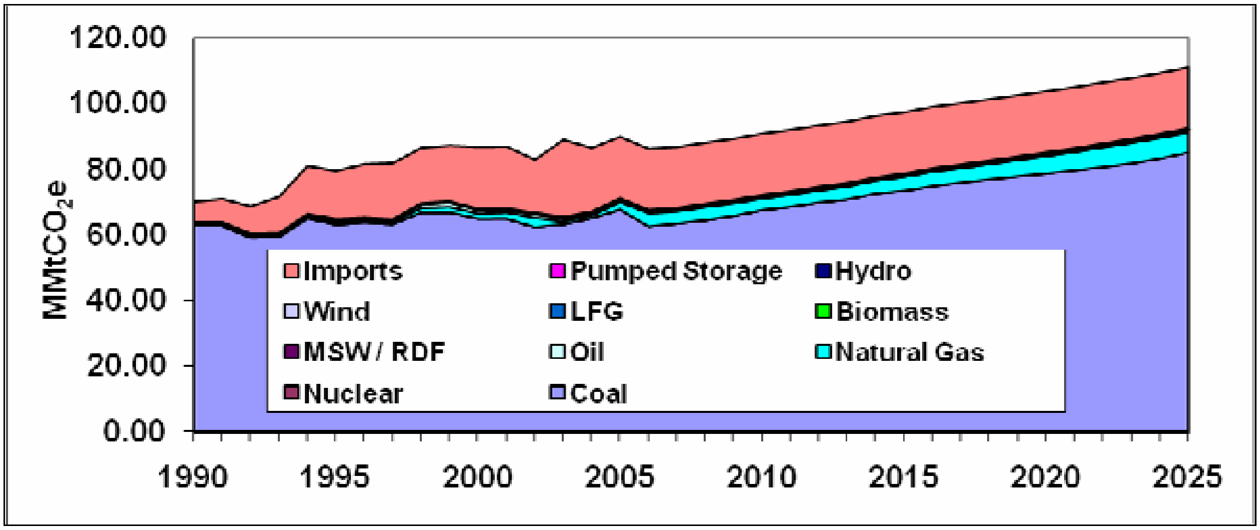
The biggest challenge facing Michigan's ES sector is the state's high reliance on coal-fired generation, and the age of the coal generation fleet, which is the second oldest in the nation. GHG emissions from the combustion of coal for the generation of electricity represent 95% of all electricity emissions, with almost all of the remainder being natural gas. Figure 3-2 shows the breakdown of in-state gross electricity generation and in-state GHG emissions by fuel type for 2005. Another challenge is increasing demand, which is projected at 1% per year (2005–2025) and assumed to be fully met through new in-state generation. This rate incorporates the current demand-side management programs in Michigan.

While the age of Michigan's coal-burning power generation fleet is a challenge, it is also an opportunity. Many plants will be candidates for retrofit or replacement within the forecast period, so the opportunity to move to lower-GHG fuels and advanced coal combustion technology is substantial. Michigan is blessed with significant wind and biomass generation

[1] Imports are estimated by taking the difference between the total electricity sales in Michigan and the sales from the in-state power generation. The data sources for the total electricity sales and the sales from in-state sources are EIA Annual Energy Outlook, 1996-2007 Editions.
[2] A more comprehensive treatment of Michigan's ES inventory and forecast projections can be found in Appendix A1 of the companion document, *Final Michigan Greenhouse Gas Inventory and Reference Case Projections 1990–2025*, Center for Climate Strategies, November 2008.

potential, and contains unusual geologic formations that offer significant potential for in-ground CO_2 storage. Several demand-side management, energy efficiency, and conservation measures recommended in the residential, commercial, and industrial sectors are detailed in Chapter 5 of this report.

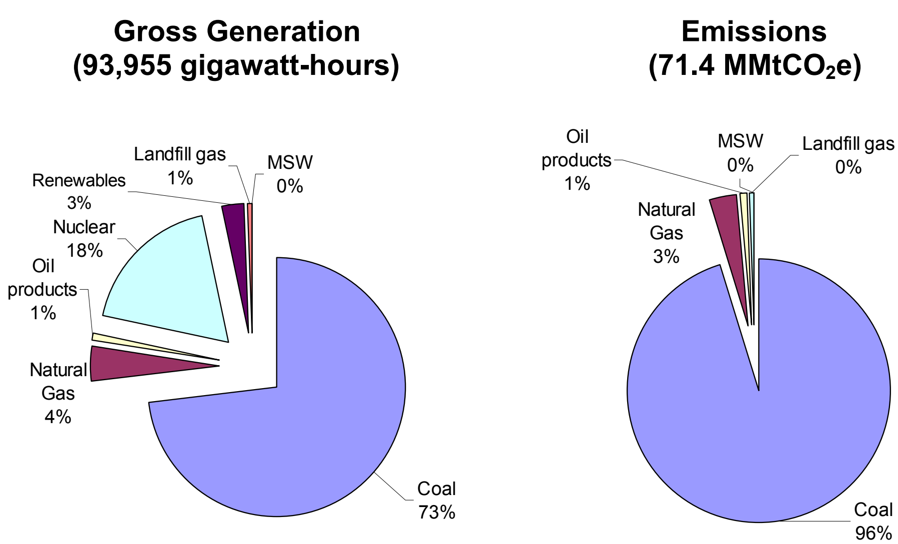
Figure 3-1. Recent and projected GHG emissions from the electricity sector, Michigan, 2005–2025 (consumption basis)



Source: *Final Michigan Greenhouse Gas Inventory and Reference Case Projections 1990–2025,* Center for Climate Strategies, November 2008.

LFG = landfill gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MSW = municipal solid waste, RDF = refuse-derived fuel.

Figure 3-2. Breakdown of Michigan in-state generation and CO_2 emissions—2005 base year



$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MSW = municipal solid waste.

Overview of Policy Recommendations and Estimated Impacts

The Michigan Climate Action Council analyzed and is recommending several policies for the ES sector that offer the potential for significant GHG emission reductions, as summarized in Table 3-1.

Table 3-1. Summary results for energy supply policy recommendations and existing actions

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
RECENT ACTION	PA 295, Clean, Renewable, and Efficient Energy Act	2.7	2.0	30.8	$1,024	$33	N/A
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	5.0	14.6	137.5	$6,600	$48.00	Unanimous
	RPS	4.6	13.7	129.5	$5,546	$42.83	
	Wind	3.7	10.3	100.4	$4,748	$47.31	
	Biomass	0.9	2.7	25.2	$376	$15	
	Solar PV	0.0	0.4	2.6	$392	$152	
	Plasma Gasification	0.0	0.3	1.3	$29	$22	
	Distributed Generation "Carve-Out"	0.4	0.9	8.0	$1,054	$131.51	
	Solar Hot Water	0.0	0.2	1.2	$26	$22.27	
	Geothermal	0.1	0.2	1.5	$82	$55	
	Wind (distributed)	0.1	0.3	2.7	$503	$186	
	Solar PV (distributed)	0.1	0.2	1.84	$508	$276	
	Biogas	0.1	0.2	2.3	$17	$7	
ES-3	Energy Optimization Standard	0.0	13.6	86.3	–$1,632	–$19	Unanimous
ES-5	Advanced Fossil Fuel Technology (e.g., IGCC, CCSR) Incentives, Support, or Requirements	*Not Quantifiable*					Unanimous
ES-6	New Nuclear Power	0.0	6.3	38.5	$1,001	$25.98	Majority[3]
ES-7	Integrated Resource Planning (IRP), Including CHP	*Not Quantifiable*					Unanimous
ES-8	Smart Grid, Including Advanced Metering	*Not Quantifiable*					Unanimous
ES-9	CCSR Incentives, Requirements, R&D, and/or Enabling Policies	*Not Quantifiable*					Unanimous
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration						Majority[4]
	Co-firing at 5%	0.2	0.2	3.3	$34.48	$10.6	

[3] 6 opposing votes [Pollack, Ettawageshik, Garfield, Heifje, Bazzani and Overmeyer] and 2 abstentions [Martinez and Calloway for Bierbaum]
[4] 3 opposing votes [Garfield, Pollack and Heifje]

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)	Level of Support
		2015	2025	Total 2009–2025			
	Co-firing at 10%	0.5	0.5	6.5	$69.43	$10.7	
	Co-firing at 20%	0.9	0.9	13.0	$134.09	$10.3	
ES-11	Power Plant Replacement, EE, and Repowering	2.5	2.0	33.2	$313	$9.4	Unanimous
ES-12	Distributed Renewable Energy Incentives, Barrier Removal, and Development Issues, Including Grid Access - TOTAL	*ES-12 Fully incorporated in distributed generation "carve-out" under ES-1.*					Unanimous
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.4	0.5	7.8	$31.91	$4.09	Unanimous
ES-15	Transmission Access and Upgrades	*Not Quantifiable*					Unanimous
	Sector Totals	**8.1**	**37.2**	**306.6**	**$6,348**	**$22**	
	Sector Total After Adjusting for Overlaps	**8.1**	**23.6**	**220.3**	**$7,980**	**$36**	
	Reductions From Recent Actions	**2.7**	**1.9**	**30.1**	**$1,025**	**$34**	
	Sector Total Plus Recent Actions	**10.8**	**25.5**	**250.4**	**$9,005**	**$36**	

$/t$CO_2$e = dollars per metric tons of carbon dioxide equivalent; CCI = Cross-Cutting Issues; CCSR = carbon capture and storage or reuse; CHP = combined heat and power; EE = energy efficiency; GHG = greenhouse gas; IGCC = integrated gasification combined cycle; IRP = integrated resource planning; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = millions of metric tons of carbon dioxide equivalent; N/A = not applicable; PA = Public Act; PV = photovoltaic; R&D = research and development.

Note: The numbering used to denote the policy recommendation is for reference purposes only; it does not reflect prioritization among these important recommendations.

These recommendations include efforts to extend and expand Public Act (PA) 295, the Clean, Renewable and Energy Efficiency Act (ES-1 and ES-3), promote the development and use of advanced fossil fuel technologies (ES-5 and ES-9), expand the use of nuclear power (ES-6), promote integrated resource planning and combined heat and power (ES-7 and ES-13), convert to a "smart grid" (ES-8), advance the use of emerging technologies (ES-10), promote improved efficiency or replacement of older generating units (ES-11), promote the expanded use of small-scale distributed generation, including renewable energy payments (ES-1 and ES-12), and improve transmission and distribution system efficiency and access. In addition to the recent actions contained in PA 295, these policy recommendations contribute to GHG emission reductions during 2009–2025, as outlined in Table 3-1.

Overall, the ES mitigation recommendations and recent actions yield annual GHG emission reductions from reference case projections of about 25.5 $MMtCO_2e$ in 2025 and cumulative reductions of 250.4 $MMtCO_2e$ from 2009 through 2025, at a net cost of approximately $9 billion through 2025 on a net present value basis. The weighted-average cost of reduced carbon for the ES measures is about $36/t$CO_2$e avoided. An overview of each policy recommendation is provided in this chapter. Additional details regarding the application of these recommendations to Michigan (targets, implementation mechanisms, parties involved, modeling approach, etc.) are provided in Appendix F.

Energy Supply Sector Policy Descriptions

The ES sector has several opportunities for mitigating GHG emissions from electricity generation, including mitigation activities associated with the generation, transmission, and distribution of electricity—whether generated through the combustion of fossil fuels, renewable energy sources in a centralized power station supplying the grid, or distributed generation facilities.

ES-1. Renewable Portfolio Standard (RPS)

A renewable portfolio standard (RPS) is a requirement that utilities supply a certain amount of annual retail sales from eligible renewable energy sources by a certain date and each year thereafter. This recommendation endorses the RPS contained within PA 295 through 2015, and then adopts the Midwestern Governors Association platform goals from 2015 through 2025. Beyond reducing utility-sector emissions of CO_2, benefits to Michigan would include lower emissions of smog and soot precursors, improved energy balance of trade, diversified fuel supply, and economic development potential. Twenty-four states plus the District of Columbia have adopted some form of an RPS. In the Midwest, these include Illinois (25% by 2025), Minnesota (27.4% by 2025), Ohio (12.5% by 2025), and Wisconsin (10% by 2015). This policy assumes that the provisions of ES-12, Distributed Generation (DG), are included here. The DG policy design in ES-12 is incorporated through a "carve-out," or guarantee, within ES-1 for both the 2015 and the 2025 goals.

ES-3. Energy Optimization Standard (EOS)

Energy optimization means energy efficiency, load management that reduces overall energy use, and related energy conservation. An energy optimization standard (EOS) requires energy savings as a percentage of total annual retail electricity sales in megawatt-hours and total annual retail natural gas sales in decatherms or equivalent thousand cubic feet in a specified year. To accomplish this, electric and natural gas providers are to develop energy optimization plans sufficient to ensure the achievement of applicable EOSs. In the Midwest, states that have adopted this policy mechanism include Minnesota (1.5% annual energy savings), Illinois (1% annual energy savings by 2011, 2% annual energy savings by 2015), and Ohio (1% annual energy savings by 2014, 2% annual energy savings by 2019). EOS goals mirror requirements under PA 295 through 2012, and then expand and extend the requirements through 2025.

ES-5. Advanced Fossil Fuel Technology

Advanced fossil fuel-based electric generation technologies include those that can be more efficient and thus lower emitting than current or older technologies. Advanced technologies combined with carbon capture and sequestration (and geostorage) or reuse (CCSR), may have the potential to materially lower CO_2 emissions associated with fossil fuel-based electricity generation. Such technologies include (but are not limited to) circulating fluidized-bed combustors, integrated gasification combined-cycle units, and pulverized coal (advanced supercritical and ultra-supercritical units). The proposed policy has three elements: a post-combustion technology pilot and demonstration project applied to a single coal unit; analysis and report on a Michigan-specific comparison of the costs and benefits of advanced methods against existing coal technologies from a GHG reduction and cost perspective; and use of financial incentives, performance requirements, mandates, or other measures to encourage or require the early adoption of CCSR.

ES-6. New Nuclear Power

Nuclear power is a large-scale low-GHG, baseload source of electricity that could complement renewable energy resources in a mix of low-GHG-emitting electric generating options. *Michigan's 21st Century Electric Energy Plan* notes that nuclear power cannot meet the need for new generation for at least 12 years due to the extremely long lead time required to bring a new nuclear plant on line. Nuclear power can, however, play a significant role in reducing GHG emissions in conjunction with other low-GHG-emitting generating technologies in the time period beyond 2020.The issue of proper storage of both existing and new nuclear waste in the Great Lakes basin is a serious issue and must be addressed. Policies that address the barriers to implementation and encourage the licensing of new nuclear plants in Michigan, as well as relicensing of existing plants, may be considered. These policies could also address opportunities for reducing the long time frame required to license and construct a new nuclear power plant. Costs and GHG reduction benefits were calculated based upon a single new plant sized at 1,550 megawatts (MW) going on line in 2020. This recommendation was approved by a majority of the MCAC but was not unanimous. There were six opposing votes [Pollack, Ettawageshik, Garfield, Heifje, Bazzani and Overmeyer] and two abstentions [Martinez and Calloway for Bierbaum]

ES-7. Integrated Resource Planning (IRP), Including CHP

Integrated Resource Planning (IRP) is a process that develops plans to meet needs for electricity services in a manner that meets multiple objectives, such as least-cost generation, emission standards, fuel diversity, and RPS requirements. An IRP process includes the evaluation of all feasible options, from both the supply and the demand sides, in a fair and consistent manner. In the IRP process, companies or the state can highlight supply-side (generation capacity) options to meet a forecasted growth in electricity demand, and can also evaluate equally technology and policy options on the demand side to satisfy the anticipated demand. In this fashion, supply and demand analyses are paired and evaluated jointly in a least-cost planning environment.

ES-8. Smart Grid, Including Advanced Metering

Smart Grid systems promote efficiency through improvements in system monitoring, control technology, and systems integration. Combining advanced metering and two-way communication to end users with the Smart Grid technology provides a system where both the utility and the customer can engage in integrated decisions, thus enabling and improving energy efficiency. In addition, a Smart Grid system allows enhanced opportunities for demand response and optimizes the deployment of distributed resources and renewable energy. This policy will provide guidelines to utilities for evaluating advanced metering infrastructure and Smart Grid technology projects, including cost-benefit analysis methodologies for determining the policy's GHG emissions benefits.

ES-9. Carbon Capture, Storage and Reuse Incentives, Requirements, R&D, and/or Enabling Policies

CCSR is a process that includes separation of CO_2 from industrial and energy-related sources, transport to a storage location, and permanent or long-term storage in isolation from the atmosphere. Michigan should initially encourage enhanced oil recovery and the accompanying modest carbon storage from this activity, and sequestration in depleted oil and gas fields within the 2–5-year time frame. By 2015, Michigan should encourage and support additional pilot/demonstration activity for deep carbon geostorage in several locations in the state. By 2020, Michigan should have a robust legal and policy framework consistent with national intent that enables full-scale industrial carbon geostorage capabilities. Some key implementation issues that will need to be explored regarding the establishment of a CCSR infrastructure include an infrastructure build-out that extends beyond Michigan, a legal and regulatory framework for geologic storage of CO_2, state-based incentives for CCSR, and comprehensive assessments of geologic reservoirs at the state and federal levels to determine CO_2 storage potential.

ES-10. Technology-Focused Initiatives

These initiatives focus on developing, promoting, and/or implementing one or more specific technologies that have the potential to reduce GHG emissions. Technologies could include (among others) hydrogen production and fuel cells for electricity storage, compressed air energy storage systems (to enable greater penetration of intermittent renewable technologies, such as wind), or biomass co-firing. This policy would provide state government and other private and public parties with resources and incentives for analysis, targeted research and development, market development, and adoption of GHG-reducing technologies that are not covered by other policies. The specific goal would be to maximize effective use of biomass for co-firing at appropriate coal plants as soon as practicable. This recommendation was approved by a majority of the MCAC but was not unanimous. There were three opposing votes [Garfield, Pollack and Heifje].

ES-11. Power Plant Replacement, EE, and Repowering

Michigan has the second-oldest fleet of power plants in the nation. The state will most likely be facing the retirement or repowering of a number of old, less efficient units within the time frame of this planning process. The opportunity to replace aging units and reduce GHG-intensive imports with more efficient in-state generation could offer a reduction in GHG emissions from this sector. Furthermore, existing coal-based generation technologies may benefit from additional technologies and upgrades to make their fuel burning more energy efficient (EE), resulting in more electric output for the amount of fuel burned. Policies to encourage generation efficiency improvements, repowering of existing plants, or power plant replacement(s) could include incentives or regulations as described in other options, with adjustments for financing opportunities and emission rates of existing plants.

ES-12. Distributed Renewable Energy

This recommendation focuses on removing barriers to and providing incentives to encourage the development of distributed renewable energy throughout the state. Distributed renewable energy is generally defined as small scale (generally less than 10 MW), located at or near the point of end use, interconnected to the distribution (as opposed to transmission) system, and more likely to have homeowner or community ownership. Increasing the use of distributed renewable energy provides electricity reliability, security, and environmental benefits. The preferred policy design would include a well-designed and fully implemented renewable energy payment (REP) program. A REP program may be designed to promote and encourage development of renewable energy projects of all sizes, ranging from small residential up to the largest utility-scale projects. The costs and benefits of this policy are incorporated into the DG "carve-out" under ES-1.

ES-13. Combined Heat and Power (CHP)

Every business in Michigan that uses energy to heat and/or cool its buildings or as part of a production process is technically a candidate to simultaneously also generate electricity at its site, using one of several commercially proven and widely used combined heat and power (CHP) technologies. CHP technologies, also referred to as "co-generation," include steam turbines with steam extraction or back pressure, gas turbines with waste heat recovery boilers, combined-cycle units, reciprocating engines with manifold exhaust and cooling heat recovery, as well as less proven technologies, such as fuel cells and Stirling engines. To achieve this goal, it will be necessary to revise regulatory policies and remove institutional barriers to allow distributed renewable energy and CHP systems to compete on a level playing field with other sources of electric and thermal energy.

ES-15a. Transmission Access and Upgrades

Various efficiency measures can be implemented to reduce transmission line losses of electricity. By reducing constraints in the transmission system, improved transmission facilities reduce congestion, hence reducing energy costs and GHG emissions and improving the efficiency of the transmission and generation system. To facilitate widespread adoption of renewable energy technologies, the current transmission system requires upgrades and additions. Renewable energy facilities may require the addition of new or improved transmission lines that must be seamlessly integrated into the transmission grid. Among other things, the policy calls for Michigan to implement a "transmission system efficiency study" to determine the most cost-effective measures to reduce line losses and improve overall system reliability and management, including improving access for new generation assets, such as renewable energy, CHP, and DG projects.

ES-15b. Distribution System Access and Upgrades

Various energy efficiency measures can be implemented to reduce distribution line losses of electricity. Regulations, incentives, and/or support programs can be applied to achieve greater efficiency of distribution system components. Such distribution system improvements will help reduce line losses and improve and manage outages, as well as enable renewable energy systems, including DG and CHP projects, to interconnect to the grid. Among other things, this policy calls for implementation of a distribution system efficiency study for Michigan to determine the most cost-effective measures to reduce line losses and improve overall distribution system reliability and management, including improving access for new generation assets, such as renewable energy, CHP, and DG projects.

Chapter 4
Market Based Policies

Overview of Market Based Policies

The Market Based Policies (MBP) technical working group (TWG) was created mid-way through the MCAC planning process in response to concerns from members of the Cross Cutting Issues (CCI) and Energy Supply (ES) TWGs that some of the policies under consideration in both TWGs required more time and attention than either could provide. After reviewing a variety of options, the MCAC decided to create a new Market Based Policies (MBP) TWG and transfer selected policies under the new group's jurisdiction. The policies of principle concern were the cap-and-trade proposal and the carbon tax proposal, but a handful of related policies were also moved. The MBP TWG renumbered and reorganized the transferred policies. The MBP TWG members were self-selected volunteers from the ES, CCI and Residential, Commercial and Industrial (RCI) TWGs.

These policies selected for approval by the MCAC are different from most other recommendations in that they are not sector-specific and they rely upon economic incentives to achieve GHG mitigation targets. One of the three recommendations requires interstate action and one is a process recommendation. During the TWG's discussions several options were merged. One policy option [a carbon tax] was not approved by a majority of the MCAC.

Key Challenges and Opportunities

Congress is expressing renewed interest in national cap-and-trade legislation, and President Obama has indicated his support for the approach. Three regions within the US are moving ahead with the development and implementation of interstate or international programs – the Northeastern Regional Greenhouse Gas Initiative (RGGI), the Western Climate Initiative (WCI) and the Midwestern Greenhouse Gas Reduction Accord (MGA).

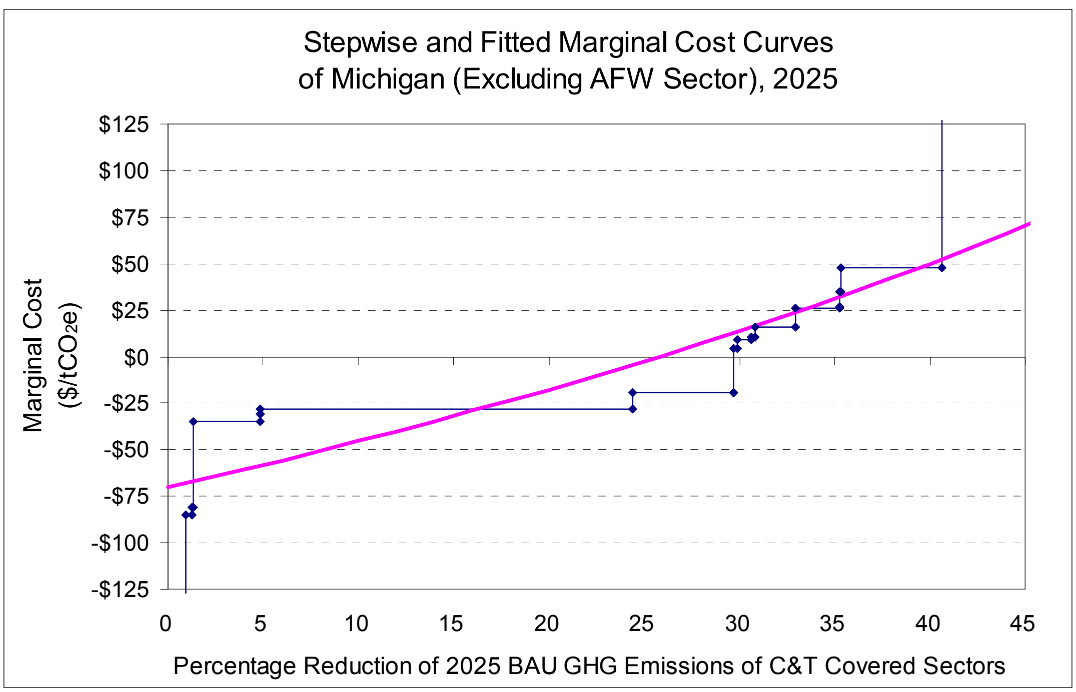
Michigan is actively participating in the development of the Midwestern Regional Greenhouse Gas Reduction Accord. The policy issues confronting the Midwestern Accord Partners will need to be evaluated regionally and by each Partner jurisdiction, and then negotiated until agreement is reached. These recommendations are offered to advise Michigan on the key program design features that Michigan should support in these regional negotiations.

It is believed that Michigan and all other participating jurisdictions in the cap-and-trade program will benefit from the combination of non-market based policies and measures such as those proposed for the sectors and the cap-and-trade program. The cap-and-trade program allows the achievement of GHG mitigation goals (the "cap") at lower cost than would otherwise be possible, and many of the non-market based policies and measures serve to remove barriers that otherwise would obstruct access to many of the low cost options. The cap also serves to ensure that GHG reduction goals are achieved even if the non-market based policies fail to perform as expected.

The relationship between the policies and measures recommended elsewhere in this report and the benefit offered by the overlay of a cap-and-trade program can be seen in a marginal cost curve as shown in Figure 4-1. This figure ranks each of the recommended policies from left to right in ascending order of cost. The horizontal (x) axis represents the percentage of GHG emission reduction, and the vertical axis represents the measure's marginal cost or savings. In the figure, each horizontal segment represents an individual mitigation option. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost or saving of reducing one metric ton of GHG with the application of the policy. The figure indicates that, collectively, the reduction potential of recommended policies from all economic sectors (excluding Agriculture, Forestry and Waste Management in this example) can avoid about 40% of 2025 baseline emissions in Michigan.

When regulated sources have the opportunity to purchase and sell emissions credits through an interstate market, the relative costs and benefits from comparable mitigation measures in all participating states become fungible. Lower cost options in one state can be developed in surplus with funding coming from sources facing higher cost options in another state. The market 'seeks out and finds' the lowest cost mitigation necessary to achieve the cap. In this way, both the sources in the states with low cost mitigation opportunities, and the sources in the states with high cost mitigation realize an economic benefit from the transaction.

Figure 4-1. Stepwise and fitted marginal cost curve of Michigan (excluding AFW sector), 2025[1]



AFW = agriculture, forestry, and waste management; BAU = business as usual; C&T = cap and trade; GHG = greenhouse gas.

[1] It should be noted that the data represented in this cost curve were derived from the Council's quantified policy recommendations, as approved. Due to the fact the Council included only a subset of all possible measures that could be taken to reduce CO2, they do not represent the full range of potential policies for an economy-wide cost curve.

Overview of Policy Recommendations and Estimated Impacts

The MCAC analyzed and is recommending three market-based policies of which only MBP-1, Cap-and-Trade, was quantified. Cap-and-trade modeling is limited to a single year, therefore cumulative costs and benefits are not available. The analysis does, however, project the program's total net economic benefit to Michigan in the target year, cost effectiveness, the flow of emissions allowances (permits) between participating jurisdictions and the allowance price. Two initial allowance distribution scenarios were modeled: free granting of allowances to regulated sources (grandfathering) and the sale of 100% of allowances by auction. Table 4-1 gives Michigan's GHG reductions and cost savings in 2020 for both the free granting and auction cases. Note that auction-case costs do not include the payments from the bidder to the state for the purchase of allowances at auction. This information can be found in table G-1-2 and Annex-1 in Appendix G.

Table 4-1. Summary results for energy supply policy recommendations and existing actions

No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2020	2025	Total 2009–2025			
MBP-1	Cap-and-trade: 20% below 2005 by 2020 (*free granting allowances*)[2]	92.48				–$25.83	Unanimous
	Cap-and-trade: 20% below 2005 by 2020 (*auctioning allowances)*[3]	92.48				–$19.33	
MBP-3	Michigan Joins Chicago Climate Exchange	*Not Quantified*					Unanimous
MBP-6	Market advisory group	*Not Quantifiable*					Unanimous

Note: The numbering used to denote the policy recommendation is for reference purposes only; it does not reflect prioritization among these important recommendations. (Gaps in numbers are due to merger of several MBP policies and rejection of one.)

Market Based Policy Descriptions

The three recommended MBP policies include the cap-and-trade program, a Michigan "lead-by-example" policy and a cap-and-trade supporting policy . They are summarized below and presented in greater detail in Appendix G.

[2] These results include mitigation costs, including payments or revenues resulting from the purchase or sale of allowances between MI emitters and out-of-state MGA partners.

[3] These results include mitigation costs but do not include payments to the state by MI emitters for the purchase of allowances at auction. The cost and revenue implications of distribution of allowances by auction can be found in table G-1-2 and Annex-1 in Appendix G.

MBP-1. Cap-and-Trade

A cap-and-trade system works by setting an overall limit on emissions (the "cap") and either selling or distributing, at no cost, emissions "allowances," or permits, to regulated entities or sources. These regulated entities must periodically surrender enough allowances to match their reported emissions or face a penalty. Cap-and-trade creates a financial incentive for emitters to continually seek out new emission-reducing options and cut their emissions as much as possible. By creating a market for the allowances, regulated entities have the choice of either purchasing allowances or directly reducing emissions and, as a result, resources are directed to the most cost-effective emissions reduction investments. To achieve overall emissions reductions over time, programs gradually lower the emissions "cap" by reducing the total number of available allowances.

The MCAC encourages national action in the implementation of a cap and trade program for the regulation of greenhouse gas emissions. In lieu of national action, or in advance of future action, Michigan should continue to participate in and encourage the development of the Midwestern Accord program. Michigan should not seek to create its own one-state cap and trade program. It is recommended that the program have the broadest possible sector coverage as soon as possible to include the maximum possible number of low cost mitigation and sequestration options. The MCAC does not make a specific recommendation on the method by which allowances are initially distributed (free granting, auction, both, etc.), but regardless of distribution method, the MCAC agrees that the *value* represented by the allowance should benefit the residents of Michigan.

MBP-3. Michigan Joins the Chicago Climate Exchange (CCX)

The Chicago Climate Exchange (CCX), launched in 2003, is the world's first and North America's only active voluntary, legally binding integrated trading system to reduce emissions of all six major greenhouse gases (GHGs), with offset projects worldwide. CCX emitting Members make a voluntary but legally binding commitment to meet annual GHG emission reduction targets. Those who reduce below the targets have surplus allowances to sell or bank; those who emit above the targets comply by purchasing CCX Carbon Financial Instrument® (CFI®) contracts. The states of New Mexico and Illinois are Members of CCX.

By joining the CCX Michigan state government will lead by example. Michigan will inventory and quantify all greenhouse gas emissions from sources that result from state government operations and are under the control of state government. State government's primary sources of GHG are typically energy usage in office buildings and transportation.

MBP-6. Market Advisory Group

GHG policies have broad based impacts and implications. As a result it is helpful to look at current and future policies from a variety of viewpoints. Some states have looked at forming groups of experts to help them evaluate both the intended and unintended consequences of GHG policies. The MCAC recommends the creation of a formal Market Advisory Group, appointed by the governor or appropriate agency head and approved by the Legislature, and working in support of the governmental agency charged with the program. The advisory group would hold regular meetings and have defined responsibilities, to include looking at the economic feasibility of implementing GHG reduction policies. In addition to offering expert advice on the design of market-based policies, the group would catalog current policies and laws in state and local government, assess how each contributes to or reduce GHGs, and provide guidance to the state's policy makers on the design of any future compliance programs to manage GHG emissions.

Chapter 5
Residential, Commercial, and Industrial Sectors

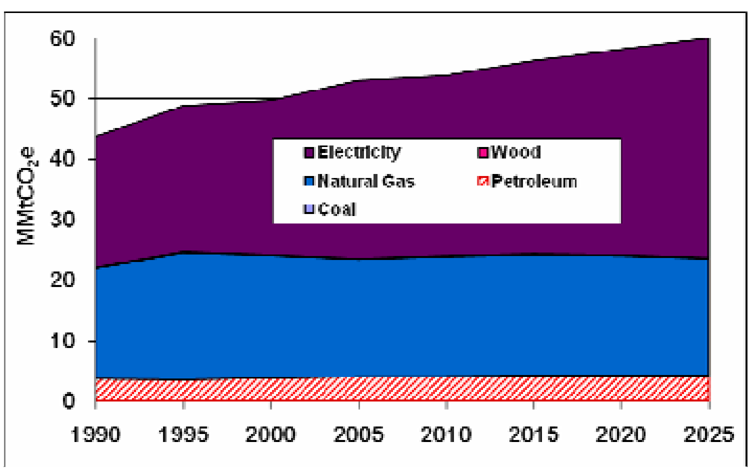
Overview of Greenhouse Gas Emissions

Activities in the residential, commercial, and industrial (RCI) sectors produce greenhouse gas (GHG) emissions when fuels are combusted to provide space heating, process heating, and other applications. In 2005, combustion of oil, natural gas, and coal in the RCI sectors contributed about 60 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) to Michigan's gross GHG emissions. These sectors contributed 24% of the 248 MMt of GHG that the state emitted overall, slightly higher than the national average of 22% for these sectors. Residential sector emissions make up approximately 40% of RCI GHG emissions; commercial sector emissions, approximately 18%;, and industrial sector emissions, approximately 42%.

Considering only the direct emissions that occur within buildings and industries, however, ignores the fact that nearly all electricity sold in Michigan is consumed for RCI activities. If the emissions from all three subsectors of RCI are included (i.e., direct fuel use, emissions associated with electricity consumption, and industrial processes), they total about 68% of the state's gross GHG emissions in 2005. Therefore, the state's future GHG emissions will depend heavily on future trends in the consumption of electricity and other fuels in the RCI sectors.

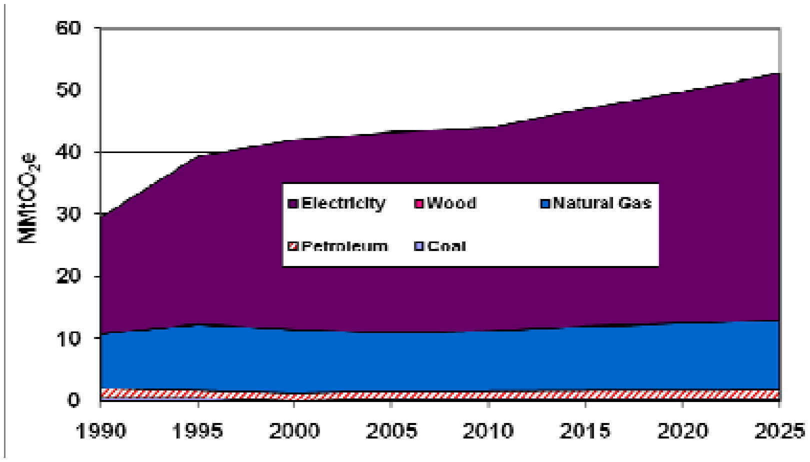
Figures 5-1 through 5-3 show the trend in GHG emissions from the RCI sectors through 2025. The figures also show the relative shares of GHG emissions, by fuel. Overall, emissions for the RCI sectors (excluding those associated with electricity consumption) are expected to increase by 4.1% between 2005 and 2025. For the 20-year period beginning in 2005 and ending in 2025, the fastest growth in GHG emissions is in the commercial sector, which is forecast to grow by 1.0% annually. GHG emissions in the residential and industrial sectors are expected to grow by 0.6% per year during this period.

Figure 5-1. Historical and projected residential greenhouse gas emissions in Michigan: 1990–2025*



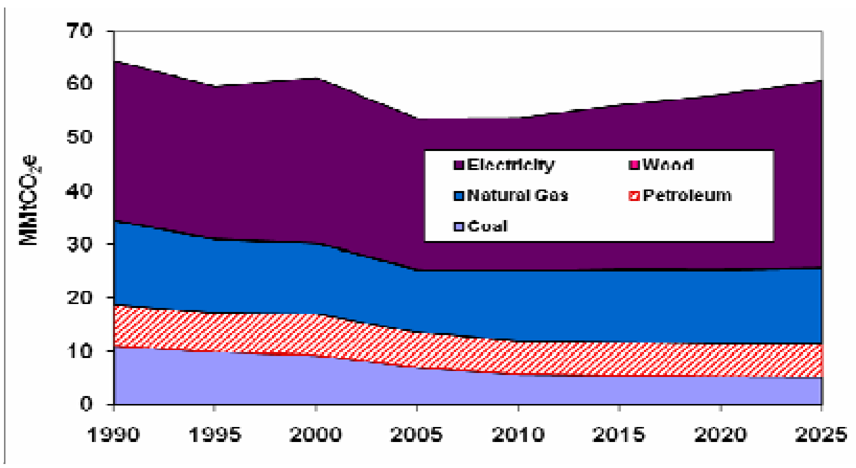
* Emissions associated with the direct use of natural gas, petroleum, coal, and wood and the consumption of electricity. Source: Consolidated Michigan Inventory and Forecast.

Figure 5-2. Historical and projected commercial sector greenhouse gas emissions in Michigan: 1990–2025*



* Emissions associated with the direct use of natural gas, petroleum, coal, and wood and the consumption of electricity. Source: Consolidated Michigan Inventory and Forecast.

Figure 5-3. Historical and projected industrial greenhouse gas emissions in Michigan: 1990–2025*



* Emissions associated with the direct use of natural gas, petroleum, coal, and wood and the consumption of electricity. Source: Consolidated Michigan Inventory and Forecast.

The projections for the period beginning in 2005 show almost no change in the overall shares of emissions that the different sectors produce. The residential sector produces 35% of total RCI GHG emissions in both 2005 and 2025; the commercial sector, produces 29% in 2005 and 30% in 2025; and the industrial sector, 36% in 2005 and 35% in 2025.

Much of the growth in GHG emissions over the period can be attributed to an average 0.94% annual growth in electricity demand over the 2005–2025 period for the RCI sectors. GHG emissions from electricity for each of the three sectors are projected to grow by 1.1% per year between 2005 and 2025.

Emissions associated with the generation of electricity to meet RCI demand account for about 55% of the emissions for the residential sector, 72% of the emissions for the commercial sector, and 52% of the emissions for the industrial sector, on average, over the 1990–2025 period. From 1990 to 2025, natural gas consumption is the next-highest source of emissions for the residential and commercial sectors, accounting, on average, for about 38% and 24% of total emissions, respectively. For the industrial sector, emissions associated with the combustion of coal, natural gas, and petroleum account for about 13%, 23%, and 12%, respectively, on average, from 1990 to 2025.

Key Challenges and Opportunities

The principal means to reduce RCI emissions include improving energy efficiency, substituting electricity and natural gas with lower-emission energy resources (such as biomass and wind), and various strategies to decrease the emissions associated with electricity production (see Chapter 3, Energy Supply Sectors). The state's limited pursuit of energy efficiency until recent years offers abundant opportunities to reduce emissions through programs and initiatives to improve the efficiency of buildings, appliances, and industrial practices. The advantages of having "low-hanging fruit" in the form of low-cost energy efficiency opportunities in the RCI sectors are countered by an underdeveloped private sector that will likely be responsible for scoping, implementing, and evaluating energy efficiency projects. These "green collar" jobs require special training and equipment that will take time for firms within the state to acquire.

Michigan has recently embarked on statewide energy efficiency programs in response to concerns about energy costs and carbon emissions. Public Act (P.A.) 295, enacted in 2008, adopted a requirement that electric providers achieve annual incremental energy savings in 2012, 2013, 2014, and 2015, and each year thereafter, equivalent to 1% of total annual retail electricity sales in megawatt hours in the preceeding year. Additionally, natural gas providers must achieve annual incremental energy savings in 2012, 2013, 2014, and 2015, and each year thereafter, equivalent to 0.75% of total annual retail natural gas sales in decatherms or equivalent thousands of cubic feet (MCF) in the preceeding year. It should be noted that incremental energy savings begin ramping up in 2008 and continue through and beyond 2015 as stipulated in P.A. 295. Further, in order to ensure this outcome, each provider must file an annual report of its progress in meeting the energy optimization portfolio with the Michigan Public Service Commission. The Commission is now developing rules and guidance to implement these programs.

The Michigan Climate Action Council (MCAC) has identified significant opportunities for reducing GHG emissions growth attributable to the RCI sectors in the state. These include expanding or launching utility demand-side management programs for electricity and natural gas and removing disincentives to efficiency investments by utilities; adopting incentives, assistance, and updated building codes to increase energy efficiency in buildings; adopting incentives and net metering for renewable energy systems implementation; enhancing consumer education and professional training and certification programs; and devoting greater attention to the energy requirements associated with water use and management in the state. The MCAC has also identified significant opportunities to reduce GHG emissions through policies addressing electricity production; these are detailed in Chapter 3.

Overview of Policy Recommendations and Estimated Impacts

The MCAC unanimously recommends a set of 10 policies for the RCI sectors, several of them in close concert with parallel policies in the energy supply (ES) sector. These policies offer significant, cost-effective GHG emissions reductions within the state. These recommendations and results are summarized in Table 4.1. The GHG emission reductions and costs per ton of GHG reductions for five of these policies were quantified. The quantified policy recommendations could lead to emission savings from reference case projections of:

- 64.9 $MMtCO_2e$ per year by 2025, and a cumulative savings of 523.9 $MMtCO_2e$ from 2009 to 2025, and
- Net cost savings of over $13 billion through 2025 on a net present value basis.[1] The weighted-average costs of these policies are a net savings of nearly $25/$tCO_2e$.

Because most energy use occurs in buildings, the recommended policies center on improving energy efficiency in buildings. There is overlap among the policies as to the types of activities and equipment they cover, but the text following Table 5-1 provides general guidance on how the policies complement each other. In brief, however, the policies focus on the following:

- RCI-1 provides for utility-operated incentives for energy efficiency that will reduce energy use.
- RCI-2 and RCI-7 lay out a set of policies to reduce overall, statewide energy use in buildings.
- RCI-3 focuses on setting regulatory policies that will establish rate structures to incentivize utilities to invest in energy efficiency, or remove disincentives that are inherent in existing utility rate structures for utilities to invest in energy efficiency.
- RCI-4 focuses on making building energy codes more stringent.
- RCI-5 and RCI-9 increase the human capital component of energy efficiency by providing education and training for energy users and energy professionals across the state.
- RCI 6 and RCI-8 focus on encouraging small-scale renewable energy capacity and generation in the state.
- RCI-10 focuses on reducing energy use among water utilities in the state.

Table 5-1. Summary list of policy recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effectiveness ($/$tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0.0	13.6	86.3	–$1,632	–$19	Unanimous
RCI-2	Existing Buildings Energy Efficiency	17.6	53.8	428.6	–$12,107	–$28	Unanimous

[1] The net cost savings, shown in constant 2005 dollars, are based on fuel expenditures; operations, maintenance, and administrative costs; and amortized, incremental equipment costs. All net present value analyses here use a 5% real discount rate.

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
	Incentives, Assistance, Certification, and Financing						
RCI-3	Regulatory (PSC) Changes To Remove Disincentives and Encourage Energy Efficiency Investments by Investor Owned Utilities (IOUs)	*Not Quantifiable*					Unanimous
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	3.6	9.8	82	–$2,865	–$35	Unanimous
RCI-5	Michigan Climate Challenge and Related Consumer Education Programs	*Not Quantifiable*					Unanimous
RCI-6	Incentives To Promote Renewable Energy Systems Implementation	0.7	1.5	14.0	$1,958	$140	Unanimous
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	15.6	47.6	380	–$11,693	–$31	Unanimous
RCI-8	Net Metering for Distributed Generation	*Fully incorporated into RCI-6*					Unanimous
RCI-9	Training and Education for Building Design, Construction, and Operation	*Not Quantifiable*					Unanimous
RCI-10	Water Use and Management	*Not Quantifiable*					Unanimous
	Sector Total After Adjusting for Overlaps*	**21.8**	**64.9**	**523.9**	**–13,014**	**–24.8**	
	Reductions From Recent Actions	**Figures adjusted include recent actions**					
	Sector Total Plus Recent Actions	**21.8**	**64.9**	**523.9**	**–13,014**	**–24.8**	

PSC = Public Service Commission; IOUs = Investor Owned Utilities; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost 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.

There is overlap in the expected emission reductions and costs among some of the policies within the RCI sectors, as well as between policies in the RCI and ES sectors. The goals laid out in RCI-2 for a 50% decrease in residential and commercial energy use and a 20% decrease in overall industrial energy use are more ambitious than similar, but smaller, goals laid out in RCI-1 and RCI-7. As a result, there is overlap among these three goals, and the most ambitious goals that are laid out in RCI-2 overlap completely with those in RCI-1 and RCI-7. The final accounting for emission reductions avoids double counting by subtracting emission reductions from RCI-1 and RCI-7 from the total. RCI-1 also overlaps with ES-3, but to avoid double counting, the emission reductions produced by ES-3 are subtracted from the total.

RCI-4, focusing on new building energy codes rather than financial incentives, does not overlap with other policies.

RCI-6, focusing on the effect of a renewable energy generation requirement from small-scale renewable energy resources, does not overlap with other policies.

There are two primary interactions between the RCI and ES sector policies, both concerning the clean energy portfolio components in policy recommendation ES-1 (Renewable Portfolio

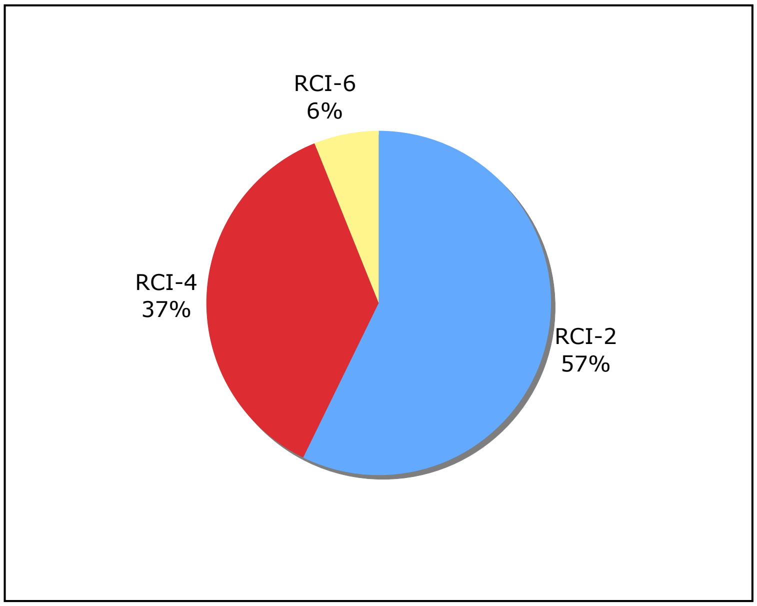
Standard). Most of the RCI policies (especially RCI-2) decrease overall electricity demand. As the renewable energy portfolio requirements are based on meeting a percentage of load with specific renewable energy, co-firing, or nuclear resources, the costs of ES-1 would be reduced by decreasing energy demand through these RCI policies. Also, an additional "feedback loop" effect is that certain ES policies (including ES-1) will have the effect of reducing GHG emissions associated with energy production, so that RCI policies that target electricity use will have a correspondingly lower impact on overall emissions. However, this impact has not been reflected in the analysis.

The policy recommendations for the RCI sectors are affected by both state and federal policies that incentivize or mandate more efficient use of energy. The federal Energy Independence and Security Act of 2007 was signed into law in December 2007. This law contains several requirements that will reduce GHG emissions as it is implemented over the next few years. These reductions were factored into the MCAC's quantification of GHG emission reductions and costs or savings.

The GHG reductions for these savings are projected to be 73.7 $MMtCO_2e$, for 2025 using the RCI Technical Work Group's (TWG's) CO_2 methodology. In addition, through P.A. 295 of 2008, Michigan enacted energy efficiency programs that will reduce GHG emissions by 3.3 $MMtCO_2e$ in 2015 using the RCI TWG CO_2 methodology and 24.6 $MMtCO_2e$ in 2025. The GHG emission reductions reported here are *net of and additional to* these existing actions. Appendix I details the assumptions and approach used to estimate reductions from these existing actions in Michigan.

Figure 5-4 shows the cumulative emission reductions from the five policy recommendations that have been quantified for the entire planning period for 2009–2025, after accounting for overlaps among these policies. There is a great deal of variation in the emission reductions from the policy recommendations. RCI-2, with its ambitious targets for energy efficiency, will have by far the greatest effect. RCI-4 will be important, but because it applies only to new construction, will be limited in its overall effect. RCI-6 is focused most heavily on new, but small-scale, generation.

Figure 5-4. Aggregate cumulative GHG emission reductions: 2009–2025*



* These are the reductions from the policy recommendations, net of overlaps between recommendations. Note, options not shown in this chart were either unquantifiable or were not counted because of overlap. Also, results have been adjusted to remove overlaps between policies; for example, RCI-7 reductions overlap with both RCI-2 and RCI-4 assuming all three policies are implemented. The chart, therefore, includes RCI-2 and RCI-4 but not RCI-7 to avoid overstating the combined benefits of the recommendations.

The policy recommendations described briefly below, and in more detail in Appendix I, not only result in significant emission reductions and overall cost savings, but offer a host of additional benefits as well. These benefits include savings to consumers and businesses on energy bills, which can have macroeconomic benefits; reduction in spending on energy by low-income households; reduced peak demand, electricity system capital and operating costs, risk of power shortages, energy price increases, and price volatility; improved public health as a result of reduced pollutant and particulate emissions by power plants; reduced dependence on imported fuel sources and correspondingly greater energy security; and green collar employment expansion and economic development.

It is also important to note that while the GHG reductions and costs or savings of these policy recommendations have been developed according to best estimates, there remains some uncertainty (e.g., due to timing, technology development, and/or more refined analysis) regarding the actual GHG reductions and costs or savings that will be revealed in their ultimate implementation. This uncertainty should be considered in the course of the state's policy prioritization and implementation decisions.

For the RCI policies recommended by the MCAC to yield the levels of savings described here, they must be implemented in a timely, aggressive, and thorough manner. This means, for example, not only putting the policies themselves in place, but also attending to the development of supporting policies that are needed to help make the recommended policies effective. While the adoption of the recommended policies can result in considerable benefits to Michigan's environment and citizens, careful, comprehensive, and detailed planning and implementation, as well as consistent support, of these policies will be required if these benefits are to be achieved.

Residential, Commercial, and Industrial Sectors
Policy Descriptions

RCI-1. Utility Demand-Side Management for Electricity and Natural Gas

By unanimous consent, the MCAC recommends increasing investment in electricity and natural gas demand-side management (DSM) programs through programs run by investor owned, municipal, and co-operative utilities, as well as energy service companies, large customers, or others. Decreasing consumption will have immediate impacts on GHG emissions. DSM activities may be designed to work in tandem with other recommended strategies that can also encourage efficiency gains.

This policy recommendation focuses on improving energy efficiency through such DSM efforts as energy efficiency, energy conservation, and peak demand reduction actions. Energy efficiency and conservation are the lowest-cost resources for reductions in electricity and natural gas use by the RCI sectors and thus for reduction of GHGs. There is a long track record of cost-effective energy efficiency initiatives at the local, state, and regional levels around the country and in Michigan. There is vast potential for improving the energy efficiency of homes, appliances, businesses, and industry in Michigan. A number of DSM efforts are already underway or mandated in Michigan, and important new energy efficiency legislation—P.A. 295 of 2008—was adopted as the MCAC was concluding its efforts.

This policy recommendation considers energy-saving goals for electricity and natural gas, and the policy, program, and funding mechanisms that might be used to achieve these goals. It is intended to work in tandem with other RCI and ES policies recommended by the MCAC; in particular, it echoes ES-3, the Energy Optimization Standard.

The goal of this policy is to bring the *total overall* demand reduction of existing actions, recent actions (including notably newly adopted P.A. 295), plus new, additional DSM activities in Michigan to save in each year 2% of the prior year's electricity use and 0.75% of the prior year's natural gas use by the residential, commercial, institutional, municipal, and industrial sectors, compared to a 3-year, weather-normalized, business-as-usual forecast that does not incorporate these goals. The policy would be implemented in three phases between 2009 and 2015, followed by a fourth, long-term phase. This goal derives in part from the efficiency goal identified in the Midwestern Governors Association's November 15, 2007, Energy Security and Climate Stewardship Platform.

RCI-2. Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing

By unanimous consent, the MCAC recommends improving the energy efficiency of existing buildings in Michigan. Because Michigan has one of the weakest energy codes in the nation, and currently utilizes many of its World War II-era industrial buildings, energy efficiency improvements provide a significant opportunity to reduce Michigan's carbon footprint. This policy would reduce energy use in existing buildings by encouraging energy efficiency upgrades and operating improvements in existing institutional, municipal, commercial, residential, and industrial buildings. Incentives, rebates, and property tax abatements are imperative to foster state-wide participation in implementing energy-efficient measures to reduce future energy generation and GHG emissions. This policy is intended to support and work in conjunction with other policies (e.g., RCI-1) to help create a sustainable and cost-effective energy efficiency program for Michigan.

The recommended goal is to reduce energy consumption per square foot of floor space in existing residential, commercial, institutional, and municipal buildings by 50% from 2002 levels by 2030, and to reduce energy consumption in the industrial sector, where building systems and process systems are often intertwined, by 20% by 2030.

RCI-3. Regulatory (PSC) Changes To Remove Disincentives and Encourage Energy Efficiency Investments by Investor-Owned Utilities (IOUs)

The MCAC unanimously recommends that regulatory changes be implemented to remove disincentives and encourage energy efficiency investments by investor-owned utilities (IOUs). Economic regulation of IOUs by the Michigan Public Service Commission (MPSC) limits their earnings potential by determining an authorized level of earnings and by establishing the allowed earnings as a percentage of the utility rate base (i.e., the value of assets, such as power plants and distribution networks used in the business). In designing the rates charged to customers to recover the utility's "revenue requirement" (expenses plus investment return on the rate base), regulators typically assign most of the revenue requirement to predicted unit sales of gas or electricity. This method creates financial incentives for the utility to increase—not decrease—its unit sales and to make investments in the traditional physical assets of the business.

Successful energy conservation and efficiency programs reduce unit sales and could thus reduce utility revenues. If program costs are expensed, there can be no incremental earnings on the program investment, no matter how successful it is. Thus, an energy efficiency program offers limited "upside" potential to utilities and poses a significant risk of harming profitability. Cooperative and municipal systems apply a different earnings model, but may risk diminished cash flow from reduced sales. Utilities' financial incentives are to maximize unit sales, not reduce them.

This financial disincentive can be offset by: (1) providing a possible incentive financial benefit for a successful efficiency program; (2) changing the rate method so that expenses and earnings are recovered by a fixed-rate charge based on the number of customers, rather than units sold; (3) allowing sales figures to be updated between rate cases; and (4) applying a system benefits charge to all distribution service customers to pay for the efficiency program. Items (2) and (3) are examples of "decoupling" revenue requirements from a projected unit sales level. Decoupling utility unit sales from profits in rate setting and/or providing the opportunity to earn profits from successful program outcomes can realign incentives to encourage effective utility investment in DSM, energy efficiency, and conservation and reduce the incentive to maximize unit sales. Item (4) ensures that all customers receiving deliveries from the local distribution utility contribute to the program costs, since the benefits are societal.

This policy is not quantifiable at this time. Its goal is to have the MPSC undertake and complete as soon as possible, but no later than December 2010, a comprehensive study identifying disincentives to energy efficiency investments by utilities and ways to remove them, as well as opportunities to encourage additional energy efficiency investment by utilities. This should be conducted in close coordination with the MCAC's ES policy recommendations, and in keeping with the provisions of P.A. 295.

RCI-4. Adopt More Stringent Building Codes for Energy Efficiency

The MCAC unanimously recommends that a higher energy standard should be required for newly constructed buildings in the state in order to reduce energy costs—the largest operations and maintenance expense. Newly constructed buildings today become the energy-consuming building stock of tomorrow. Strong building energy codes can be an effective way to eliminate the use of "least-efficient" energy practices in new or renovated buildings.

The 2030 Challenge is a global initiative that targets all new buildings and major renovations to reduce their fossil-fuel consumption by 50% by 2010 and incrementally increase this standard for new buildings to "carbon neutrality" in 2030. The 2030 Challenge has been adopted by the U.S. Conference of Mayors; National Association of Counties; American Institute of Architects; U.S. Green Building Council; International Council for Local Environmental Initiatives; Congress for the New Urbanism; states of Illinois, Minnesota, California, and New Mexico; and numerous counties and cities. Also, the 2030 Challenge is supported by the American Society of Heating, Refrigerating & Air-Conditioning Engineers. New building standards that meet the 2030 Challenge are currently being developed. To meet or exceed the 2030 Challenge for a 50% GHG reduction by 2010 would require Michigan to achieve a 30% improvement beyond the requirements of the 2006 International Energy Conservation Code (IECC).

The goal of this policy is to strengthen Michigan's energy building codes for residential, commercial, institutional, municipal, and covered industrial construction to match those of the 2030 Challenge. To meet the initial 2030 Challenge goal of 50% GHG reduction by 2010, Michigan should adopt an energy code that requires 30% energy performance improvement beyond the requirements of the 2006 IECC. In addition, thermal envelope inspections should be mandatory for all new building construction to ensure that they are built as designed and energy efficiency performance objectives are met in the completed structures. Michigan's current codes and standards can be used as baseline references; the baseline year for energy-saving comparisons should be 2008. Michigan should also adhere to periodic upgrades of the national standards for new residential, commercial, institutional, municipal, and industrial buildings, and review and upgrade existing state and local building codes accordingly.

RCI-5. Michigan Climate Challenge and Related Consumer Education Programs

The MCAC unanimously recommends that the state lead by example regarding education and outreach by fully implementing the Michigan Climate Challenge (MCC) as one of its key efforts in this area. Doing so would encourage Michigan businesses, institutions, local and regional governments, and the general public to make a voluntary public commitment to undertake actions to reduce GHG emissions in their communities.

The Michigan Department of Environmental Quality, working in conjunction and consultation with other state agencies, will develop and launch the MCC and include a Web-based "Online Pledge" to encourage voluntary GHG reductions throughout Michigan. The MCC will provide Web-based resources and information in the form of a "Climate Action Toolkit" for individuals and organizations to consider implementing. The toolkit will contain specific recommendations for reducing GHG emissions and identify measures that can minimize the impacts of climate change, so as to be better prepared to adapt to its effects.

Each local government official, small business owner, and citizen plays an integral part in this effort. Together, these individual actions will reduce the risks to the environment now and in the future. The MCC will provide the opportunity and resources for communities, organizations, businesses, and individuals to recognize climate change risks and commit to specific actions to reverse those changes, enabling Michigan to move forward in addressing climate change.

RCI-6. Incentives To Promote Renewable Energy Systems Implementation

By a unanimous vote, the MCAC recommends that Michigan set as a minimum target the addition of small-scale, customer-sited, renewable distributed generation (DG) consistent with its overall annual goals for renewable generation. Customer-sited DG powered by renewable energy sources provides electricity system benefits, such as avoided capital investment and avoided transmission and distribution losses, while also displacing fossil-fuel generation and thus reducing GHG emissions. Increasing the use of renewable DG in Michigan can be achieved through a combination of regulatory changes and incentives.

DG technologies exist across the spectrum of RCI facilities. Customer-sited renewable DG can include solar photovoltaic systems, wind power systems, biogas and landfill gas-fired systems, geothermal generation systems, and systems fueled by biomass wastes or biomass collected or grown as fuel. Policies to encourage and accelerate the implementation of customer-sited renewable DG can include direct incentives or requirements for power purchases, market incentives related to the pricing of electricity output by renewable DG, state goals or directives, and favorable rules for interconnecting renewable generation systems with the electricity grid. Incentives for non-electric renewable energy applications should also be included.

Supporting measures for this policy include training and certification of installers and contractors, net metering and other pricing arrangements, interconnection standards, and the creation or support of markets for biomass fuels. Through an educational campaign (see policy recommendations RCI-5 and Cross-Cutting Issues [CCI]-5), individuals and businesses can also gain a better understanding of renewable energy options and of the requirements of the program ultimately adopted in Michigan.

The goal of this recommendation is to increase total annual electrical generation from small-scale, customer-sited distributed renewable sources in Michigan by 2% by 2025. This recommendation is designed to be accomplished in parallel with and as an addition to the 25% Renewable Portfolio Standard goal set out in policy recommendation ES-1. Total energy supply as a result of these two policies would be 27% from renewable sources.

RCI-7. Promotion and Incentives for Improved Design and Construction in the Private Sector

Revolving loan funds are proven and effective tools for promoting energy efficiency in state and local government facilities. The MCAC unanimously recommends that this tool should be utilized in the private sector as well. This recommendation would facilitate investment in energy efficiency improvements by providing zero-interest loans to local governments, which, in turn, would extend the program to private entities. Energy cost savings for private-sector participants would provide cash flow for repaying the principal, with the cost of the program for the local governments limited to interest payments and loan administration.

Incentives, such as permitting and fee advantages, tax credits, and financing incentives (e.g., “green mortgages” or property tax abatements for buildings certified to Leadership in Energy and Environmental Design standards) should be used to encourage retrofit of existing residential, commercial, institutional, municipal, and industrial buildings or the development of non-traditional, off-grid, low- carbon, and carbon-neutral energy sources. The state can work with financial institutions to develop loan tools for these programs. Eligibility for the loans would be based on the energy standards chosen. Michigan jurisdictions that have adopted enforceable standards will be eligible for managing the loans. The IECC, or alternative standard, must be enforced. This policy assumes a gradually increasing energy efficiency code for new construction, backed up by strong, consistent enforcement measures.

Encouraged by the incentives offered, the goal of this recommendation is to have all residential, commercial, institutional, municipal, and industrial buildings achieve 15% better energy efficiency than that required by the 2006 IECC by 2015 and 30% better efficiency than that required by the 2006 IECC by 2025.

RCI-8. Net Metering for Distributed Generation

By a unanimous vote, the MCAC recommends implementing aggressive net metering policies to encourage increased electric generation capacity from DG sources. Net metering enables individuals or businesses to obtain financial benefits from small electricity generators installed at their home or business location. It allows consumers to deliver any excess generation from their small generators to the utility through the standard energy meter, which runs both forward and backward during the billing period. The utility charges customer generators only for the net amount of energy they take from the utility during the period, recognizing at retail rates all the electricity the customer generators produce. There are several variations on this basic form of net metering that may be considered.

A voluntary, statewide net metering program was adopted by the MPSC in March 2005 (Case No. U-14346), but was limited to renewable energy facilities under 30-kilowatt (kW) capacity and was capped at 100 kW or 0.1% of a utility's peak load. Qualifying facilities could be sized no larger than necessary to meet the customer's needs. Several billing configurations are permitted at the option of the utility, starting with the basic net metering form, with credits for excess generation being for allowed up to one year. Any excess credits after one year go to the utility to offset program costs. All regulated investor-owned and cooperative electric utilities are participating. The federal Energy Policy Act of 2005 requires the state to consider adopting a new standard, whereby all public utilities would have to offer net metering service to their customers. The MPSC is considering whether to adopt this standard and is also considering other possible changes to the voluntary program described above.

The Michigan legislature is considering requiring a statewide program with larger size limits on the facilities and the total program cap, a mandate to use the basic net metering form, and related measures on interconnection of facilities. The goal of this recommendation is to have 392 megawatts (MW) of electric generation capacity from DG sources installed by 2015, increasing to 1,344 MW by 2025.

RCI-9. Training and Education for Building Design, Construction and Operation

The MCAC unanimously recommends that Michigan provide up-to-date building performance, code compliance, and mechanical equipment training, and develop a certification program for code officials, builders, and contractors and facility operators who successfully complete energy efficiency and related green building training programs. Such training programs should be offered to building code officials, homebuilders, commercial construction contractors, heating/ventilation/air conditioning contractors, electricians, plumbers, carpenters, remodelers, other construction trade professionals, and facility operators. Training programs should focus on: (1) proper construction and maintenance practices with building envelope and mechanical performance standards, as established in revised Michigan building energy codes (see recommendations RCI-4 and RCI-7); and (2) proper construction and maintenance practices with building envelope and mechanical performance standards, as identified in "beyond code" building programs.

Proactive education programs for building trade professionals are a necessary component for successfully improving energy-efficient construction practices. Improved construction standards resulting in energy-efficient buildings can only be accomplished if building code officials and building trade contractors, subcontractors, and facility operators are properly educated in building envelope and mechanical performance building and maintenance techniques. Properly trained building code officials, building trade professionals, and facility operators will help ensure consistent quality control and enforcement of Michigan's enhanced building codes and market-based building performance practices. Training programs are also needed to respond to periodic upgrades of national standards, as well as to changes in state and local building codes. Training should cover new RCI buildings, plus retrofits that are subject to building energy codes. The goal of this recommendation is to begin initial training under such a program in 2009.

RCI-10. Water Use and Management

By unanimous vote, the MCAC recommends that water utilities be required to track and report their energy use, and that a comprehensive study be conducted to identify and adopt potential energy efficiency improvements by water utilities. A considerable amount of energy is used to pump, treat, and deliver water across the state. However, too little is currently known about water utilities' energy use and how greater efficiency could be achieved. This recommendation aims to fill those knowledge voids and reduce energy consumption by: (1) reducing overall water use, and (2) improving the efficiency and management of the water supply and management facilities (wastewater treatment, potable water, irrigation, etc.) in the state.

The state's primary users of water are currently agricultural consumers, municipal consumers, and industrial users. Energy is necessary to pump this water from underground aquifers and open-water sources to users, and to treat it in wastewater facilities after it is used. Improved water use and handling efficiencies will reduce the amount of electricity used for water distribution, and thus reduce energy costs for users and associated GHG emissions from power plants.

Five specific recommendations are detailed in Appendix I: (1) accelerate investment in water use efficiency; (2) increase the energy efficiency of all water and wastewater treatment operations; (3) increase energy production by water and wastewater agencies from renewable sources, such as in-conduit hydropower and biogas; (4) encourage and create incentives for technologies with the capability to reduce water use associated with power generation; and (5) ensure that power plants use the best management practices and economically feasible technology available to conserve water (via siting, evaluation, permitting, or other processes).

The goal of this recommendation is to improve the average energy efficiency of water utilities in the state (in terms of kilowatt-hours used per gallon pumped) by 20% between 2010 and 2013, and to achieve a 10% overall water savings by 2025.

Chapter 6
Transportation and Land Use Sectors

Overview of Greenhouse Gas Emissions

The transportation sector, which includes light- and heavy-duty (on-road) vehicles, aircraft, rail engines, and marine engines, is one of the largest contributors of gross greenhouse gas (GHG) emissions in Michigan. This sector accounted for 24% of Michigan's gross GHG emissions in 2005, which was slightly under the national average of 27%. By 2025, the share of emissions associated with the transportation sector is anticipated to decrease slightly to 22%, primarily due to low growth in the number of vehicle miles traveled (VMT) and the more stringent fuel economy standards of the Energy Independence and Security Act.

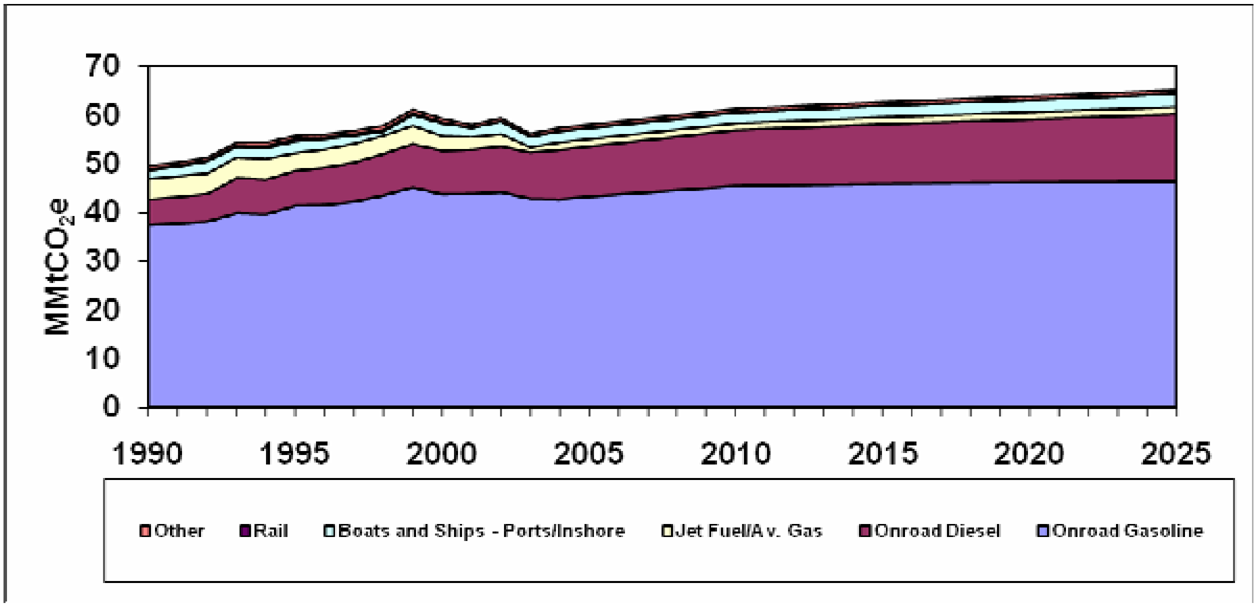
From 1990 to 2005, Michigan's GHG emissions from transportation fuel use have risen steadily at an average rate of about 1.1% annually. The GHG emissions associated with Michigan's transportation sector also rose accordingly, increasing by 8 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) emissions during the same time period from about 50 $MMtCO_2e$ to 58 $MMtCO_2e$.

Carbon dioxide (CO_2) accounts for about 98% of transportation GHG emissions, with most of the remaining transport-related GHG emissions coming from nitrous oxide (N_2O) emissions from gasoline engines. Emissions released from on-road gasoline consumption account for approximately 74% of the transportation sector's GHG emissions. This has historically been the largest share of transportation GHG emissions, and this trend is forecast to continue.

Figure 6-1 shows historic and projected transportation GHG emissions by fuel and source. As a result of an increase in total vehicle miles traveled (VMT), on-road gasoline consumption increased by about 16% between 1990 and 2005. Meanwhile, on-road diesel fuel consumption rose by 96% during that period, accounting for 18% of GHG emissions from the transportation sector in 2005, suggesting an even more rapid growth in freight movement within or across the state.

Growth in VMT is expected to be very low in Michigan, primarily due to limited economic and population growth in the future. GHG emissions from on-road gasoline consumption are projected to increase by about 7%, and GHG emissions from on-road diesel consumption are expected to increase by 34% between 2005 and 2025. The consumption of these fuels will significantly contribute to the projected 12% increase in transportation emission levels for the entire state of Michigan over 2005 levels by 2025.

Figure 6-1. Transportation GHG emissions by fuel source, 1990–2025



$MMtCO_2e$ - million metric tons of carbon dioxide equivalent; av. gas = aviation gas.

Key Challenges and Opportunities

Michigan has substantial opportunities to reduce transportation emissions. The principal means to reduce emissions from transportation and land use (TLU) are:

- Improving vehicle operations efficiency,
- Replacing conventional gasoline and diesel with lower-emission fuels, and
- Reducing the growth of VMT.

The use of fuels with lower per-mile GHG emissions is growing in Michigan, and larger market penetration is possible. Conventional gasoline- and diesel-fired vehicles can use low-level blends of biofuels. Alternative-technology vehicles can also use higher-level blends of biofuels, as well as other types of alternative fuels, such as natural gas and hydrogen. The type of fuel used is a crucial determinant of impact on emissions, as some alternative fuels have relatively little GHG benefit. Currently, the most prevalent biofuel in Michigan is corn-based ethanol, which has minimal GHG benefit from a life-cycle perspective.[1] Key determinants of impact will be the development and deployment of fuel types. At present, fuel distribution infrastructure is a constraining factor.

Reducing the growth of VMT is crucial to mitigating GHG emissions from transportation. Developing smarter land-use and transportation development patterns that reduce trip length and support transit, ride sharing, biking, and walking can contribute substantially to this goal.

[1] Biofuels analysis was based on information from the Argonne National Laboratory's GREET model, version 1.8, which indicates a life-cycle emission reduction of 15.9% for E85 corn ethanol. See Appendix I for more details on assumed reduction factors for various types of biofuels.

Developing better planning methods and regulations, and increasing funding of multiple modes of transportation will be key components in achieving these goals.

Overview of Policy Recommendations and Estimated Impacts

The Michigan Climate Action Council (MCAC) recommends a set of 10 policies for the TLU sector that offer the potential for major economic benefits and emission savings. Implementing these policy recommendations could lead to emission reductions of:

- 10.5 $MMtCO_2e$ per year by 2025, and
- 95.1 $MMtCO_2e$ cumulative from 2009 through 2025.

The weighted-average cost effectiveness of the recommended policies is about –\$36/tCO_2e, representing a cost savings. This average value includes policies that have both much lower and much higher likely costs per ton.

The estimated impacts of the individual policies are shown in Table 6-1. The MCAC policy recommendations are described briefly here and in more detail in Appendix I of this report. The recommendations not only result in significant emission reductions, but offer a host of additional benefits as well. These benefits include reduced local air pollution; more livable, healthier communities; and economic development and job growth from in-state biofuel production. To yield the levels of savings described here, the recommended policies need to be implemented in a timely, aggressive, and thorough manner.

There are three complementary TLU policy options that serve to reduce single occupancy vehicle travel. Congestion mitigation (TLU-5) is designed to improve traffic flow and travel time via expanding the use of intelligent transportation systems. Land use planning and incentives (TLU-6) strategies include promoting and expanding regional growth management options that result in more compact, mixed-use, transit-oriented, walkable development as well as transportation system management and pricing that allows for greater investment in alternatives to the single occupancy vehicle, such as public transit. The transit and travel options of TLU-7 complement TLU-5 and TLU-6 by providing the increased public transit capacity and service improvements needed to achieve the aggressive statewide goals for increasing transit ridership as well as carpool and vanpool participation.

Two policy options recognize that Michigan can reduce GHG emissions in the transportation sector by encouraging more energy-efficient freight movement – (TLU-8) Increase Rail Capacity and Address Rail Freight System Bottlenecks, and (TLU-9) Great Lakes Shipping. These options seek to improve rail and marine infrastructure to take advantage of opportunities to move freight via the most efficient means of transport possible in the Midwest.

TLU-1 focuses on further developing biofuels and expanding the biofuels market can significantly reduce GHG emissions, while boosting the state's economy.

Table 6-1. Summary list of MCAC Transportation and Land Use (TLU) policy recommendations

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$) 2015	2025	Total 2009–2025	Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
TLU-1	Promote Low-Carbon Fuel Use in Transportation	2.6	5.9	53	$820	$16	Unanimous
TLU-2	Eco-Driver Program	1.1	2.2	22	–$3,921	–$176	Unanimous
TLU-3	Truck Idling Policies	0.36	0.76	7.0	–$596	–$85	Unanimous
TLU-4	Advanced Vehicle Technology	0.01	0.03	0.19	$281	$1,458	Unanimous
TLU-5	Congestion Mitigation	0.08	0.18	1.7	–$135	–$81	Unanimous
TLU-6	Land Use Planning and Incentives	0.14	0.43	3.2	–$598	–$189	Unanimous
TLU-7	Transit and Travel Options	0.13	0.54	3.5	$655	$185	Unanimous
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.10	0.19	2.0	$69	$35	Unanimous
TLU-9	Great Lakes Shipping	0.24	0.27	2.5	NQ	NQ	Unanimous
	Sector Totals	**4.76**	**10.5**	**95.1**	**–$3,425**	**-$36**	**N/A**
	Sector Total After Adjusting for Overlaps	**4.76**	**10.5**	**95.1**	**–$3,425**	**-–36**	**N/A**
	Reductions From Recent Actions	**0**	**0**	**0**	**$0**	**$0**	**N/A**
	Sector Total Plus Recent Actions	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; NQ = not quantified.

Note: Negative numbers indicate cost savings.

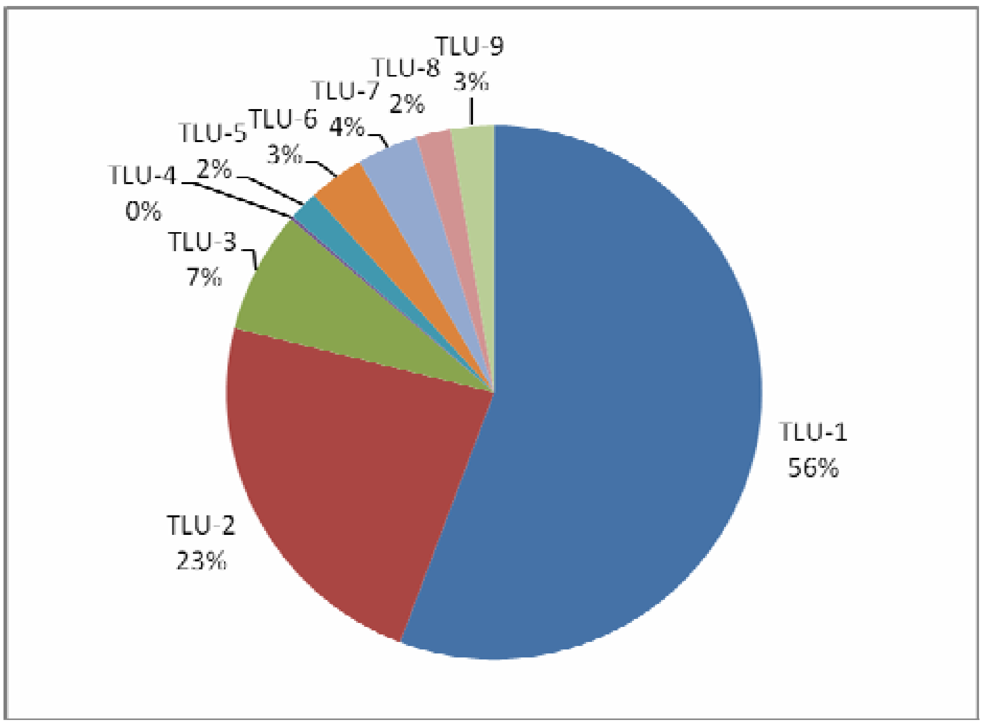
Michigan can achieve greater alternative fuel use through a combination of research and development, as well as through implementing voluntary and mandatory measures. Promoting Low-Carbon Fuel Use in Transportation (TLU-1) can help make biofuels more efficient and more available, while at the same time providing an economic benefit to the Michigan economy by promoting in-state development and production of these fuels.

Public education, towards more efficient driving practices in TLU-2 (Eco-Driver Program), works in conjunction with a number of the other recommended policies. Educating citizens on how they can minimize their impact, operate their vehicle more efficiently, and cut their GHG emissions can be a key to the success of many of these policies. Reducing truck idling (TLU-3) can also serve to reduce the GHG impact of transportation without any change in VMT.

The advanced vehicle technology option (TLU-4) seeks to achieve per vehicle GHG emission benefits beyond those expected to be achieved via the new CAFÉ standards, by providing incentives for public fleet owners to purchase advanced technology vehicles. This policy could serve to strengthen Michigan as a leader of automotive research, which would have benefits across the state. In addition, progress on advanced vehicle technology can have benefits beyond Michigan for energy security, economic growth and environmental quality.

Figure 6-2 shows the breakdown of the projected impacts of the recommended TLU policies, taken together, in terms of avoided GHG emissions. For the TLU policies recommended by the MCAC to yield the levels of savings described here, the policies must be implemented in a timely, aggressive, and thorough manner. This means, for example, not only putting the policies themselves in place, but also attending to the development of supporting policies that are needed to help make the recommended policies effective. While adoption of the recommended policies can result in considerable benefits to Michigan's environment and consumers, careful, comprehensive, and detailed planning and implementation, as well as consistent support of these policies will be required if these benefits are to be achieved.

Figure 6-2. Aggregate GHG emission reductions from all MCAC Transportation and Land Use (TLU) recommendations, 2009–2025



Transportation and Land Use Sectors
Policy Descriptions

The policy recommendations summarized here not only result in significant emission reductions and cost savings but also offer a host of additional benefits, such as reduced local air pollution; more livable, healthier communities; and increased transportation choices.

TLU-1. Promote Low-Carbon Fuel Use in Transportation

This policy recommendation promotes low-carbon transportation fuels through a package of incentives, education, and standards, including recommendations by the Michigan Renewable Fuels Commission (RFC). The goal is to reduce the average “carbon intensity” of on-road transportation fuels sold within the state to achieve a 5% reduction of GHG emissions on a life cycle carbon dioxide basis by 2015 and 10% reduction by 2025. The policy follows the June 2007 report of the Michigan RFC that recommended a variety of actions to stimulate the production and use of renewable, low-carbon fuels within the state. These include: (1) a low-carbon fuels program to encourage federal policy in this area and consider establishing a state policy; (2) establish a next-generation renewable fuels feedstock program with a goal of achieving 10% use of renewable fuels by 2012 and 25% by 2025; and (3) create a green retailers program with tax incentives for E85 and biodiesel sales that rewards retail and wholesale outlets that attain benchmarks in the sale of biofuels.

TLU-2. Eco-Driver Program

Because driving behavior can significantly influence a vehicle’s fuel economy performance, this policy would establish an eco-driving program. This program would incorporate a wide range of initiatives that can help drivers maximize the fuel efficiency from their existing vehicles by better understanding the direct impact that driving style, driving patterns, vehicle technologies, and vehicle maintenance (such as proper tire inflation) have on a vehicle’s fuel economy. The primary focus of an eco-driving campaign would target light-duty vehicles, where driver education on eco-driving principles would have the greatest benefit. An integrated eco-driving program in Michigan would be designed to achieve a fuel-economy increase of at least 10% in the mid-term and up to 20% in the long-term.

A properly designed eco-driving program must move beyond a list of driver “tips” and focus on providing the appropriate tools and programs to systematically change driver behavior. Key eco-driving principles would cover: driving style, starting and idling, trip planning, vehicle drag/weight, proper maintenance and vehicle technology applications. The eco-driving program would include program initiatives on direct driver training, general eco-driving education, vehicle maintenance, and vehicle applications such as real-time fuel economy indicators. The program would also consider a low-rolling-resistance tire initiative, options to have currently licensed drivers to undergo additional driver training and options to incorporate direct eco-driver training in the process of commercial truck licensing.

TLU-3. Truck Idling Policies

This policy option aims to reduce GHG and other emissions from unnecessary idling of heavy-duty vehicles, including trucks and buses. Much of this idling takes place during mandatory rest periods to provide heating or cooling of the truck's cabin air. Additional idling occurs during vehicle operation, for example, when loading and unloading buses and trucks. The implementation of public and private fleet anti-idling policies and ordinances, targeted education of bus and truck operators, and creation of low-cost means to access available EPA-verified technologies will help encourage emissions reductions from heavy-duty diesel engines.

Heavy-duty engine idling can be reduced by (1) providing increased availability of electrification at privately owned truck stops or encouraging greater use of auxiliary power units (APUs; on-board generators) for heating, cooling, and other creature comforts on heavy-duty vehicles, (2) providing financial assistance (e.g., low-interest revolving loans) to truck-stop operators and truck owners/operators for infrastructure development or equipment purchase and (3) providing targeted educational activities as appropriate with truck, bus, and truck-stop owners and operators.

This policy has a goal of achieving diesel idling reductions from heavy-duty diesel engines of 40% by 2015 and 80% by 2025. It would also promote the adoption of a Michigan anti-idling law based on the EPA Model State Idling Law and/or encourage adoption of local ordinances to address idling during operation of buses and heavy trucks.

TLU-4. Advanced Vehicle Technology

This recommendation calls for the creation of a policy that will expand the development and use of more efficient vehicle design and/or hybrid propulsion systems. The goal is to make loans and subsidies available to municipalities, local governments, and waste management organizations to encourage more rapid adoption of advanced vehicles by public fleets (transit agencies and schools) to achieve the use of advanced vehicle technologies (hybrid or hydrogen technology) in 10% of the fleet by 2025.

This policy could serve to reestablish Detroit as a leader of automotive research, which would have benefits across the State. In addition, progress on advanced vehicle technology can have benefits for beyond the borders of Michigan in terms of energy security, economic growth, and environmental quality.

TLU-5. Congestion Mitigation

The goal of this policy recommendation is to improve traffic flow and travel time through expanding the use of intelligent transportation systems (ITS). In conjunction with expanding ITS, the following actions should also be considered: identifying and improving key bottlenecks, constructing modern roundabouts at appropriate intersections, and continuing the use of the MDOT courtesy patrol on congested roadways. A 4-day workweek and flex-time should be encouraged to reduce congestion. All of these elements contribute to reducing travel delay for both recurring and nonrecurring congestion.

Promoting the development of intermodal freight terminals will facilitate freight shipment on rail and air thus reducing the volume of freight on Michigan roadways. By supporting these efforts, the congestion mitigation policy option will allow for more efficient travel and increased economic output.

The goals for this policy are to reduce travel time delay from recurring and nonrecurring congestion in Michigan's major urban areas (Metro Detroit and Grand Rapids) by 10% by 2025 and to reduce travel time related to nonrecurring congestion (i.e., road construction) by continuing to implement and refine the Michigan Work Zone Safety and Mobility Policy.

TLU-6. Land Use Planning and Incentives

State policies and programs need to be implemented that encourage local and regional planning and development strategies in order to reduce the projected growth of VMT and corresponding GHG emissions. The state will enable each region to adopt a unique mixture of policies to reach reduction goals in its own manner. Strategies include promoting and expanding regional growth management options that result in more compact mixed-use, transit-oriented, walkable development; transportation system management and pricing that allows for greater investment in alternatives to the single-occupancy vehicle, such as public transit; and use of other land-use–related economic development tools as recommended in the Michigan Land Use Leadership Council's Report (2003).

The goals are (1) to reduce low density development and the conversion of greenfield open land to development 25% by 2015, 50% by 2025, and 80% by 2050; (2) to encourage communities to utilize an "infill" approach for both new and redevelopment projects by focusing on areas where infrastructure already exists; and (3) to work to ensure that at least 60% of new/future statewide growth utilizes more compact development or transit-oriented development design.

These goals can be accomplished through: (1) multi-jurisdictional land use planning and zoning policies, tax base sharing, and providing state and local incentives; (2) market-based approaches in future land development and housing policies that focus investments toward achieving higher density, transit-oriented, and compact or mixed-use development; (3) integrated transportation policies, investments, system management, and pricing; and (4) enactment of a new Statewide Comprehensive Planning Law.

TLU-7. Transit and Travel Options

This policy recommendation focuses on reducing the number of single-occupant vehicle trips and improving the efficiency of daily travel by: (1) creating, enhancing, and promoting public transit options such as commuter rail, light rail, streetcars, and bus rapid transit; (2) enhancing transit service through route expansion, increased service frequency, longer service hours, and/or better system coordination; and (3) facilitating increased carpooling, vanpooling, biking, and walking. These actions will reduce GHG emissions by decreasing VMT, thus reducing fuel consumption. The first goal is to double transit ridership by 2015 and double it again by 2025 (for longer line-haul systems). The second goal is to double the number of carpool and vanpool participants by 2015 and double again by 2025.

A number of actions are included to help achieve the goals, including amending the Michigan Constitution to provide a broader range of funding mechanisms for public transit, building additional park-and-ride lots, provide incentives for transit-oriented development, incorporate bike lanes into roadway construction/reconstruction, encourage/require sidewalks in new developments and encourage their addition in areas where they are now absent, implement metropolitan transit plans, pursue implementation of inter-city transit service where it is cost-effective and undertake a public education campaign to effectively communicate the benefits of public transit to people who are not current users.

TLU-8. Increase Rail Capacity and Address Rail Freight System Bottlenecks

This policy encourages more energy efficient freight movement via railroads, where it is practical to do so. Making or facilitating transportation infrastructure improvements that increase rail capacity, support connectivity, and reduce rail freight system bottlenecks will help accomplish this shift. For short hauls, truck freight is, and will likely continue to be, the mode of choice; intermodal rail freight tends to be most effective for trips of 700-800 miles or longer. This policy will reduce transportation sector GHG emissions from freight movement by making system improvements with the goal of increasing the tonnage of rail freight traveling to, through and from Michigan an additional 50% by 2020.

Freight tonnage for shipments to, through, and from Michigan is expected to increase on all freight modes, but by far the majority of this increase is anticipated to be truck freight. Increasing the projected tonnage of rail freight an additional 50% by 2020 potentially shifts million of tons of cargo that would otherwise travel by truck. It is important to recognize that shipping decisions are made by the private sector, and are not under the control of government. Investment to encourage greater use of rail lines and intermodal shipping must be made with that reality in mind. A variety of approaches are suggested to accomplish this, including construction of intermodal terminals, preserving existing service and preserving right-of-ways for future new service.

TLU-9. Great Lakes Shipping

This policy recommendation promotes the use of marine transportation as the most energy-efficient form of surface transportation to move cargo over long distances (150 miles or more). While Great Lakes shipping decisions and services are private sector responsibilities, the public sector has a role in providing navigation channels and related infrastructure. Actions include maintaining the existing marine infrastructure, maintaining federal navigation channels to their congressionally authorized depths, improving the marine infrastructure by deepening commercial navigation channels at selected commercial ports, encouraging the development or expansion of "short sea shipping" (also known as "marine highway") within the Great Lakes, as well as considering the use of ferry boats to move people and cars and consider a biodiesel program at Michigan ports if it is feasible to burn this fuel in marine diesel engines. The focus of this policy is on increasing shipping within the Great Lakes – not on increasing traffic through the St. Lawrence Seaway.

Chapter 7
Agriculture, Forestry, and Waste Management Sectors

Overview of GHG Emissions

The agriculture, forestry, and waste management (AFW) sectors are responsible for moderately low amounts of Michigan's current greenhouse gas (GHG) emissions. The total AFW contribution to carbon dioxide equivalent (CO_2e) gross emissions in 2005 was 14 million metric tons (MMt), or about 6% of the state's total. It is important to note that the AFW sector emissions exclude combustion-related GHGs, such as diesel fuel consumption in the agriculture sector. These fuel combustion emissions are included as part of the industrial fuel combustion sector (and covered in the Residential, Commercial, and Industrial Sectors chapter). The AFW contribution to net emissions in 2005 was less than 1% of the state's total after accounting for the net sequestration of carbon in the forestry sector.

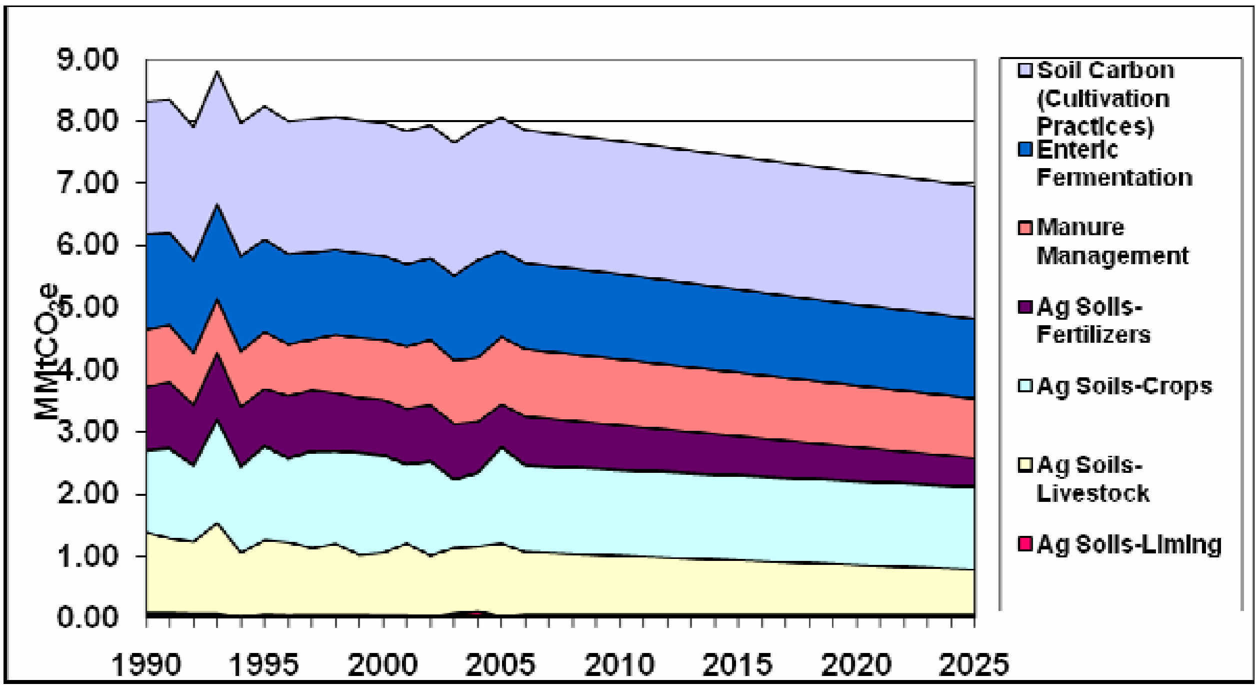
Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric (intestinal) fermentation, manure management, agriculture soils, and agriculture residue burning. As shown in Figure 7-1, emissions from soil carbon losses from agricultural soils, livestock soils, manure management, enteric fermentation, and fertilizer application all make significant contributions to the sector totals. Emissions include CO_2 emissions from oxidized soil carbon, application of urea, and application of lime. Sector emissions also include (N_2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic and livestock manure) application, production of nitrogen-fixing crops (legumes), and agricultural burning activity.

Note that, in keeping with U.S. Environmental Protection Agency (EPA) methods and international reporting conventions, the Michigan 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 Michigan Climate Action Council (MCAC) process. In the forestry sector, since all of the state's forests are managed in some way, all emissions are treated as "anthropogenic," or from human activities. GHG reporting conventions treat all managed forests as anthropogenic sources. Sources, such as CO_2 from forest fires and decomposing biomass, are captured within the inventory and forecast (as part of the carbon stock modeling performed by the U.S. Forest Service [USFS]). However, CH_4 emissions from decomposition of organic matter/biomass in forests are not currently captured due to a lack of data. This methane is from decomposition in oxygen-free (anaerobic) areas, particularly marshes and bogs.

The CO_2 emissions occurring from the cultivation of organic soils are a large contributor to the state's total agricultural GHG emissions. By 2025, the contribution from this source is estimated to be about 30% of the total agriculture emissions. The next-highest contributor in 2025 is estimated to be agricultural soils from crop production, at about 19% (including N_2O from decomposition of crop residue). Methane emissions from digestive processes in ruminant animals, known as enteric fermentation, are declining slightly due to lower animal populations; however, they are estimated to be the third-highest contributor to agriculture sector totals in 2025, also at around 19%.

Forestry and land use emissions refer to the net CO_2 flux[1] from forested lands in Michigan, which account for about 53% of the state's land area. The inventory is divided into two primary subsectors: the forested landscape and urban forestry and land use. Both subsectors capture net carbon sequestered in forest biomass, urban trees, landfills, and harvested wood products. In addition, other GHG sources, such as N_2O emissions from fertilizer application in urban areas and CH_4 and N_2O emissions from prescribed burns and wildfires, are included.

Figure 7-1. Historical and projected gross GHG emissions from the agriculture sector, Michigan, 1990–2025



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

As shown in Table 7-1, USFS data suggest that Michigan's forests sequestered about 12.7 $MMtCO_2e$ per year in 2005 (this excludes estimates of carbon flux from forest soils based on recommendations from the USFS). The negative numbers in Table 7-1 indicate a CO_2 sink rather than a source. Even after accounting for the GHG sources from urban soils and prescribed burns/wildfires, the forestry and land use sectors are still estimated to have been a net GHG sink. Hence, during this period, forest carbon losses due to forest conversion, wildfire, and disease were estimated to be smaller than the CO_2 sequestered in forest 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. The forecast for the sector out to 2025 remains a net sequestration of –12.7 $MMtCO_2e$.

[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.

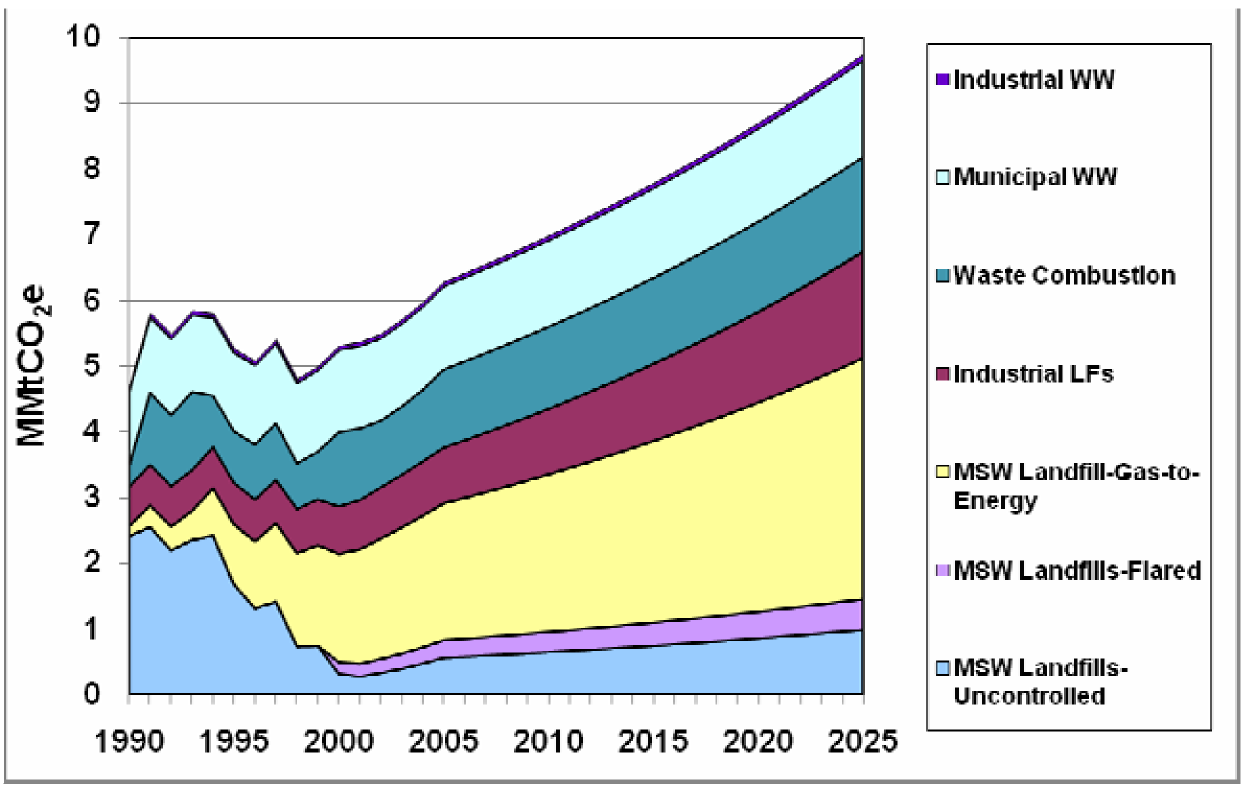
Table 7-1. Forestry and land use flux and reference case projections (MMtCO_2e)

Sector	1990	2000	2005	2010	2020	2025
Forested Landscape (excluding soil carbon)	–27.8	–8.77	–8.77	–8.77	–8.77	–8.77
Urban Forestry and Land Use	–10.1	–3.69	–3.91	–3.91	–3.91	–3.91
Forest Wildfires	0.02	0.02	0.02	0.02	0.02	0.02
Sector Total	**–37.9**	**–12.4**	**–12.7**	**–12.7**	**–12.7**	**–12.7**

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 7-2 shows estimated historical and projected emissions from the management and treatment of solid waste and wastewater. Emissions from waste management consist largely of CH_4 emitted from landfills, while emissions from wastewater treatment include both CH_4 and N_2O. Emissions are also included for municipal solid waste (MSW) combustion. Overall, the waste management sector accounted for about 3% of Michigan's total gross emissions in 2005. While emissions are expected to grow significantly by 2025, the contribution to the state's total is expected to remain at about 3%.

Figure 7-2. Estimated historical and projected GHG emissions from waste and wastewater management in Michigan, 1990–2025



MMtCO_2e = million metric tons of carbon dioxide equivalent; MSW = Municipal Solid Waste; LFs = landfills; WW = wastewater.

Key Challenges and Opportunities

Michigan has substantial opportunities to reduce emissions in the AFW sectors. The principal means to reduce emissions in these areas are:

- Improving methods for managing municipal solid waste,
- Adopting management practices to increase carbon sequestration in both forestlands and urban canopies,
- Improving production and utilization of biomass for use in both solid fuel and liquid fuel applications, and
- Promoting farming practices that result in GHG savings.

Opportunities for GHG mitigation in the AFW sectors involve measures that can reduce emissions within these sectors or reduce emissions in other sectors. Within these sectors, changes in crop cultivation can reduce GHG emissions by building soil carbon (indirectly sequestering carbon from the atmosphere) or through more efficient nutrient application (reducing N_2O emissions and embedded GHG emissions within those nutrients). The implementation of improved farming and harvesting techniques, as well as utilization of biomass for bio-based products, has the potential to reduce future emissions relative to current emissions from this sector and other sectors.

Enhanced management of the state's forests can lead to higher levels of carbon sequestration. These enhancements can be achieved through afforestation projects and enhanced stocking in existing forests. Conversion of land to development results in a loss of current and future carbon sequestration potential. Slowing or stemming conversion rates provides opportunities for carbon sequestration. In the waste management sector, waste reduction measures and landfill gas capture and utilization can reduce landfill CH_4 emissions.

Actions taken within the AFW sectors can also lead to GHG reductions outside the sectors: the establishment of short-rotation woody crops (for example, on marginal agricultural lands) for producing biomass energy feedstocks can replace fossil fuel consumption, including transportation fuels and fuels used to produce electricity or steam in the energy supply (ES) sector. Similarly, actions that promote solid waste reduction, recycling, or use of waste sources for energy or bio-based products can reduce emissions within the sector (future landfill CH_4 as noted above), as well as emissions associated with the production of products and packaging (recycled products often require less energy to produce than similar products from virgin materials). Finally, urban forestry projects can reduce energy consumption within buildings through shading and wind protection.

Overview of Policy Recommendations and Estimated Impacts

The MCAC recommends a set of 10 policies for the AFW sector that offer the potential for major economic benefits and emission savings. Implementing these policy recommendations could lead to emission reductions of:

- 17 $MMtCO_2e$ per year by 2025, and

- 147 $MMtCO_2e$ cumulative from 2009 through 2025, after adjusting for overlaps with other sectors.

The weighted-average cost-effectiveness of the recommended policies is about –$11/$tCO_2e$, representing a cost savings. This average value includes policies that have both much lower and much higher likely costs per ton.

The 10 policy recommendations for the AFW sectors address a diverse array of activities capturing emission reductions both within and outside of these sectors (e.g., energy consumption in the ES and Transportation and Land Use [TLU] sectors). The estimated impacts of the individual policies are shown in Table 7-2. The MCAC policy recommendations are described briefly here and in more detail in Appendix J of this report. The recommendations not only result in significant emission reductions, but also offer a host of additional benefits, including protection of biodiversity, reduced local air pollution, and economic development and job growth. To yield the levels of savings described here, the recommended policies need to be implemented in a timely, aggressive, and thorough manner.

The following are primary opportunities for GHG mitigation identified by the MCAC:

- **Agricultural crop production:** Programs can be implemented with growers to utilize cultivation practices that build soil carbon and reduce nutrient consumption. By building soil carbon, CO_2 is indirectly sequestered from the atmosphere. New technologies in the area of precision agriculture offer opportunities to reduce nutrient application and fossil fuel consumption. Promotion of local food production could reduce the transportation miles and fossil fuel use associated with importing food products from other areas.
- **Production of liquid biofuels:** Production of renewable fuels, such as ethanol from crop residue, forestry biomass, or municipal solid waste and biodiesel from waste vegetable oils, can produce significant reductions when they are used to offset consumption of fossil fuels (e.g., gasoline and diesel in transportation and other combustion sources). This is particularly true when these fuels are produced using processes and/or feedstocks that have much lower fossil fuel inputs than those from conventional sources (sometimes referred to as “advanced” or “next generation” biofuels). The goals to produce more biofuels in-state are linked to the recommendations under TLU-1, Promote Low Carbon Fuel Use in Transportation. The costs and benefits of liquid biofuels production are combined with the TLU policy on biofuels consumption and presented with the results for that sector.
- **Expanded use of forest, agricultural, and MSW biomass:** Expanded use of renewable energy and bio-based products from biomass removed from forests, crop residues, lawn and garden waste, or MSW can achieve GHG benefits by offsetting fossil fuel consumption (to produce either electricity or heat/steam) and replacing fossil-based products. Programs to expand sustainably produced biomass fuel production will most likely be needed to supply a portion of the fuel mix for the renewable energy goals of policy recommendation ES-1, Renewable Portfolio Standard.
- **Enhancement/protection of forest carbon sinks:** Through a variety of programs, enhanced levels of CO_2 sequestration can be achieved and carbon can be stored in the state’s forest

biomass. These include afforestation[2] projects, reforestation programs (restocking of poorly stocked forests), urban tree programs, and wildfire risk reduction. Programs aimed at reducing the conversion of forested lands to non-forest cover will also be important to retain what is currently a net forest CO_2 sink in Michigan.

- **Changes in MSW management practices:** By promoting source reduction, advanced MSW recycling practices, improved organics management, and increased collection and utilization of landfill methane, the GHG emissions associated with collecting, transporting, and managing MSW can be reduced. The emissions reduced in this sector would come primarily from waste management but may also provide a reduction in the fossil fuel used to transport waste. When the life-cycle GHG reductions of source reduction/recycling/organics management are considered, the results are substantial: over 35 $MMtCO_2e$/yr could be reduced by 2025.

Table 7-2. Summary list of AFW policy recommendations

Policy No.	Policy Recommendation		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
			2015	2025	Total 2009–2025			
AFW-1	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production		3.3	10	79	$1,649	$21	Unanimous
AFW-2*	In-State Liquid Biofuels Production		*Included in the Results of TLU-1*					Unanimous
AFW-3	Methane Capture and Utilization From Manure and Other Biological Waste		0.09	0.14	1.5	$4.7	$3	Unanimous
AFW-4	Expanded Use of Bio-based Materials	A. Use of Bio-based Products	.08	.21	1.7	–$108	–$62	Unanimous
		B. Utilization of Solid Wood Residues	NQ					Unanimous
AFW-5	Land Use Management That Promotes Permanent Cover	A. Increase in Permanent Cover Area	0.08	0.21	1.8	$63	$34	Unanimous
		B. Retention of Lands in Conservation Programs†	0.05	0.11	1.1	$24	$23	Unanimous
		C. Retention/ Enhancement of Wetlands	*Not Quantified*					Unanimous
AFW-6	Forestry and Agricultural Land Protection	A. Agricultural Land Protection	0.46	1.1	10	$864	$85	Unanimous
		B. Forested Land Protection	*Not Quantified*					Unanimous
		C. Peatlands/ Wetlands Protection	*Not Quantified*					Unanimous

[2] Afforestation refers to the establishment of forest on lands that have not historically been under forest cover.

Policy No.	Policy Recommendation		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
			2015	2025	Total 2009–2025			
AFW-7**	Promotion of Farming Practices That Achieve GHG Benefits	A. Soil Carbon Management	0.7	1.7	15	–$200	–$13	Unanimous
		B. Nutrient Efficiency	0.05	0.12	1.1	–$27	–$26	Unanimous
		C. Energy Efficiency	0.13	0.32	2.9	–$102	–$35	Unanimous
		D. Local Food	*Not Quantified*					Unanimous
AFW-8	Forest Management for Carbon Sequestration and Biodiversity	A. Enhanced Forestland Management	0.53	1.42	12.05	$800	$66	Unanimous
		B. Urban Forest Canopy	1.2	2.9	26	–$346	–$13	Unanimous
		C. Reduce Wildfire	*Not Quantified*					Unanimous
AFW-9**	Source Reduction, Advanced Recycling, and Organics Management							Unanimous
	In-State GHG Reductions		1.4	3.0	28	–$3,136	–$112	
	Full Life-Cycle Reductions		14.5	35.3	314	–$3,136	–$10	
AFW-10	Landfill Methane Energy Programs		0.91	2.7	22	–$35	–$2	Unanimous
	Sector Totals[†]		**9**	**23**	**201**	**–$548**	**–$3**	
	Sector Total After Adjusting for Overlaps[††]		**6**	**17**	**147**	**–$1,634**	**–$11**	
	Reductions From Recent Actions		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
	Sector Total Plus Recent Actions		**6**	**17**	**147**	**–$1,634**	**–$11**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; TBD = to be determined; N/A = not applicable

Note that negative costs represent a monetary savings.

* The quantification results for AFW-2 (biofuel production volumes and costs) were used as inputs to the quantification of the results of TLU-1, which covers consumption of biofuels in Michigan.

** The analyses for AFW-5, AFW-7, and AFW-9 include the full life-cycle costs of the policies. In the case of AFW-9, it is estimated that a significant fraction of the reductions will occur out of state. In-state reductions refer only to those occurring from reduced landfilling and waste combustion (these are broken out separately in the table above).

† The reductions from AFW 5B (Retention of Lands in Conservation Programs) have been left out of the sector totals, since they relate to a soil carbon protection measure where the estimated emissions (from conservation acres being returned to active cultivation) are not included in the business as usual (BAU) inventory and forecast (I&F). The costs have been included in the sector totals, since these will be incurred in order to retain the level of emissions in the BAU I&F. For AFW-5, AFW-7, and AFW-9, these include the reductions that are expected to occur within the state.

†† See below for discussion of overlap adjustments.

Overlap Discussion

The amount of GHG emissions reduced or sequestered and the costs of a policy recommendation within the AFW sectors in some cases overlap with other AFW policies or policies in other sectors. For the MCAC recommendations, overlap occurs between AFW-9 and AFW-10 in the waste management sector. One of the policy elements of AFW-9 covers enhanced management of organic wastes in the MSW sector. To the extent that these wastes are being diverted from landfills to other waste management facilities (e.g., composting facilities), less organic waste is available to generate landfill methane. This effect has been accounted for in the quantification of AFW-10; hence, the values shown for AFW-10 above assume successful implementation of AFW-9.

Overlap also occurs with some of the quantified benefits and costs of policy recommendations within other sectors. Every effort has been made to determine where those overlaps occur and to eliminate double counting. As displayed in the table above, the AFW sector totals have been adjusted accordingly, as follows:

- AFW-1 outlines how biomass may be utilized for energy production. The ES Technical Work Group (TWG) also quantified the use of biomass for energy production (specifically ES-1 and ES-10). AFW-1 utilizes a greater amount of biomass than the ES policies post-2011. The biomass demand requirements for ES (in millions of British thermal units) and the GHG reductions and costs associated with its use were removed from the AFW sector totals in the table above, as these were considered to be accounted for under the ES analyses.
- AFW-2 outlines how biofuels could be produced in-state to offset GHG emissions from fossil-based fuels (primarily in the transportation sector). The TLU TWG also quantified the benefits and costs of increased use of biofuels in TLU-1. To avoid double counting, the goals of biofuel production in AFW-2 and biofuel consumption in TLU-1 were aligned, and then the estimated AFW-2 biofuel production volumes and costs were used as input to the analysis of biofuel consumption under TLU-1. Hence, the benefits and costs of AFW-2 are captured in the overall results of TLU-1. To avoid confusion, those results are left out of the summary table above. The quantification of production volumes and costs is still included in the AFW-2 documentation shown in Appendix J.

Agriculture, Forestry, and Waste Management Sector Policy Descriptions

The AFW sectors include emission mitigation opportunities related to the use of biomass energy, protection and enhancement of forest and agricultural carbon sinks, control of agricultural N_2O emissions, production of renewable liquid fuels, afforestation and forest management, and lower municipal solid waste management emissions.

AFW-1. Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production

This policy dedicates a sustainable quantity of biomass from agricultural crop residue, wood industry process residues, unused forestry residues, and MSW biomass resources for efficient conversion to energy and economical production of heat, steam, or electricity. This biomass should be used in an environmentally acceptable and sustainable manner, considering proper facility siting and feedstock use, including co-location of production facilities with heat- and steam-utilizing facilities. The objective is to create concurrent reduction of CO_2 due to displacement of fossil fuels, considering life-cycle GHG emissions associated with viable collection, hauling, and energy conversion and distribution systems. This policy includes a recommendation for a complete inventory of the state's biomass resources. The primary goal of this policy is to produce 10% of total in-state electric generation from sustainable biomass feedstock by 2025.

AFW-2. In-State Liquid Biofuels Production

This recommendation promotes sustainable in-state production and consumption of transportation biofuels from agriculture, forestry, and MSW feedstocks to displace the use of gasoline and diesel. This recommendation also promotes the in-state development of feedstocks, such as cellulosic material, and production facilities to produce either liquid or gaseous biofuels with low carbon content. As with AFW-1, production of biomass for biofuel production must be done in a sustainable manner. Adoption of biofuel production must be done in a way that maintains the sustainability of feedstock, food, and other commodity supplies and natural resources. Upon successful implementation of this policy, Michigan consumption of biofuels produced in-state will result in better GHG benefits than these same fuels obtained from a national or international market due to lower embedded CO_2 (resulting from out-of-state fuels produced using feedstocks/production methods with lower GHG benefits, and from transportation of biodiesel, ethanol, other fuels, or their feedstocks from distant sources). Successful implementation of AFW-1 and AFW-2 will also lead to higher levels of in-state energy expenditures remaining in Michigan.

AFW-3. Methane Capture and Utilization From Manure and Other Biological Waste

This policy seeks to reduce the amount of methane emissions and recapture energy from organic waste materials from livestock, agricultural residues, and solid waste through the promotion of anaerobic digestion, gasification, and other similar technologies. Co-mingling of organic wastes with manure can substantially increase biogas production, while providing a sustainable method for treatment and disposal. In addition, co-products may be created by these technologies, such as stable fertilizer products and building materials. These technologies make a twofold contribution to climate protection: the usual discharge of methane into the atmosphere is prevented, and the burning of fossil fuels is replaced with renewable energy (biogas). The goal of this policy is to reduce GHG emissions from handling, treatment, and storage of livestock manure and organic waste by 15% by 2015 and 25% by 2025 through improved manure management practices and methane utilization.

AFW-4. Expanded Use of Bio-based Materials

This policy seeks to promote the manufacture, use, recycling, and reuse of materials made from biological products, such as wood, fiber, wheat board, agricultural by-products, biodegradable plastics, and green chemistry applications. These products reduce GHG emissions by sequestering carbon and displacing the production of fossil-based products. Additional GHG reductions can be achieved by promoting the use of Michigan-produced materials, which results in lower transport-associated emissions. This policy does not refer to energy uses, such as electricity or ethanol production, which are covered in AFW-1 and AFW-2. The goals associated with this policy are to utilize 100,000 tons of bio-based products annually by 2025, and to reclaim 150,000 tons of solid wood residues from manufacturing processes, deconstruction sites, and urban/suburban trees annually by 2025.

AFW-5. Promote Continuous Vegetative Cover

This recommendation is the maintenance and promotion of continuous vegetative cover, such as wind breaks and winter cover crops to prevent soil erosion, increase carbon sequestration, and provide new biomass sources. It also promotes the planting of cover crops with higher carbon content than current cover on marginal lands, including buffer strips, roadsides, on-off ramp areas, and transportation medians. GHG savings occur from carbon sequestration in the vegetative cover, indirect sequestration via carbon accumulation in soil, and reduced fertilizer application. The goals associated with this policy are to increase the acreage of lands with permanent cover by 10% by 2025 (existing land that is not under forest cover); retain 90% of lands coming out of the federal Conservation Reserve Program by 2025 in some type of permanent cover; and reduce rates of carbon loss by restoring or enhancing the maximum feasible percentage of wetlands by 2025.

AFW-6. Forestry and Agricultural Land Protection

This policy seeks to reduce the rate at which agricultural and forestlands and wetlands are converted to developed uses. The protection of these lands through conservation tools, such as land grants and easements and tax benefits, will retain the above- and below-ground carbon on these lands, as well as the future carbon sequestration potential of these lands. Markets for natural products from agriculture, forests, and wetlands also serve as incentives to keep these lands in their current state rather than convert them to development. GHG reductions come from the prevention of release of carbon from conversion of these lands. Additionally, indirect benefits occur through the reduction of urban sprawl, thus avoiding additional emissions from vehicle miles traveled. The goals associated with this policy are to reduce the rate of conversion from agriculture to developed use by 50% by 2025; maintain or increase forestland acreage by 2025, without converting agricultural land to forest, unless it has higher carbon sequestration potential; and protect and restore northern peatlands and other wetlands to prevent releases of GHGs, which will allow existing peatlands to continue to sequester carbon.

AFW-7. Promotion of Farming Practices That Achieve GHG Benefits

This recommendation addresses both agricultural soil carbon management, as well as nutrient management to achieve GHG benefits. For soil carbon management, conservation-oriented management of agricultural lands, cropping systems, crop management, and agricultural practices may regulate the net flux of CO_2 from soil. This recommendation has four separate elements: (1) soil carbon management, where CO_2 reductions occur indirectly via the building of soil carbon levels; (2) nutrient management, where GHG reductions occur through more efficient use of fertilizer, which lowers fossil fuel use though lower application energy requirements in addition to reduced N_2O emissions following application; also, life-cycle GHG reductions associated with the production and transportation of fertilizers are reduced; (3) an energy efficiency element that seeks to reduce GHG emissions by reducing the amount of fossil fuel consumed by farming and harvesting practices through improved technologies and increases in efficiency; and (4) the promotion of locally produced food, which reduces fossil fuel consumption by reducing food miles. The specific goals associated with these four policy elements are: increase conservation tillage farming to 4 million acres by 2025; adopt soil management and nutrient management practices on 5 million acres by 2025; reduce the net on-farm fossil fuel energy consumption by 50% by 2025; and increase the local/regional purchasing of locally grown agricultural produce and products by 50% by 2025.

AFW-8. Forest Management for Carbon Sequestration and Biodiversity

This recommendation focuses on the state's existing forested lands, recognizing the significant role that Michigan's forests play in lowering the state's net GHG emissions (a sink of ~13 $MMtCO_2e$/yr) and that management could be enhanced to achieve greater net GHG benefits. The goals associated with this policy are: enhance forestland management (including improved stocking of understocked stands) across the state on 1 million acres through afforestation and reforestation by 2025; achieve 40% canopy cover in urban communities by 2025 (this element also provides energy savings through shading and wind protection); and implement wildfire reduction community-wide protection plans for 10–12 identified communities at risk by 2025 (reducing wildfire risk protects forest carbon stores and maintains forest carbon sequestration levels).

AFW-9. Source Reduction, Advanced Recycling, and Organics Management

This recommendation seeks to improve the GHG profile of MSW management in the state by reducing waste generation, increasing recycling, and improving organics management. GHG savings occur through the reduction in landfill methane generation due to lower amounts of waste being landfilled in the future. Even more important from a GHG reduction perspective are the life-cycle emission reductions achieved via source reduction and recycling. Reducing or recycling products and packaging reduces the GHG emissions associated with their manufacture and transport, leading to significant overall reductions. While a large portion of these reductions would occur out of state, the MCAC recognizes the importance of this recommendation in achieving net GHG benefits. The policy goals are to achieve a 75% MSW recycling and enhanced organics management rate by 2025, and a 50% recycling rate for industrial, commercial, and new construction waste by 2025.

AFW-10. Landfill Methane Energy Programs

The renewable energy (methane) created at landfills during anaerobic degradation of wastes unable to be utilized in recycling and compost programs can be used to displace fossil fuel through the installation of methane control and collection systems. The goal of this policy is to implement controls or waste management options at MSW landfills, such that 50% of the methane emissions are avoided by 2025 that would be generated under business-as-usual conditions.

Chapter 8
Cross-Cutting Issues

Overview of Cross-Cutting Issues

Some issues relating to climate policy cut across multiple sectors. The Michigan Climate Action Council (MCAC) addressed such issues explicitly in a separate Cross-Cutting Issues (CCI) Technical Work Group (TWG). Cross-cutting recommendations typically encourage, enable, or otherwise support emission mitigation activities and/or other climate actions. The types of policies considered for this sector are not readily quantifiable in terms of greenhouse gas (GHG) reductions and costs or cost savings. Nonetheless, if successfully implemented, they help build a foundation for other recommendations and will contribute to GHG emission reductions and implementation of the MCAC's policy recommendations described in Chapters 3–7 of this report.

The CCI TWG developed recommendations for 10 policies (see Table 8-1) that were then reviewed, revised, and ultimately adopted by the MCAC members present and voting. Nine of the recommendations are focused on enabling GHG emission reductions and mitigation activities, while one (CCI-8–Adaptation and Vulnerability) addresses adaptation to the changes expected from the effects of GHGs that will remain in the atmosphere for decades.

Key Challenges and Opportunities

The MCAC was charged with developing proposed GHG reduction goals for Michigan, along with a set of policy recommendations designed to achieve such goals. The MCAC established 2005 as the baseline year and identified a mid-term goal of reducing the 2005 GHG baseline by 20% by 2020 and a long-term goal of an 80 % reduction by 2050.

The MCAC based its recommendations on its review of the potential overall emission reduction estimates (as compared to the GHG emissions inventory and forecast for business as usual) for 33 of 54 policy recommendations for which emission reductions were quantified. It also considered the goals and targets adopted by several other states in its deliberations. While 21 other MCAC policy recommendations were not readily quantifiable, some of them would most likely achieve or contribute to additional reductions, including several of the CCI policy recommendations.

A key challenge for the state in seeking to achieve these GHG reduction goals will be to identify available resources needed to implement many of the initiatives outlined in this report, particularly given the struggling economic conditions in the state and across the country. The MCAC will need to work closely with other state, local, federal, and tribal governmental entities, the private sector, institutions of higher education, citizens, and others to examine these opportunities.

Another key challenge for the state is the need to proactively engage with the federal government in developing appropriate federal programs and policies, while simultaneously working with other state and regional entities to design and implement strategies most effectively employed at this level.

In spite of these challenges, the nexus between seeking a new energy economy and significantly reducing GHG emissions in the state offers a rare opportunity for Michigan to be a leader in developing selected renewable energy technologies and enhancing economic and employment conditions.

Table 8-1. Summary list of CCI policy recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
CCI-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not Quantified*					Unanimous
CCI-2	Statewide GHG Reduction Goals and Targets	*Not Quantified*					Unanimous
CCI-3	State, Local, and Tribal Government GHG Emission Reductions (Lead by Example)	*Not Quantified*					Unanimous
CCI-4	Comprehensive Local Government Climate Action Plans (Counties, Cities, Etc.)	*Not Quantified*					Unanimous
CCI-5	Public Education and Outreach	*Not Quantified*					Unanimous
CCI-6	Tax and Cap/ Cap and Trade	*MCAC approved creation of new Market-Based Policies Technical Work Group as the lead for this policy.*					Transferred
CCI-7	Seek Funding for Implementation of MCAC Recommendations	*Not Quantified*					Unanimous
CCI-8	Adaptation and Vulnerability	*Not Quantified*					Unanimous
CCI-9	Participate in Regional, Multi-State, and National GHG Reduction Efforts	*Not Quantified*					Unanimous
CCI-10	Enhance and Encourage Economic Growth and Job Creation Opportunities Through Climate Change Mitigation	*Not Quantified*					Unanimous
CCI-11	Enhance and Encourage Community Development Through Climate Change Mitigation: Address Environmental Justice	*Not Quantified*					Unanimous

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

Overview of Policy Recommendations and Estimated Impacts

Cross-cutting issues include policies that apply across the board to all sectors and activities. Cross-cutting recommendations typically encourage, enable, or otherwise support emission mitigation activities and/or other climate actions. The MCAC recommends that 10 such policies be adopted and implemented in Michigan. All are enabling policies that are not quantified in terms of metric tons of GHG reduction or costs.

Detailed descriptions of the individual CCI policy recommendations as presented to and approved by the MCAC can be found in Appendix K of this report. Following are highlights of some of the policies recommended by MCAC:

Michigan is currently participating in the multi-state Climate Registry. The state needs to institute formal GHG inventory, forecast, and reporting functions to be carried out by a state agency. Using standardized protocols, the state should prepare annual inventories of emission sinks and sources and should develop forecasts of future GHG emissions in at least 5- and 10-year increments extending at least 20 years into the future. The state should also develop reporting protocols for facility-level reporting of all significant GHG emissions. Where possible, the state should coordinate these efforts with other states, regions, tribes, and the federal government.

Table 8-2 presents the MCAC's proposed GHG reduction goals for Michigan. These goals are consistent with goals being considered by the Midwestern Governors Regional Greenhouse Gas Reduction Accord process: achieve a 20% reduction of GHGs below 2005 levels by 2020 and an 80% reduction below 2005 levels by 2050. The MCAC recommends that these goals be established through executive or legislative action. The state should also develop a tracking system to measure progress over time in achieving GHG reductions against its recommended goals.

Table 8-2. MCAC-recommended goals for GHG reduction

Year	Reduction From 2005 Levels
2005	Baseline
2020	20%
2050	80%

The MCAC encourages other governmental entities and academic institutions to establish GHG reduction goals for their respective jurisdictions, and to develop plans, programs, and other initiatives to achieve their respective goals. The state is already engaged in numerous “Lead by Example” initiatives to find additional energy efficiencies and GHG reductions in state procurements for buildings, vehicle fleets, and office equipment. These initiatives, which are detailed in CCI-3, Appendix K, should be compiled, tracked, and shared among entities in Michigan. This should help stimulate private-sector and individual citizen actions as well.

A public education and outreach effort will be a key to building a broad base of awareness and support for the recommendations of this report. The MCAC has identified numerous strategies over several years to do so in conjunction with academic, business, local government, and other partners in this process. These outreach efforts are spelled out in CCI-5, Appendix K and are targeted to the following audiences: state government, policymakers, future generations, community leaders and community-based organizations, citizens, industrial and economic sectors, and tribal governments.

While many of the MCAC recommendations will save resources over the next 11 years, as documented through this MCAC process, some policy recommendations will require additional resources to implement. The state should immediately seek and establish capital investments and other funding sources for the implementation of the MCAC's recommendations. State government should lead the efforts to generate investment and financial support. Other sectors, including local government, industry, services, agriculture, consumers, and higher education, should also be involved. The state should examine alternative financing mechanisms, such as those listed in CCI-7, Appendix K, and develop proposals to implement those that are the most promising.

Given Michigan's vulnerability to impacts of climate change, the state should undertake a comprehensive planning effort to assess and address the impact of climate change on the Great Lakes, the state's natural resources, and wildlife and fisheries. The state should start by developing a scoping document that identifies technical and financial resources and research needed to undergo a comprehensive planning process in 2009. When applicable and feasible, the scoping document should identify ongoing and intended research efforts that could contribute to the planning process. A multi-agency and diverse stakeholder team should be formed to follow through with the planning process in 2009 and beyond. A detailed list of tasks is included in CCI-8, Appendix K.

The state is a participant in the Midwestern Governors Regional Greenhouse Gas Reduction Accord and Energy Security and Climate Stewardship Platform. The state should continue this proactive engagement with other states in the region in developing cost-effective, multi-state reduction strategies. At the same time, the state will be pushing for progressive action at the federal level to address climate change. Michigan will also work with the 12 federally recognized tribes in the state to help coordinate local climate change strategies (see CCI-9, Appendix K). This will be accomplished through either existing agencies or a designated state entity charged with climate change issues, and through the use of existing agreements between the Michigan Department of Environmental Quality (MDEQ) and tribes, such as the Water Accord, or newly created mechanisms that allow government-to-government dialog on environmental issues of mutual interest. Likewise, Michigan will welcome and seek out a mechanism to coordinate its climate change and GHG reduction efforts with national tribal organizations, such as the climate mitigation and adaptation dialog recently initiated by the National Congress of American Indians, the Council of Energy Resource Tribes, and others. Michigan should also further investigate, and if it is determined to be in the state's best interest, join The Climate Registry (TCR) and the Chicago Climate Exchange (CCX).

It has been demonstrated that there are numerous economic and employment opportunities associated with implementation of many of the MCAC-recommended GHG reduction policies. The MCAC recommends that the state implement robust measures to retain existing clean tech business and attract new investment. Some categories for attention may include: provide more attractive financial incentives, implement policies that enhance and encourage economic growth, seek more federal support, utilize Michigan's existing resources and economic opportunities, protect water resources, invest in walk-able neighborhoods and transportation mode choices, support a diverse agricultural base, maintain traditional support for Michigan's excellent public research universities, and encourage and facilitate Michigan's strong social infrastructure. Appendix K, CCI-10 presents numerous additional examples and details about these initiatives.

Finally, there is an opportunity to enhance sustainable community development and address environmental justice issues in Michigan as climate change mitigation is addressed at the local level. To do so, the state needs a collaborative planning process—transformational responses that allow for distribution of costs and benefits and opportunities for change. Numerous examples and initiatives to do so are outlined in CCI-11, Appendix K.

Cross-Cutting Issues
Policy Descriptions

CCI-1. Inventories, Forecasting, Reporting, and Registry

GHG emission *inventories* track statewide emission trends and quantify emissions from individual sources and sinks (both anthropogenic and natural). They can be used to inform state leaders and the public and to verify GHG reductions associated with GHG reduction programs.

GHG *forecasts* are scenario-based predictions of future emission trends built on inventories and projected economic trends. These forecasts are useful for identifying the factors that affect trends and highlighting opportunities for mitigating emissions or enhancing sinks.

Detailed GHG *reporting* is needed from all major GHG sources[1] in order to develop accurate inventories. Reporting is also required for sources to participate in GHG reduction programs, such as market-based systems like cap and trade and carbon taxation. Participation in a reporting program prior to the establishment of a GHG reduction program establishes an early baseline that can be used to avoid disincentives to abate emissions prior to establishment of the reduction program.

A GHG *registry* enables recording of GHG emission reductions in a central repository. Registries can establish "ownership" of emission reductions, protect baselines, and provide a mechanism for regional cooperation. Registries can also provide a foundation for future trading programs and facilitate the identification of opportunities for reductions.

CCI-2. Statewide GHG Reduction Goals and Targets

In Executive Order No. 2007-42, the Governor directed the MCAC to recommend specific short-term, mid-term, and long-term GHG reduction goals or targets for Michigan. Additionally, the Midwestern Regional Greenhouse Gas Reduction Accord, signed by Governor Granholm on November 15, 2007, establishes a requirement for its staff and appropriate state agency

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[1] According to The Climate Registry, individual sources are defined either as "entities" (i.e., any corporation, institution, or organization) recognized under U.S. law, or as "facilities" (i.e., any installation or establishment located on a single site or on contiguous or adjacent sites that are owned or operated by an entity). See http://www.theclimateregistry.org/downloads/GRP.pdf for additional details. The official definition of a "source" is left to MDEQ, but facility-level reporting is strongly recommended.

representatives to set regional GHG reduction targets that are consistent with member states' targets. The establishment of a Michigan statewide goal or target can provide vision and direction, a framework within which implementation of MCAC policy recommendations can proceed effectively, and a basis of comparison for periodic assessments of progress. GHG reduction goals or targets recommended by the MCAC should be consistent with the parallel goal of an efficient, robust Michigan economy. In pursuit of similar climate progress, approximately 20 other states have established GHG reduction goals or targets.

The Intergovernmental Panel on Climate Change (IPCC) determined that atmospheric GHGs must remain below 400–450 parts per million of carbon dioxide equivalent (CO_2e) to have a reasonable chance of staying below 2°F of warming. This concentration is considered the stabilization target. The IPCC further calculated that the industrialized nations' cumulative emissions over the 2000–2050 period must remain less than 700 gigatons (Gt) of CO_2e. This means that the world's industrialized nations must reduce emissions 70%–80% below 2000 levels by 2050 to help prevent global temperature increases. For its share, the United States needs to reduce its GHG emissions by about 80% by 2050 in order to stay within its estimated "safe" range of 160–265 $GtCO_2e$ for that same 50-year period. That comes to a 20% per decade reduction, or 2% per year.

The target years and GHG reduction goals included in this policy recommendation reflect a high level of uncertainty regarding the costs and benefits of implementing GHG reduction policies in Michigan. These goals have been examined in the second phase of the process and considered in combination with the results of the modeling and evaluation of the selected policy recommendations.

In accordance with the *Michigan Climate Action Council Interim Report,* "the strategy development process must evaluate and consider economic and environmental impacts, including the implementation costs or cost savings for individuals, communities, businesses, and jobs in Michigan." The policy recommendations detailed by the six TWGs (Agriculture, Forestry, and Waste Management; Energy Supply; Residential, Commercial, and Industrial; Transportation and Land Use; Cross-Cutting Issues; and Market-Based Policies) include policies to reduce GHG emissions at low net cost, and identify opportunities for substantial net savings. Implementation of carefully crafted policy recommendations should bring significant economic benefits to the Michigan economy, by reducing fuel costs through efficiency measures, by reducing the export of capital from the state, and by stimulating the Michigan economy through the creation of new opportunities and jobs in energy efficiency, clean energy technologies, renewable energy development, transportation, and land-use planning.

The MCAC has modified the preliminary target year and GHG reduction goals from those originally proposed in the MCAC Interim Report to those consistent with the goals being considered by the Midwestern Governors Association. They are presented in Table 8-2. The policies recommended by the MCAC appear to be able to achieve a 20% reduction below 2005 levels by 2020. To do so, however, it will be necessary for the state to move expeditiously forward with near-term implementation of the policy initiatives outlined in this MCAC Final Report. This includes instituting formal mechanisms to monitor and verify GHG reduction progress and periodically adjusting reduction goals and strategies when needed.

The MCAC also recommends that a formal performance tracking mechanism be developed to gauge progress in Michigan toward achievement of the goals and targets.

CCI-3. State, Local, and Tribal Government GHG Emissions (Lead by Example)

The state of Michigan and many local and tribal governments have undertaken various policy and program actions in several key areas to obtain GHG emission reductions and improve energy efficiency. Many of these ongoing and future efforts can provide practical and working examples of what can be done by nongovernmental organizations, academic institutions, and even private citizens to reduce GHG emissions. Much more effort is planned and should be undertaken to further improve Michigan's energy efficiency and reduce our carbon dependency and emission rate, as outlined in Appendix K of this report.

State, local, and tribal governments are responsible for providing a multitude of services for the public that are delivered through very diverse operations. This also makes them responsible for overseeing wide-ranging GHG emission activities and provides leadership opportunities to work with universities, nonprofit organizations, and the private sector to reduce emissions and increase energy efficiency. For example, the state of Michigan is a major consumer of electricity and, as such, can promote the development of environmentally benign generation and purchase a significant portion of its power through a certified "green power" program.

While the incentive for this action will be, in part, market driven as energy costs increase, it will only be achievable through a continued comprehensive analysis of current operations, identification of significant GHG sources, and implementation of changes in technology, procedures, behavior, operations, and the services provided. State, local, and tribal governments must find ways to encourage and provide incentives for reducing GHG emissions in a variety of ways. One of the most important is to link GHG reductions to energy expenditures, and demonstrate that reduction in one leads to reduction in the other.

CCI-4. Comprehensive Local Government Climate Action Plans

A number of local and regional cities and municipalities in Michigan have already taken steps and initiated programs and activities to mitigate climate change in their communities. Many of these cities and communities—23 in Michigan and over 900 cities nationwide—are also signatories to the U.S. Mayors Climate Protection Agreement, and have a stated goal of reducing CO_2 emissions by 7% below 1990 baseline levels by 2012. Furthermore, cities and communities in Michigan are helping to develop and support additional climate change accountability programs, such as the Midwestern Regional Greenhouse Gas Reduction Accord, TCR, and the Michigan Renewable Energy Program.

The state and tribal governments, regional metropolitan councils (e.g., the Grand Valley Metro Council), Michigan Municipal League, and others could all help create awareness about climate change issues and lead by example in developing climate change programs that are coordinated with the MCAC. Additionally, these organizations and entities could help communicate best practices and success stories through a variety of outlets, such as workshops, conferences, summit meetings, a Web site clearinghouse, education and outreach to public and municipal officials, as well as recognizing local government GHG and CO_2 emission reduction achievements.

CCI-5. Public Education and Outreach

Public education and outreach is essential to cultivating broad support for GHG reduction activities. Education and outreach will target at least seven specific audiences in Michigan according to policy recommendations made by MCAC members. These efforts will seek to create awareness of climate change issues, along with providing justification for policies designed to reduce GHG emissions. Public education and outreach efforts should build upon existing work being done by state, tribal, and local agencies, utility companies, and nonprofit organizations.

CCI-6. Tax and Cap Policies / Cap and Trade

The lead for developing this policy recommendation was transferred by the MCAC to the Market-Based Policies TWG (see Chapter 4).

CCI-7. Seek Funding and Financing for Implementation of MCAC Recommendations

Michigan will seek and stimulate funding and investment to implement the MCAC climate solution recommendations. Accordingly, Michigan will position itself to successfully compete for federal and international assistance and matching funds in adaptation and mitigation of climate change impacts. Funding decisions will take into account both economic and environmental impacts, including the implementation costs or cost savings for individuals, communities, and businesses, as well as similar funding actions made by other Midwest states and regions. As Michigan allocates funding for MCAC recommendations, the state will work to identify choices that provide the best opportunities for mitigation of, and adaptation to, climate change. Concurrently, Michigan will implement initial funding investments that require few long-term costs. In addition, Michigan aims to reduce the costs associated with climate change activities, while fostering economic growth within the state.

CCI-8. Adaptation and Vulnerability

Climate change is a potentially serious threat to communities, natural resources, and wildlife in Michigan, the United States, and around the world. While addressing the source of climate change and related GHG mitigation options is critical, it is also important that decision makers and the citizens of Michigan understand how climate change is affecting and will affect the natural resources and natural resource-based economic activity in the state. Additional attention, research, and funding are needed to assess the impact of climate change on Michigan's fisheries and wildlife and help them adapt, while also reducing the other stressors on their habitats and ecosystems. Communications, research, and funding are also needed to assess and moderate climate change's impact on Michigan's land and other natural resource-based industries (forestry, agriculture, tourism, and recreation).

The state of Michigan should undertake a comprehensive planning effort to assess and address the state's vulnerability to climate change and adaptation opportunities. Various organizations and agencies in the state are already collecting some of the information needed for such an assessment and efforts should be made to coordinate and consolidate these information-gathering activities.

CCI-9. Participate in Regional, Multi-State, and National GHG Reduction Efforts

The MCAC recognizes that collaboration is a key to the successful implementation of the state climate change strategies. Because the execution of policies designed to reduce climate change affects all sectors of society, actions must be broad-based and inclusive. For this reason, collaborative regional and multi-state reduction efforts offer promising possibility for accomplishing the MCAC's target goals. Joint regional, multi-state, multi-province, and in some cases, national approaches to GHG emission reductions and energy efficiency options can provide greater opportunities for success, particularly because the issue of climate change is not constrained to political boundaries. Accordingly, Michigan recognizes, has considered, and has joined other regional and national, market-based GHG reduction strategies. Such strategies propose to mitigate and adapt to climate change in various sectors, including energy supply, residential, commercial, industrial, transportation, land use, agriculture, forestry, and waste management.

The current initiatives include the state's membership in the Midwestern Regional Greenhouse Gas Reduction Accord, whereby the member governors and Canadian prime minister agreed to establish a midwestern GHG reduction program with targets and time frames that are consistent with state policies. Also included in this initiative is the development of a market-based, multi-sector cap-and-trade program to achieve reductions. An additional joint initiative is MDEQ's participation on the Steering Committee for the development of TCR. The multi-state TCR was designed to be an essential piece of infrastructure for the development of state and federal climate change programs by forming a partnership to produce a protocol for measuring GHG emissions. A third significant initiative offering opportunities for multi-state collaboration is the CCX. Michigan, as well as all other members of the CCX, must achieve a minimum 6% reduction in GHG emissions from 2000 levels by 2010. This goal is in accordance with Michigan reduction targets.

These developments will be continued and will function as models to form the basis of future Michigan GHG reduction programs. Michigan should consider developing supplementary or ancillary registry capacities or opportunities to meet all of the state's needs. Michigan will continue to examine the decisions made by other states and regions, particularly in the Midwest states and in Canada, to identify opportunities for collaboration with other GHG reduction efforts. Michigan will also implement regional climate reduction initiatives, such as a regional carbon cap-and-trade system (unless a national system supersedes this need).

The Governor and the Michigan legislature should aggressively push for and continue to encourage federal action to reduce GHG emissions and to ensure that Michigan is well represented and protected at the federal level. An aggressive approach to GHG reductions within the United States will have a significant effect on the international reductions needed to begin reversing global warming trends. Ultimately, many of the climate protection issues need to be addressed at the national level. Michigan must help shape these national initiatives.

CCI-10. Enhance and Encourage Economic Growth and Job Creation Opportunities Through Climate Change Mitigation

Michigan's response to climate change can serve as a catalyst for increasing economic activity, in addition to reducing GHG emissions. Michigan is already home to two of the world's leading solar power manufacturers, and over 25 businesses provide components for the growing commercial wind energy industry. Investors in the clean tech sector are constantly seeking locations that offer the most advantageous markets. Texas, Colorado, New York, and Pennsylvania have recently added thousands of green collar jobs by offering start-up capital, tax breaks, and energy policy that welcomes clean energy. Michigan has a capable workforce, engineering expertise, and substantial manufacturing capacity. The state also possesses considerable natural resources that could establish it as a leader in renewable energy. Given the intense competition from other states and nations, however, additional incentives and supportive government policies will be necessary to maximize investment in Michigan.

CCI-11. Enhance and Encourage Community Development Through Climate Change Mitigation: Address Environmental Justice

Climate change is predicted to cause significant changes in both the atmosphere and the natural environment, including increases in extreme weather events and droughts, as well as rises in sea level in some regions and lower water levels in the Great Lakes.

Although all segments of Michigan's population and economy will be affected by climate change, certain communities run the risk of being disproportionately burdened by costs and challenges, particularly poor communities and communities of color. As evidenced by the impact of Hurricane Katrina in New Orleans, communities in the United States continue to be unprepared—socially, financially, and environmentally—for major natural events.

Even in the absence of major natural disasters, climate change has the potential to devastate an unprepared economy. Transitional costs will likely be regressive and could further burden populations already suffering from economic hardship with unbearable costs.

To encourage community development through climate change mitigation and ensure that vulnerable communities are protected, the state must engage a range of communities in a collaborative planning process that works toward a transformational response to climate change. This response must be tailored to the regressive costs posed by climate change, and must act to address the economic and health impacts of a warming climate.

Appendix A
Executive Order Establishing the Michigan Climate Action Council

On November 14, 2007, Governor Jennifer M. Granholm issued Executive Order No. 2007-42 establishing the Michigan Climate Action Council (MCAC).

The Executive Order, provided as an attachment, is also available at:
http://www.miclimatechange.us/ewebeditpro/items/O46F13992.pdf

STATE OF MICHIGAN
OFFICE OF THE GOVERNOR
LANSING

JENNIFER M. GRANHOLM
GOVERNOR

JOHN D. CHERRY, JR.
LT. GOVERNOR

EXECUTIVE ORDER
No. 2007 – 42

DEPARTMENT OF ENVIRONMENTAL QUALITY

MICHIGAN CLIMATE ACTION COUNCIL

WHEREAS, Section 1 of Article V of the Michigan Constitution of 1963 vests the executive power of the State of Michigan in the Governor;

WHEREAS, the world's scientific community has concluded with a very high level of confidence that emissions of carbon dioxide, methane, and other greenhouse gases are causing the Earth's climate to warm;

WHEREAS, the extent of warming of the Earth's climate depends upon actions taken today to reduce greenhouse gas emissions;

WHEREAS, the State of Michigan can play an important role in meeting the challenge of global climate change while simultaneously spurring economic growth;

WHEREAS, recent studies on the net positive economic and environmental impacts of renewable portfolio standards, energy efficiency standards, and other policy actions for Michigan offer a compelling case for immediate proactive steps to address climate change;

WHEREAS, actions to reduce greenhouse gas emissions such as improving energy efficiency, conserving natural resources, and developing renewable energy sources are beneficial as they reduce costs and spur economic development and job creation;

WHEREAS, establishment of a climate action council will assist this state in identifying the best opportunities to mitigate and adapt to climate change, reduce costs, and foster economic growth in Michigan;

NOW, THEREFORE, I, Jennifer M. Granholm, Governor of the State of Michigan, by virtue of the power and authority vested in the Governor by the Michigan Constitution of 1963 and Michigan law, order the following:

I. DEFINITIONS

As used in this Order:

A. "Department of Environmental Quality" or "Department" means the principal department of state government created under Executive Order 1995-18, MCL 324.99903.

B. "Council" means the Michigan Climate Action Council created under Section II of this Order.

C. "Greenhouse gas" means a gas from a human-generated activity that traps heat within the atmosphere of the Earth causing climate change, including, but not limited to, carbon dioxide, methane, nitrous oxide, ozone, and fluorinated gases.

D. "Climate change" refers to any significant change in measures of climate, such as temperature, precipitation, or wind, lasting for an extended period of time of a decade or longer.

E. "Renewable energy source" means that term as defined under Section 10g of 1939 PA 3, MCL 460.10g.

II. CREATION OF THE MICHIGAN CLIMATE ACTION COUNCIL

A. The Michigan Climate Action Council is created as an advisory body within the Department of Environmental Quality.

B. The Council shall consist of the following members:

1. The Director of the Department of Environmental Quality.

2. The Director of the Department of Agriculture.

3. The Director of the Department of Labor and Economic Growth.

4. The Director of the Department of Management and Budget.

5. The Director of the Department of Natural Resources.

6. The President of the Michigan Strategic Fund.

7. The Chairperson of the Michigan Public Service Commission.

8. The State Climatologist.

9. 27 other residents of this state appointed by the Governor.

C. Members of the Council shall serve until December 31, 2008.

D. A vacancy on the Council for a member appointed under Section II.B.9 shall be filled in the same manner as the original appointment.

E. The Director of the Department shall serve as the Chairperson of the Council. The Council shall elect a member of the Council to serve as Vice-Chairperson of the Council.

III. CHARGE TO THE COUNCIL

A. The Council shall act in an advisory capacity and shall do all of the following:

1. Produce an inventory and forecast of greenhouse gas emissions in Michigan and their sources from 1990 to 2020.

2. Consider potential state and multi-state climate change mitigation and adaptation actions in each of the following sectors, and such other sectors as deemed appropriate by the Council:

a. Energy supply.

b. Residential.

c. Commercial and industrial.

d. Transportation.

e. Land use.

f. Agriculture.

g. Forestry.

h. Waste management.

3. Compile a comprehensive climate action plan for this state with specific recommendations for reducing greenhouse gas emissions in Michigan, including, but not limited to, identification of mitigation and adaptive measures for state and local units of government, businesses, and Michigan residents to minimize climate change and better prepare for the effects of climate change in Michigan.

4. Advise state and local governmental entities on measures to address climate change.

B. The Council shall complete its work in the following two phases:

1. The Council shall develop a comprehensive list of policy recommendations to reduce greenhouse gas emissions, including preliminary short-term, mid-term, and long-term greenhouse gas emissions reduction goals or targets for this state, for submission as an interim report to the Governor by April 30, 2008.

2. The second phase of the Council's work shall include all of the following, which shall be presented, along with any recommended legislation, to the Governor in a final report of the Council, issued by December 31, 2008:

a. Further development of the policy recommendations included in the interim report of the Council under Section III.B.1 and analysis of the greenhouse gas reduction potential, estimated costs and savings, other environmental benefits, and feasibility of the recommendations.

b. Recommendations for appropriate short-term, mid-term, and long-term greenhouse gas emissions reduction goals or targets for this state.

c. Assessment of climate change impacts to this state, the likelihood of occurrence, and recommendations for potential adaptive measures.

d. A comprehensive climate action plan for this state.

C. The Council shall complete its work by December 31, 2008.

IV. OPERATIONS OF THE COUNCIL

A. The Council shall be staffed and assisted by personnel from the Department, subject to available funding. Any budgeting, procurement, or related management functions of the Council shall be performed under the direction and supervision of the Director of the Department.

B. The Council shall adopt procedures consistent with Michigan law and this Order governing its organization and operations.

C. A majority of the members of the Council serving constitutes a quorum for the transaction of the Council's business. The Council shall act by a majority vote of its serving members.

D. The Council shall meet at the call of the Chairperson and as may be provided in procedures adopted by the Council.

E. The Council may establish advisory workgroups composed of representatives of entities participating in Council activities or other members of the public as deemed necessary by the Council to assist the Council in performing its duties and responsibilities. The Council may adopt, reject, or modify any recommendations proposed by an advisory workgroup.

F. The Council may, as appropriate, make inquiries, studies, investigations, hold hearings, and receive comments from the public. The Council may also consult with outside experts in order to perform its duties, including, but not limited to, experts in the private sector, organized labor, government agencies, and at institutions of higher education.

G. Members of the Council shall serve without compensation. Members of the Council may receive reimbursement for necessary travel and expenses consistent with relevant statutes and the rules and procedures of the Civil Service Commission and the Department of Management and Budget, subject to available funding.

H. The Council may hire or retain contractors, sub-contractors, advisors, consultants, and agents, and may make and enter into contracts necessary or incidental to the exercise of the powers of the Council and the performance of its duties as the Director of the Department deems advisable and necessary, in accordance with this Order, the relevant statutes, and the rules and procedures of the Civil Service Commission and the Department of Management and Budget.

I. The Council may accept donations of labor, services, or other things of value from any public or private agency or person.

J. Members of the Council shall refer all legal, legislative, and media contacts to the Department.

V. MISCELLANEOUS

A. All departments, committees, commissioners, or officers of this state, or of any political subdivision of this state, shall give to the Council or to any member or representative of the Council, any necessary assistance required by the Council or any member or representative of the Council, in the performance of the duties of the Council so far as is compatible with its, his, or her duties. Free access shall also be given to any books, records, or documents in its, his, or her custody, relating to matters within the scope of inquiry, study, or review of the Council.

B. This Order shall not abate any suit, action, or other proceeding lawfully commenced by, against, or before any entity affected under this Order. Any suit, action, or other proceeding may be maintained by, against, or before the appropriate successor of any entity affected under this Order.

C. The invalidity of any portion of this Order shall not affect the validity of the remainder of the Order, which may be given effect without any invalid portion. Any portion of this Order found invalid by a court or other entity with proper jurisdiction shall be severable from the remaining portions of this Order.

D. This Order is effective upon filing.

Given under my hand and the Great Seal of the State of Michigan this 14th day of November in the year of our Lord, two thousand seven.

JENNIFER M. GRANHOLM
GOVERNOR

BY THE GOVERNOR:

Secretary of State

FILED WITH SECRETARY OF STATE
ON 11/14/07 AT 2:47 PM

Appendix B
Description of the Michigan Climate Action Council Process

Memorandum

To: Michigan Department of Environmental Quality

From: The Center for Climate Strategies

Re: Work Plan for Launch of the Michigan Climate Action Council

Date: December 12, 2007

This memorandum outlines the proposed work plan for the Michigan Climate Action Council (MCAC). Initially the purpose and goals of the process are described, including the proposed general outline of the final report and the overall timing and milestones. Also described are the design of the process, including key principles and guidelines. A set of general MCAC meeting agendas follows, showing the progression of the process over time. Lastly, an outline of the budget and funding plan is presented, along with a description of the project team.

Purpose and Goals of the Michigan Climate Action Council

In an Executive Order dated November 14, 2007, Governor Jennifer M. Granholm directed the Department of Environmental Quality (DEQ) to establish the Michigan Climate Action Council (MCAC) to identify opportunities for Michigan to respond to the challenge of global climate change while becoming more energy efficient, more energy independent, and spurring economic growth. The Governor and the DEQ have requested that the Center for Climate Strategies (CCS) assist the MCAC in the development of a Michigan climate action plan. Through this memorandum, we are responding to the request, asking for review and approval of our proposed work plan, and providing a commitment to provide substantial cost share to ensure success of the project. Upon approval, we propose to move quickly to launch the first meeting of the process.

The MCAC will be a broad-based group of Michigan stakeholders charged with making a comprehensive set of state-level policy recommendations to the Governor in a climate action plan. CCS proposes to facilitate the MCAC in a consensus building process, in close coordination with the DEQ.

The goals of the MCAC process include:

1. Review and approval of a current and comprehensive inventory and forecast of greenhouse gas (GHG) emissions in Michigan from 1990 to 2020.
2. Development of a recommended set of individual policy recommendations to reduce GHG emissions in Michigan through 2020, in two phases:
   (a) Phase one will produce a set of preliminary recommendations and an interim report with executive and legislative branch policy recommendations for consideration by the Governor and Legislature by April, 2008.
   (b) Phase two will produce a more detailed set of policy recommendations and include significant analysis of the emissions reductions expected from those policy measures in a final report due to the Governor *by* December 31, 2008*.*
3. Development of recommended goals for statewide reductions in the amount of GHGs emitted by activities in Michigan.

Interim and Final Reports

The MCAC Interim Report to the Governor is expected by April 30, 2008. It will contain a preliminary inventory and forecast of Michigan GHG emissions, an initial set of policy option priorities identified by the MCAC for consideration in connection with the 2008 legislative session and preliminary recommendations regarding potential goals for reducing GHG emissions in Michigan.

The MCAC final report to the Governor is expected no later than December 31, 2008*.* It will compile and summarize the final recommendations of the MCAC and cover the following areas:

1. Executive Summary
2. History and Status of State Actions
3. Inventory and Forecast of Michigan GHG Emissions
4. Proposed Goals for Reducing Greenhouse Gas Emissions in Michigan
5. Recommended Policy Actions by Sector:
   a. Energy Supply
   b. Residential, Commercial, and Industrial
   c. Transportation and Land Use
   d. Agriculture, Forestry, and Waste Management

    e. Cross Cutting Issues (Emissions Reporting, Registries, and Education)

6. Technical Appendices

Timing and Milestones

The first in-person meeting of the MCAC will be held in December 2007 Preliminary recommendations will be included in an Interim Report that will be developed by CCS by April 30, 2008. Phase II of the process will begin with meeting four, to be held in June 2008. CCS will issue the Final Report of the MCAC following its final meeting. For each of the five Technical Work Groups (TWG), two or more teleconference calls or meetings will be held between each of the MCAC meetings.

The following draft schedule is suggested for planning purposes:

Draft MCAC Calendar

Date	Meeting*
PHASE I	
December 12, 2007	1st MCAC meeting
February 2008	2nd MCAC meeting
April 2008	3rd MCAC meeting
April, 2008	Interim MCAC Report with Preliminary Recommendations
PHASE II	
June 2008	4th MCAC meeting
September 2008	5th MCAC meeting
November 2008	6th MCAC meeting
December 31, 2008	Final MCAC Report
Between MCAC Meetings	TWG conference calls and meetings

Design of the Process

The MCAC process will follow the format of CCS policy development processes used successfully in a number current and completed state-level climate action planning initiatives. The CCS planning process combines techniques of alternative dispute resolution, community collaborative decision-making, and corporate strategic planning in a combined form of facilitation and technical analysis known as "evaluative facilitation." This consensus-building model supports informed and collaborative self-determination by a broadly representative group of designated stakeholders and technical experts. Activities of the MCAC will be transparent, inclusive, stepwise, fact-based, and consensus driven. The MCAC process will seek but not mandate consensus and will use formal voting to determine the level of support for individual options.

The MCAC process relies on intensive use of information and interaction, and requires substantial organization and communication among facilitators, participants, and technical analysts. CCS will oversee and manage this information exchange and decisional process in partnership with the DEQ. CCS will provide central coordination of MCAC and TWG activities though a project director team and a group of CCS technical facilitators and consultants. The CCS team provides close coordination of MCAC, TWG, facilitation, and technical support activities.

To facilitate learning, collaboration, and task completion by the MCAC members, CCS will provide a series of decision templates for each step in the process, including: a catalog of state actions with ranking criteria, a balloting form for identification of initial priorities for analysis, a draft policy option template for the drafting and analysis of individual recommendations, a quantification principles and guidelines document for each TWG, and a final report format. CCS will also provide meeting materials for each MCAC meeting and TWG teleconference call, including: a PowerPoint presentation of the discussion items, an agenda and notice of the meeting, a draft summary of the previous meeting for review and approval, and additional handouts as needed. Materials will be provided by CCS in advance through website posting and email notice with a goal of seven-days advance notice. CCS will provide and manage a project website (www.miclimatechange.us) in close coordination with the DEQ. All website materials are reviewed by the DEQ prior to posting. Examples of CCS project websites can be found at www.climatestrategies.us.

The MCAC process includes the following key principles and guidelines:

- The process is fully transparent. All materials considered by the MCAC and TWGs are posted to the project website, and all meetings are open to the public. The quantification of all potential policy options is transparent with respect to the data sources, methods, key assumptions, and uncertainties used by CCS in its joint work with participants. In addition, policy design parameters and implementation methods for recommended actions are fully transparent, including goal levels, timing, coverage of parties, and implementation mechanisms. The transparency of technical analysis, policy design, and participant viewpoints is critical to the identification and resolution of potential conflicts.

- The process is inclusive. A diverse group of MCAC members, in combination with additional TWG members chosen by the DEQ to represent a broad spectrum of interests and expertise in Michigan. A ground rule for participation is to be supportive of the process, but members are free to disagree on specific decisions within the process. The public also is invited to provide meaningful review of and input to decisions.
- The process is stepwise. Each step of the process builds incrementally on the former toward a final solution. Sufficient time, information, and interaction are provided between steps to ensure comfort with decisions and quality of results.
- The process will seek but not mandate consensus. Votes will be taken at key milestones in the process in order to advance to next steps. Alternatives that address barriers to consensus will be developed by the MCAC with the assistance of CCS, as needed. Voting is conducted by simple request for objection at the point of decision (by hand), followed by resolution of conflicts with the development of alternatives, as needed, to proceed. Final votes by the MCAC include support at three levels, including: unanimous consent (no objection), super majority (five objections or less), and majority (less than half object). Typically the early stages of the process proceed with unanimous consent, and supermajority if needed. Final recommendations may include recommendations at all three levels. Almost all final recommendations in prior processes have enjoyed unanimous consent, with a few falling short. The final report by CCS will document MCAC recommendations and views on each policy option, including alternative views as needed.
- The process is comprehensive. The MCAC will explore solutions in all sectors and across all potential implementation methods, including a variety of voluntary and mandatory implementation mechanisms. The total number of policies considered and recommended by the MCAC is typically 50 or more. Recommendations may include state-level and multi-state actions (regional and national). Mitigation of all GHGs will be examined, including carbon dioxide, methane, nitrous oxide, and synthetic gases. Units will be expressed in million metric tons carbon dioxide equivalent (MMTCO2e). Similarly, all forms of energy supply and use and all forms of economic development are open for consideration as they relate to GHG mitigation actions. Any significant actions taken by the executive or legislative branches during the process will be included in an updated reference case forecast of emissions.
- The process is guided by clear decision criteria for the selection and

design of recommended actions. These include consideration of: (1) GHG reduction potential; (2) cost or cost savings per ton GHG removed: (3) co-benefits, including economic, environmental, and energy policy improvements; and (4) feasibility issues.

- The process is quantitative. Results of MCAC decisions will include explicit descriptions of policy design parameters and results of economic analysis. Recommendations can include both quantified and non-quantified actions, with emphasis on quantification of GHG reduction potential and cost or cost savings for as many recommendations as possible. Additional quantification needs related to co-benefits or feasibility issues will be evaluated on a case-by-case basis pending MCAC input and available resources.
- The process covers short, medium, and long-term periods of action. The time period of analysis for emissions inventories and reference case projections includes years 1990-2020. Recommendations for action typically include the present to year 2020, with estimated benefit and cost impacts being reported for intermediate years such as 2010 and 2020. These time frames can be adjusted to if needed to consider longer time horizons.
- This process is implementation oriented. The goal of the process is ultimate adoption of specific policies by the state of Michigan based on planning recommendations of the MCAC and subsequent, more detailed analyses as needed. Accordingly, to support group consideration, implementation, design, and feasibility issues are provided at a conceptual level appropriate to support further consideration by the Governor.

MCAC Meeting Objectives and Agendas

The objectives and agendas for each of the MCAC and TWG meetings are listed below, with notes regarding each of decisions of the MCAC.

PHASE I: MEETING ONE

- Objectives:
    - Introduction to the process, presentation of preliminary fact finding (inventory and forecast of emissions, catalog of state actions), formation of TWGs and identification of preferences (no votes, however, MCAC members should be prepared to select one or more TWGs for their participation)
    - Introduction to the GHG goal setting process including examples from other states

- Agenda:
    - Introductions
    - Purpose and goals
    - Review of the MCAC process
    - Review of climate science and impacts (as needed)
    - Review of the status of and reasons for state climate change action, and related energy and commerce improvements
    - Review of the draft Michigan emissions inventory & forecast
    - Review of Michigan actions already underway and introduction to the draft catalog of existing state climate mitigation actions
    - Review GHG emission reduction goals and targets in other states
    - Formation of TWG's, next meeting agenda, time, location, date
    - Public input

Interim TWG calls will cover: (1) review and suggested revisions to the draft inventory and reference case projections; (2) review and suggested additions to the catalog of policy options; (3) Review other state goals and targets

PHASE I: MEETING TWO

- Objectives:
    - Addition of potential actions to the draft catalog of state actions (by vote)
    - Identification of potential revisions to the draft emissions inventory and forecast (by vote if/as needed)
    - Discuss options and determine viability of establishing preliminary GHG reduction goals /targets for Michigan.
- Agenda:
    - Introductions
    - Review and approval of previous draft meeting summary
    - Review and approval of additional actions to the catalog of possible Michigan policy actions
    - Discussion of the process for identifying initial priorities for TWG analysis
    - Recommended updates to inventories and baseline forecasts

- Discuss options for establishing Michigan GHG reduction goals and targets
- Next meeting agenda, time, location, date
- Public Input

Interim TWG calls will cover: (1) suggested revisions to the emissions inventory and reference case projections, (2) early ranking of options in the catalog and straw voting for initial "priority for analysis" options, (3) options for state goals and targets, (4) identification of potential early action items for Interim Report

PHASE II: MEETING THREE

- Objectives:
  - Review and approval of initial executive branch and legislative recommended policy actions for legislative recommendation and further development of TWG identified policy options (by vote)
  - Review and approval of revisions to the emissions inventory and forecast (by vote if/as needed)
  - Complete prioritization of policy options for inclusion in the interim report.
  - Identify any potential early action recommendations
  - Identify preliminary goals and targets for further consideration in the Michigan climate change process.
- Agenda:
  - Introductions
  - Review and approval of previous draft meeting summary
  - Final agreement on inventories and baseline forecasts (preferable)
  - Review and approval of TWG suggested lists of initial policy priorities for analysis
  - Discussion of process for developing straw policy design proposals
  - Formulation of preliminary GHG reduction goals and targets for consideration in Michigan.
  - Update on Next Steps, Compilation of Interim Report
  - Briefing on quantification methods
  - Next meeting agenda, time, location, date
  - Public Input

Interim TWG calls will cover: (1) development of straw proposals for design parameters for individual options, (2) next steps for analysis of options, and (3) further development of preliminary options for Michigan GHG reduction goals.

PHASE II: MEETING FOUR

- Objectives:
  - Approval of TWG suggested straw proposals for policy design (goals, timing, coverage of parties) (by vote)
  - Approval of any additions to the list of priority for analysis policy options if/as needed (by vote)
  - Preparation for quantification phase of the process (briefing and discussion)
- Agenda:
  - Introductions
  - Review and approval of previous draft meeting summary
  - Review and approval of straw proposals for policy design
  - Discussion of quantification principles and guidelines, and key assumptions for TWG analysis of policy options
  - Next meeting agenda, time, location, date
  - Public Input

Interim TWG calls will cover: (1) review of proposed quantification procedures for individual options, including proposed data sources, methods, assumptions; (2) review of first round of quantification results; and (3) identification of early consensus options for recommendation for MCAC approval.

MEETING FIVE

- Objectives:
  - Review and approval of early consensus policy recommendations (by vote)
  - Identification of specific barriers to consensus, and potential alternatives for non-consensus policy options (discussion) to be considered further by TWGs
  - Review options for establishing GHG emission reduction goals and targets for Michigan.
- Agenda:

  - Introductions
  - Review and approval of previous draft meeting summary
  - Begin review and approval of the list of draft policy options, with results of analysis for individual options
  - Identification of barriers and alternatives for remaining options, with guidance for additional work on options to TWGs
  - Review of final report progress and plans
  - Discuss options for GHG emission reduction goals and targets for Michigan.
  - Next meeting agenda, time, location, date
  - Public Input

Interim TWG calls will cover: (1) final revisions to alternative policy option design parameters, quantification approaches, and/or implementation mechanisms as needed, and (2) final analysis of options and alternative approaches.

PHASE II: MEETING SIX

- Objectives:
  - Review and approval of draft pending policy recommendations not yet approved, including additional options if/as needed (by vote)
  - Review and approval of proposed GHG emission reduction goals and targets for Michigan.
- Agenda:
  - Introductions
  - Review and approval of previous draft meeting summary
  - Review and approval of the list of final draft pending policy options, with results of analysis for individual options and cumulative emissions reductions potential for all options combined
  - Identification of barriers and alternatives for remaining options, with guidance for additional work on options to TWGs (if needed)
  - Approve proposed GHG emission reduction goals for Michigan,
  - Review of final report progress and plans
  - Next meeting agenda, time, location, date
  - Public Input

Interim TWG calls (if needed) will cover: (1) final revisions to alternative policy option design parameters, quantification approaches, and/or implementation mechanisms as needed; (2) final analysis of options and alternative approaches.

FINAL REPORT

- Draft report language by CCS to the MCAC and public
- First round of review and inputs to CCS
- Updated draft report language to the MCAC and public
- Final MCAC call to discuss suggested changes to the final report
- Final report transmitted to the DEQ by CCS

Participant Roles and Responsibilities

The MCAC process involves a number of parties with specific roles and responsibilities, as follows:

Governor

The Governor convenes the climate action plan process and MCAC through executive order, appoints members of the MCAC in conferral with the DEQ, requests and receives final recommendations from the MCAC for a comprehensive state climate action plan, appoints a chair and agency oversight team from the DEQ, and acts on final recommendations as deemed appropriate.

DEQ

The DEQ will announce and convene the process on behalf of the Governor, appoint additional members to the TWGs in conferral with the Governor, receive recommendations from the MCAC process through CCS for distribution to the Governor. The DEQ will work in partnership with CCS to support timely and orderly completion of tasks, good-faith participation, and resolution of issues by MCAC members. The DEQ will enforce ground rules, open and close MCAC meetings, coordinate agency activities related to support of the process, assist CCS by providing support for successful completion of the process, and provide day-to-day assistance to CCS with coordination, communications, logistics, and technical assistance.

Center for Climate Strategies

The Governor and the DEQ have asked CCS to partner in forming and conducting a participatory statewide climate action planning process to meet the goals of the MCAC. CCS will work in partnership with the DEQ to achieve the overall goals of the process. In this role, CCS will design the MCAC process and provide facilitation and technical support to the MCAC and its TWGs through a team of project managers, facilitators, and technical analysts to support MCAC needs.

CCS serves as an impartial and expert party and does not take positions on issues or direct the parties toward particular solutions. As such, CCS serves as a group mediator, but not as an arbitrator. CCS will manage and facilitate meetings and votes during meetings, schedule meetings in coordination with the Chair, develop meeting agendas, and produce documents for MCAC and TWG consideration, and perform and present technical analysis.

CCS abides by the Model Standards of Conduct for Mediators approved by the American Arbitration Association, the Litigation Section and the Dispute Resolution Section of the American Bar Association, and the Society of Professionals in Dispute Resolution. CCS also ensures that adequate funding exists to successfully complete the process through private sources, as needed.

MCAC

The MCAC is appointed by the Governor in consultation with the DEQ. It makes final recommendations for specific climate policy actions and approves a final Michigan GHG emissions inventory and forecast. MCAC members are appointed to respond to the goals and timelines of the process. CCS will facilitate MCAC activities, provide supporting analysis of options under consideration, and deliberate and cast votes in an open-group format.

Technical Work Groups

TWG members will be comprised primarily of MCAC members assigned to specific sector-based TWGs of interest by the DEQ, with guidance by CCS. They may include non-MCAC individuals with technical expertise and interest of importance to the process. The TWGs will provide guidance to MCAC members on decisions related to milestones in the stepwise process. TWGs will also provide assistance to CCS in the identification, design, and quantification of policy recommendations. Sector based TWGs include:

a. Energy Supply (heat and power);
b. Residential, Commercial, Industrial (energy efficiency and conservation, and industrial process);
c. Transportation and Land Use;
d. Agriculture, Forestry and Waste Management; and
e. Cross Cutting Issues (reporting, registries, public education, goals, etc.).

Government Agencies

Agency participants provide liaison to MCAC and TWG meetings and related activities in support of the DEQ and CCS team. This includes technical review and input to TWG meetings. The DEQ may also appoint agency representatives as MCAC or TWG members.

The Public

The public is invited to attend MCAC meetings and provide review and input to MCAC and TWG members. Other public input mechanisms may be developed as needed based on guidance from the DEQ.

Participant Guidelines

MCAC and TWG members are expected to follow certain codes of conduct during the process, including:

- Participants are expected to support the process and its concept fully and, through the group process, in good faith directly collaborate toward the goals of the MCAC and TWGs.
- Participants are expected to act as equals during the process to ensure that all members have equal footing during deliberations and decisions.
- Participants must attend meetings and stay current with information provided to the group and the decisions of the group.
- Participants are asked not to reconsider decisions already made in the stepwise process. Once the MCAC reaches a milestone by vote, it moves to the next step.
- Participants represent only themselves when making MCAC decisions and/or speaking about the process with the media or in other public settings.
- Participants should refrain from personal criticisms and provide objective, fact-based comments and alternatives during MCAC and TWG discussions.

Project Budget

CCS and MDEQ have agreed upon a projected budget for the project. The estimated CCS budget for completion of startup and completion of the MCAC process covers the core facilitation process and quantification of approximately 50 policy recommendations. Changes in the number of meetings, number of policy options, or type of analysis may require additional budget support.

Project Funding

CCS works with a group of private foundation donors to provide cost share to its state partners to ensure a timely and successful launch and completion of the planning processes and other phases of the project. Key donors have pledged support for the MCAC. Pending the DEQ approval of this process design memo, CCS pledges adequate core commitments to launch the process and fully fund its completion.

Project Team

The CCS project team consists of the following members (CCS may alter the team configuration based on need during the process):

Facilitation and Project Management

- **Tom Peterson, Tom Looby, Randy Strait, Ken Colburn**

Inventory and Forecast Team

- **Randy Strait, Maureen Mullen, Dan Wei, Bill Dougherty, Luanna Williams**

Technical Work Group Facilitators and Consultants

Energy Supply

- **Jeff Wennberg (Lead Facilitator), Donna Boyson, Dan Wei, Michael Lazarus (Sr. Technical Advisor)**

Residential, Commercial, and Industrial

- **Jeff Wennberg (Lead Facilitator), David Vonhippel, Donna Boyson, Michael Lazarus**

Agriculture, Forestry and Waste Management

- **Steve Roe (Lead Facilitator), Katie Bickell, Jen Jenkins, Gloria Flora, Brad Strode, Peter Kuch, Joe Pryor?**

Transportation and Land Use

- **Jim Wilson (Lead Facilitator), Lewison Lemm, Bill Cowart, Wick Havens, Sean Mulligan**

Cross Cutting Issues

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Appendix D
Greenhouse Gas Emissions Inventory and Reference Case Projections

A separate report titled "Michigan Greenhouse Gas Inventory and Reference Case Projections, 1990–2025," was used throughout the Michigan Climate Action Council (MCAC) process to provide detailed documentation on current and projected emissions. The preliminary draft report (January 2008), was reviewed by the Council and its six Technical Work Groups and revised to address comments approved by the MCAC as the process and analysis moved forward.

The final report, incorporating the comments provided by the Technical Work Groups that were approved by the MCAC and incorporated into the final report during November 2008, is available at: http://www.miclimatechange.us/ewebeditpro/items/O46F20484.pdf. At the 6th MCAC meeting in November 2008, the Council approved the final GHG Inventory and Forecast Report.

Appendix E
Methods for Quantification

Memorandum

To: Michigan Climate Action Council

From: The Center for Climate Strategies

Subject: Quantification of Climate Mitigation Policy Options

Date: May 22, 2008

This memo summarizes key elements of the recommended methodology for estimating GHG impacts and cost effectiveness for draft policy options for analysis considered amenable to quantification. The quantification process is intended to support custom design and analysis of draft policy options, and provide both consistency and flexibility. Feedback is encouraged.

Key guidelines include:

- Focus of analysis: **Net GHG reduction potential** in physical units of million metric tons (MMt) of carbon dioxide equivalent (CO_2e) and **net cost per metric ton reduced** in units of dollars per metric ton of carbon dioxide equivalent ($/t$CO_2e$). Where possible, full life cycle analysis is used to evaluate the net energy (and emissions) performance of actions (taking into account all energy inputs and outputs to production). Net analysis of the effects of carbon sequestration is conducted where applicable.
- Cost-effectiveness: Because monetized dollar value of GHG reduction benefits are not available, physical benefits are used instead, measured as dollars per metric ton of carbon dioxide equivalent ($/t$CO_2e$) (cost or savings per ton) or "cost effectiveness" evaluation. Both positive costs and cost savings (negative costs) are estimated as a part of compliance cost.
- Geographic inclusion: Measure GHG impacts of activities that occur within the state, regardless of the actual location of emissions reductions. For instance, a major benefit of recycling is the reduction in material extraction and processing (e.g. aluminum production). While a policy option may increase recycling in Michigan, 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. These emissions reductions are counted towards the achievement of the state's emission goal, since they result from actions taken by the state.
- Direct vs. indirect effects: "Direct effects" are those borne by the entities implementing the policy recommendation. For example, direct costs are net of any financial benefits or savings to the entity. "Indirect effects" are defined as those borne by the entities other than those implementing the policy recommendation. Indirect effects will be quantified on a case-by-case basis depending on magnitude, importance, time available, need and availability of data. (See additional discussion and list of examples below.)

- Non-GHG (external) impacts and costs: Include in qualitative terms where deemed important. Quantify on a case-by-case basis as needed depending on need and where data are readily available.
- Discounting and annualizing: Discount a multi-year stream of net costs (or savings) to arrive at the "net present value cost" of the cost of implementing a policy option. Discount costs in constant 2005 dollars using a 5% annual real discount rate for the project period of 2009 through 2025 (unless otherwise specified for the particular policy option). Capital investments are represented in terms of annualized or amortized costs through 2025. Create an annualized cost per ton by dividing the present value cost or cost savings by the cumulative reduction in tons of GHG emissions.
- Time period of analysis: Count the impacts of actions that occur during the project time period and, using annualized emissions reduction and cost analysis, report emissions reductions and costs for specific target years of 2015 and 2025. Where additional GHG reductions or costs occur beyond the project period as a direct result of actions taken during the project period, show these for comparison and potential inclusion.
- Aggregation of cumulative impacts of policy options: In addition to "stand alone" results for individual options, estimate cumulative impacts of all options combined. In this process we avoid simple double counting of GHG reduction potential and cost when adding emission reductions and costs associated with all of the policy recommendations. To do so we note and or estimate interactive effects between policy recommendations using analytical methods where significant overlap or equilibrium effects are likely.
- Policy design specifications and other key assumptions: Include explicit notation of timing, goal levels, implementing parties, the type of implementation mechanism, and other key assumptions as determined by the Michigan Climate Action Council (MCAC).
- Transparency: Include policy design choices (above) as well as data sources, methods, key assumptions, and key uncertainties. Use data and comments provided by MCAC to ensure best available data sources, methods, and key assumptions using their expertise and knowledge to address specific issues in Michigan. Modifications will be made through facilitated decisions.

For additional reference see the economic analysis guidelines developed by the Science Advisory Board of the US EPA available at:
http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html.

Examples of Direct/Indirect Net Costs and Savings

Note: These examples are meant to be illustrative.

Residential, Commercial, and Industrial (RCI) Sectors

Direct Costs and/or Savings

- Net capital costs (or incremental costs 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 (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)

Indirect Costs and/or Savings

- Re-spending effect on economy
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)
- 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)

Energy Supply (ES) Sector

Direct Costs and/or Savings

- Net capital costs (or incremental costs relative to reference case technologies) of renewables or other advanced technologies resulting from policies

- Net O&M costs (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

Indirect Costs and/or Savings

- Re-spending effect on economy
- Higher cost of electricity reverberating through economy
- Energy security
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)

Agriculture, Forestry, and Waste Management (AFW) Sectors

Direct Costs and/or Savings

- Net capital costs (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 (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

Indirect Costs and/or Savings

- Net value of employment impacts
- Net value of human health benefits/impacts
- Net value of ecosystem health benefits/impacts (wildlife habitat; reduction in wildfire potential; etc.)
- Value of net environmental benefits/impacts (value of damage by air or water pollutants on structures, crops, etc.)
- Net embodied energy of water use in equipment or facilities relative to standard practice
- Reduced VMT and fuel consumption associated with land use conversions (e.g., as a result of forest/rangeland/cropland protection policies)

Transportation and Land Use (TLU) Sector

Direct Costs and/or Savings

- Incremental cost of more efficient vehicles net of fuel savings.
- Incremental cost of implementing Smart Growth programs, net of saved infrastructure costs.
- Incremental cost of mass transit investment and operating expenses, net of any saved infrastructure costs (e.g., roads)
- Incremental cost of alternative fuel, net of any change in maintenance costs

Indirect Costs and/or Savings

- 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 safety.
- Energy security
- Net value of employment impacts

Appendix F
Energy Supply Policy Recommendations

Summary List of Policy Recommendations

No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effectiveness ($/$tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
RECENT ACTION	PA 295, Clean, Renewable, and Efficient Energy Act	2.7	2.0	30.8	$1,024	$33	N/A
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	5.0	14.6	137.5	$6,600	$48.00	Unanimous
	RPS	4.6	13.7	129.5	$5,546	$42.83	
	Wind	3.7	10.3	100.4	$4,748	$47.31	
	Biomass	0.9	2.7	25.2	$376	$15	
	Solar PV	0.0	0.4	2.6	$392	$152	
	Plasma Gasification	0.0	0.3	1.3	$29	$22	
	Distributed Generation "Carve-Out"	0.4	0.9	8.0	$1,054	$131.51	
	Solar Hot Water	0.0	0.2	1.2	$26	$22.27	
	Geothermal	0.1	0.2	1.5	$82	$55	
	Wind (distributed)	0.1	0.3	2.7	$503	$186	
	Solar PV (distributed)	0.1	0.2	1.84	$508	$276	
	Biogas	0.1	0.2	2.3	$17	$7	
ES-3	Energy Optimization Standard	0.0	13.6	86.3	–$1,632	–$19	Unanimous
ES-5	Advanced Fossil Fuel Technology (e.g., IGCC, CCSR) Incentives, Support, or Requirements	*Not Quantifiable*					Unanimous
ES-6	New Nuclear Power	0.0	6.3	38.5	$1,001	$25.98	Majority[1]
ES-7	Integrated Resource Planning (IRP), Including CHP	*Not Quantifiable*					Unanimous
ES-8	Smart Grid, Including Advanced Metering	*Not Quantifiable*					Unanimous
ES-9	CCSR Incentives, Requirements, R&D, and/or Enabling Policies	*Not Quantifiable*					Unanimous
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration						Majority[2]
	Co-firing at 5%	0.2	0.2	3.3	$34.48	$10.6	
	Co-firing at 10%	0.5	0.5	6.5	$69.43	$10.7	
	Co-firing at 20%	0.9	0.9	13.0	$134.09	$10.3	

[1] Six (6) opposing votes [Pollack, Ettawageshik, Garfield, Heifje, Bazzani, Overmeyer] and two (2) abstentions [Martinez and Calloway for Bierbaum]

[2] Three (3) opposing votes [Garfield, Pollack and Hiefje]

No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
ES-11	Power Plant Replacement, EE, and Repowering	2.5	2.0	33.2	$313	$9.4	Unanimous
ES-12	Distributed Renewable Energy Incentives, Barrier Removal, and Development Issues, Including Grid Access - TOTAL	*ES-12 Fully incorporated in distributed generation "carve-out" under ES-1.*					Unanimous
	Solar Hot Water						
	Geothermal						
	Distributed Wind						
	Solar PV						
	Biogas						
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.4	0.5	7.8	$31.91	$4.09	Unanimous
ES-15	Transmission Access and Upgrades	*Not Quantifiable*					Unanimous
	Sector Totals	**8.1**	**37.2**	**306.6**	**$6,348**	**$22**	
	Sector Total after Adjusting for Overlaps	**8.1**	**23.6**	**220.3**	**$7,980**	**$36**	
	Reductions From Recent Actions	**2.7**	**1.9**	**30.1**	**$1,025**	**$34**	
	Sector Total Plus Recent Actions	**10.8**	**25.5**	**250.4**	**$9,005**	**$36**	

$/tCO_2e = dollars per metric tons of carbon dioxide equivalent; CCI = Cross-Cutting Issues; CCSR = carbon capture, and storage or reuse; CHP = combined heat and power; EE = energy efficiency; ES = Energy Supply; GHG = greenhouse gas; IGCC = integrated gasification combined cycle; IRP = integrated resource planning; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = millions of metric tons of carbon dioxide equivalent; N/A = not applicable; PA = Public Act; PV = photovoltaic; R&D = research and development; TWG = Technical Work Group.

Note: The numbering used to denote each policy recommendation is for reference purposes only; it does not reflect prioritization among these important recommendations.

Overlap Discussion

Several of the energy supply recommendations overlap with each other insofar as they reduce the carbon dioxide (CO_2) intensity of Michigan's electricity supply. Energy Supply (ES) recommendations ES-1, ES-6, ES-10, ES-11, ES-12, and ES-13 all reduce the amount of CO_2 generated by each unit of electricity. The results presented in the table above account for this overlap.

Specifically, when estimating the amount of emissions avoided, the CO_2 intensity of a unit of electricity was reduced to account for multiple recommendations being implemented concurrently. For example, ES-3 avoids less CO_2 when ES-1 is implemented (i.e., when renewables displace primarily coal-fired generation). Therefore, a particular recommendation becomes less cost-effective when other recommendations are implemented concurrently, because while the cost of implementing the particular recommendation remains constant, the amount of CO_2 that the recommendation avoids will have decreased.

The reductions estimated to occur under ES-1, ES-6, ES-10, ES-11, ES-12, and ES-13 all assume successful implementation of each other. In the row labeled “Sector Total after Adjusting for Overlaps,” each of these recommendations accounts for the decreased CO_2 intensity resulting from all the other recommendations. Therefore, a scenario wherein some recommendations are implemented and others are not implemented would generate results that differ from those presented above.

Because ES-12 contributes to the targets established in ES-1, ES-12 has been designed as a "carve-out" of ES-1 to avoid overlap. ES-12, therefore, represents specific percentages of the goals outlined in ES-1. The emission reductions that would result from ES-12 have been accounted for in ES-1.

ES-3 is a direct overlap of Residential, Commercial, and Industrial (RCI) recommendation RCI-1. Therefore, the reductions under ES-3 are omitted from the sector totals table.

ES-1. Renewable Portfolio Standard

Policy Description

A renewable portfolio standard (RPS) is a requirement that utilities supply a certain amount of annual retail sales from eligible renewable energy sources by a certain date and each year thereafter. Beyond reducing utility-sector emissions of CO_2, benefits to Michigan would include lower emissions of smog and soot precursors, improved energy balance of trade, diversified fuel supply risk, and economic development potential. Michigan currently meets over 4% of its electricity needs from renewable sources.

Twenty-four states plus the District of Columbia have adopted some form of an RPS. In the Midwest, these include Illinois (25% by 2025), Minnesota (27.4% by 2025), Ohio (12.5% by 2025), and Wisconsin (10% by 2015).

Policy Design

Goals and Timing:

Goals are stated as a percentage of annual sales and represent total renewable contribution and not "new" or "incremental."

Short-term target (consistent with recently passed Michigan energy legislation [Public Act (PA) 295 of 2008])

- 10% by 2015.[3]
- Of this, at least 0.4% (468 gigawatt-hours [GWh] from 240 megawatts [MW]) will be supplied from small-scale distributed generation (DG) sources.

Long-term goals (consistent with the Midwestern Governors Association [MGA] platform)

- 20% by 2020.
- 25% by 2025, at least 1.1%, of which (1,396 GWh from 715 MW) will be supplied from small-scale DG.
- 30% by 2030.

Parties Involved: An RPS provision within state law will affect all aspects of Michigan's energy sector and the state's population. Therefore, all aspects of Michigan society will need to

[3] Public Act (PA) 295 specifies with up to 10% of the RPS able to be met with energy optimization (10% of the 10% RPS) or advanced cleaner energy credits (7% of the 10% RPS). Eligible renewable resources include; solar water heat, solar thermal process heat, photovoltaics, landfill gas produced from MSW, wind, biomass, certain hydroelectric, tidal, geothermal electric, municipal solid waste, gasification, industrial waste heat, and clean coal. Michigan RPS is subject to "cost caps" and extensions to meet RPS are permitted Consumer Energy must meet 200 MW of renewable energy capacity by 2013 and 500 MW of renewable capacity by 2015, and: Detroit Edison must meet 300 MW of renewable energy capacity by 2013 and 600 MW of renewable capacity by 2015. Credit Trading is available; Alternative Compliance Payments are not available.

participate in the formation of policy, in the generation and delivery of energy, or pay for renewable energy resources either (1) voluntarily through signing up for existing renewable energy programs offered by utilities and others, or (2) through costs embedded in general rates, through power supply cost recovery mechanisms, or through other social funding mechanisms. Renewable energy will need to be evaluated within statewide long-term energy planning and also within company-specific integrated resource planning (IRP), as detailed in another ES policy recommendation. Participation is required for all electricity distribution providers in Michigan.

Other:

- Given the economic benefits to Michigan of locating renewable energy projects and related manufacturing operations in the state, provisions that encourage these activities should be carefully considered.
- As defined within the Michigan Clean, Renewable, and Efficient Energy Act, 2008 PA 295, Part 1, Section 9, (I) "Renewable energy resource" means a resource that “naturally replenishes over a human, not a geological, time frame and that is ultimately derived from solar power, water power, or wind power. Renewable energy resource does not include petroleum, nuclear, natural gas, or coal. A renewable energy resource comes from the sun or from thermal inertia of the Earth and minimizes the output of toxic material in the conversion of the energy and includes, but is not limited to, all of the following:
    - (i) Biomass.
    - (ii) Solar and solar thermal energy.
    - (iii) Wind energy.
    - (iv) Kinetic energy of moving water, including all of the following:
        - (A) Waves, tides, or currents.
        - (B) Water released through a dam.
    - (v) Geothermal energy.
    - (vi) Municipal solid waste.
    - (vii) Landfill gas produced by municipal solid waste.”
- Mechanisms that expose renewable energy projects to competitive bidding should be explored.
- This policy recommendation assumes that the provisions of ES-12, Distributed Renewable Energy, are included here. The DG policy design in ES-12 represents the DG "carve-out," or guarantee, within ES-1 within both the 2015 and the 2025 goals.
- Legislative support for the streamlining of siting, zoning, and permitting for renewable energy projects will be of significant importance to achieve the long-term RPS goals of greater than 10%.
- Long-term RPS goals beyond 10% will need to allow sufficient flexibility for delays in development and construction timing due to the need for development of the electric transmission system and the risks and challenges of developing offshore renewable energy systems.

Implementation Mechanisms

Available policy mechanisms to implement an RPS requirement include a legislative act or regulatory action by the Michigan Public Service Commission (MPSC), within its jurisdiction. In any case, program development and administration would be directed by the MPSC. Enforcement of the RPS requirement needs to balance the application of some form of a noncompliance penalty with allowance for a cost cap to control overall program costs. Typically, a renewable energy credit-trading program will also be instituted to facilitate the development of a viable intrastate renewable energy market. Renewable energy payments (REPs, also known as feed-in tariffs) as described in ES-12 are intended to be available under this policy to small- and large-scale generators at appropriate rates and terms.

There are a number of options for setting the REP price. For commercial-level distributed renewable energy projects, the REP price would most likely need to be set high enough to cover costs and ensure a reasonable return on investment. For household-level distributed renewable energy projects, the REP price needs to be set high enough to provide an adequate incentive for the homeowner to invest in the project. Homeowners would consider the financial incentive, the avoided costs of purchasing electricity over the life of the project, and such intangibles as the benefit of energy independence and the knowledge of knowing that they are powering their homes with little or no carbon footprint.

Related Policies/Programs in Place

In September 2008, the Michigan legislature enacted S.213, and Governor Granholm signed this bill into law (PA 295 of 2008), creating the "Clean, Renewable, and Efficient Energy Act." The act calls for the MPSC to order electric utilities to submit an energy optimization plan to the MPSC, demonstrating how they will comply with the new RPS. The RPS mandates that 10% of the state's electricity be derived from renewable sources by 2015, with some exceptions.

Section 51 of the act describes the electric providers' annual RPS reporting requirements, as well as the February 15, 2011, report the MPSC must submit to the legislature, which summarizes the data collected by the electric providers and describes whether the RPS and energy optimization programs have been cost-effective, etc.

According to the U.S. Department of Energy (DOE), 24 states plus the District of Columbia have RPS requirements in place. Together, these jurisdictions account for more than half of the electricity sales in the United States. Four other states—Illinois, Missouri, Virginia, and Vermont—have nonbinding goals for adoption of renewable energy instead of an RPS.[4]

Utilities and some municipal suppliers in Michigan currently offer renewable energy options to customers through voluntary programs. These programs allow customers to opt to supply a portion of their load from renewable energy sources for a pricing premium.

Type(s) of GHG Reductions

CO_2.

[4] Source: http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm

Estimated GHG Reductions and Costs or Cost Savings

F-1-1. Estimated GHG reductions and costs of or cost savings from ES-1.

ES-1. Renewable Portfolio Standard	2015	2025	Units
GHG emission reductions	5.0	14.6	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$6,600	Million $
Cumulative emissions reductions (2009–2025)		137.5	Million metric tons of CO_2
Cost-effectiveness		$48.00	$/metric ton of CO_2

CO_2 = carbon dioxide; GHG = greenhouse gas.

Data Sources:

- U.S. DOE Energy Information Administration (EIA) 2007 Annual Energy Outlook (AEO).
- U.S. DOE, Office of Energy Efficiency and Renewable Energy, "Economic Benefits, Carbon Dioxide (CO_2) Emissions Reductions, and Water Conservation Benefits from 1,000 Megawatts (MW) of New Wind Power in Michigan" (http://www.windpoweringamerica.gov/pdfs/economic_development/2008/mi_wind_benefits_factsheet.pdf).
- Conversation with Recovered Energy, Inc. (for plasma gasification).

Quantification Methods: New renewables were assumed to displace primarily coal-fired power, as reflected in the Michigan inventory and forecast (I&F). The values presented above reflect the minimum amounts specified in the recent RPS legislation.

In order to quantify this recommendation, the first step was to identify the phase-in dates and percentages for the RPS. The second step identified the allocation among specific technologies that would fulfill the RPS obligation. This allocation is presented in Table F-1-2 under the Key Assumptions section of this recommendation. The next step identified capacity factors and total energy generation from each of these renewable generation sources in order to meet the RPS goals. Transmission and distribution losses were taken into account at this stage for central station generation. In order to estimate costs, capital, operation and maintenance, as well as fuel costs where relevant were incorporated into the model. These elements combined to produce the estimate of costs for meeting the RPS.

For the "carve-out" portion of this recommendation, the ES Technical Work Group (TWG) first determined the magnitude of the carve-out, as a percentage of total electrical energy consumption in the state, set at 1.1% (715 MW) in 2025, phased in from a level of 0.4% (240 MW) in 2015. This quantity of energy generated by distributed sources was spread across wind, solar photovoltaic (PV), and biogas based on the DG carve-out percentages shown above. Based on the capacity factors determined by the TWG, the total required capacity was calculated. Costs are based on the levelized cost of electricity from the various sources. The avoided cost of electricity is consistent with all other recommendations.

It is important to note that the costs presented here represent the total direct cost to society (public and private), as defined by the borders of the state of Michigan. Capital and operating costs are included in the total, regardless of who within Michigan actually pays these costs.

Therefore, DG costs reflect the total cost to ratepayers, taxpayers, and homeowners for recommended subsidies, incentives, and private expenditures. This policy recommends methods for creating the incentives necessary to achieve the goals, but does not prescribe specific rates, which would be set through the existing legislative and regulatory processes. It is believed that the goals can be achieved through the availability of public-sector incentives representing a fraction of the total costs presented here.

Key Assumptions:

The following portfolio of new renewables was used, based on input from the TWG.

Table F-1-2. Assumed portfolio of renewables

Type of Electricity Generation	2015	2025	Units
Wind	80%	75%	of RPS
Biomass	19%	20%	of RPS
Solar PV	1%	3%	of RPS
Plasma gasification	0%	2%	of RPS

PV = photovoltaic

The following assumptions were used for each type of generation:

Table F-1-3. Assumptions used for types of electricity generation

Types of Generation and Assumptions	2015	2025
Wind		
Capital cost ($/kW)	$1,650	$2,000
Transmission cost ($/kW)	$120	$120
Capacity factor	25%	25%
Solar Thermal		
Capital cost ($/kW)	$3,004	$2,524
Transmission cost ($/kW)	$80	$80
Capacity factor	25%	25%
Biomass		
Capital cost ($/kW)	$2,800	$2,500
Transmission cost ($/kW)	$80	$80
Capacity factor	90%	90%
Solar PV		
Capital cost ($/kW)	$4,915	$4,331
Transmission cost ($/kW)	$80	$80
Capacity factor	15%	15%
Geothermal		
Capital cost ($/kW)	$1,126	$3,231

Types of Generation and Assumptions	2015	2025
Transmission cost ($/kW)	$80	$80
Capacity factor	85%	85%
Plasma Gasification		
Capital cost ($/kW)	$9,601	$9,000
Transmission cost ($/kW)	$80	$80
Capacity factor	85%	85%

$/kW = dollars per kilowatt; PV = photovoltaic.

A second set of assumptions applies to the DG "carve-out." This analysis assumes that 1.1% of the total consumption (715 MW) is supplied by small-scale DG by 2025. This goal is phased in beginning at 0.4% of total consumption (240 MW) beginning in 2015. The analysis assumes that three technologies will fill these goals as follows:

Table F-1-4. Distributed generation "carve-out"

Type of Electricity Generation	2015	2025	Units
Wind	40%	40%	of carve-out
Solar PV	25%	25%	of carve-out
Biogas	35%	35%	of carve-out

PV = photovoltaic.

These results rely on additional assumptions for capacity factors as follows:

Table F-1-5. Assumed capacity factors

Type of Electricity Generation	Capacity Factor
Wind (distributed)	18%
Solar PV (distributed)	15%
Biogas	65%
Geothermal	85%

PV = photovoltaic.

Finally, capital costs are based on the following assumptions:

Table F-1-6. Assumed capital costs

Type of Electricity Generation	Capital Cost ($/kWh)	
	2015	2025
Wind (distributed)	$6,000	$5,000
Solar PV (distributed)	$8,131	$6,756
Biogas	$3,250	$3,250

$/kWh = dollars per kilowatt-hour; PV = photovoltaic.

Key Uncertainties

- Feasibility of plasma gasification.
- Future capital costs for all types of renewable generation.

Additional Benefits and Costs

The use of renewable sources in lieu of fossil fuels often reduces emissions of criteria pollutants and air toxics in addition to greenhouse gases (GHGs). These reductions offer indirect public health and related economic benefits, none of which is quantified or included here.

Feasibility Issues

The RPS enacted in 2008 and effective in 2015 is equivalent to the policy recommended here for 2015. The policy recommended here calls for progressively more stringent renewable contributions in 2020, 2025, and 2030. The likelihood that future legislatures will extend and expand the RPS will depend in part on the experience with the 2015 requirement.

Meeting the target for the DG "carve-out" will be extremely challenging, given the high costs and low capacity factors for distributed wind.

Status of Group Approval

Approved.

Level of Group Support

Unanimous

Barriers to Consensus

None.

ES-3. Energy Optimization Standard

Policy Description

Energy optimization means energy efficiency, load management that reduces overall energy use, and related energy conservation. An energy optimization standard (EOS) requires energy savings as a percentage of total annual retail electricity sales in megawatt-hours (MWh) and total annual retail natural gas sales in decatherms or equivalent thousand cubic feet (MCF) in a specified year. To accomplish this, electric and natural gas providers are to develop energy optimization plans sufficient to ensure the achievement of applicable energy optimization standards. Ratepayers benefit from avoided construction costs of new power plants, and lower utility bills for those who directly participate in available energy efficiency programs.

In the Midwest, states that have adopted this policy mechanism include Minnesota (1.5% annual energy savings), Illinois (1% annual energy savings by 2011, 2% annual energy savings by 2015), and Ohio (1% annual energy savings by 2014, 2% annual energy savings by 2019).

Policy Design

Goals and Timing: The 2008–2012 energy optimization program savings goals included below are established by PA 295 of 2008. Goals for years 2013–2015 are given under Tier 2 below. For years beyond 2015, Section 97 of the act requires the MPSC, by September 30, 2015, to review opportunities for additional cost-effective energy optimization programs, and to make any recommendations for legislation providing for the continuation, expansion, or reduction of EOSs. For the purposes of modeling a long-term energy optimization goal under this policy recommendation (Tier 3), the 2015 goals for incremental energy savings were extended through 2025 to mirror how the long-term goal was established under the MGA energy efficiency policy option EE-1: Establish Quantifiable Goals for Energy Efficiency.

Tier 1: 2008–2012 Electricity Energy Optimization Program Savings

- Biennial incremental electricity savings in 2008–2009 equivalent to 0.3% of total annual retail electricity sales in MWh in 2007.
- Annual incremental electricity savings in 2010 equivalent to 0.5% of total annual retail electricity sales in MWh in 2009.
- Annual incremental electricity savings in 2011 equivalent to 0.75% of annual retail electricity sales in MWh in 2010.
- Annual incremental electricity savings in 2012 of 1.0% of annual retail electricity sales in MWh in 2011.

Tier 1: 2008–2012 Natural Gas Energy Optimization Program Savings

- Biennial natural gas savings in 2008–2009 equivalent to 0.1% of total annual retail natural gas sales in decatherms or equivalent MCF in 2007.
- Annual incremental natural gas savings in 2010 equivalent to 0.25% of total annual retail natural gas sales in decatherms or equivalent MCF in 2009.

- Annual incremental natural gas savings in 2011 equivalent to 0.5% of total annual retail natural gas sales in decatherms or equivalent MCF in 2010.
- Annual incremental natural gas savings in 2012 of 0.75% of total annual retail natural gas sales in 2011.

Tier 2: 2013–2015

- Annual gross savings for electricity equal to 1.33% in 2013, 1.66% in 2014, and 2.0% in 2015. For natural gas, 0.75% annual gross savings by 2015 and each year thereafter, based upon prior year sales.

Tier 3 (Long Term)

- Annual incremental electricity savings in 2016 and each year thereafter through 2025 equivalent to 2.0% of total annual retail electricity sales in MWh in the preceding year. Annual incremental natural gas savings in 2016 and each year thereafter through 2025, equivalent to 0.75% of total annual retail natural gas sales in decatherms or equivalent MCF in the preceding year.

Parties Involved: Participation is required for all electricity and natural gas distribution providers in Michigan. Consistent with PA 295, if a given utility does not wish to run its own energy efficiency programs, it may collect funding through surcharges on customer bills to fund a third-party administrator to design and implement such programs in that utility's service territory.

Other: Complementary policies that better align utility decision making with energy efficiency are essential. Utilities should be allowed to capitalize and recover their investments in energy efficiency programs (analogous to what they do with the power plants the Michigan Climate Action Council [MCAC] is trying to avoid having them build), and they should be made whole for the revenue erosion through decoupling. Refer to the residential, commercial, and industrial (RCI) sectors policy recommendation RCI-1 (Utility Demand-Side Management), RCI-3 (Regulatory Changes To Encourage Energy Efficiency), and RCI-7 (Public Benefits Funding). In addition, ES-7 (Integrated Resource Planning [IRP], Including CHP) is an important mechanism to fully tap cost-effective energy savings beyond the initial EOS requirement.

Implementation Mechanisms

Tier 1 goals have already been enacted through PA 295. Available policy mechanisms to implement additional EOS requirements could include a legislative act or regulatory action by the MPSC, within its jurisdiction. Funding for the required programs could be included in utility bills, either assessed as a public benefits charge or incorporated as part of the normal rate case proceedings, for all customer classes. Alternatively, funding could come from a general appropriation from the legislature to customers as a subsidy through tax abatement or incentives for implementing energy efficiency measures.

Because Michigan has electric choice, the program must be competitively neutral—thus funded equally by all customers and available to all customers. Stated differently, the programs, funding, and savings must not create structural advantages or disadvantages for utilities or alternative electric suppliers.

Related Policies/Programs in Place

PA 295 of 2008 establishes Michigan's EOS and related requirements through 2012. Section 97 of the act describes the electric providers' annual energy optimization plan reporting requirements as well as various reports the MPSC must provide the legislature, which summarize the data collected by the electric providers and describe such things as the rate impacts, recommendations for legislative action, and cost-effectiveness of the energy optimization program. The quantitative goals and results of this act are shown below:

Electric providers must achieve the following collective minimum energy savings:

- Biennial incremental energy savings in 2008–2009 equivalent to 0.3% of total annual retail electricity sales in MWh in 2007.
- Annual incremental energy savings in 2010 equivalent to 0.5% of total annual retail electricity sales in MWh in 2009.
- Annual incremental energy savings in 2011 equivalent to 0.75% of total annual retail electricity sales in MWh in 2010.
- Annual incremental energy savings in 2012, 2013, 2014, and 2015 and each year thereafter equivalent to 1.0% of total annual retail sales in MWh in the preceding year.

A natural gas provider must meet the following minimum energy savings:

- Biennial incremental energy savings in 2008–2009 equivalent to 0.1% of total annual retail natural gas sales in decatherms (Dth)* or equivalent MCF in 2007.
- Annual incremental energy savings in 2010 equivalent to 0.25% of total annual retail natural gas sales in Dth or equivalent MCF in 2007.
- Annual incremental energy savings in 2011 equivalent to 0.5% of total annual retail natural gas sales in Dth or equivalent MCF in 2007.
- Annual incremental energy savings in 2012, 2013, 2014, and 2015 equivalent to 0.75% of total annual retail natural gas sales in Dth or equivalent MCF in the preceding year.

These legislated actions will result in the effects on energy consumption and GHG emissions shown in Table F-3-1.

Table F-3-1. Estimated GHG reductions and costs of or cost savings from recent[5] legislated actions

Recent Legislated Actions: Utility Demand-Side Management for Electricity and Natural Gas	2015	2025	Units
GHG emission savings	3.3	24.6	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		–$4,415	Million $
Cumulative emissions reductions (2009–2025)		193.9	Million metric tons of CO_2
Cost-effectiveness		–$23	$/metric ton of CO_2

CO_2 = carbon dioxide; GHG = greenhouse gas.

* Decatherm (Dth): A measurement of the heat equivalent to one million British thermal units (Btus).

[5] Recent actions are those that have been approved but not yet implemented.

Also, the Customer Choice and Electricity Reliability Act of 2000 authorized the creation of a Low-Income and Energy Efficiency Fund, administered by the MPSC via grants to qualifying organizations. The purpose of the fund is to provide utility service shutoff and other protection for low-income customers and to promote energy efficiency by all customer classes. Since 2002, approximately $89 million (24% of available funds) has been used for efficiency-related grants.

According to the Alliance to Save Energy, several states have set performance standards for their energy efficiency programs. However, the regulatory environment in some of these states is quite different from that in Michigan or the Midwest in general. Programs that work in one state may not be fully or partly applicable in another jurisdiction, such as Michigan. The following programs are for illustrative purposes and do not purport to be goals for Michigan per se.[6]

- *Texas* requires utilities to avoid a percentage of the forecast increase in electric demand through efficiency programs, rising to 20% starting in 2009. *Illinois* requires electricity savings rising to 2% of sales in 2015, and *Minnesota* requires 1.5% annual savings starting in 2010.
- *Pennsylvania, Nevada, Hawaii, and North Carolina* include energy efficiency and renewable energy as options in a broader RPS.
- *Connecticut* revised its RPS to require utilities to save 4% of electricity use by 2010 through residential and commercial programs and combined heat and power.
- The *California* Public Utilities Commission sets multi-year targets for electric and natural gas utilities based on a study of how much cost-effective savings the programs can achieve.
- *Colorado*'s largest utility, Xcel, has agreed to achieve a set level of savings, and *Vermont* has performance requirements in its contract with an independent efficiency provider.

Type(s) of GHG Reductions

Primarily CO_2 reductions resulting from avoided electricity generation, but could reduce to some degree all six statutory GHGs (CO_2, methane [CH_4], nitrous oxide [N_2O], hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], and sulfur hexafluoride [SF_6]).

Estimated GHG Reductions and Costs or Cost Savings

The estimated GHG reductions and cost savings from this policy recommendation that are additional to the results of the legislation presented in Table F-3-1 above are as follows;

Table F-3-2. Estimated GHG reductions and costs of or cost savings from ES-3

ES-3. Energy Optimization Standard	2015	2025	Units
GHG emission savings	0.0	13.6	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		–$1,632	Million $
Cumulative emissions reductions (2009–2025)		86.3	Million metric tons of CO_2
Cost-effectiveness		–$19	$/metric ton of CO_2

[6] Source: http://www.ase.org/content/article/detail/4070.

This analysis assumes that the costs of and benefits from PA 295 of 2008 are treated as "recent actions," as shown in table F-3-1. The benefits and costs shown in table F-3-2 result from the recommended policy above and beyond PA 295. PA 295 states that energy optimization targets will only continue beyond 2015 if the utilities have been achieving their targets and the MPSC issues a report to the legislature saying it is reasonable to expect utilities to keep meeting them. The analysis in Tables F-3-1 and F-3-2 assumes that this condition is met and these reductions continue at the same pace between 2015 and 2025.

Data Sources: Projections for energy sales are based on AEO 2008 projections for energy sales in Michigan. The cost of energy is based on the most recent EIA data. The levelized costs of natural gas savings and electricity savings are based on data provided (September 2008) by the American Council for an Energy Efficient Economy (ACEEE), with the electricity cost based on ACEEE's survey of numerous electricity efficiency programs across the country. The primary data source is ACEEE's *Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies*.

Quantification Methods: Energy savings for both electricity and natural gas are calculated by multiplying the percentage of energy to be saved by the amount of energy projected to be sold in the baseline year. Those electricity or natural gas savings are then multiplied by the cost of electricity and natural gas savings and by the avoided electricity and gas costs to produce a net total cost of this policy recommendation. In the case of these energy efficiency measures, the total cost is negative—meaning the energy efficiency measures produce net savings.

Key Assumptions: All emission reductions shown are incremental to any energy savings required by existing Michigan legislation. The goal of this policy recommendation is 2% electricity savings and 0.75% natural gas savings, phased in between 2009 and 2015. The savings targets continue through the year 2025. The analysis also assumes that the residential, commercial, and industrial sectors meet the same energy savings goals, and that all energy sales in all three sectors must meet the same energy savings targets. The other key cost assumptions, based on the data sources described above, are presented in Table F-3-3.

Table F-3-3. Some key cost assumptions

Types of Costs	Assumptions
Levelized Cost of Electricity Savings	$30/MWh
Avoided Electricity Delivery Cost	$60/MWh
Levelized Cost of Natural Gas Savings	$2.5/MMBtu
Avoided Delivered Natural Gas Cost	$7.7/MMBtu

MMBtu = million British thermal units; MWh = megwatt-hour.

Key Uncertainties

Key uncertainties are related to the assumed avoided cost of energy. If the assumed avoided cost (the energy that consumers do *not* need to purchase, as a result of energy efficiency measures) rises, then the policy recommendation's cost per metric ton ($/t) of CO_2 reduced decreases. If the avoided cost of energy falls, then the $/t$CO_2$ reduced increases.

Additional Benefits and Costs

Energy efficiency measures that reduce the use of fossil fuels often reduce emissions of criteria pollutants and air toxics in addition to GHGs. These reductions offer indirect public health and related economic benefits, none of which is quantified or included here.

Emission reduction benefits beyond those recommended here may also be achieved through ES-7 (Integrated Resource Planning, [IRP], Including CHP). The IRP policy is not quantified due to the multiple uncertainties associated with the results of future planning efforts. Nonetheless, real and measurable reductions should be produced through IRP. IRP-related emission reductions may provide mitigation beyond the requirements of the EOSs.

Feasibility Issues

The EOSs for electricity and natural gas recommended here are equivalent to the one recently enacted by Michigan through 2012. EOSs beyond 2012 would require legislative action.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-5. Advanced Fossil Fuel Technology

Policy Description

Advanced fossil fuel-based electric generation technologies include those that can be more efficient and thus lower-emitting generation technologies than current or older technologies. Alternative, advanced fossil generation may include technologies different from conventional ones that could have higher or lower efficiencies but pose other advantages. Advanced fossil generation technologies combined with carbon capture and storage or reuse (CCSR) may have the potential to materially lower CO_2 emissions associated with fossil fuel-based electricity generation. Such technologies include (but are not limited to) circulating fluidized-bed combustors, integrated gasification combined-cycle (IGCC) units, and pulverized coal (advanced supercritical and ultra-supercritical units). The classes of supercritical technologies (advanced and ultra) serve to increase electric output (efficiency) through increases in pressure and temperature in the combustion and heat transfer cycles. IGCC technologies may offer low-emission capability for certain measured or regulated parameters.

Policies to encourage the development of these technologies may include performance requirements, mandates, or incentives to use advanced coal technologies for new coal plants, such as a performance requirement for new fossil fuel-fired power plants to achieve a specific CO_2 emission rate. Alternatively, a mandate might require that all or a portion of new coal plants be of a certain technology or include certain control technologies. Incentives could take the form of direct financial subsidies or assistance in securing low-interest financing. A combination of mandates and incentives may be desirable to balance incentives for replacing older existing power plants.

As with certain advanced electric generation technologies, CCSR technology will most likely increase the cost of generating electricity. Policies to encourage development of CCSR technology should include a state agency tasked with promoting CCSR and with the ability to mandate changes and/or offer financial incentives to capture, store, and/or reuse CO_2.

Policy Design

The proposed policy has three elements:

1. *A post-combustion technology pilot and demonstration project applied to a single coal unit.* Given Michigan's promising opportunities for carbon geostorage, a pilot or demonstration project is proposed to fund and manage the application of a promising technology to capture, transport, and store carbon. The state should act in partnership with industry, the federal government, and others to develop a project plan, budget, and funding proposal.
2. *Michigan-specific comparison of the costs and benefits of advanced methods.* Analyze and report a Michigan-specific comparison of the costs and benefits of advanced methods, such as IGCC and supercritical technologies, against existing coal technologies from a GHG reduction and cost perspective. The policy will not propose to set goals to achieve broad GHG reductions, but rather will perform a general analysis within the MCAC process of the current state of the costs and benefits of these emerging technologies.

3. *State actions to promote CCSR.* Use financial incentives, performance requirements, mandates, or other measures to encourage or require the early adoption of these technologies. Since these technologies are not yet mature, consideration will be given to specific incentives, etc., but this policy will not be quantified as predictably contributing to GHG reductions at this time.

Goals: This policy is not quantified, as stated above.

Timing: The post-combustion CCSR technology pilot project will be in operation in the 2012–2013 time frame. A preliminary analysis of all of the various advanced technologies will be undertaken through this process. If indicated, a more detailed analysis may be recommended. State actions to promote CCSR should be implemented as soon as the analysis indicates that technology maturity as well as costs and benefits are supported.

Parties Involved: Michigan Departments of Environmental Quality (MDEQ) and Natural Resources (MDNR), MPSC, DOE, owners of coal-fired generating units. Michigan's universities have detailed knowledge of the state's unique geology and will be a valued partner in CCSR evaluations and analyses.

Other: None.

Implementation Mechanisms

As adopted from the MGA Advanced Coal and Carbon Capture and Storage (AC/CCS) Renewable Energy Policy Options 1 & 2:

- *Provide state support for front-end engineering and design (FEED).* FEED studies provide the cost estimates needed to secure private investment in power plant projects. State tax credits or grants can help offset FEED study costs and allow utilities and developers to recoup those initial engineering costs that are most difficult to finance. This approach has been effective in Illinois, North Dakota, and Wyoming in spurring project development, and is under consideration in other parts of the Midwest.
- *Provide direct state financial incentives (grants, tax credits, loan guarantees, and performance wrap engineering/procurement/construction coverage).* States should establish the same incentives as or incentives complementary to those in the federal Energy Policy Act of 2005 to help reduce the financial cost of the overall project once engineering and cost studies are completed.
- *Allow regulated utilities cost recovery for appropriate commercial projects.* Utilities committed to developing advanced technology coal plants with CCSR should be ensured cost recovery, as long as they meet a state commission's standards for proper spending decisions. States should also consider a comparable process for merchant and independent power producers involved in request for proposal (RFP) bidding processes.
- *Enhance IRP policies, where applicable, by using them to encourage low-CO_2 coal technologies.* Regional leaders should adopt well-designed IRP rules to weigh the full costs, benefits, and risk characteristics of various resource options. Doing so would improve the accuracy of "least-cost" planning for generation options, which currently penalizes advanced coal and CCSR proposals because it does not fully address future regulatory and

environmental costs. Future risks to be factored in should include fuel price fluctuation, carbon constraints, emission limits of criteria pollutants and mercury, and technology uncertainty.

- *Modify state policies and regulatory programs to favor advanced CO_2-limiting generation technologies with CCSR over conventional pulverized coal units.* These policies could include:
  1. A low-carbon electricity portfolio standard or objective that combines fossil electricity generation resources (such as IGCC with CCSR) with traditional renewable resources;
  2. A CCSR portfolio standard for electricity providers;
  3. A CO_2 performance standard for all new electric power plants;
  4. Innovative, long-term power purchase agreements to provide developers with higher rates of return and reduced risk in exchange for price stability that benefits ratepayers (allowing regulators to qualify more stable prices as a benefit);
  5. Specific incentives and financing assistance to replace or repower existing coal plants in favor of advanced generation technologies with CCSR;
  6. Market-based environmental regulatory programs to provide incentives to invest in low-CO_2 emission technologies with flexibility and certainty for achieving reductions; and
  7. Three-party covenants in which the federal government provides credit, the state regulatory commission provides an assured revenue stream from the syngas to protect the federal credit, and a project developer provides equity and initiative to build the project.
- *Increase federal funding of incentives to accelerate deployment of advanced coal technologies with CCSR at commercial scale.* Current federal funding is completely inadequate, given the scale of the task and urgency of commercializing advanced coal technologies with CCSR. Midwestern governors call on the region's congressional delegation to expand significantly the federal commitment of resources in this area.
- *Provide incentives for deployment of innovative coal gasification technologies, including co-gasification of biomass and underground coal gasification, and the utilization of captured CO_2.* Co-gasification of biomass feedstocks with coal has been commercially demonstrated in Europe and, when combined with CCSR, could provide CO_2-neutral or even CO_2-negative energy production. Underground coal gasification has entered commercial operation overseas and has the potential to bring the capital costs of CCSR with coal to at or below that of conventional pulverized coal generation. Finally, research is underway to convert captured CO_2 into useful and advanced materials and other products.

The following regards the CCSR aspect of this policy (repeated in ES-9).

- Consider an infrastructure build-out that extends beyond Michigan. In this context, the term "infrastructure" should be understood to include regional power markets. Developers will not build advanced coal generators with CCSR, or retrofit existing generators with CCSR, unless these units will be competitive in regional power markets (e.g., PJM and Midwest Independent Transmission System Operator [MISO]), taking into account their anticipated construction costs.

- Develop a report that quantifies the costs and benefits and potential capacity of enhanced oil recovery (EOR). This report will identify CO_2-EOR resource potentials in Michigan, and will quantify the potential GHG reduction benefits of CO_2-EOR projects.
- Review regulations of other states governing or potentially relating to CO_2 capture and underground injection. This review will provide guidance by laying out existing statutes and regulations and identifying gaps in regulation for policymakers.
- Develop a legal and regulatory framework for geologic storage of CO_2. To set the stage for geologic storage projects to move forward in a 5–10-year time frame, Michigan must establish the necessary legal and regulatory framework in partnership with the federal government. Michigan must ensure that the necessary statutes and regulations for geologic storage are in place, including guidance on pipelines, injection, monitoring, mitigation, verification, and long-term liability.
- Evaluate and comment on the underground injection control (UIC) regulations proposed by the U.S. Environmental Protection Agency (EPA) on geologic sequestration of CO_2. EPA's UIC regulations related to geologic sequestration will have broad impacts on CCSR project development and technology deployment.
- Provide state-based incentives for CCSR, encompassing projects that use captured CO_2 for EOR as well as deep-saline formation storage. Stability in the CO_2 credit market is also important for CCSR.
- Provide EOR project development assistance. Michigan has a mature oil and gas industry, with many small oil and gas producers that have not traditionally used CO_2-EOR, in part because they are not large enough to develop projects. The public sector, companies, and trade associations can play a useful role in helping to identify the specific mechanisms by which producers can band together to leverage cost-effective projects.
- Support comprehensive assessments of geologic reservoirs at the state and federal levels to determine CO_2 storage potential. Governments should build on the work of the DOE-funded regional sequestration partnerships to complete comprehensive, basin-level geologic assessments of storage potential. Regions with a history of oil and gas exploration tend to have better data available on geologic formations, making such assessments easier and less expensive, although these regions suffer the deficiency of having much previous drilling that can diminish reservoir integrity. Detailed, accurate mapping of lesser-known potential reservoirs for CCSR will require continued federal and state investment.
- Participate in and/or fund sufficient underground injection tests to prepare for future storage on a widespread commercial basis. Congress and the president should support sufficient federal funding for DOE to ensure a robust program of tests to demonstrate to the private sector, policymakers, and the public the viability, efficacy, and safety of widespread commercial geologic storage of CO_2. These tests should focus on a variety of geologic settings, including reservoirs other than oil-and-gas-bearing formations, and should produce guidelines for appropriate monitoring, mitigation, and verification.
- Evaluate the feasibility of alternate sequestration options for jurisdictions without as-yet adequately documented underground injection potential, such as the western Upper Peninsula. This includes evaluating the cost and feasibility of CO_2 pipelines from other areas

of the state and other CO_2 sequestration options, such as mineralization, carbon nano-fibers, or biological means.

- Consider the use of transported synthetic natural gas to areas where near-term carbon storage options are as yet unknown. This could also allow better use of peaking/intermediate generating capacity and complement the expanded development of wind power.

Related Policies/Programs in Place

See Table F-9-1. MDEQ, MDNR, the Michigan Attorney General, and others are currently mapping out the various regulatory matters pertaining to CCSR to identify appropriate actions to address such issues as landowner rights, liability (both short and long term), revenue streams, environmental impacts, and other issues as identified.

Type(s) of GHG Reductions

Principally CO_2.

Estimated GHG Reductions and Costs or Cost Savings

Not applicable. This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

The key uncertainties fall into three categories: technological and cost uncertainties for some capture, transport, and storage technologies; legal uncertainties, such as permitting, liability, and property rights; and sequestration uncertainties, such as the long-term suitability for certain geologic formations.

Additional Benefits and Costs

It is expected that real and measurable emission reduction benefits will result from the implementation of CCSR and other advanced technologies. However, it is not possible to reliably predict the magnitude of these savings or their costs or cost savings at this time. A proposed pilot project would be designed to answer some of these questions.

Feasibility Issues

The feasibility of advanced technologies depends upon resolving the legal issues and successfully demonstrating that the technologies and storage methods are reliable and cost-effective. The feasibility of the pilot project depends upon the availability of sufficient funding.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-6. New Nuclear Power

Policy Description

Nuclear power is a large-scale low-GHG, baseload source of electricity that could complement renewable energy resources in a mix of low-GHG-emitting electric generating options. According to the Nuclear Energy Institute, nuclear energy generates over 70% of the carbon-free electricity in the United States and avoids almost 700 million metric tons of CO_2 emissions that otherwise would be emitted by fossil fueled generation. Evaluation of CO_2 emissions on a total life-cycle basis (i.e., mining, to fuel shipping, to fuel disposal) indicates that CO_2 emissions from nuclear energy are comparable to most other non-emitting energy sources, such as solar, wind, and hydropower. The United Nations' Intergovernmental Panel on Climate Change and other international and U.S. policy groups recognize that nuclear energy should play a significant role in global GHG emission-reduction policies. EIA, EPA, and the Clean Air Task Force all depended heavily in their modeling on new nuclear power to meet the proposed required GHG emission reductions of the Lieberman-Warner Climate Security Act of 2008.

Nuclear energy accounts for approximately 25% of electricity generation in Michigan from four nuclear power plants:

- Donald C. Cook 1 (AEP), Bridgman, MI—1016 MW (license expiration in 2034);
- Donald C. Cook 2 (AEP), Bridgman, MI—1077 MW (license expiration in 2037);
- Fermi 2 (Detroit Edison), Newport, MI—1,111 MW (licence expiration in 2025); and
- Palisades (Entergy), Covert, MI—775 MW (license expiration in 2031).

Michigan's 21st Century Electric Energy Plan (21st Century Plan) recognizes the need for new baseload plants to be built in Michigan to meet forecasted electric growth in Michigan. The 21st Century Plan also notes that nuclear power cannot meet the need for new generation for at least 12 years due to the extremely long lead time required to bring a new nuclear plant on line. Nuclear power can, however, play a significant role in reducing GHG emissions in conjunction with other low-GHG-emitting generating technologies in the time period beyond 2020. The 21st Century Plan contains legislative and regulatory recommendations for providing financing for construction of new power plants in Michigan.

Barriers to the implementation of new nuclear plants may include the following:

- Public concerns regarding the safety and reliability of nuclear power plants, especially following high-profile incidents, such as Three Mile Island and Chernobyl.
- Continued uncertainty regarding federally mandated long-term used fuel storage.
  - DOE filed a license application after much delay for the Yucca Mountain geologic repository on June 3, 2008. The licensing process begins the first step in creating a permanent disposal facility in the United States for used nuclear and radioactive waste.

   - Used fuel recycling or reprocessing is not performed in the United States for economic reasons. The federal government and the nuclear industry are supporting research and development on advanced recycling technologies.
- High capital costs that continue to rise for all baseload generating options.
- State regulatory structures that may prevent cash return on new plant investments until after commercial operation, and that may in turn increase the overall customer cost of the plant.
- A long federal licensing process for new nuclear plants that effectively makes deployment of a new nuclear plant more than an 11-year project.

Nuclear power can continue to provide baseload power to a growing Michigan economy, while also reducing or avoiding overall GHG emissions. Policies that address the barriers to implementation and encourage the licensing of new nuclear plants in Michigan, as well as relicensing of existing plants, should be considered. These policies could also address opportunities for reducing the long time frame required to license and construct a new nuclear power plant.

Policy Design

Goals:

- Develop policy recommendations to encourage the licensing and construction of baseload nuclear power plants in Michigan. Recommendations should consider:
   - State-level legislative and regulatory approaches to overcome barriers and facilitate construction of new nuclear plants;
   - Increased utilization of federal initiatives (e.g., DOE incentives, such as loan guarantees) to encourage development of nuclear energy;
   - Public outreach efforts to demonstrate the improved safety of nuclear power and to highlight the GHG reduction potential of nuclear power; and
   - Assurances that spent fuel will be stored safely and, if at all possible, safely away from the Great Lakes.
- Identify GHG emission reduction or avoidance potential as a result of new nuclear plant construction or relicensing of existing plants in Michigan through 2030.

Timing: Beginning in 2009.

Parties Involved: MPSC, regulated utilities, the U.S. Nuclear Regulatory Commission (NRC), MDEQ, Michigan legislature.

Other: On September 18, 2008, Detroit Edison submitted to the NRC a combined construction and operating license application for a new nuclear plant to be located at the site of Detroit Edison's existing Fermi 2 power plant near Monroe. The filing of the application will preserve the option for Detroit Edison to build a nuclear power plant in the future after the extensive (3–4-year) federal licensing review process, as well as maintain eligibility for Federal Production Tax Credits. The submittal of the license application does not guarantee that Detroit Edison will build a plant.

Implementation Mechanisms

Many implementation mechanisms for increased use of nuclear power to mitigate GHG emissions will be managed at the federal level, including incentives for new commercial reactors, radioactive waste management policy, research and development priorities, power plant safety and regulation, and security against terrorist attacks. Michigan should implement policies that support federal incentives and that will encourage development of additional nuclear power in the state.

Similar to financing construction of other fossil fuel baseload assets, the Michigan regulatory process is not conducive to major investments by the utilities without structural changes to the cost recovery and cost allocation processes. At the state level, the following mechanisms may help facilitate construction of new nuclear power plants:

- MPSC should allow electric utilities to recover financing interest costs in base rates for certified capital improvement construction work (as opposed to waiting until the plant is operational to collect a cash return on the interest) through the ratemaking process. This would be consistent with language in HB 5524, enacted on October 6, 2008.
- The Michigan legislature should provide tax and other incentives to investors and equity partners that can help to fund nuclear plants.
- The existing IRP process in Michigan (see ES-7) should include nuclear generation in the plan to meet the needs of future generations in Michigan.

New nuclear plants within Michigan will require highly skilled and highly paid workers during the plant's construction and operation. Michigan universities and colleges should consider enhancing programs that will attract engineering, science, and related disciplines that can support a growing nuclear energy industry.

In addition, state and local governments, the educational community, and the environmental community should partner in conducting educational and community outreach on the GHG benefits, safety, and risks of nuclear power.

Related Policies/Programs in Place

- Federal incentives for nuclear energy in the recent Energy Policy Act of 2005 included (among others) the following:
  - Extending the Price Anderson Act, which limits liability for nuclear power plant accidents to 2025;
  - Increased safety, security, and radioactive waste disposal measures; and
  - Tax credits for new nuclear plants in service prior to January 2021.
- The NRC is currently the regulatory agency for nuclear facilities.
- The Michigan comprehensive energy legislation that was signed into law on October 6, 2008 (HB 5524, SB 213, and HB 1048), should be expected to facilitate the construction of new baseload generation in Michigan by providing rate recovery for financing the costs of new capital expenditures, as well as limiting the number of customers who can pick their energy providers (i.e., leave the regulated utilities). Limiting the number of customers who choose

alternative suppliers provides more certainty to lenders that an electric utility will have the customers to help pay for the cost of building a nuclear power plant.

Type(s) of GHG Reductions

CO_2.

Estimated GHG Reductions and Costs or Cost Savings

The costs and GHG emission reduction benefits of nuclear power are analyzed to illustrate the current DTE Energy (Fermi 3) nuclear unit being proposed on the existing site of Fermi 2, near Monroe, Michigan. This nuclear unit, sized at 1,550 MW, has had the combined operating and licensing application (COLA) filed by DTE with the NRC. The illustration in Table F-6-1 assumes a single 1,550-MW unit is permitted and constructed and comes on line in 2020. Costs are annualized over the expected life of the unit. Cumulative GHG reduction benefits accrue for the years 2020–2025.

Table F-6-1. Estimated GHG reductions and costs of or cost savings from a 1,550-MW nuclear unit

ES-6. New Nuclear Power	2015	2025	Units
GHG emission savings	0.0	6.3	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$1,001	Million $
Cumulative emissions reductions (2009–2025)		38.5	Million metric tons of CO_2
Cost-effectiveness		$25.98	$/metric ton of CO_2

Data Source: AEO 2008.

Quantification Methods: New nuclear power is assumed to displace primarily coal-fired power, as reflected in the Michigan I&F. The values presented above *do not* reflect the recent RPS legislation, but do account for reductions associated with other options.

- Assume a given capacity of a nuclear facility (1,550 MW).
- Assume the commissioning date (2020).
- Assume a capacity factor (93%).
- Calculate the electricity generation (capacity x time x capacity factor).
- Determine the annualized cost of the program, based on EIA AEO 2008 data.
- Determine the avoided cost, based on the amount of electricity generation.
- Determine the net costs and the net present value.
- Determine the emissions avoided, based on electricity generation.

Key Assumptions:

- A new nuclear facility would come on line in 2020, operating for only 5 years before the end of the modeled period of 2009–2025.

- The levelized costs of nuclear power are $90.00/MWh in 2015 and $85.51/MWh in 2025.The following line items are included in the levelized costs:

  Construction Costs

  - Combined Operating License Application [COLA] Preparation Costs
  - COLA Review Support Costs
  - NRC Costs & Fees
  - Program Office Costs
  - University of Michigan Office of Engineering Outreach and Engagement [OE^2] Engineering Staff for COLA Review Support
  - Other Project Management Costs
  - General Program Management Costs
  - Certificate of Need Development/Support
  - Owner's Engineer Costs
  - NRC Costs & Fees (During Construction)
  - Site Preparation & Development Costs
  - Site Prep & Development Engineering Costs
  - Wetlands Replacement
  - Reactor Technology Costs
  - Owner's Balance of Plant Costs
  - Owner's Plant Staffing Costs (Pre-Commercial Operation Date [COD])
  - Spare Parts
  - Direct Construction Cost
  - Project Indirects
  - Insurance
  - Property Tax
  - Sales Tax
  - Performance Bond Costs
  - Construction Indirects
  - Other Indirect Costs (Administrative and General)
  - Contingency
  - First Fuel Load (Included in Fuel Costs)
  - Allowance for Funds Used During Construction

  Costs Included in Busbar

  - Average Rate Base
  - Pre-Tax Return on Rate Base
  - Operations & Maintenance
  - Administrative and General

- Fuel Amortization
- Fuel Decommissioning
- Decommissioning Fund
- Depreciation
- Property Taxes
- Insurance
- NRC Fees
- Production Tax Credit (None Currently Assumed)
- Power Ascension to COD Sales

Key Uncertainties

- Actual date of commissioning a new nuclear facility.
- Future capital costs.
- The ultimate disposition of spent fuel. Concern over the hazardous nature and persistence of spent fuel remains an uncertainty despite recent federal efforts to license the Yucca Mountain Repository. Opposition from Nevada and others has raised the expectation that multiple legal challenges are all but certain. Additional concerns have been raised regarding the capacity of Yucca Mountain to meet the needs of both current and planned reactors due to major delays in repository licensing and renewed interest in new nuclear power plants prompted by concerns for GHG emissions from fossil fuel-fired generation.

Additional Benefits and Costs

As discussed under the Policy Description and Policy Design sections.

Feasibility Issues

Some of the recommended policy changes require legislative approval. Ultimate disposition of spent fuel is also a feasibility issue, as noted under Key Uncertainties above.

Status of Group Approval

Approved.

Level of Group Support

Majority—16 in favor, 6 opposed, and 2 abstentions.

Barriers to Consensus

MCAC members who voted against this policy recommendation expressed a range of concerns about the fate of existing and new high-level waste, or spent fuel. Members who were both in favor of and opposed to the policy expressed frustration over the failure of the federal government to fulfill its promise to site and license a permanent high level waste repository. As a result, spent fuel is being stored on site at both active and decommissioned plants awaiting federal action. Because these sites are adjacent to the Great Lakes, members believe they represent an unacceptable risk to the lakes and surrounding environment. Members voting against the policy expressed the concern that until a solution to this problem is found, no new plants should be constructed. Various concerns were raised by MCAC members regarding ES-6, including storage of nuclear waste (dry & wet cask) adjacent to the Great Lakes and connecting waterways, storage of such wastes on tribal lands and the capacity and status of long-term storage at the Yucca Mountain facility. Because of these concerns, those members in opposition believe that conditioning the approval of new nuclear plants on the resolution of the spent fuel storage problem would also place pressure on the federal government to accelerate efforts to resolve this issue. Two members abstained.

ES-7. Integrated Resource Planning (IRP), Including CHP

Policy Description

IRP is a process that develops plans to meet needs for electricity services in a manner that meets multiple objectives, such as least-cost generation, emission standards, fuel diversity, and RPS requirements. An IRP process includes the evaluation of all feasible options, from both the supply and the demand sides, in a fair and consistent manner. The IRP process can also build in flexibility (in manner of either probability analysis or scenario analysis) to account for future uncertainties in the technologies, costs, capacities, and markets. While originally targeted primarily toward cost minimization, IRP processes have increasingly considered the environmental risks and the potential costs associated with future regulation of GHGs.

IRP is a process that is analogous in many ways to utility least-cost planning. In the IRP process, companies or the state can highlight supply-side (generation capacity) options to meet a forecasted growth in electricity demand, and can also evaluate equally technology and policy options on the demand side to satisfy the anticipated demand. Demand-side measures include energy efficiency, distributed generation, and peak-shaving measures. In this fashion, supply and demand analyses are paired and evaluated jointly in a least-cost planning environment.

Policy Design

Goals: To refine the existing comprehensive state resource adequacy plan (the IRP) for Michigan that meets the reliability, environmental, public health, and economic policies of the state. The plan should support and attempt to balance all four policies. Any IRP process should be focused on the various stakeholders, with emphases on the load-serving utilities.

Timing: The IRP process could be implemented by the end of 2009. The MPSC could refine and update the state's Comprehensive Resource Plan, developed as a part of the Capacity Needs Forum and the 21st Century Plan planning process, or it could direct *de novo* analysis to meet load-serving entity demand in 2009, with the first IRP and RFP issued by early 2009.

Parties Involved: MPSC, MDEQ, regulated electric utilities, alternative energy suppliers [AESs], independent power providers (IPPs), generators, environmental and consumer advocates, renewable energy industry, energy efficiency industry, financial community, and public health representatives. It should be noted that an effective IRP process is transparent and open to full public intervention with discovery.

Implementation Mechanisms

Michigan has adopted IRP requirements for electric utilities under H.5524, Sec. 6s (11) (a)–(g) (see Related Policies/Programs in Place). The MPSC must establish the necessary standards to make this provision effective.

Related Policies/Programs in Place

Under Michigan's current IRP requirements for electric utilities (H.5524, Sec. 6s (11) (a)–(g)), the MPSC must establish standards to be met by electric utilities seeking a certificate of necessity for construction of an electric generation facility, a significant investment in an existing electric generation facility, or a purchase of an existing electric generation facility, to enter into a power purchase agreement for the purchase of electric capacity for a period of 6 years or longer for that construction, investment, or purchase if that construction, investment, or purchase costs $500 million or more and a portion of the costs would be allocable to retail customers in Michigan. The specific requirements are as follows:

> "(11) The commission shall establish standards for an integrated resource plan that shall be filed by an electric utility requesting a certificate of necessity under this section. An integrated resource plan shall include all of the following:
>
> (a) A long-term forecast of the electric utility's load growth under various reasonable scenarios.
>
> (b) The type of generation technology proposed for the generation facility and the proposed capacity of the generation facility, including projected fuel and regulatory costs under various reasonable scenarios.
>
> (c) Projected energy and capacity purchased or produced by the electric utility pursuant to any renewable portfolio standard.
>
> (d) Projected energy efficiency program savings under any energy efficiency program requirements and the projected costs for that program.
>
> (e) Projected load management and demand response savings for the electric utility and the projected costs for those programs.
>
> (f) An analysis of the availability and costs of other electric resources that could defer, displace, or partially displace the proposed generation facility or purchased power agreement, including additional renewable energy, energy efficiency programs, load management, and demand response, beyond those amounts contained in subdivisions (c) to (e).
>
> (g) Electric transmission options for the electric utility."

Michigan also adopted an energy optimization (EO) requirement under PA 295 of 2008 (S.213), the Clean, Renewable, and Efficient Energy Act (Subpart B, sec. 71–97). The EO plan must be designed to delay the need for constructing new electric generating facilities and thereby protect consumers from incurring the costs of such construction. The EO plan is essentially a demand-side energy efficiency requirement, with limits and exceptions. The statute requires:

> "an electric provider's energy optimization programs . . . shall collectively achieve the following minimum energy savings:
>
> (a) Biennial incremental energy savings in 2008-2009 equivalent to 0.3% of total annual retail electricity sales in megawatt hours in 2007.
>
> (b) Annual incremental energy savings in 2010 equivalent to 0.5% of total annual retail electricity sales in megawatt hours in 2009.
>
> (c) Annual incremental energy savings in 2011 equivalent to 0.75% of total annual retail electricity sales in megawatt hours in 2010.
>
> (d) Annual incremental energy savings in 2012, 2013, 2014, and 2015 and, subject to section 97, each year thereafter equivalent to 1.0% of total annual retail electricity sales in megawatt hours in the preceding year."

Natural gas providers are required to:

> "Meet the following minimum energy optimization standards using energy efficiency programs under this subpart:
>
> (a) Biennial incremental energy savings in 2008-2009 equivalent to 0.1% of total annual retail natural gas sales in decatherms or equivalent MCFs in 2007.
>
> (b) Annual incremental energy savings in 2010 equivalent to 0.25% of total annual retail natural gas sales in decatherms or equivalent MCFs in 2009.
>
> (c) Annual incremental energy savings in 2011 equivalent to 0.5% of total annual retail natural gas sales in decatherms or equivalent MCFs in 2010.
>
> (d) Annual incremental energy savings in 2012, 2013, 2014, and 2015 and, subject to section 97, each year thereafter equivalent to 0.75% of total annual retail natural gas sales in decatherms or equivalent MCFs in the preceding year."

The provisions in PA 295 are not an IRP process, but they require utilities to plan and implement programs to achieve specified energy savings for similar purposes.

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Estimated GHG Reductions and Costs or Cost Savings

Not applicable. This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

None.

Additional Benefits and Costs

It is expected that real and measureable emission reductions will result from the implementation of this policy. However, it is not possible to reliably predict the magnitude of these savings or their costs or cost savings.

Feasibility Issues

With the passage of H.5524, most feasibility issues have been resolved. The MPSC must set standards for projecting energy and capacity purchased or produced pursuant to any renewable portfolio standard, energy efficiency program, or load management and demand response savings.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-8. Smart Grid, Including Advanced Metering

Policy Description

Smart Grid systems promote efficiency through improvements in system monitoring, control technology, and systems integration. Combining advanced metering and two-way communication to end users with the Smart Grid technology provides a system where both the utility and the customer can engage in integrated decisions, thus enabling and improving energy efficiency. In addition, a Smart Grid system allows enhanced opportunities for demand response and optimizes the deployment of distributed resources and renewable energy. The policy to develop Smart Grid systems supports the overall goal of reducing GHG emissions by improving energy efficiency in all areas of the electric grid operations, including generation dispatch, transmission, and distribution systems.

Title XIII of the 2007 Energy Independence and Security Act describes the characteristics of the Smart Grid beyond advanced metering infrastructure (AMI). Although the industry has not settled on a clear definition, Title XIII provides a sense of what is meant by the Smart Grid, including such features as increased use of digital information and controls to improve reliability, security, and efficiency of the electric grid; optimization of grid operations and resources; deployment of distributed resources, including renewables; incorporation of demand response resources and energy efficiency resources; deployment of smart technologies for metering, communications concerning grid operations and status, and distribution automation; integration of smart appliances; integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles; provision to consumers of timely information and control options; development of interoperability standards for grid-connected appliances and infrastructure; and identification of barriers to adoption of Smart Grid technologies and practices. It is a common belief that moving to the Smart Grid will be a phased evolution, and that policy guidelines for the Smart Grid should be established with the long-term view in mind.

The Federal Energy Regulatory Commission (FERC) has defined advanced metering as a system that records customer consumption and possibly other data hourly or more frequently, and that provides daily or more frequent transmittal of the measurements over a communication network to a central collection point. AMI includes advanced meters, communications networks, and data management systems. This technology ultimately allows consumers much greater opportunity to manage their electricity consumption. Further information about AMI technologies is available at http://www.ferc.gov/legal/staff-reports/09-07-demand-response.pdf.

Policy Design

This policy will provide guidelines to utilities for evaluating AMI and Smart Grid technology projects, including cost-benefit analysis methodologies for determining GHG emission benefits. Energy efficiency in this context is defined as improvements in energy utilization (kWh) and demand (kW) as realized at the end user or on the utility delivery system.

Goal: The potential benefits of Smart Grid and AMI are such that all regulated electric utilities and other load-serving entities should develop a plan to deploy AMI, including an appropriately configured two-way communication network with capability to interact with customer home and business devices by 2015. Such AMI deployment should enable interoperability with future implementation of Smart Grid technologies.

Timing: As described above.

Parties Involved: Michigan regulated utilities, other load-serving entities, and the MPSC.

Other: None.

Implementation Mechanisms

- Establish a select work group of utility representatives from the Smart Grid Collaborative to participate in the AMI minimum functionality criteria investigation work group and in a Smart Grid work group. These work groups will develop and recommend policy guidelines and cost-benefit methodologies to the MPSC.
- Conduct AMI, demand response, and Smart Grid pilots to determine and validate the policy guidelines and potential of energy efficiency and GHG savings.
- Apply the policy in the development of utility general rate case filings that include AMI and Smart Grid investments.

Related Policies/Programs in Place

The MPSC commenced the Smart Grid collaborative in an order issued in Case No. U-15278 on April 24, 2007, related to Smart Grid technologies:

> [T]he Commission Staff (Staff) shall convene a collaborative process to monitor national smart power grid infrastructure developments. When options appear cost effective and practical to implement, the Staff should establish evaluation criteria and standards, triggering pilot programs or broader deployment in Michigan. The collaborative should emphasize reviewing and adopting technologies that make the grid flexible and efficient, enable distributed technologies, and preserve reliability.
>
> *April 24, 2007, order, p. 1.*

In April 2008, an MPSC staff report was filed in the Smart Grid collaborative docket, which recommended that the MPSC undertake a public input process to develop minimum AMI functionality guidelines. Subsequently, on July 1, 2008, the MPSC issued an order in Case No. U-15620, which directed MPSC staff to begin an investigation of minimum functionality criteria necessary for rate recovery of infrastructure investments by regulated utilities. In its order, the MPSC recognized that the investigation must consider that AMI infrastructure developed today will be a foundation for a continually evolving technology, and so guidelines and policies need to be flexible. A staff report on preliminary findings of this investigation was filed on October 1, 2008. Among staff comments was the recommendation that development of minimum AMI functionality standards should be the subject of a rulemaking procedure, as opposed to a less formal approach of developing guidelines.[7]

[7] Link to the full staff report: http://efile.mpsc.cis.state.mi.us/efile/docs/15620/0025.pdf.

This policy is in keeping with the Smart Grid collaborative directive and the subsequent investigation into minimum functionality standards for AMI rate recovery of infrastructure investments.

There are no other known policies or programs of this nature in Michigan that combine AMI and Smart Grid technologies.

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Dynamic pricing and demand response.

Operational efficiencies: system losses and reduction in field workforce vehicle emissions.

Estimated GHG Reductions and Costs or Cost Savings

Not applicable. This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Two areas of uncertainty are the potential of demand/price response programs and the potential for grid efficiency improvements by deploying new technology. The first is a customer demographic, acceptance, program design, and pricing issue and how that impacts energy savings. The second is an issue of system design and operating practices. The uncertainties can be minimized through the implementation of well-designed pilots.

Additional Benefits and Costs

Other benefits for AMI and Smart Grid technologies include operational efficiencies, avoided costs, credit and collections, remote disconnects/reconnects, outage management, meter accuracy, and theft reduction. Each utility's business case would be unique based on the relation of these and other benefits to the utility's current operating and business practices.

Feasibility Issues

It would require approximately 2 years to deploy technologies, gather baseline data, and pilot demand/price response programs and Smart Grid treatments to validate energy efficiency saving. This would provide a more credible basis for evaluating wide-scale implementation.

Technologies that have not reached maturity would not be able to be evaluated.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-9. Carbon Capture, Storage, and Reuse Incentives, Requirements, R&D, and/or Enabling Policies

Policy Description

Carbon capture and storage or reuse (CCSR) is a process that includes separation of CO_2 from industrial and energy-related sources, transport to a storage location, and permanent or long-term storage in isolation from the atmosphere. Ideally, the CO_2 from large point sources, such as power plants, can be compressed and transported for storage in geological formations for use in industrial processes or for enhanced recovery of oil and gas. The net reduction of emissions to the atmosphere through CCSR depends on the volume of CO_2 captured, the volume of CO_2 storage available, and the amount of CO_2 retained in geostorage or used for other purposes.

CCSR technology will most likely increase the cost of generating electricity. Policies to encourage development of CCSR technology should include a state agency tasked with evaluating CCSR and with the ability to recommend changes and/or financial incentives to capture, store, and/or reuse CO_2.

Technology to capture and store or reuse CO_2 from power plants continues to evolve. Some of these technologies are in fact in industrial-scale use in a limited number of cases or applications, principally to support enhanced oil recovery (EOR), while others are in the early developmental stages. Specifically, CO_2 injection for EOR is currently being used in Michigan. Further potential use of CO_2 injection for EOR is also very probable. Industrial-scale, long-term geostorage in deep saline formations is not as well developed or proven, though there is strong potential in Michigan based on the state's geology.

In addition, a host of non-technological challenges must be addressed before CCSR can be realized at a large scale. These include permitting, liability, property rights, monitoring, and other public policy questions.

Further research and development (R&D) to improve all phases of CCSR, including transport, is needed. Further localized studies to identify geologically sound geological strata are needed before this can play a significant role in reducing GHG emissions. The process of evaluating the potential of Michigan's brine formations for carbon sequestration has commenced. In early 2008, as part of a sequestration test, 10,000 metric tons of CO_2 were injected into a suitable geological formation. The test was successful and is now in the post-injection monitoring mode. If the Michigan investigation yields promising results, the state should move in a deliberate fashion to evaluate the potential of other areas and geological formations. Shared information from similar projects throughout the United States will assist in proving the use of brine aquifer storage potential.

Policy Design

Goals: Promote the safe and effective use of EOR and deep carbon geostorage using Michigan's promising geological assets.

Timing: Michigan should initially encourage EOR and the accompanying modest carbon storage from this activity, and sequestration in depleted oil and gas fields within the 2–5-year time frame. By 2015, Michigan should encourage and support additional pilot/demonstration activity for deep carbon geostorage in several locations in the state. By 2020, Michigan should have a robust legal and policy framework consistent with national intent that enables full-scale industrial carbon geostorage capabilities.

Parties Involved: Federal, state, and regional bodies, along with all applicable stakeholders.

Other: None.

Implementation Mechanisms

As adopted from the MGA AC/CCS-1.

Some of the key implementation issues that will need to be explored regarding the establishment of a CCSR infrastructure are as follows:

- Consider an infrastructure build-out that extends beyond Michigan. In this context, the term "infrastructure" should be understood to include regional power markets. Developers will not build advanced coal generators or retrofit existing generators with CCSR, unless these units will be competitive in regional power markets (e.g., PJM and MISO), taking into account their anticipated construction costs.
- Develop a report that quantifies the costs and benefits and potential capacity of EOR. This report will identify CO_2-EOR resource potentials in Michigan and quantify the potential GHG reduction benefits of CO_2-EOR projects.
- Review regulations of other states governing or potentially relating to CO_2 capture and underground injection. This review will provide guidance by laying out existing statutes and regulations and identifying gaps in regulation for policymakers.
- Develop a legal and regulatory framework for geologic storage of CO_2. To set the stage for geologic storage projects to move forward in a 5–10-year time frame, Michigan must establish the necessary legal and regulatory framework in partnership with the federal government, and must ensure that the necessary statutes and regulations for geologic storage are in place, including guidance on pipelines, injection, monitoring, mitigation, verification, and long-term liability.
- Evaluate and comment on the UIC regulations proposed by EPA on geologic sequestration of CO_2. EPA's UIC regulations related to geologic sequestration will have broad impacts on CCSR project development and technology deployment.
- Provide state-based incentives for CCSR, encompassing projects that use captured CO_2 for EOR as well as for storage in deep saline formations. Stability in the CO_2 credit market is also important for CCSR.
- Provide EOR project development assistance. Michigan has a mature oil and gas industry, with many small oil and gas producers that have not traditionally used CO_2 EOR, in part because they are not large enough to develop projects. The public sector, companies, and trade associations can play a useful role in helping to identify the specific mechanisms by which producers can band together to leverage cost-effective projects.

- Support comprehensive assessments of geologic reservoirs at the state and federal levels to determine CO_2 storage potential. Governments should build on the work of DOE-funded regional sequestration partnerships to complete comprehensive, basin-level geologic assessments of storage potential. Regions with a history of oil and gas exploration tend to have better data available on geologic formations, making such assessments easier and less expensive, although these regions suffer the deficiency of having much previous drilling that can diminish reservoir integrity. Detailed, accurate mapping of lesser-known potential reservoirs for CCSR will require continued federal and state investment.
- Participate in and/or fund sufficient underground injection tests to prepare for future storage on a widespread commercial basis. Congress and the president should support sufficient federal funding for DOE to ensure a robust program of tests to demonstrate to the private sector, policymakers, and the public the viability, efficacy, and safety of widespread commercial geologic storage of CO_2. These tests should focus on a variety of geologic settings, including reservoirs other than oil-and-gas-bearing formations, and should produce guidelines for appropriate monitoring, mitigation, and verification.
- Evaluate the feasibility of alternate sequestration options for jurisdictions without adequately documented underground injection potential, such as the western Upper Peninsula. This includes evaluating the cost and feasibility of CO_2 pipelines from other areas of the state and other CO_2 sequestration options, such as mineralization, carbon nano-fibers, or biological means.
- Consider the use of transported synthetic natural gas to areas where near-term carbon storage options are unknown. This could also allow better use of peaking/intermediate generating capacity and complement the expanded development of wind power.

Related Policies/Programs in Place

MDEQ, MDNR, and the Attorney General are currently mapping out the various regulatory matters pertaining to CCSR to identify appropriate actions to address such issues as landowner rights, short- and long-term liability, revenue streams, environmental impacts, and other issues as identified. Legislation will be required to ensure that CO_2 can be effectively sequestered and that the costs of this effort are adequately addressed. The state will need to participate in efforts to define and manage long-term liability and to address the issue of property rights and pore space rights[8] for injection and sequestration into deep geologic formations.

Table F-9-1 provides the legislative status of CCSR in states and provinces. It is reprinted from the Interstate Oil and Gas Compact Commission Web site @ www.iogcc.state.ok.us.

[8] These are the legal rights to inject a gas or liquid into the rock formation to fill or occupy the voids (pores) within the formation.

Table F-9-1. Status by state and province of CO_2 storage legal and regulatory development 5/8/2008

State/ Province	Active Effort Begun	Legislation Draft/ Enacted	Regulations Draft/ Enacted	Summary of Status	Date Info Updated	Link to Additional Information
Alabama	No			Something could emerge in 2008 legislative session.	2/7/2008	
Alaska	No				2/7/2008	
Arizona	No				4/24/2008	
Arkansas	No				4/24/2008	
California	Yes			Report already released (see link), being further developed.	4/29/2008	http://www.energy.ca.gov/2007publications/CEC-500-2007-100/CEC-500-2007 100-SF.PDF
Colorado	No				4/28/2008	
Florida	No				2/19/2008	
Georgia	No				2/7/2008	
Idaho						
Illinois	Yes	Enacted: Senate Bill 1704		SB 1704: Clean Coal–FutureGen. Creates the Clean Coal FutureGen for Illinois Act for the purpose of providing the FutureGen alliance with adequate liability protection, land-use rights, and permitting certainty to facilitate the siting of the FutureGen Project in Illinois.	4/28/2008	
Indiana	Yes				2/19/2008	
Kansas	Yes	Enacted: House Bill 2419 (2007)		HB 2419 mandated development of regulations no later than July 1, 2008. Preliminary draft has been developed and will go through public notice and hearing process this spring.	2/7/2008	
Kentucky	No				2/19/2008	
Louisiana	No				2/14/2008	
Maryland	No				2/22/2008	
Michigan	Yes	Part 615 Oil and Gas Regulations Part 625, Mineral Well Regulations (NREPA)		Part 615 regulates CO_2 injection utilized for EOR. Part 625 may regulate permitting and well construction for CO_2 storage.	4/28/2008	http://www.legislature.mi.gov

State/ Province	Active Effort Begun	Legislation Draft/ Enacted	Regulations Draft/ Enacted	Summary of Status	Date Info Updated	Link to Additional Information
		Draft SB 707, 708, 801, 1166, 1184 and HB 5604		Bills are introduced; require development of regulations prior to July 1, 2008, provide for tax credits and exemptions to electric generating facilities capturing and sequestering carbon dioxide, tax credits for emission reductions and sequestration, tax credits for purchasing and constructing capture machinery or equipment, and authorization for storage of GHG on state-owned lands.		
Mississippi	No				2/19/2008	
Missouri	No				2/14/2008	
Montana	Yes				2/14/2008	
Nebraska	No				2/14/2008	
Nevada	No				2/26/2008	
New Mexico	Yes			Report issued on December 1, 2007, to (see link) Governor's Climate Change Action Implementation Team. No legislative action in 2008.	4/28/2008	*A Blueprint for the Regulation of Geologic Sequestration of Carbon Dioxide In New Mexico*: http://www.emnrd.state.nm.us/ocd/documents/CarbonSequestrationFINALREPORT1212007.pdf
New York	Yes				2/14/2008	
North Carolina	No				2/14/2008	
North Dakota	Yes			Rules were promulgated in 2007 but based on comments submitted and analysis by the North Dakota Attorney General's office, it was concluded that statutory jurisdiction was lacking in a few critical areas. A work group composed of representatives from the lignite and oil & gas industries, PCORP, the North Dakota Industrial Commission and the Attorney General's Office has been formed to develop a bill based on the IOGCC	5/8/2008	

State/ Province	Active Effort Begun	Legislation Draft/ Enacted	Regulations Draft/ Enacted	Summary of Status	Date Info Updated	Link to Additional Information
				model statute for introduction during the 2009 North Dakota legislative session. Once legislation is passed and signed into law, rules will be re-promulgated.		
Ohio	Yes	Enacted: Ohio SB 221	No; Using EPA Class V temporarily.	Pending legislation includes some requirements to limit carbon emissions and charges state agencies to develop rules.	5/7/2008	http://www.legislature.state.oh.us/bills.cfm?ID=127_SB_221
Oklahoma	Yes			SB 1765 pending. This bill will determine which agency will take the lead.	3/27/2008	http://webserver1.lsb.state.ok.us/WebBillStatus/main.html
Oregon	No				4/24/2008	
Pennsylvania	No				2/14/2008	
South Carolina	No				2/26/2008	
South Dakota	No				2/14/2008	
Texas	Yes				2/7/2008	
Tennessee	No				4/29/2008	
Utah	Yes			SB 202 passed by legislature and signed by Governor requiring, among other things, development of rules and recommended legislative changes by January 1, 2011.	4/2/2008	http://le.utah.gov/~2008/htmdoc/sbillhtm/sb0202s01.htm
Virginia	No				2/21/2008	
Washington	Yes	Enacted: http://www.leg.wa.gov/pub/billinfo/2007-08/Pdf/Bills/Session%20Law%202007/6001S.SL.pdf	DRAFT: http://www.ecy.wa.gov/lawsrules/wac173407_218/Draft_Rule/OTS1277.2final.pdf	Process begun. Public hearings held in April 2008. Final rule adoption expected in June 2008.	4/24/2008	
West Virginia	Yes			Preparing draft legislation. Possible introduction in 2008 legislative session.	2/7/2008	

State/ Province	Active Effort Begun	Legislation Draft/ Enacted	Regulations Draft/ Enacted	Summary of Status	Date Info Updated	Link to Additional Information
Wyoming	Yes	Enacted: http://legisweb.state.wy.us/2008/Enroll/HB0089.pdf AND http://legisweb.state.wy.us/2008/Enroll/HB0090.pdf		Two bills were introduced and passed by the legislature and signed by the Governor in March 2008. One addresses ownership and the other regulatory issues. Both bills required and passed by a 2/3 majority in both houses. Legislation on eminent domain aspect of CO_2 storage will likely be addressed in 2009.	4/15/2008	
Alberta	Yes			The province of Alberta is in the process of conducting a review of its current regulatory framework for large-scale implementation of geological storage. The province has also recently established a Carbon Capture and Storage Development Council (a partnership between governments, industry, and scientific researchers) to conduct an assessment of CCSR and to recommend steps for implementation in Alberta, including a legal and regulatory framework. The Council will be reporting back to the Alberta government in the fall of 2008.	5/8/2008	
British Columbia	Yes				2/21/2008	
Newfound-land & Labrador	No				2/19/2008	
Nova Scotia	Yes			The lead in Nova Scotia on climate change issues is now with the Department of Environment. An initiative is under way to examine the potential for the sequestration of CO_2 into both offshore and onshore geologic formations.	4/26/2008	
Saskatche-wan	Yes				2/14/2008	

CO_2 = carbon dioxide; EPA = U.S. Environmental Protection Agency; GHG = greenhouse gas; HB = House Bill; IOGCC = Interstate Oil and Gas Compact Commission; NREPA = Natural Resources and Environmental Protection Act; PCORP = Plains CO_2 Reduction Partnership; SB = Senate Bill.

Type(s) of GHG Reductions

Principally CO_2.

Estimated GHG Reductions and Costs or Cost Savings

Not applicable. This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

As noted under the Policy Description section, the key uncertainties fall into three categories: technological and cost uncertainties for some capture, transport, and storage technologies; legal uncertainties, such as permitting, liability, and property rights; and sequestration uncertainties, such as the long-term suitability for certain geologic formations. Technological uncertainties apply at all phases of the project, from carbon capture to compression and transportation to injection to long-term injection field integrity.

Additional Benefits and Costs

It is expected that real, measurable, and potentially substantial emission reduction benefits will result from the implementation of this policy. However it is not possible to reliably predict the magnitude of these savings or their costs or cost savings at this time.

Feasibility Issues

As noted in the Policy Description and Key Uncertainties sections, feasibility depends upon resolving the legal issues and successfully demonstrating that the technologies and storage methods are reliable and cost-effective.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-10. Technology-Focused Initiatives

Policy Description

States can undertake initiatives focused on developing, promoting, and/or implementing one or more specific technologies that have the potential to reduce GHG emissions. Technologies could include (among others) hydrogen production and fuel cells for electricity storage, compressed air energy storage systems (to enable greater penetration of intermittent renewable technologies, such as wind), or biomass co-firing. Biomass co-firing can be a low-cost, near-term means of converting biomass to electricity and displacing a fraction of coal use by adding up to 20% biomass in high-efficiency coal boilers.

Policy Design

Goals: This set of policies would provide state government and other private and public parties with resources and incentives for analysis, targeted R&D, market development, and adoption of GHG-reducing technologies that are not covered by other policies. The overall goals would be:

- To position Michigan as a world leader in climate-related technology development and deployment,
- To achieve actual emission reductions from technology investments, and
- To develop state industries with high in-state and export capability.

The specific goal would be to maximize effective use of biomass for co-firing at appropriate coal plants as soon as practicable. Co-firing needs to be based on a comprehensive fuel supply study ensuring that the expected supply is supported by the use of sustainable forestry practices. The proximity and availability of individual baseload generation assets to suitable supplies of biomass (forest feedstock) need to be determined on a case-by-case basis. Based upon a review of the Wolverine Power Cooperative/Michigan Technological University biomass study and report, this policy assumes three rates of co-firing: 5%, 10%, and 20%. All three assume that the plant is new and designed and constructed specifically to be operated in this fashion.

The Michigan Department of Labor and Energy Growth (MDLEG) Energy Office is preparing to issue an RFP to determine the available amount of biomass in Michigan. The Agriculture. Forestry, and Waste Management TWG has calculated the availability of biomass for all uses in Michigan and included the demand from this plant in the budget, assuming a co-fire rate of 10%. If a higher co-fire rate is used, there is sufficient excess biomass to meet the demand.

Timing: This policy is intended to come into effect in 2009, and would continue indefinitely as an enabling mechanism for other climate-related policies aimed to reduce GHG emissions from the electric utility sector.

Parties Involved: Michigan government, private and public partners on a voluntary basis, owners and operators of coal-fired generators, providers and growers of biomass fuel.

Implementation Mechanisms

Enact legislation to include electricity generated by the biomass fraction at a co-fired facility as eligible for a renewable energy credit (REC) allowance if the owner can demonstrate that the biomass was harvested using sustainable forestry practices.

Related Policies/Programs in Place

Biomass (i.e., co-firing) is currently an eligible renewable energy technology under the Michigan energy legislation for RPS. However, the incentive as drafted provides no REC allowance for those IPPs using biomass as a feedstock. Other than this, no federal or state programs currently exist to promote biomass-to-energy production.

Type(s) of GHG Reductions

CO_2.

Estimated GHG Reductions and Costs or Cost Savings

The MCAC is aware of three active proposals to construct new baseload coal/biomass co-fired facilities: the cities of Lansing and Holland, and Wolverine Power Rogers City. Wolverine Power provided the MCAC analyses and studies undertaken in support of its proposed Rogers City plant. This analysis of this policy recommendation examined a specific scenario for that particular co-fired power plant. This analysis and recommendation are informational only, and are not intended to be an endorsement of the Rogers City proposal or any other specific proposed facility.

The Wolverine Power Rogers City facility is a fluidized bed facility. Note that the results reported below may be specific to this power plant. Other coal technologies would yield different results. In addition, it is important to note that this analysis is based on a single power plant. Biomass fuel costs, in particular, are assumed not to change as a result of an increase in usage from this single power plant. If many co-firing facilities were built in Michigan, the demand on biomass fuel would grow, and it is likely that biomass fuel costs would increase as a result.

This analysis examines three potential co-firing rates for the proposed Wolverine Power Rogers City facility. A biomass availability study has been conducted for this proposed facility. Any such proposal must be analyzed on a case-by-case basis; therefore, it should not be assumed that these results are typical or directly scalable to other proposals. All assumptions that are common to this as well as other options are described in the description of common assumptions above.

ES-10-specific assumptions are as follows: GHG reductions provided here are based on three different scenarios: a 5%, a 10%, and a 20% co-fired coal plant with the CO_2 emissions from the existing Michigan fuel mix. (See Tables F-10-1, F-10-2, and F-10-3, below.) The assumption is that the coal plant is a new facility.

Table F-10-1. Estimated GHG reductions and costs of or cost savings from ES-10 with 5% co-firing

ES-10. Technology Based Initiatives: ***5% Co-Firing Option***	**2015**	**2025**	**Units**
GHG emission savings	0.2	0.2	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$34.48	Million $
Cumulative emissions reductions (2009–2025)		3.3	Million metric tons of CO_2
Cost-effectiveness		$10.59	$/metric ton of CO_2

CO_2 = carbon dioxide; GHG = greenhouse gas

Table F-10-2. Estimated GHG reductions and costs of or cost savings from ES-10 with 10% co-firing

ES-10. Technology Based Initiatives: ***10% Co-Firing Option***	**2015**	**2025**	**Units**
GHG emission savings	0.5	0.5	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$69.43	Million $
Cumulative emissions reductions (2009–2025)		6.5	Million metric tons of CO_2
Cost-effectiveness		$10.67	$/metric ton of CO_2

CO_2 = carbon dioxide; GHG = greenhouse gas

Table F-10-3. Estimated GHG reductions and costs of or cost savings from ES-10 with 20% co-firing

ES-10. Technology Based Initiatives: ***20% Co-Firing Option***	**2015**	**2025**	**Units**
GHG emission savings	0.9	0.9	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$134.09	Million $
Cumulative emissions reductions (2009–2025)		13	Million metric tons of CO_2
Cost-effectiveness		$10.30	$/metric ton of CO_2

CO_2 = carbon dioxide; GHG = greenhouse gas

Data Sources: This analysis is designed to show the costs of and GHG emission reductions from co-firing at the Wolverine Power Rogers facility. Therefore, figures are based on data provided by Brian Warner of Wolverine Power, and on that company's estimates and research as to costs, operating characteristics, and other factors for constructing and operating this co-fired facility.

Quantification Methods: The quantification relied on three scenarios for co-firing, as described above, although based on information provided by Wolverine Power, capacity factors for each co-firing scenario were assumed to be equal, at 92.5%.

Key Assumptions: Key assumptions for this analysis are the facility begins operation in 2012, and the plant has an assumed life of 30 years. According to Wolverine Power, the heat plant heat rate should be identical, at 10,000 British thermal units per kilowatt-hour (Btu/kWh) for each of the three scenarios. The primary difference among the three scenarios is capital cost for additional biomass storage and handling. That incremental capital cost is assumed to be as shown in Table F-10-4.

Table F-10.4. Assumed incremental capital costs for the three co-firing scenarios

Scenario	Additional Cost
5% Co-firing	$12/kW
10% Co-firing	$25/kW
20% Co-firing	$40/kW

kW = kilowatt.

The base capital cost for the co-fired power plant is assumed to be $2,140, although because this analysis focuses only on the *incremental* cost of the co-firing option, the base capital cost of the power plant does not affect the final outcome reported above. The costs of biomass fuel and coal, based on estimates provided by Wolverine Power (for biomass) and by DTE and Consumers Energy (for coal), are expected to be $4.75 for biomass and $3.50 for coal in 2015. These costs are assumed to escalate annually at a constant 2.5% rate for each.

Key Uncertainties

The key uncertainties that may influence this analysis are related to possible changes in capital costs for biomass co-firing and future biomass fuel costs. For example, if more than one plant were to compete for the same biomass resource, at a minimum, the cost of that resource would increase for all competing facilities. Furthermore, even if multiple plants were constructed in a manner to avoid local competition, the statewide increase in demand could also increase the fuel cost, given the limited supply and competing demands from other sectors.

There is some question about whether certain biomass co-firing technologies could result in higher GHG emissions than other coal-based technologies. Policymakers are encouraged to clarify this issue prior to making decisions about specific projects.

Additional Benefits and Costs

An additional concern may be the effect of co-firing coal and biomass on the emissions of non-GHG regulated pollutants. The existing regulatory process will address these issues.

Feasibility Issues

The main concerns for feasibility are regulatory. For example, using biomass in a manner that qualifies for REC allowance credits will require certification that the feedstock was grown and harvested in a renewable, or sustainable, fashion.

Status of Group Approval

Approved.

Level of Group Support

Super majority—18 in favor, 3 opposed.

Barriers to Consensus

MCAC members voting against this policy recommendation expressed the concern that new co-firing generating facilities would still be burning coal as the primary fuel and, therefore, represent the continuation of reliance on coal for generation of electricity, which they oppose.

ES-11. Power Plant Replacement, EE, and Repowering

Policy Description

Michigan has the second-oldest fleet of power plants in the nation. The state will most likely be facing the retirement or repowering of a number of old, less efficient units within the time frame of this planning process. In addition, both the Upper and Lower Peninsulas are net importers of electrical power. The opportunity to replace aging units and reduce GHG-intensive imports with more efficient in-state generation could offer a reduction in GHG emissions from this sector. Furthermore, existing coal-based generation technologies may benefit from additional technologies and upgrades to make their fuel burning more efficient, resulting in more electric output for the amount of fuel burned. However, certain existing policies, such as New Source Review (NSR), deter some efficiency improvements. NSR is the general term applied to the permitting requirements of new stationary sources or modifications of existing stationary sources under the Clean Air Act. NSR encompasses the Prevention of Significant Deterioration (PSD)[9] permitting requirements for attainment areas[10] and the NSR permitting requirements for nonattainment areas.

Generation efficiency improvements refer to increasing generation efficiency at power stations through incremental improvements at existing plants (e.g., more efficient boilers and turbines, improved air and feedwater heaters, condensers, or improved power plant control systems). An efficiency upgrade results in lower GHG emissions at the same or a higher level of electrical output.

Repowering existing power plants refers to the engineering and installation of technologies that enable switching to lower- or zero-emitting fuels for these plants, including the use of biomass or natural gas in place of coal or oil.

Power replacement refers the wholesale removal and replacement of an existing plant with another plant of similar or different technologies. Replacement plants of new, modern design are inherently more efficient than the older generation technologies in terms of GHG emissions per unit of fuel consumed.

Policies to encourage generation efficiency improvements, repowering of existing plants, or power plant replacement(s) could include incentives or regulations as described in other recommendations, with adjustments for financing opportunities and emission rates of existing plants. The cost basis of these activities could be evaluated for cost and performance within the context of an IRP model described in ES-7. This evaluation would be part of an overall plan identifying cost-effective options for reducing system CO_2 and other emissions to applicable regulatory levels or limits on a short-term and long-term basis, requiring generation owners to pursue

[9] Federal PSD/NSR requirements are in 40 CFR 52.21. Michigan requirements are in R 336.2801–2830 and R 336.2901–2908.

[10] An attainment area is a geographic zone within which the concentration of a pollutant is considered to meet U.S. National Ambient Air Quality Standards. These standards are set per pollutant, so it is possible for a zone to meet these standards for a certain pollutant and not for another.

cost-effective options for reducing their emissions profile through measures identified above, and creating financial incentives that reward such emission reductions.

Policy Design

Estimates of efficiency improvements at existing power plants could range up to 5% of heat rate.

Repowering coal-fired generation with natural gas for instance could result in efficiency improvements of up to 30% of heat rate, assuming the availability of natural gas. Full or partial repowering of coal-fired generation with biomass-based fuels may also be feasible in some limited circumstances predicated on plant configuration and fuel availability.

New generation assets could realize efficiency improvements over existing older generation technologies of up to 10% of heat rate for coal-fired generation.

Goals:

- Electric generators should evaluate the efficacy of efficiency upgrades, repowering, and/or plant replacements against other generation options, including GHG compliance cost options, such as a market-based procurement of allocations that the company would need to meet its generation output.[11]
- Convene a stakeholder group comprised of staff from electric generators, MDEQ, MPSC, and others to study and potentially propose a publicly funded pilot project on the repowering of an existing baseload coal-fired power plant. The stakeholder group would solicit and evaluate proposals for repowering from generator owners, and select the most viable project, with a preference for the project that had the potential for the greatest GHG reductions per unit cost. The process would involve, among other activities, securing public funding, site and/or facility selection, permit coordination, contract scope and effectuation, pilot project authorization by the owner, and cost recovery authorization as appropriate for the type of ownership of the plant.
- Evaluate and determine appropriate funding sources for partial reimbursement of the successful respondent to the RFP on the pilot project. It is recommended that $50 million in funding be secured for this pilot project.
- Evaluate potential policy deterrents, such as NSR, to determine if modifications should be advocated to help achieve desired climate benefits.

Timing: Efficiency could be improved over short periods of time, while repowering and replacements could take up to 10 years to implement.

Parties Involved: This recommendation applies to all Michigan generation owners. For regulated utilities, efficiency upgrades, repowering, and power plant replacement would ultimately be evaluated through one of the MPSC review processes. For unregulated generators,

[11] A reliable estimate of benefits and costs from efficiency, repowering, and replacement will not be known until the utility studies are completed. Not as a goal, but for the purpose of estimating GHG reduction potential and cost-effectiveness at this time, it is assumed that 75% of the coal-fired fleet are candidates for efficiency improvements, 5% are candidates for repowering with natural gas, and 5% are candidates for replacement with advanced-technology coal.

these projects would be economically driven based on market forces. For municipals, their local boards or commissions would evaluate these projects.

Other: None.

Implementation Mechanisms

The planning and emission reduction requirements for regulated utilities could be implemented through planning processes already implemented by the MPSC. For IPPs, the costs and benefits of such efficiency increases or upgrades would be evaluated against the locational marginal pricing or other financial recovery mechanism.

Related Policies/Programs in Place

For regulated utilities owning generation assets, the IRP process is strongly related to the selection of cost-effective generation technologies. Michigan has adopted IRP requirements for electric utilities under H.5524, Sec. 6s (11) (a)–(g) (see ES-7).

On August 6, 2008, in Case No. U-15631, the MPSC directed utilities with fossil fuel generation to file 10-year fossil fuel generation efficiency plans with the MPSC by December 31, 2008. The MPSC directed that these plans should include a comprehensive technical and economic analysis of the consequences resulting from the potential retirement of existing fossil fuel generation facilities, and plans for repair or replacement of units. In addition to cost and service issues, the analysis should address environmental concerns, including potential GHG abatement measures.

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Estimated GHG Reductions and Costs or Cost Savings

The estimation of the potential GHG reductions and costs in Table F-11-1 employs the assumptions listed in Table F-11-2. The repowering pilot project goal above is assumed to be a 25-MW coal-fired facility for which a $50 million demonstration grant would be targeted.

Table F-11-1. Estimated GHG reductions and costs of or cost savings from ES-11

ES-11. Power Plant Replacement, Energy Efficiency, and Repowering	2015	2025	Units
GHG emission savings	2.5	2.0	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$313	Million $
Cumulative emissions reductions (2009–2025)		33.2	Million metric tons of CO_2
Cost-effectiveness		$9.4	$/metric ton of CO_2

Data Sources: Mostly placeholders to be confirmed by the ES TWG.

Quantification Methods: Improvements at facilities are modeled as new generation, displacing primarily coal generation. Reductions account for the impacts of other energy supply recommendations.

Key Assumptions:

Table F-11-2. Key assumptions used to estimate the GHG reductions and costs of or cost savings from ES-11

Types of Improvements	Assumptions
Applicability	
Improvements at existing plants	75% of all plants
Refiring coal plants with natural gas	5% of all plants
Replacing old technology with new	5% of all plants
Cost of Efficiency Improvements	
Improvements at existing plants	$500/kW
Refiring coal plants with natural gas	$1,000/kW
Replacing old technology with new	$2,000/kW

kW = kilowatt.

Key Uncertainties

- Applicability (see assumptions above).
- Cost of improvements (see assumptions above).
- Repowering a coal-fired plant with natural gas will reduce GHG emissions, but will also increase the cost factor for the plant. Increasing the cost factor will affect when and how often the plant is dispatched, effectively reducing the capacity factor, and thereby affecting the GHG savings. For those periods when the repowered plant is not dispatched, lower-cost generation will be used, which in most cases will be coal-fired. This is why there is not a 1:1 relationship for GHG reductions per MW in this analysis. Given the complexity of generation costs and availability, it is not possible to project the exact net GHG reductions from repowering.
- The actual results of the generator-specific evaluation of efficiency, repowering, and technology improvements will not be known until the evaluation is completed.
- Power plant efficiency projects (e.g., turbine blade replacements) may trigger the NSR permitting process that can require the installation of best available control technologies (BACTs) for conventional pollutants, such as sulfur dioxide (SO_2), oxides of nitrogen (NO_X), and particulate matter (PM). The business case for making the efficiency improvement may be negated by the cost of installing BACTs on an existing unit. The ongoing EPA NSR utility enforcement initiative has created an era of uncertainty for power plant owners in making any kind of modifications to their plants that could trigger NSR. Unfortunately, this uncertainty results in postponements or delays in efficiency projects and perpetuates emissions from older and less efficient power plants. The actual cost associated with installing BACT will be facility-specific and could vary widely. BACT reviews are performed by permitting agencies on a case-by-case basis and take into account such factors as energy consumption, environmental impacts, and economic costs. Recent BACT reviews conducted by the MDEQ have identified the following estimated costs for BACTs:
  - $4,000/ton of SO_2 removed,

- $8,000/ton of NO_X removed,
- $2,000/ton of PM removed, and
- $3,000/ton of carbon monoxide removed.

These are very approximate estimates, and will vary considerably depending on boiler types, fuels burned, design and configuration of the plant, and interactions among different control technologies. The multitude of variables makes it difficult to assess the need for and cost of BACT for modifications to existing plants; therefore, these costs are not included in the model.

Additional Benefits and Costs

None.

Feasibility Issues

The pilot project is dependent on the availability of funding. Repowering, efficiency, and technology improvements will require capital funding and possibly cost recovery.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-12. Distributed Renewable Energy

Policy Description

This policy recommendation focuses on removing barriers to and providing incentives to encourage the development of distributed renewable energy throughout the state. Distributed renewable energy is generally defined as small scale (generally less than 10 MW), located at or near the point of end use, interconnected to the distribution (as opposed to transmission) system, and more likely to have homeowner or community ownership.[12] Increasing the use of distributed renewable energy provides electricity reliability, security, and environmental benefits. Policies that have been developed and implemented successfully elsewhere to promote distributed renewable energy can be adapted for Michigan.

Policy Design

The main focus of this policy is developing and leading the market to produce distributed renewable energy by assuring investors of the opportunity to earn a reasonable return. Michigan must seek an appropriate combination of policies fitting the state's unique circumstances, which together will provide sufficient leverage/incentives to establish and grow a vibrant market. This could include any combination of utility rate treatment, financial incentives, tax policy, and consumer education.

The preferred policy design would include a well-designed and fully implemented renewable energy payment (REP) program. While this policy recommendation and associated goals specifically refer to distributed renewable energy, there is interest in making REPs available to large-scale projects also. A REP program may be designed to promote and encourage development of renewable energy projects of all sizes, ranging from small residential up to the largest utility-scale projects.

Goals: With an objective to completely open the distributed renewable energy market, set a goal for new distributed renewable energy to reach 0.4% of Michigan's electricity consumption by 2015, and increase the goal to 1.1% of consumption by 2025. These goals represent 468 GWh of distributed generation in 2015 and 1,396 GWh in 2025, which will be generated from 240 MW of new capacity in 2015 and 715 MW of new capacity in 2025.

Small-scale renewable energy not connected to the grid and non-electric generating renewable resources, such as geothermal heating and cooling and solar thermal domestic water heating systems, should be encouraged. Incentive programs should be developed according to the schedule in Table F-12-1, such that by 2025, an additional 1% of Michigan households are making use of these systems.

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[12] "Self-Service Power" defined in MCL 460.10a(6a). See http://www.legislature.mi.gov/(S(dm4pmzapcyxj0fi2oor0t5fa))/mileg.aspx?page=getobject&objectname=2000-PA-0141&query=on.

Table F-12-1. Proposed schedule for developing incentive programs

Year	Cumulative Percentage of Michigan Housing Units With Each Type of System at End of Year Range	Solar Thermal Domestic Water Heating		Geothermal Heating and Cooling	
		Annual Installations	Cumulative Installations at End of Year Range	Annual Installations	Cumulative Installations at End of Year Range
2010–2014	0.125%	1,125	5,625	1,125	5,625
2015–2019	0.375%	2,250	16,875	2,250	16,875
2020–2024	0.875%	4,500	39,375	4,500	39,375
2025	1%	5,625	45,000	5,625	45,000

There are 4.5 million housing units in Michigan. See http://quickfacts.census.gov/qfd/states/26000.html.

A public education program would determine and widely disclose to the public the full cost accounting for renewable energy and fossil fuel production, including costs to public health and the environment. The public education program should be adequately funded.

Timing: As soon as possible.

Parties Involved: Legislation must be passed to provide for property tax exemptions. After passage of legislation, utilities would administer the REPs and net metering programs under the supervision of a state agency. The local distribution utility interconnection process is currently under review, and an improved process is under development at the direction of the MPSC. Efforts to quantify the benefits of distributed renewable resources would be undertaken by a state agency. State agencies have already provided funding on a county-by-county basis to work with local governments to develop model distributed wind energy facility siting and zoning ordinances. This work could be continued and expanded to other counties and to other types of renewable energy resources.

Other: The net metering policy helps remove barriers by requiring utility companies to provide access to the power grid, including streamlining and simplifying their interconnection procedures. Supplemental policies could (1) provide assistance and incentives to local units of government to streamline and modernize zoning and siting rules and processes, and (2) determine and widely disclose to the public full cost accounting for renewable energy and fossil fuel production, including costs to public health and the environment.

Implementation Mechanisms

Legislation is most likely needed to establish the REP program.

REPs would provide for producers of renewable electrical energy to be paid an established rate for each kilowatt-hour of energy they "feed into" the grid. The key principles of REPs include:

- The REP price should be set just high enough to cover costs and ensure a reasonable return on investment for commercial installations. Prices vary according to the source of the energy (sun, wind, water, biomass, etc.) and the size of the energy-producing installation.[13] For

[13] See for example: Gipe, Paul (2007). *Advanced Renewable Tariff Pricing Worksheets*. Web site: http://www.wind-works.org/PricingWorksheets/ARTsTariffsPricingWorksheets.html. Mendonça, Miguel (2007). *Feed-In Tariffs,*

household-level distributed renewable energy projects, the REP price needs to be set high enough to provide an adequate incentive for the homeowner to invest in the project. Homeowners would consider the financial incentive, the avoided costs of purchasing electricity over the life of the project, and such intangibles as the benefit of energy independence and the knowledge of knowing that they are powering their homes with little or no carbon footprint.

- Barriers to interconnection must be removed. Implementation of ES-15a (Transmission Access and Upgrades) and ES-15b (Distribution System Access and Upgrades) are key elements to successful implementation of REPs. A fully implemented REP program would have no limit on the amount of renewable energy that can be sold to utility companies.
- Distributed renewable energy producers must be able to obtain 15–20-year tariffs. All tariffs are transparent and open for inspection.
- The utility companies can recoup their increased costs of paying higher prices for renewable energy by spreading these costs among all their customers.
- An independent government review board periodically sets the prices and terms for new tariffs. It is expected that the REP price will decrease for new installations as technology advances decrease the costs of distributed renewable generation.

The financial subsidy need not come from utility ratepayers. Any source of public funding could be used to augment utility rates.

Based on the design of the REP program, net metering may be an additional incentive and a complement to the REP program for certain types of distributed renewable energy. The net metering program may be established either through legislation or through state agency actions. The simplest form of net metering allows owners of grid-connected distributed energy (generating units on the customer side of the meter, often limited to some maximum kW level) to be billed based on net usage and receive a credit for excess electricity from their electricity supplier. This type of net metering provides several incentives for distributed renewable energy by reducing transaction costs (e.g., no need to negotiate contracts for the sale of electricity back to the utility or purchase expensive upgraded meters), and reducing customer utility bills by providing for monthly netting of customer electricity usage.

For grid-connected and non-grid-connected distributed renewable energy, consideration should be given to how other incentives, such as tax credits, property tax exemptions, installation cost rebates, and low-interest loans, would best complement the REP program. These additional incentives may have a high impact on the development of renewable energy that is not grid-connected and non-electricity-generating renewable resources, such as solar thermal domestic water heating and geothermal heating and cooling systems. Such non-electricity generating systems reduce the use of electricity needed for household heating and cooling, which would benefit from these economic incentives. Such incentives may be established through a combination of legislation or state agency actions.

Utilities, state agencies, environmental groups, and other interested parties should develop and implement the renewable energy public education program.

Accelerating the Deployment of Renewable Energy, World Future Council, Earthscan. Web site: http://www.earthscan.co.uk/default.aspx?tabid=298.

Related Policies/Programs in Place

On October 6, 2008, PA 295 was enacted. Part 5 of the act requires the MPSC to establish a statewide net metering program applicable to electric utilities and alternative electric suppliers. The program provides "true net metering" for eligible generators with a capacity of 20 kW and under, and "modified net metering" for eligible generators with a capacity of up to 150 kW, and methane digesters with a capacity of up to 550 kW. Electric utilities and alternative electric suppliers are required to offer net metering until the size of their program reaches 1% of their in-state peak load for the preceding year.

Since 1991, Germany, Spain, Denmark, and over 40 other nations, states, and provinces, have successfully implemented REPs as incentives for homeowners, farmers, businesses, etc., to become producers or increase their production of renewable energy. In many of these countries, these policies are called "feed-in tariffs." Eighteen out of 25 European Union countries have established a variety of different feed-in tariff designs.[14]

With REPs, producers of distributed renewable energy are offered long-term, standard tariffs with prices intended to provide developers with ample revenues to assure them a reasonable return on their investment. As such, REPs have the potential to increase overall production and use of renewable energy, and decrease consumption and burning of fossil fuels. At least some researchers believe REPs represent the fastest, least expensive means for supporting wide growth of distributed renewable energy.

A bill titled Michigan Renewable Energy Sources Act was introduced in the Michigan House during 2008.[15]

New Jersey, Colorado, Pennsylvania, Maryland, and California are states with net metering programs that received an "A" grade in *Freeing the Grid*.[16]

Michigan currently has a limited net metering program available to customers of regulated utilities. The program is not standardized and varies widely by utility. As of the most recent reporting period, 23 customers were participating in the program.

The MPSC issued an order on August 6, 2008, in Case No. U-15316, adopting the Energy Policy Act of 2005 net metering standard.[17] Utilities are ordered to file an application for approval of a new net metering tariff by December 31, 2009. Utilities that file a rate case before that date or that have a rate case pending on the date of issuance of this order do not need to file a separate application for the new tariff.

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[14] Klein, Arne; Held, Ann; Ragwitz, Mario; Resch, Gustav; Faber, Thomas. (2007). Evaluation for different feed-in tariff design options: Best practice paper for the International Feed-in Cooperation. German Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Web site: http://www.feed-in-cooperation.org/images/files/best_practice_paper_final.pdf.

[15] See HB 5218, http://www.legislature.mi.gov/(S(fg1phg45vqwgaqijnikisaao))/mileg.aspx?page=getObject&objectName=2007-HB-5218.

[16] See *Freeing the Grid*, 2007 Edition, Network for New Energy Choices, available at: www.newenergychoices.org.

[17] See the order at: http://efile.mpsc.cis.state.mi.us/efile/docs/15316/0022.pdf.

Other forms of financial incentives for renewable energy include special utility rates, tax credits (for example, the Federal Production Tax Credit[18]), installation cost rebates, and low-interest loans. Both New Jersey and California have had very successful rebate programs.[19]

As of January 2008, six utilities in Michigan are member utilities of Wisconsin Public Power, Inc. These utilities offer rebates or low-interest loans for qualifying solar thermal domestic water heating, solar photovoltaic, and small-scale wind installations.[20]

The MDLEG Energy Office implemented a $3/watt incentive program for small solar and wind systems in 2001. The program budget was $300,000 from the State Energy Program grant from DOE. It was anticipated that the program would start slowly after January 1 and end late in calendar year 2001. By the end of March, 18 incentives had been approved. By the end of April, 86 incentives and the entire budget of $300,000 had been approved. The 86 incentives represented 47 kW of solar energy and 62 kW of wind energy. The Energy Office learned that there was a significant amount of interest on the part of consumers, and the budget was not large enough to have a program in place for a reasonable amount of time. A 4-month program generated significant interest, but also a lot of disappointment.

In 2005, a, MDLEG Energy Office solar thermal domestic water-heating program offered incentives totaling $415,000. Of the 117 systems receiving incentives, 20 rebates were provided for repair of existing systems. Rebates varied within a range of $2,000–$4000, based on the type of system selected. At the time the program ended, approximately $290,000 had been spent.

Type(s) of GHG Reductions

CO_2.

[18] See http://www.dsireusa.org/library/includes/incentivesearch.cfm?Incentive_Code=US13F&state=US&currentpageid=7&search=TableState&EE=1&RE=1 for more information on the production tax credit.

[19] See http://www.njcleanenergy.com/renewable-energy/programs/core-rebate-program/incentives/core-rebate-program for information on New Jersey's rebate program. See http://www.gosolarcalifornia.ca.gov/csi/index.html for information on California's solar rebate program.

[20] See http://www.wppisys.org/programs_services/default.asp?CategoryID=38&SubcategoryID=82.

Estimated GHG Reductions and Costs or Cost Savings

Table F-12-2. Estimated GHG reductions and costs of or cost savings from ES-12

ES-12. Distributed Renewable Energy	2015	2025	Units
GHG emission savings	0.40	0.92	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$1,054	Million $
Cumulative emissions reductions (2009–2025)		8.0	Million metric tons of CO_2
Cost-effectiveness		$131	$/metric ton of CO_2

Note: these results are included as the 'carve-out' in ES-1

Data Sources:

- AEO 2008.
- Data provided by MPSC.
- U.S. DOE, Office of Energy Efficiency and Renewable Energy (EERE). *A Plan for the Integrated Research, Development, and Market Transformation of Solar Energy Technology.* Available at: www1.eere.energy.gov/solar/solar_america/pdfs/sai_draft_plan_Feb5_07.pdf.

Quantification Methods: Distributed generation would displace primarily coal-fired electricity. Solar hot water and geothermal energy would displace 50% natural gas heating and 50% electricity heating.

Key Assumptions:

- Table F-12-3 presents the portfolio of new distributed generation that was used, based on input from the TWG:

Table F-12-3. Portfolio of new distributed generation used to quantify ES-12

Type of Electricity Generation	2015	2025	Units
Wind	40%	40%	of new distributed generation
Solar photovoltaic	25%	25%	of new distributed generation
Biogas	35%	35%	of new distributed generation

- Solar hot water installations: 7,875 homes by 2015; 45,000 by 2025.
- Geothermal installations: 7,875 homes by 2015; 45,000 by 2025.
- Table F-12-4 presents the assumptions used for the capital costs for each type of generation.

Table F-12-4. Assumptions for estimating the capital costs of new distributed generation

Capital Costs	2015	2025	Units
Solar hot water	$4,459	$5,203	$/installation
Geothermal	$16,000	$16,000	$/installation
Wind (distributed)	$6,000	$5,000	$/kW
Solar photovoltaic (distributed)	$8,131	$6,756	$/kW
Biogas	$2,500	$2,500	$/kW

- Avoided emissions rate: 0.73 metric tons of carbon dioxide per megawatt-hour (tCO_2/MWh) (2015); 0.56 tCO_2/MWh (2025). This accounts for the effect of other recommendations (ES-1, ES-3, ES-6, ES-10, ES-11, ES-12, and ES-13).
- Biogas heat rate: 10,000 Btu/kWh.
- It is important to note that the costs presented here represent the total direct cost to society (public and private), as defined by the borders of the state of Michigan. Capital and operating costs are included in the total, regardless of who within Michigan actually pays these costs. Therefore, DG costs reflect the total cost to ratepayers, taxpayers, and homeowners for recommended subsidies, incentives, and private expenditures. This policy recommends methods for creating the incentives necessary to achieve the goals, but does not prescribe specific rates, which would be set through the existing legislative and regulatory processes. It is believed that the goals can be achieved through the availability of public-sector incentives representing a fraction of the total costs presented here.

Key Uncertainties

Future capital costs.

Additional Benefits and Costs

Distributed renewable energy anticipates a relatively large number of small-scale installations. The successful implementation of the policy will require the establishment of a large number of enterprises to meet the new demand. This will create many new jobs requiring new skills. In addition, the demand will most likely spur R&D of new technologies, which will further promote investment and job creation.

Feasibility Issues

None.

Status of Group Approval

Approved

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-13. Combined Heat and Power (CHP)

Policy Description

The state of Michigan and the various stakeholders involved all recognize that the state needs to increase its electric generation resources, while at the same time reduce associated GHG emissions to address the impact of global warming and improve its business climate so that the job pool for its citizens can grow.

Literally, every business in Michigan that uses energy to heat and/or cool its buildings or as part of a production process is technically a candidate to simultaneously also generate electricity at its site, using one of several commercially proven and widely used combined heat and power (CHP) technologies. CHP technologies, also referred to as "co-generation," include steam turbines with steam extraction or back pressure, gas turbines with waste heat recovery boilers, combined-cycle units, reciprocating engines with manifold exhaust and cooling heat recovery, as well as less proven technologies, such as fuel cells and Stirling engines. Every currently used fuel source (including natural gas, coal, biomass, landfill gas, and municipal solid waste) can be and has been used for such purposes. If, and only if, there is a match between the real-time requirements for thermal energy and the electrical load that is generated, then the energy/fuel requirements to produce a given amount of electricity can be less than half of what is possible with even the largest and most efficient power generation technologies in existence today.

As a "co-benefit" of this inherent efficiency, CHP installations significantly reduce GHG emissions by increasing the overall efficiency of fuel use relative to making the same energy products (i.e., power and heat) separately in stand-alone installations.

Policy Design

A new approach to planning, constructing, and utilizing generation resources is envisioned by this policy. This new approach would favor on-site distributed generation opportunities (along with energy efficiency, demand-side management, and renewable resources), and then central station units as needed to meet supplemental demand.

To achieve this goal, it will be necessary to revise regulatory policies and remove institutional barriers to allow distributed renewable energy and CHP systems to compete on a level playing field with other sources of electric and thermal energy.

Goal: Set a goal for CHP facilities of up to 10% (180–2,000 MW) by 2020. This target does not include the current target of 10% for the RPS as proposed in ES-1 or established as a goal under PA 295. This would be accomplished with a phase-in beginning in 2010. It should achieve a goal for CHP equal to 15% of in-state CHP technical potential at commercial and industrial facilities by 2020, with a phase-in beginning in 2010.

Timing: As noted above.

Parties Involved: Financial incentives would be administered by a state agency, such as the Michigan Economic Development Corporation or Department of Treasury, possibly managed through the MPSC, with regulatory assistance through the MDEQ and provided to IPPs and commercial and industrial entities.

Other: A source of funds to cover these financial incentives would need to be determined. It may be possible to link incentives to (or condition them upon) the manufacture and installation of associated CHP equipment within the state of Michigan. Possible "seed money" funding sources could include bond funds, securitization monies, etc., with long-term financing mechanisms (revolving loan funds) to sustain the effort.

Implementation Mechanisms

A variety of implementation mechanisms can be utilized to address the various barriers and issues related to greater market penetration of CHP. The ES TWG recommends the use of the following mechanisms as necessary to achieve the goals stated under the Policy Design section:

- *Information and education*—If Michigan industries are going to seriously consider incorporating CHP into their business plans on a widespread basis, then a significant level of marketing of the incentives available must be provided. Michigan's utilities, MDEQ, and MDLEG are the likely candidates for such marketing efforts. This assumes that incentives recognizing the value of the potential capacity to reduce GHG emissions through the application of CHP technology to existing steam production facilities will, in fact, be made available, and the impact of such incentives on the CHP economics can be demonstrated.
- *Technical assistance*—The one area where technical assistance may prove to be invaluable is with regard to interconnection requirements, particularly for sell-back installations. Long lead times and expensive analysis to review such issues as system stability will have a very negative impact on the feasibility of wide-scale application of CHP, unless some entity, such as the electric utility, can shoulder this responsibility. Costs incurred for such activities should be recouped from all ratepayers as a legitimate capacity planning and procurement expense.
- *Financial incentives*—A state entity, such as the Michigan Strategic Fund, should be empowered to provide long-term loans to facilities employing CHP technology. Such loans should be designed to generate internal rates of return adequate to meet the risk/reward requirements of Michigan businesses, as well as take into account job development and emissions criteria. Projects meeting such criteria might be candidates for some sort of guaranteed loan recovery similar to a utility plant after the facility is operational and is found to be useful by the MPSC. Similarly, utility ownership of such facilities as dedicated on-site producers should be facilitated.
- *Regulatory policies*—Utility standby rates need to be redesigned to reflect an aggregate diversity to be found in many smaller facilities, rather than treating each facility on a stand-alone basis. The odds of numerous smaller units being out of service at any one given time and the ability to schedule maintenance in smaller increments suggest that a large number of units could be backed up with a relatively small reserve, and thus reduce such costs significantly. High standby costs have been attributed to being a major barrier to the implementation of CHP on a larger scale.
- *Codes and standards*—CHP facilities will produce more emissions—not less—at a given location than just the production of steam or power alone. Some means to address this issue

needs to be incorporated into the permitting process, so that the two-for-one emission benefits of CHP can be taken into account.

Generating electricity and heat is a cost-intensive undertaking that carries considerable risk to any Michigan business or institution that might consider implementing such projects. There are numerous barriers to CHP, including:

- Inadequate or incomplete information.
- Institutional barriers, such as high transaction costs and long return on investments due to such factors as small project size; high financing costs because of lender unfamiliarity and perceived risk; "split incentives" between building owners and tenants; and utility-related policies, such as interconnection requirements, high standby rates, exit fees, etc.
- Lack of standard offer or long-term contracts.
- Payment at avoided cost levels and lack of recognition for emission reduction value provided.

Policies to remove these barriers can include:

- Making interconnection rules and procedures less onerous and more conducive to encouraging CHP applications.
- Improving rates and fees policies.
- Streamlining or simplifying permitting processes.
- Recognizing the emission reduction value provided by CHP.
- Offering financing packages and bonding programs that would in turn make it easier for struggling manufacturers to make the capital investment required.
- Providing power procurement policies, such as "feed-in tariffs," that make it easier for facilities with excess generation to sell their product (electricity).
- Improving education and outreach on the potential of CHP.

Related Policies/Programs in Place

Federal and state tax policy could be adjusted to make CHP more attractive. Where such changes cannot be made directly, steps should be taken to improve the viability of facilities within the existing regulations. For example, biomass-fueled CHP does not qualify for a federal production tax credit if the power is consumed internally. If the utility buys the power under a simultaneous buy/sell structure, then the project would qualify and would receive a credit worth 1–2 cents per kWh for up to 10 years, depending on the fuel type.

Similarly, RECs may not be made available for many such facilities, regardless of fuel source, if the power is used internally. Some means needs to be established to monetize the REC value of such generation within an RPS. Even fossil-fueled CHP should receive credit somewhere—under either an RPS or an efficiency standard of some sort—because of its ability to reduce overall emissions.

See Annex F-1 to this appendix for background information on CHP potential and associated narrative, excerpted from the 2007 MPSC *Michigan's 21st Century Electric Energy Plan*.

Type(s) of GHG Reductions

Reductions in CO_2 emissions from fossil fuel-based combustion sources (coal, oil, etc.) as CHP electric production would reduce demand and output from such facilities. Many Michigan facilities with large steam loads have been backed off or even shut down due to economic considerations in the marketplace. Overall, GHG emission reductions from retrofitting CHP systems on older boilers on existing sites are more beneficial than constructing new state-of-the-art facilities.

Estimated GHG Reductions and Costs or Cost Savings

Table F-13-1. Estimated GHG reductions and costs of or cost savings from ES-13

ES-13. Combined Heat and Power (CHP)	2015	2025	Units
GHG emission savings	0.4	0.5	Million metric tons of CO_2
Cumulative net costs (present value) (2009–2025)		$32	Million $
Cumulative emissions reductions (2009–2025)		7.8	Million metric tons of CO_2
Cost-effectiveness		$4.09	$/metric ton of CO_2

Data Sources:

- *The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector*. Available at: http://www.eere.energy.gov/de/pdfs/chp_comm_market_potential.pdf.

Quantification Methods: Modeled as heat-driven CHP, where heat displaces 50% natural gas heat and 50% electricity heat. Electricity derived from waste heat displaces primarily coal power.

Key Assumptions:

- Capital costs: $4,000/kW for coal and $1,200/kW for natural gas.
- Non-fuel operation and maintenance (O&M) costs: $12/MWh for coal and $5/MWh for natural gas (to be revised).
- New CHP to be powered as follows: 90% by coal, 10% by natural gas.

Key Uncertainties

- Future capital costs.
- O&M costs.
- Ratio of new coal CHP to new natural gas CHP.

Additional Benefits and Costs

Secondary economic benefits can be expected as a result of lowered energy costs for industries, businesses, and institutions utilizing CHP. Such benefits result from a more competitive cost structure, which can lead to increased employment, profitability, and investment. For public- and nonprofit-sector institutions, benefits may include greater productivity and lower costs.

Feasibility Issues

As stated in the Policy Design and Implementation Mechanisms sections of this policy recommendation, CHP fails to be fully utilized due to regulatory and other constraints. Many of these barriers can be removed without harmful consequences, but this is most likely not true of all. For example, depending on the size and location of the facility, emissions of regulated air pollutants might be elevated on a localized basis due to less stringent thresholds for smaller boilers or pre-existing ambient air quality concerns.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-15a. Transmission Access and Upgrades

Policy Description

Issue 1—Various efficiency measures can be implemented to reduce transmission line losses of electricity. Utilities and transmission system operators use a variety of components throughout the transmission system to manage losses. A portion of each kWh generated is lost in the transmission activity. Improving the efficiency of the system lowers the amount of energy consumed in the transmission function and directly reduces generator fuel consumption. By reducing constraints in the transmission system, improved transmission facilities reduce congestion, hence reducing energy costs and improving the efficiency of the transmission and generation system. Increasing the efficiency of these components can further reduce losses and associated GHG emissions. Regulations, incentives, and/or support programs can be applied to achieve greater efficiency of transmission and distribution system components.

Opportunities exist to increase or improve transmission line carrying capacity through the implementation of new construction and retrofit activities on the transmission grid, including incorporating advanced composite conductor technologies and other advanced technologies (static VAR compensators, phase shifters, etc.), as well as grid management software. In addition, increasing the voltage of high-voltage lines will increase the efficiency of the transmission system and will facilitate access to all sources of generation. As transmission voltage increases, the capacity of the line is greatly increased (a 765-kilovolt [kV] line can have 5–6 times the load ability of a 345-kV line). This higher capacity and reduced resistance results in increased efficiency and lower losses, which means generation is reduced. The economics of such transmission improvements needs to be justified, with the participation of the Midwest Independent [Transmission] Service Operator, Inc. (MISO), to the extent the improvements provide benefits to Michigan customers using the cost recovery in transmission rates.

Issue 2—To facilitate widespread adoption of renewable energy technologies, the current transmission system requires upgrades and additions. These transmission improvements will enable renewable energy systems and CHP projects to interconnect to the grid. Improvements in the bulk power system will also provide the operational flexibility required by the addition of renewable resources.

Issue 3—Renewable energy facilities may require the addition of new or improved transmission lines that must be seamlessly integrated into the transmission grid. Measures facilitating development of these projects can be a critical part of Michigan's renewable energy future—for example, renewable energy projects "queue issues," relative to MISO's coordination efforts with FERC. FERC has approved MISO's proposals to streamline the queue process.

Policy Design

Goals:

- Implement a transmission system efficiency study for Michigan to determine the most cost-effective measures to reduce line losses and improve overall system reliability and management, including improving access for new generation assets, such as renewable energy, CHP, and distributed generation projects.

- Assess the effectiveness of the existing transmission system to accommodate new generation assets, including renewable energy projects and CHP projects, and implement infrastructure improvements and development to meet the future demand of existing and new power generation.
- Reassess the effectiveness of siting and routing of transmission lines to accommodate new generation assets, including commercial-scale renewable energy projects (wind).

Timing: These studies should be conducted and completed in 2009.

Parties Involved: The MPSC, investor-owned utilities, municipal utilities, and cooperatives.

Other: None.

Implementation Mechanisms

The MPSC and other stakeholders would work with MISO to implement the transmission system efficiency study, which would address each of the above goals.

Related Policies/Programs in Place

In July 2008, the MPSC established the Michigan Planning Consortium to improve the planning process for electricity infrastructure projects and identify possible ways to reduce costs to ratepayers.

MISO's transmission expansion planning process involves assessing existing transmission adequacy and reliability and sets forth measures to remediate and address these deficiencies. This planning process is overseen by FERC, as the MISO tariff is administered by FERC and subsequently authorized accordingly. MISO is the North American Electric Reliability Corporation Planning Authority for its member footprint and performs regional planning in accordance with the FERC Planning Principles delineated in Order 890. These planning principles provide mechanisms to ensure that the regional planning process is open, transparent, and coordinated and includes reliability and economic planning considerations and mechanisms for equitable sharing of expansion costs. The MISO planning process integrates the local planning processes of MISO member companies into a coordinated regional transmission plan and identifies additional expansion requirements.

The MISO planning process objectives include:

- Planning to:
    - Provide an efficient and reliable transmission system,
    - Provide access to diverse energy resources,
    - Expand trading opportunities, and
    - Enable state and federal energy policy objectives to be met.
- Interconnecting new generation and transmission.
- Providing transmission service.

The planning activities are performed collaboratively between the MISO planning staff and the planning staffs of the transmission owners, with regular input from stakeholder groups. MISO recently augmented its transmission planning process to include a Michigan Sub-Regional Technical Study Task Force to address Michigan-specific transmission planning issues.

The purpose of Act 30 of 1995, titled the Electric Line Certification Act, is to regulate the location and construction of certain electric transmission lines.

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Estimated GHG Reductions and Costs or Cost Savings

Not applicable. This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

As noted under the Policy Description section, uncertainties mainly result from a lack of Michigan-specific information and planning. In addition, cost and permitting uncertainties are associated with the desire to have the transmission grid support new generation assets, such as renewables and CHP.

Additional Benefits and Costs

It is expected that measurable emission reduction benefits will result from the implementation of this policy. However, it is not possible to reliably predict the magnitude of these savings or their costs or cost savings at this time.

Feasibility Issues

As noted under the Policy Description and Key Uncertainties sections.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-15b. Distribution System Access and Upgrades

Policy Description

Issue 1—Various energy efficiency measures can be implemented to reduce distribution line losses of electricity. Utilities and transmission system operators use a variety of components throughout the distribution system to manage losses. Increasing the efficiency of these components can further reduce losses and associated GHG emissions. Regulations, incentives, and/or support programs can be applied to achieve greater efficiency of distribution system components. In general, higher capacity and reduced impedance result in increased efficiency and lower losses, which means generation is reduced.

Issue 2—Infrastructure improvements to the distribution system through various measures to reduce line losses and enhance throughput may be required to meet long-term electricity demands and improve the efficiency of operations system-wide in Michigan. Such distribution system improvements will help reduce line losses and improve and manage outages, as well as enable renewable energy systems, including distributed generation and CHP projects, to interconnect to the grid.

Issue 3—In addition to distribution system upgrading issues, various barriers regarding distribution system access need to be addressed to facilitate greater adoption of renewable energy technologies, CHP, and distributed generation.

Policy Design

Goals:

- Implement a distribution system efficiency study for Michigan to determine the most cost-effective measures to reduce line losses and improve overall distribution system reliability and management, including improving access for new generation assets, such as renewable energy, CHP, and distributed generation projects.
- Assess the effectiveness of existing distribution lines to accommodate new generation assets, including renewable energy projects, CHP projects, and other distributed energy projects, and implement infrastructure improvements and development in order to meet the future demand of existing and new power generation.

Timing: These studies should be conducted and completed in 2009.

Parties Involved: The MPSC, investor-owned utilities, municipal utilities, and cooperatives.

Other: None.

Implementation Mechanisms

The distribution system efficiency study can be implemented by order of the MPSC for investor-owned utilities and co-operatives. Municipal utilities would be handled by other such applicable authorizations, as granted and approved by their local governing bodies. The focus of the study will be based on the above goals.

Related Policies/Programs in Place

Michigan has Electric Interconnection Standards in place for all regulated electric utilities.[21]

In October 2006, the MPSC began an investigation into the **i**nterconnection of new generation to the distribution system. As part of the investigation, formal rulemaking to revise the Electric Interconnection Standards has commenced.[22]

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Estimated GHG Reductions and Costs or Cost Savings

Not applicable. This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Cost and permitting uncertainties are associated with the desire to have the distribution system support new generation assets, such as renewables and CHP.

Additional Benefits and Costs

It is expected that measureable emission reduction benefits will result from the implementation of this policy. However, it is not possible to reliably predict the magnitude of these savings or their costs or cost savings at this time.

Feasibility Issues

As noted under the Policy Description and Key Uncertainties sections.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

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[21] See http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=46000481&Dpt=LG&RngHigh=.

[22] See http://efile.mpsc.cis.state.mi.us/efile/viewcase.php?casenum=15239.

Barriers to Consensus

None.

Annex F-1

(Excerpts taken from *Michigan's 21st Century Electric Energy Plan*[23])

III. RENEWABLE RESOURCES AND ALTERNATIVE TECHNOLOGIES FOR MICHIGAN

A. Renewable Resource Forecasting

Modeling indicates a potential for at least 1,100 MW, and up to 2,700 MW, of new electric power capacity development in Michigan from renewable resources with another **180 MW available from combined heat and power, or CHP**. Forecasting in this area is particularly problematic, in light of the rapid pace of technological advancements and policy changes that will affect renewables. It is thus important to revisit renewable resource modeling on a regular basis, and to expand the renewable portfolio when appropriate.

Renewable resource assessment modeling for the Plan shows that Michigan's electric supply portfolio can achieve 7–10 percent renewable energy by the end of 2015. Based on the energy forecast, this amounts to approximately 5,200 to 9,200 GWh of additional renewable energy by December 31, 2015. The resource assessment conducted for the Plan demonstrates that Michigan has ample resources available to meet this level of renewable energy for electricity production.

CHP is useful when there is need for both electricity and process steam at a location. CHP facilities use fuel to make steam to turn an electric generator, and then use the leftover steam in the factory's processes.

<u>Estimate of CHP Potential – Alternative Technologies Workgroup</u>

1. Introduction and Methodology

1.1 Introduction

The purpose of this supplemental document is to describe the methodology used to estimate the potential achievable new supply of electricity that could be reasonably developed over the next 10 years at Michigan's large industrial, institutional and commercial facilities.

1.2 Methodology

During the prior Capacity Needs Forum (CNF) process, the combined heat and power (CHP) Team was able to use boiler permit data from the Department of Labor and Economic Growth (DLEG) to identify the scope of Michigan's large and medium sized boilers. Unfortunately, the boiler permit database did not indicate the degrees to which boilers were actually in use, making it difficult to accurately calculate the capacity factors of the selected boilers. The CHP Team therefore had to rely on ad hoc information regarding which steam boilers were actually available to potentially add CHP systems.

Fortunately, during the 21st Century Energy Planning process, the CHP Team was able to obtain better data from the Michigan Department of Environmental Quality (MDEQ), Michigan Air

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[23] The entire *Michigan's 21st Century Electric Energy Plan* is available at: http://www.dleg.state.mi.us/mpsc/electric/capacity/energyplan/index.htm.

Emissions Reporting System (MAERS) Database. This database not only has a comprehensive universe of industrial, institutional, and commercial boilers in its system, but it also indicates the type and amount of fuel they consumed in 2005. Using this fuel data, the CHP Team could calculate capacity factors for all boilers in use in 2005—providing a major improvement in accuracy of the projected results. Using the boilers database supplied by MDEQ, the CHP Team went through the following steps:

Step 1: Calculate Capacity Factors—The CHP Team calculated capacity factors for each boiler where both capacity and fuel usage was available in the MAERS database. 159

Step 2: Categorize Boilers by Size (MMBTUHR Capacity)—All boilers were first classified into the following categories:

- Industrial boilers
- Large boilers (100+ MMBTUHR)
- Medium boilers (26–99 MMBTUHR)
- Small boilers (20–25 MMBTUHR)
- Very small boilers (<20 MMBTUHR)
- Commercial boilers (including institutional and municipal)
- Other boilers (all boilers for which capacity factors could not be calculated)
- A total of 884 boilers were considered as a result of Step 2.

Step 3: Sort Out Non-CHP Candidates Based on Location—The CHP Team reviewed each category and removed boilers located at:

- Existing utilities, merchant plants or independent power producer facilities;
- Known CHP sites; or
- Steel mills.

Those boilers that used wood as a fuel were also excluded in this step, since these biomass fueled boilers are included in the state's renewable standard. A total of 228 boilers were excluded as a result of Step 3.

Step 4: Sort Out Non-CHP Candidates Based on Usage—Next, the CHP Team excluded most boilers that had one or more of the following concerns:

- Questionable data
- Low pressures (<150 PSI)
- Capacity factors less than 25 percent
- Consumed less than 50 MCF of natural gas (if capacity factor was unknown); and
- Fueled with wood (this was transferred to the Renewable Energy Subgroup for inclusion in their analysis.

A total of 431 boilers were excluded as a result of Step 4.

Step 5: Sort for Economic Suitability—The CHP Team conducted a "positive sort" to select boilers that were located at businesses thought to be likely to adopt CHP due to business factors, or due to prior feasibility studies known to members of the Team. Rejected boilers were moved to the "Excluded" worksheet. A total of 225 industrial boilers were kept. 160

Step 6: Conducted CHP Supply Analysis—Once a dataset was established of potential boilers that were established in suitably located facilities and businesses considered more likely adopters of CHP, the Team summarized key information. The CHP Team began to evaluate CHP electrical production potential. In this effort, it was assumed that natural gas boilers would be equipped with higher efficiency gas turbines, while boilers fueled with coal, oil, or other fuels would be equipped with steam turbines. It was further assumed that design megawatt (MW) capacity would exceed calculated output by 35 percent.

The estimated kilowatt-hours (kWh) of each category of boilers was then calculated at CHP "penetration rates" of 100 percent, 50 percent, and 27 percent. Effective heat rates and average MW/boiler estimates were also calculated for each category of boilers.

Estimates of additional CHP potential from three additional specific sources: new ethanol plants, steel mills, and cement kilns, were then added.

The CHP Team realizes each of these three sectors represent significant CHP potential, but the team was able to make only preliminary estimates of this potential, based upon prior knowledge of group members.

Annex F-2
ES-15a and ES-15b

EXPLANATORY NOTES:

NOTE 1:

<100 kV is handled under MPSC regulations/procedures at distribution level (Interconnection & Net-metering for smaller generators). Generally speaking generation systems less than 1 MW in size are connected at the distribution level. MPSC has been actively working with stakeholders on revising interconnection procedures and net-metering policy.

>100 kava and up is handled by MISO/FERC for regulations/procedures at the transmission level. Generally speaking, large generation is considered 20 MW or higher in size.

NOTE 2:

Siting new lines is difficult due to "not in my back yard" issues and the time involved to review and rule on regulatory siting cases. The cost of line construction along with the availability of transmission components are issues when attempting to build and repair transmission facilities, but they are not specifically issues related to siting or location/routes. The costs of transmission construction, cost recovery, and cost allocation currently fall under the jurisdiction of FERC and are addressed in various MISO forums.

Siting new lines can reduce carbon emissions by reducing transmission losses, increasing the efficiency of the flow of energy, and enabling cleaner renewable energy resources to reach the market. Reducing the barriers to constructing transmission in new corridors should be encouraged in order to encourage new industrial and commercial developments and renewable generation additions and expansions. Transmission is also key in connecting renewable resources to the grid, which will further reduce dependency on traditional fossil fuel generation, resulting in lower carbon emissions.

NOTE 3:

All of the stated energy initiatives are facilitated by a robust transmission system. For instance, transmission is essential in the integration of renewable resources that have a naturally variable component to the output at any one point in time. A perfect example is wind, which is variable and needs transmission to balance the variability for reliability purposes. Transmission also provides essential support for other initiatives, like CHP and Smart Grid. While both are implemented at the distribution level, the transmission system provides backup and demand response when those sources are not available. Like renewable generation sources, these programs can introduce some variability in load and generation balance. A robust transmission system maintains reliability in the face of this variability. Transmission also facilitates traditional and renewable sources of generation and provides a safe and reliable delivery system. The problems associated with the generator interconnection “queue process” must be addressed to move viable renewable projects and new fossil-fuel baseload projects through the queue more quickly. MISO has proposed measures to streamline this process with FERC and FERC has approved the proposals.

NOTE 4:

Cost allocation issues between states (in MISO footprint) and their respective regulatory processes, unique project situation, and market condition are factors that affect transmission planning and are an integral component of sound transmission planning.

NOTE 5:

Cost recovery and cost allocation issues of utilities and regional transmission organizations and the respective regulatory process, unique project situation, and market condition are factors that affect distribution system planning and are an integral component of sound project planning.

Appendix G
Recommendations for Market-Based Policies

Summary List of MCAC Policy Recommendations

No.	Policy Recommendations		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
			2020	2025	Total 2009–2025			
MBP-1	Cap and Trade	20% below 2005 by 2020 (*Free-Granting Allowances*)[1]	92.48				–$25.83	Unanimous
		20% Below 2005 by 2020 (*Auctioning Allowances*)[2]	92.48				–$19.33	
MBP-3	Michigan Joins Chicago Climate Exchange		*Not Quantified*					Unanimous
MBP-6	Market Advisory Group		*Not Quantifiable*					Unanimous

Note: The numbering used to denote the policy recommendation is for reference purposes only; it does not reflect prioritization among these important recommendations.

[1] These results include mitigation costs, including payments or revenues resulting from the purchase or sale of allowances between Michigan emitters and out-of-state Midwestern Governors Association (MGA) partners.

[2] These results include mitigation costs but do not include payments to the state by Michigan emitters for the purchase of allowances at auction. The cost and revenue implications of distribution of allowances by auction can be found in Table G-1-2 and Annex G-1.

MBP-1. Cap and Trade

Policy Description

A cap-and-trade (C&T) system works by setting an overall limit on emissions and either selling or distributing, at no cost, emission "allowances," or permits, to regulated entities or sources. These regulated entities must periodically surrender enough allowances to match their reported emissions or face a penalty. In a system that freely grants allowances, sources that can reduce their emissions at a lower cost than the allowance price may do so and may sell unused allowances to sources that cannot achieve reductions as cost-effectively. In a system where allowances are initially sold, cost-effective emission reductions reduce the number of allowances that must be purchased. Either way, C&T creates a financial incentive for emitters to continually seek out new emission-reducing options and cut their emissions as much as possible. With the creation of a market for the allowances, regulated entities have the choice of either purchasing allowances or directly reducing emissions. As a result, resources are directed to the most cost-effective emission reduction investments. To achieve overall emission reductions over time, programs gradually lower the emissions "cap" by reducing the total number of available allowances.

Perhaps the best-known example of a C&T program is the U.S. Environmental Protection Agency (EPA) program to cut sulfur dioxide (SO_2) emissions from power plants. Established under the 1990 Clean Air Act Amendments, this program successfully proved the emissions trading concept by achieving dramatic, cost-effective reductions. More recently, the trading approach has been applied to greenhouse gas (GHG) emissions by the European Union (EU)[3] and has been proposed by several U.S.-based initiatives, including the Northeast Regional Greenhouse Gas Initiative (RGGI),[4] the Western Climate Initiative (WCI),[5] and the Midwestern Regional Greenhouse Gas Reduction Accord (Midwestern Accord).[6]

Michigan is actively participating in the development of the Midwestern Accord. The policy issues confronting the Midwestern Accord partners will need to be evaluated regionally and by each partner jurisdiction, and then negotiated until agreement is reached. These recommendations are offered to advise Michigan on the key program design features that it should support in these regional negotiations.

Policy Design

The C&T policy is designed and analyzed to work in concert with non-C&T policies and measures. The integration of other policies serves to reduce compliance costs and ease attainment of goals and caps. Emission reductions, costs, and cost savings from many of these other measures help Michigan comply with the cap; they also serve as a basis for the C&T. As a

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3 http://ec.europa.eu/environment/climat/emission.htm

4 http://www.rggi.org

5 http://www.westernclimateinitiative.org

6 http://midwesternaccord.org/

result, the expected operation of the C&T program is integrated with other policies and policy recommendations, and is not presented as a stand-alone program.

Ultimately the pollution-cutting performance of a C&T program depends largely on how it is structured. Key design parameters are discussed separately below.

Geographic Scope

The Michigan Climate Action Council (MCAC) encourages national action in the implementation of a C&T program for the regulation of GHG emissions. In lieu of national action, or in advance of future action, Michigan should continue to participate in and encourage the development of the Midwestern Accord program.

Michigan should not seek to create its own one-state C&T program. The benefits of the C&T program are greatest when the market has access to a large number of low-cost mitigation options. Compliance costs will generally rise as the geographic scope of the program shrinks. In addition, the smaller the program's geographic scope, the greater is the concern for "leakage" and within-region versus out-of-region competition.

Sector Coverage

It is recommended that the program have the broadest possible sector coverage as soon as possible to include the maximum possible number of low-cost mitigation and sequestration options. This would include electricity generation; industrial sources; fossil fuel extraction, processing, and transportation; transportation fuels; and residential and commercial fuel supply. The transportation fuels and residential and commercial fuel supply sectors would most likely have to be regulated upstream of the actual point of emissions. The regulated entity in the transportation and residential and commercial sectors may need to be the fuel blender, distributor, or importer. It is recognized that some sectors may not be appropriate for regulation under a C&T program, and others may be appropriate but may need to be phased-in over time. Some sectors or sources deemed inappropriate for regulation may still be included in the program through the use of offset credits, such as agriculture, forestry, and some aspects of waste management. Consideration should also be given to applying other mechanisms, such as a carbon tax, to the small subset of sources within agriculture, forestry, and waste management (AFW) that are neither regulated under the C&T program nor included within that program as available for offset purposes.

When deciding which sectors should be regulated and when, consideration should be given to:

- *Data quality*—Sectors or sources with incomplete or unreliable historic emissions data or those for whom GHG emission or related fuel consumption data have not been reported would be difficult to effectively regulate. Michigan should identify sectors and sources that are appropriate for regulation and begin collecting the necessary source data in advance of regulation to ensure that emission caps are properly set and compliance can be measured and enforced.
- *Emissions reduction potential*—Emissions from some sectors contribute relatively little to Michigan's "footprint," and may be disproportionately difficult to document and regulate. Sectors with low reduction potential should be evaluated for inclusion from the standpoint of administrative burden or other appropriate concern.

- *Data reliability*—Sectors or sources with emissions that are very difficult to measure may be exempt from regulation out of a concern for the uncertain reliability of compliance measurements. Some agriculture and forestry sources, for example, present a significant challenge to those seeking an accepted, consistent, and verifiable measurement of emissions.

Allowance Value and Distribution

The MCAC represents a diversity of views on the issue of allowance distribution. Some members believe that the free allocation of allowances to covered entities is the best and most appropriate way to minimize costs to ratepayers, consumers, and businesses. Other members believe that auctioning allowances is the most equitable and simplest distribution method, and generates revenues that can be applied in a variety of ways to promote emission reductions and protect consumers from the impact of higher energy prices. Some members believe that a combination of free allocation and auctioning would be the best approach, particularly at the beginning of the program.

Regardless of distribution method, the MCAC agrees that the *value* represented by the allowance should benefit the residents of Michigan. In the electricity sector, for example, regulated utilities would be required to pass the value of a freely granted allowance (whether used or sold) onto the ratepayer through rate setting. Freely granted allowances for unregulated electric sector sources could be distributed to regulated load-serving entities, once again relying upon rate setting to direct the economic benefit to the ratepayer. In a full or partial auction system, the revenues from the sale of the allowances could be applied in a variety of ways to benefit the residents. Examples include tax reductions or direct payments, perhaps directed largely for the benefit of low-income consumers. Other uses could include investments in energy- or climate-related technological transformation and research and development, or public investments in end-use energy efficiency, providing both energy cost and emission reduction benefits. Another suggestion for the use of auction revenues is public investment to mitigate the cost of industry and worker transition.

Given the broad sector coverage recommended here, the MCAC recognizes that the matter of allowance distribution is complex. Determining the most appropriate means of ensuring that consumers realize the economic benefit from the value of the allowance will require careful study. Distribution methods or rules may need to vary across and within sectors to ensure value is directed to the benefit of consumers and recognize the multiplicity of concerns for intra- and inter-regional competition, particularly within the industrial sector.

Offsets

Regulated sources can comply with the C&T program in three ways: they can reduce emissions directly, they can acquire and surrender allowances sufficient to cover their emissions, or they can invest in qualifying offset projects and surrender offset credits. Offset projects are undertaken voluntarily and generate revenue for the project owner through the sale of offset credits, which are equivalent to government-issued allowances. Emission reductions from regulated sources are therefore not eligible as offset projects; otherwise these reductions would be double counted, once for the benefit of the regulated source under the cap, and again for the benefit of the offset purchaser. To ensure the integrity of the emissions cap, offset projects reduce emissions or sequester carbon from uncapped, out-of-sector projects that are recognized by the program as qualifying for allowance credit. In most cases, any emissions included under any C&T program's cap cannot be reduced and also qualify as an offset credit under any other

C&T program. Offsets provide an incentive for low-cost investments in uncapped emission reductions as an alternative to higher-cost, in-sector reductions or allowance purchases.

The MCAC agrees that offsets should be part of the program, and that given reasonable assurances that the offsets would have integrity, no geographic limitations should be imposed. The MCAC also recommends that Michigan should take the lead in developing the standards and protocols for verifiable forestry-based offsets.

There was not agreement on whether the use of offset credits should be limited or unlimited. Some members supported unlimited use of offsets, citing the compliance cost mitigation benefits. Others expressed the concern that if the program allowed 100% compliance with offsets, then in-sector emission reductions would not take place. In addition, placing limits on the use of offsets would encourage the transition to new technologies within the capped sectors.

Price Mitigation Mechanisms

C&T programs often feature one or more allowance price mitigation mechanisms to provide regulated sources compliance flexibility and smooth inherent market instability, especially in the early years of the program. A good example is offsets, which serve multiple purposes, including allowance price mitigation. Other program design features that provide compliance flexibility and mitigate allowance prices include allowance banking, allowance borrowing, and allowance price caps or "safety valves." Policymakers are encouraged to further investigate and consider these mechanisms in the development of the C&T program.

Reporting

The MCAC endorses the Midwestern Governors Association (MGA) draft recommendation for participation in and use of The Climate Registry (TCR), or a similar registry that is widely deployed and recognized, as the basis for a reporting program.

Leakage

Leakage occurs when, in response to program incentives (e.g., emission caps), utilities choose to increase out-of-region fossil-based power purchases or investors choose to construct new generation units in unregulated border jurisdictions. Leakage can also occur in the manufacturing sector where sources subject to GHG reduction requirements move to jurisdictions with lesser or no GHG reduction requirements, including areas outside the United States. In either case, both the environmental benefits and in-state investment are lost. Under a national program, leakage for utilities becomes a minor issue, but remains a major issue for carbon-intensive manufacturing that can relocate to areas with less stringent environmental requirements. Leakage for the power sector can be addressed through careful design of the point-of-regulation, as in the First Jurisdiction Deliverer (FJD) plan in the WCI. FJD requires compliance from any generator within the region, plus any entity that imports fossil-based power from outside the WCI region.[7] The MGA draft recommendation also proposes the use of FJD. The MCAC recognizes that in any regional program leakage is a serious concern and must be considered, evaluated, and addressed.

[7] While RGGI does not address the issue of leakage within the program design, it recognizes the issue and will monitor inter-regional contracts and purchases to assess whether leakage is occurring. RGGI has indicated that if leakage proves to be a serious issue, action will be taken to address it.

Trial Period

The MCAC recommends that the program include a trial period to allow the program and the regulated community to adjust to the requirements.

Early Actions

Early actions are investments in mitigation measures that predate the program. Because these programs typically take years to design and implement, there is a concern that sources will delay mitigation investments until the program begins to ensure that they earn proper credit. Any delay in mitigation works contrary to the purpose of the program, so most programs offer some form of hold-harmless feature to protect early actors from suffering a penalty as a result of their actions, or an incentive to recognize or encourage these early actions. The MCAC recommends that the C&T program award tradable allowance or offset credits for early actions taken after a threshold date that are verifiable and meet standards comparable to those applied to offsets.

Goals: Reductions resulting from complementary policies and measures plus those realized through the C&T program should be designed to achieve the Michigan and MGA regional goals.

Timing: The MCAC recommends that the first compliance period of the C&T program begin on January 1, 2012, and that the regional cap and state allocation budgets be designed to support the regional goal, as stated above, in 2020.

Parties Involved: Potentially regulated entities in covered sectors, all MGA partner jurisdictions, the MGA, TCR.

Other: None.

Implementation Mechanisms

The Midwestern Accord partners are developing both a proposed design and a model rule for the implementation of the regional C&T program. The model rule will be developed with opportunity for regional public comment, but once completed, possibly in the third quarter of 2009, each partner state and province will have to follow its own procedures to adopt the rule for that jurisdiction. In some or all cases, enabling legislation will be needed to authorize the adoption of the rule. In cases where enabling legislation is not required, legislators may still wish to enact legislation encouraging or limiting the state's participation.

Related Policies/Programs in Place

There are no C&T programs in place to reduce GHG emissions in Michigan. Michigan has participated in the U.S. EPA SO_2 C&T program as well as the oxides of nitrogen ozone season trading program. Related GHG C&T programs are RGGI and WCI. RGGI began operating on January 1, 2009, and WCI is planned to begin on January 1, 2012. The Chicago Climate Exchange (CCX), a voluntary carbon trading program described in MBP-3, includes Michigan-based companies and institutions among its members.

Type(s) of GHG Reductions

All six statutory GHGs (carbon dioxide [CO_2], methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride)

Estimated GHG Reductions and Costs or Cost Savings

The complete modeling results and analysis are attached as Annex G-1. The methodology used to develop the marginal cost curves of states/provinces and the general assumptions adopted in the simulations may be found in Annex G-3. Specific data and methods used for the development of the Michigan cost curve can be found in Annex G-2.

The MGA partners include six U.S. states: Iowa, Illinois, Kansas, Michigan, Minnesota, and Wisconsin; and one Canadian province: Manitoba. MGA has recently announced its draft goals and timing for the C&T program: to reduce GHG emissions by 15%, 20%, or 25% below 2005 levels in 2020. In Annex G-1 of this appendix, we simulated these three alternative MGA goals for 2020. We also examined an alternative set of goals based on the MCAC tentative target for 2025: to reduce GHGs by 25%–35% from the 2002 emissions level in 2025. In this analysis, we applied three alternative MCAC 2025 goals (25%, 30%, and 35% below the 2002 level) to all the MGA partners to study the cost implications of a C&T program in 2025.

For the purpose of informing MCAC recommendations, we analyzed two sectoral coverage scenarios in our simulations:

- Assuming economy-wide coverage (except AFW), and
- Assuming only the power sector is covered.

In each of the two above sectoral coverage scenarios, we applied the set of MGA goals and the set of MCAC goals to the total emissions from the C&T covered sectors. Full results are given in Annex G-1.

We also analyzed two alternative allowance distribution cases: a 100% free-granting case and a 100% auction case, both throughout the MGA region. In the auction case:

- We assumed there would be no permit trading among the partners.[8]
- According to the Coase theorem,[9] in equilibrium, each partner will choose to mitigate the same level of emissions as in a permit trading market, and will buy allowances for its remaining emissions from the auctioneer.
- The auction price would be the same level as the equilibrium price in a permit trading market.
- The auction revenues can be used ("recycled") for a variety of public purposes, such as to fund research and development in clean energy technologies, subsidize business expenditures on mitigation, and reduce various taxes. However, the impacts of recycling those revenues are not included in the simulation below.

Since the MCAC has adopted the mid-point MGA goal as the recommendation, and given that this policy recommends the economy-wide (excluding AFW) sector coverage approach, these results are presented below for both the 100% auction and the free-granting assumptions for

[8] In reality, a secondary market will develop and permits will be bought and sold. This assumption is made to facilitate modeling and analysis.

[9] The Coase theorem, named for economist Ronald H. Coase, states that when trade in an externality is possible and there are no transaction costs, bargaining will lead to an efficient outcome, regardless of the initial allocation of property rights.

initial allowance distribution. Full results of all goals, scenarios, and cases can be found in Annex G-1 of this appendix.

In the C&T simulations for the recommended goal (20% below 2005 levels for 2020), the permit price in the trading market would be $35.35 per metric ton of carbon dioxide equivalent (tCO_2e) emissions in 2020 for the economy-wide (excluding AFW) case.

The emission reductions from the C&T covered sources within Michigan under the economy-wide C&T program are expected to be 103.32 million (MM) tCO_2e in 2020. Since Michigan is expected to be a permit seller in the market in any of the sectoral coverage scenarios, the emission reductions undertaken by the in-state C&T covered sources would exceed the reduction requirement indicated by the state emission caps. Michigan sources would sell the surplus permits earned through over compliance to the other MGA partners and gain a profit.

The economy-wide simulation (excluding the AFW sectors) results, including both the free-granting case and the auction case, with the three alternative MGA 2020 GHG reduction goals and the three alternative MCAC 2025 goals, are presented in Tables G-A1-1 to G-A1-12 in Annex G-1 of this appendix. The power sector-only C&T simulation results are presented in Tables G-A1-13 to G-A1-24.

Free-Granting Case

In all the free-granting simulation cases, if we compare the net cost for each state/province after trading with the before-trading mitigation cost, we find that all states/province are better off as a result of participating in trading, since all the post-trading net costs are smaller than the pre-trading net costs. The gains from trading are shown in the Cost Saving column in the results tables. Compared with the pre-trading situation, Michigan can achieve cost savings of $193 million in 2020 in the economy-wide C&T program. Table G-1-1 gives the economy-wide results for the Michigan free-granting case. Full results are presented in Annex G-1.

Table G-1-1. 100% Free-granting results for Michigan—economy-wide (excluding AFW) program

Michigan-Only Economy-wide (Excluding AFW); Assuming Free Grant of Allowances	Before Trading Mitigation Cost (million $)	After Trading			Cost Savings (million $)	Permits Traded ($MMtCO_2e$)[a]	Emissions Reduction With Trading		Emission Reduction Goal (percent from BAU)
		Mitigation Cost (million $)	Trading Payments/ Revenues (million $)	Net Payment/ Revenue + Cost (million $)			($MMtCO_2e$)	(percent from BAU)	
With MGA goal 20% below 2005 levels by 2020	–$2,195	–$1,788	–$601	–$2,389	–$193	–17	92.48	35.3	28.81

[a] Represents number of permits bought or sold.

BAU = business as usual; AFW = agricultural, forestry and waste management; MCAC = Michigan Climate Action Council;; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-1-1 Column Head Key

"Before Trading Mitigation Cost" means the net cost or net cost savings (negative numbers) to reduce GHG emissions from Michigan sources, including any savings, such as those resulting from reduced fuel or electricity purchases, assuming all reductions necessary to meet the stated goal are made.
"After Trading Mitigation Cost" means the net cost or net cost savings (negative numbers) to reduce GHG emission reductions from Michigan sources, including any savings, such as those resulting from reduced fuel purchases, assuming a regional cap-and-trade program is in place.
"After Trading Payment/Revenue" means the total payments by or revenues to Michigan sources resulting from the purchase or sale, respectively, of emission allowances through the cap-and-trade program. Negative numbers mean Michigan sources will sell more allowances in the market than they purchase.
"After Trading Net Payment/Revenue and Cost" is the total cost of or cost savings (negative numbers) from in-state mitigation plus allowance purchases and sales.
"Cost Savings" is the "Before Trading Mitigation Cost" less the "After Trading Net Payment/Revenue and Cost."
"Permits Traded" is the net number of allowances purchased or sold by sources within Michigan. Negative numbers mean Michigan has a relatively large number of low-cost mitigation options and will be a net importer of mitigation investment capital and a net exporter of allowances.
"Emissions Reduction with Trading (MMtCO_2e)" means the tons of CO_2e that will be mitigated in Michigan as a result of the trading program.
"Emission Reduction With Trading (percent from BAU)" means the expected percentage reduction from in-state business-as-usual emissions in the target year. Percent reductions in excess of the "Emission Reduction Goal (percent from BAU)" in the next column mean Michigan sources will "overcomply" in order to sell allowances to out-of-state sources at a profit.
"Emission Reduction Goal (percent from BAU)" means the target year business-as-usual emission reductions necessary to meet the goal.

Auction Case

In the auction case, there would be no permit trading among states. In equilibrium, each state will choose to mitigate the same level of emission as it would in a permit trading market, but each partner would buy allowances for its remaining emissions from the auctioneer. The auction price would be the same level as the equilibrium price in a permit trading market. For the economy-wide program, the auction payments would be approximately $6 billion in 2020. These auction costs are not real resource costs to society; rather, they are transfer payments from one entity (the regulated source) to another (the state). In our analysis, the impacts of recycling the auction revenues through government investment in new efficiency technologies, direct efficiency investments, tax relief or other measures are not included. Table G-1-2 gives the economy-wide results for the Michigan auction case. Full results are given in Annex G-1.

Table G-1-2. 100% Auction results for Michigan – economy wide (excluding AFW) program

Michigan Only Economy-wide (Excluding AFW); Assuming Auction of Allowances	Total BAU Emissions in 2020 ($MMtCO_2e$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2e$)	Auction Payment[b] by Emitters/ Revenue to the State (million $)	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2e$)				
With MGA goal 20% below 2005 levels by 2020	261.99	35.3	92.48	169.51	$5,992	–$1,788	$4,205

[a] In equilibrium, each state will choose to mitigate the same level of emissions as in a permit trading market.

[b] The auction price would be the same level as the equilibrium price in a permit trading market.

BAU = business as usual; AFW = agricultural, forestry and waste management; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-1-2 Column Head Key

"Total BAU Emissions in 2020 ($MMtCO_2e$)" means total Michigan business-as-usual emissions from all covered sources in the year corresponding to the goal.
"Emission Reduction Undertaken by Michigan Sources (percent from BAU)" means the in-state emission reductions in the goal year expressed as a percentage of business-as-usual emissions.
"Emission Reduction Undertaken by Michigan Sources ($MMtCO_2e$)" means the in-state emission reductions in the goal year expressed in million metric tons of CO_2 equivalent.
"Emission Allowances Bought From Auctioneer ($MMtCO_2e$)" means the number of allowances that will be purchased by Michigan sources at auction.
"Auction Payment by Emitters/Revenue to the State" means total payments by Michigan sources for the purchase of allowances as shown in "Emission Allowances Bought From Auctioneer ($MMtCO_2e$)." This also represents the total revenues to the state of Michigan from the sale of these allowances.
"Mitigation Cost" means the net cost of or cost savings (negative numbers) from total expenditures for GHG emission reductions from Michigan sources, less savings, such as those resulting from reduced fuel purchases.
"Total Payments and Costs" means the total of Mitigation Costs and Auction Payments made by all sources in Michigan.

Data Sources:

Marginal cost curves for states/province are developed directly: (1) on the basis of assessment of state-level actions developed through the stakeholder processes in Minnesota, Iowa, and Michigan (developed on the basis of reduction potentials and mitigation costs of individual policy options presented in Center for Climate Strategies [CCS] final (or draft) climate change action reports for these three states); or (2) by approximation methods for the other states and province based on cost curves from states with direct data. Currently, no direct cost curve data are available for Midwestern partners other than Minnesota, Iowa, and Michigan. The marginal cost curves of Manitoba and Wisconsin are approximated based on Minnesota data. The cost curve of Kansas is approximated based on Iowa data. The cost curve of Illinois is approximated based on Michigan data. The approximation methods we adopted are described in the Quantification Methods section following this section.

GHG Mitigation Options Data Sources:

Minnesota Climate Change Advisory Group. 2008. *Minnesota Climate Change Advisory Group Final Report: A Report to the Minnesota Legislature*. http://www.mnclimatechange.us/MCCAG.cfm.

Iowa Climate Change Advisory Council. 2008. Quantification analysis of mitigation options from the EEC, CRE, TLU, and AFW Subcommittees.

3. Michigan Climate Action Council. 2008. Quantification analysis of mitigation options from the ES, RCI, and TLU TWGs of Michigan.

Emissions Inventory and Forecast Data Sources:

For Manitoba: L. Williams and S. Roe. 2008. "Task 0 State-Provincial GHG Summaries Tech Memo 1-31-08.doc" and associated Excel workbooks.

For Iowa, Minnesota, Michigan, and Kansas: Final or Draft Inventory and Forecast Analysis by CCS.

World Resources Institute. 2007. *Illinois Greenhouse Gas Emissions Inventory and Projections*. Prepared for the Illinois Climate Change Advisory Group. http://www.epa.state.il.us/air/climatechange/documents/07-02-22/il-emissions-overview-v5.pdf.

World Resources Institute. 2007. *Wisconsin Greenhouse Gas Emissions Inventory and Projections*. Prepared for the Wisconsin Task Force on Global Warming. http://dnr.wi.gov/environmentprotect/gtfgw/documents/WRI-WI_Inventory_Final.pdf.

Quantification Methods:

The MGA partners' C&T simulations use a nonlinear programming model of emission allowance trading. This model is based on the well-established principles of the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities.[10] Partners with relatively high mitigation costs will accomplish only part of their reduction obligation by their own mitigation activities, and will cover their remaining obligations by purchasing permits in the market. The compliance costs of these partners are equal to their own abatement cost plus the cost of permits. Partners with relatively low costs will have the incentive to mitigate more than their reduction targets indicate, so that they can sell their surplus permits to other partners at a profit. For these partners, compliance costs are equal to their own abatement cost minus the revenues from selling permits. The nonlinear programming model requires equalization of the marginal cost of all trading participants with the equilibrium permit

[10] See, e.g., T. Tietenberg (2007), "Tradable Permits in Principle and Practice," in J. Freeman and C. Kolstad (eds.), *Moving to Markets: Lessons from Twenty Years of Experience*. New York: Oxford University Press.

price. This ensures minimization of total net compliance costs for each partner and minimization of total abatement cost for the C&T program as a whole.[11]

For states with the state climate change action plans developed, the marginal abatement cost curves are based on the reduction potential and mitigation cost or saving data of individual options that are quantitatively analyzed by the stakeholder process. We used the following approximation methods to develop marginal abatement cost curves for states and Manitoba without direct data at present.

One of the adjacent states for which direct reduction and cost data are available is selected as the reference. We assume that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit GHG removed for each option is assumed to be at the same level as that of state A. Third, the mitigation potentials of each option are assumed to be proportional to the total mitigation potential in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states. For example, if the emissions from the power sector are 50 $MMtCO_2e$ and 100 $MMtCO_2e$ in state A and state B, respectively, the mitigation potentials of the Energy Supply options for state A are multiplied by a factor of 2 (100/50 = 2) for application to state B.

Figure G-A3-1 and Figure G-A3-2 in Annex G-1 show the economy-wide (excluding AFW sector) and power sector only marginal cost curves for all the MGA partner states and Manitoba.

Key Assumptions:

All emissions considered are consumption-based and are gross emissions (excluding sinks).

- Marginal cost curves embody direct mitigation costs only.
- Marginal cost curves do not include various transaction costs.
- Marginal cost curves do not distinguish between producer versus consumer allocation of permits.

For the basic model:

Offsets, safety valve (permit price limit), and banking and borrowing are not included. These features can be included in advanced versions:

- Free allocation to grandfathered sources and auction of all allowances.

Key Uncertainties

A number of design variables (including the reduction targets, sectoral coverage, allocation methods, flexibility mechanisms, and level of complementary measures) can affect the simulation results, such as permit prices, in-state mitigation volume, trading volume, and cost savings from joining the C&T program. The uncertainties should be evaluated by the Market

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[11] See, for example, B. Stevens and A. Rose (2002), "A Dynamic Analysis of the Marketable Permits Approach to Global Warming Policy: A Comparison of Spatial and Temporal Flexibility," *Journal of Environmental Economics & Management* 44(1):45–69; A. Rose, T. Peterson, and Z. Zhang (2006), "Regional Carbon Dioxide Permit Trading in the United States: Coalition Choices for Pennsylvania," *Penn State Environmental Law Review* 14(2):203–229.

Advisory Group described in MBP-6 to better understand the costs and benefits of a C&T program in Michigan.

As noted in the quantification methods and in Annex G-1, cost curves for Manitoba, Wisconsin, Kansas and Illinois were approximated from comparable states for which data are available. While these approximations are generally useful for this type of analysis, they are not as reliable as results based on state-specific action plans. The trading flows and costs would most likely change somewhat if state-specific data were to be used.

Additional Benefits and Costs

As noted above, the C&T analysis does not consider the price paid by those purchasing allowances at auction as a "cost" in the program. The analysis does not consider any benefits or value derived from the use of those revenues by the state for the purposes recommended in the Allowance Value and Distribution section under Policy Design, or any other use.

Feasibility Issues

As noted in the discussion.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

MBP-3. Chicago Climate Exchange

Policy Description

The Chicago Climate Exchange (CCX), launched in 2003, is the world's first and North America's only active voluntary, legally binding integrated trading system to reduce emissions of all six major GHGs, with offset projects worldwide.

CCX members are leaders in GHG management and represent all sectors of the global economy, as well as public-sector innovators. Reductions achieved through CCX are the only reductions made in North America through a legally binding compliance regime, providing independent, third-party verification by the Financial Industry Regulatory Authority (formerly the National Association of Securities Dealers). The founder, Chairman, and Chief Executive Officer of CCX is economist and financial innovator Dr. Richard L. Sandor, who was named a Hero of the Planet by *TIME Magazine* in 2002 for founding CCX, and in 2007 as the "father of carbon trading."

CCX members make a voluntary but legally binding commitment to meet annual GHG emission reduction targets. Those who reduce emissions below the targets have surplus allowances to sell or bank, while those who emit above the targets comply by purchasing CCX Carbon Financial Instrument® (CFI®) contracts. The states of New Mexico and Illinois are members of CCX.

The commodity traded at CCX is the CFI contract, each of which represents 100 metric tons (t) of CO_2 equivalents. CFI contracts are comprised of Exchange Allowances and Exchange Offsets. Exchange Allowances are issued to emitting members in accordance with their emission baseline and the CCX Emission Reduction Schedule. Exchange Offsets are generated by qualifying offset projects.

The goals of CCX are to:

- Facilitate the transaction of GHG allowance trading with price transparency, design excellence, and environmental integrity.
- Build the skills and institutions needed to cost-effectively manage GHGs.
- Facilitate capacity building in both public and private sectors to facilitate GHG mitigation.
- Strengthen the intellectual framework required for cost-effective and valid GHG reduction.
- Help inform the public debate on managing the risk of global climate change.

The benefits of CCX membership are:

- Being prepared to mitigate financial, operational and reputational risks.
- Reducing emissions using the highest compliance standards with third-party verification.
- Proving concrete action on climate change to shareholders, rating agencies, customers, and citizens.
- Establishing a cost-effective, turnkey emissions management system.

- Driving policy developments based on practical, hands-on experience.
- Gaining leadership recognition for taking early, credible, and binding action to address climate change.
- Establishing an early track record in reductions and experience with the growing carbon and GHG market.

NOTE: Various Michigan-based businesses are members of CCX, including Ford Motor Company, Dow Corning, Steelcase, DTE Energy, Smurfit-Stone, Knoll Inc., DuPont, and Michigan State University. In addition, the states of Illinois and New Mexico are also members of CCX.

Policy Design

- Leading by example—Michigan will inventory and quantify all GHG emissions from sources that result from state government operations and are under the control of state government. Typically speaking, state government's primary sources of GHG emissions are energy use in office buildings and transportation.
- Michigan will join CCX,[12] which requires a 6% reduction in GHG emissions from state governmental sources between a baseline of 1998–2000 and 2010, and possibly additional reductions beyond 2010 under CCX Phase 3 requirements.

Goals: Emission reductions from state operations consistent with CCX Phase 2 requirements.

Timing: Michigan should consider joining CCX in 2009 and achieving the 2020 reduction goal. If there is insufficient time to achieve this reduction, Michigan should join in 2009 or 2010 and participate beginning with Phase 3.

Parties Involved: Governor Granholm and Executive Office staff, various executive departments and agencies, Michigan legislature.

Other: Contracts for GHG reductions are legally binding and extend for multiple years. To the degree that compliance with those contracts imposes a cost on the state, the legislature would be obligated to appropriate the necessary funds to purchase credits if the state of Michigan were unable to meet associated GHG reductions.

Alternately, membership and compliance may present opportunities for new revenues (for example, offset credits for biological sequestration on state forest lands), which would be under the jurisdiction of the legislature through the budget-setting process.

Implementation Mechanisms

The MCAC suggests the state of Michigan join the CCX by issuance of an Executive Order though the Governor's office. A determination of the necessity for involving the Michigan

[12] See http://www.chicagoclimatex.com/.

legislature in this process needs to be made accordingly. Illinois and New Mexico have joined the CCX. (Illinois joined by Executive Order 11 of 2006 [see http://www.illinois.gov/gov/execorder.cfm?eorder=54.])

Related Policies/Programs in Place

No related policies or programs are in place Michigan. However the state, under Executive Directive No. 2007-22 (http://www.michigan.gov/gov/0,1607,7-168-36898-180298--,00.html), has committed to reducing the carbon footprint of state government by reducing energy consumption and furthering efficiency efforts in fleet management, green procurement, and recycling. This effort would complement the voluntary GHG reduction commitments required as part of being a member of CCX.

Specifically, all state buildings under the Department of Management and Budget and other state agencies under the executive branch have a goal of achieving 10% reduction in energy use by December 31, 2008, and a further goal of 20% reduction in grid-based energy purchases by December 31, 2015, when compared to energy use and purchases ending fiscal year ending September 30, 2002.

In addition, the Midwestern Accord[13] plans to establish a Midwestern Greenhouse Gas Reduction Program (hereafter Midwestern GHG Program) to reduce GHG emissions in member states through the following actions:

- Establish GHG reduction targets and time frames consistent with those of MGA member states and provinces;
- Develop a market-based and multi-sector C&T mechanism to help achieve GHG reduction targets;
- Join TCR to enable tracking, management of, and crediting for entities that reduce GHG emissions; and
- Develop and implement other associated mechanisms and policies as needed to achieve the GHG reduction targets, such as a low-carbon fuel standard and regional incentives and funding mechanisms.

NOTE: The Michigan Department of Environmental Quality (MDEQ) participates on the Steering Committee for the development of TCR, a multi-state program designed to be an essential piece of infrastructure for the development of state and federal climate change programs. Thirty-nine states and the District of Columbia in the United States, six states in Mexico, nine Canadian provinces, and three Native American tribes have already signed on to join TCR. More information about TCR is available at http://www.theclimateregistry.org/.

Type(s) of GHG Reductions

CO_2.

[13] Midwestern Accord participating states and provinces: Illinois, Iowa, Kansas, Manitoba, Michigan, Minnesota, and Wisconsin; observer states: Indiana, Ohio, South Dakota.

Estimated GHG Reductions and Costs or Cost Savings

This policy has not been quantified. However, MDEQ analysis indicates that achievement of the 2010 CCX goal is possible with the successful implementation of Executive Directive No. 2007-22.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

The CCX Phase 3 goals are not known. Therefore it is not possible to judge the costs and benefits of achieving them.

Additional Benefits and Costs

Additional benefits include those identified under 'Benefits of Membership' in the Policy Description section of this recommendation. Additional costs may be an issue if Michigan fails to achieve the contractually required reductions. In this event, the state legislature would be obligated to purchase or sponsor offset credits or projects. It is also possible that with or without the need for offset credits, Michigan could invest in state offset projects and sell the credits through the CCX mechanism and generate additional revenues.

Feasibility Issues

Given that several other states have already joined CCX, no feasibility issues have been identified.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

MBP-6. Market Advisory Group

Policy Description

The MCAC is tasked with considering potential state and multi-state actions to mitigate and adapt to climate change in various sectors, including energy supply, energy efficiency and conservation, industrial process and waste management, transportation and land use, and agriculture and forestry, as well as advising state and local government on measures to address climate change.

GHG policies have broad-based impacts and implications. As a result, it is helpful to look at current and future policies from several viewpoints. Some states have looked at forming groups of experts to help them evaluate both the intended and unintended consequences of GHG policies. For example, California has formed a Market Advisory Committee (MAC) to help formulate a GHG C&T system in the state. The California MAC has proposed a set of guiding principles and has developed an initial set of recommendations for a California C&T program. Minnesota also considered a similar panel of experts to evaluate GHG policies, and recommended a similar panel of experts at the Midwestern Accord regional level.

Michigan has unique economic, social, and legislative structures that separate the state from implementing specific policies verbatim that California or Minnesota has adopted in relation to GHG emission reduction. However, Michigan can benefit from a multidisciplinary approach when looking at how current and future polices will affect the overall physical and economic environment in the state. The Market-Based Policies (MBP) Technical Work Group (TWG) recommends to the MCAC the creation of a formal Market Advisory Group (MAG), appointed by the Governor or appropriate agency head and approved by the state legislature, and working in support of the MDEQ. The MAG would hold regular meetings and have defined responsibilities, to include examining the economic feasibility of implementing GHG reduction policies. In addition to offering expert advice on the design of market-based policies, the MAG would catalog current policies and laws in state and local government, assess how each contributes to or reduces GHGs, and provide guidance to the state's policymakers on the design of any future compliance programs to manage GHG emissions. The MAG would consist of economists, actuaries, scientists, policy advisors, academics, attorneys, planners, engineers, as well as members of the public, all of whom would serve without pay.

Policy Design

Goals: This recommendation consists of current and future policy evaluation and guidance to help evaluate and assess the economic, social, and environmental impacts of policy on GHG emissions on an ongoing basis. The appointment of a MAG is recommended to provide analysis and guidance for this purpose. It should possess scientific, economic, and legal expertise to provide an experts' review of policies and programs.

Timing: The MAG should be in place in advance of the start of a regional or national C&T program, preferably before the end of 2009 to take maximum advantage of the MAG’s input.

Parties Involved: The MAG should be composed of individuals with particular expertise in key areas, such as economics, markets, climate science and policy, law, planning, statistics, engineering, and academia, as well as in other jurisdictions or for other pollutants, key covered sectors, and finance. Involved parties beyond those represented in the MAG would include a very wide range of stakeholders from the regulated community, environmental community, all levels of government, and the general public.

Other: The MAG should encourage public comment throughout its deliberations.

Implementation Mechanisms

Authority of the MAG

To advise policymakers, such as the MDEQ, Michigan Public Service Commission, Michigan Economic Development Corporation, Attorney General's office, state legislature, and Governor on GHG policies, potential negative and positive impacts on the environment, public health, the economy, and the well-being of the citizens of Michigan, and to recommend policies to optimize the benefits and reduce the costs of the policies in the future.

MAG Membership and Governance

The governor would appoint 11 persons for 3-year staggered renewable terms without pay, with technical experience in such areas as: finance; sources of emissions, such as the mobile sources; electricity generation and transmission; industrial sources; carbon credit trading firms; public health, and resource-based economics and econometric modeling. At least one person appointed by the Governor would represent the public at large. All appointments would be subject to legislative advice and consent.

MAG members would be allowed to include other experts from the public and private sectors as necessary to conduct its analyses and make its recommendations.

The MAG would conduct elections tri-annually. It would be organized with a Chair, Vice Chair, and Secretary-Treasurer; take action as needed by a majority vote of its appointed members; establish a budget and work plan with milestones; and otherwise conduct itself under processes used by business to ensure the timely and high-quality delivery its recommendations.

Budget

The MAG would conduct its analyses and make its recommendations on an ongoing basis, with financial resources provided by legislative appropriations.

Reporting

The MAG would provide its recommendations orally or in writing to policymakers. These would reflect comments from the members of the public and private sectors that the MAG agreed to accept. The MAG would explain its rationale for accepting and not accepting comments when it finalized recommendations. Copies of final recommendations and the rationale for accepting/not accepting comments would be posted on the Internet.

The MAG would annually summarize its activities to policymakers and the public via the Internet, and would hold quarterly meetings open to the public to describe progress on its work plan.

Related Policies/Programs in Place

Any market-based GHG regulatory program, such as the MGA C&T program.

Type(s) of GHG Reductions

Principally CO_2 but other GHGs as well, if they are regulated under the adopted market-based program.

Estimated GHG Reductions and Costs or Cost Savings

This policy is not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

None.

Additional Benefits and Costs

None.

Feasibility Issues

None.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

Annex G-1

Analysis of MGA Cap and Trade in 2020 and 2025

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December 25, 2008

This summary presents the simulation results of Midwestern Governors Association (MGA) Cap and Trade (C&T) Program. For the detailed specifications of our policy design model, the methodology we used to develop the marginal cost curves of states/provinces, and the general assumptions we adopted in the simulations, please refer to Annex G-3, "Modeling of Cap and Trade Programs."

The MGA partners include six U.S. states: Iowa, Illinois, Kansas, Michigan, Minnesota, and Wisconsin; and one Canadian province: Manitoba. MGA has recently announced its draft goals and timing for the C&T program: to reduce greenhouse gas (GHG) emissions by 15%, 20%, and 25% below 2005 levels in 2020. In the following C&T analysis, we simulate these three alternative MGA goals for 2020. We also examine an alternative and much more stringent set of goals based on the Michigan Climate Action Council (MCAC) tentative target for 2025: to reduce GHGs by 25%–35% from the 2002 emissions level in 2025. In this analysis, we apply three alternative MCAC 2025 goals (25%, 30%, and 35% below the 2002 level) to all the MGA partners to study the cost implications of a C&T program in 2025.

For the purpose of informing committee recommendations, we analyzed two sectoral coverage scenarios in our simulations:

- Assuming economy-wide coverage (except for agriculture, forestry, and waste), and
- Assuming only the power sector is covered.

In each of the two sectoral coverage scenarios, we applied the set of MGA goals and the set of MCAC goals to the total emissions from the C&T covered sectors. Our model is sufficiently flexible to accommodate any sectoral coverage strategy in future analyses.

We also analyzed two alternative allowance distribution cases: a 100% free-granting case and a 100% auction case, both throughout the MGA region. In the auction case:

- We assumed there will be no permit trading among the partners.[14]
- According to the Coase Theorem, in equilibrium, each partner will choose to mitigate the same level of emissions as in a permit trading market, and will buy allowances for its remaining emissions from the auctioneer.
- The auction price will be the same level as the equilibrium price in a permit trading market.

[14] In reality, a secondary market will develop and permits will be bought and sold. This assumption is made to facilitate modeling and analysis.

- The auction revenues can be used ("recycled") to fund research and development in clean energy technologies, subsidize business expenditures on mitigation, and reduce various taxes. However, the impacts of recycling those revenues are not included in the simulation below.

The economy-wide simulation (excluding the Agriculture, Forestry, and Waste Management [AFW] sectoral) results, including both the free granting case and the auction case, with the three alternative MGA 2020 GHG reduction goals and the three alternative MCAC 2025 goals, are presented in Tables G-A1-1 to G-A1-12. The power sector-only C&T simulation results are presented in Tables G-A1-13 to G-A1-24.

In each results table for the free granting case, the second column shows the mitigation cost for each partner to achieve the reduction target before it enters the C&T Program—i.e., the cost of each state's own mitigation activities to achieve the reduction goal. Negative numbers in this column indicate overall cost savings for a given state. Columns 3 to 5 show the mitigation cost, trading cost, and net cost (the sum of the mitigation and trading costs) after the partners enter the C&T Program. Partners with relatively high mitigation costs will accomplish only part of their reduction obligation through their own mitigation activities, and will cover their remaining obligations by purchasing permits in the market. Partners with relatively low costs will have the incentive to mitigate more than their reduction targets indicate, so that they can sell their surplus permits to other partners at a profit. In the Trading Cost column, negative numbers represent revenues from the sale of permits. Column 6, Cost Saving, presents the difference in the net cost before and after permit trading. Columns 7 and 8 show the permits purchased/sold by each partner and the emissions reduced by in-state mitigation activities in millions of metric tons of carbon dioxide equivalent ($MMtCO_2e$). Finally, columns 9 and 10 compare the emission reductions in percentage terms with and without trading, respectively, for each partner.

In each results table of the auction case, the second column shows the business as usual (BAU) emissions level in the target year. Columns 3 and 4 present the emission reductions undertaken by the partners in both percentage and quantity terms. Column 5 presents the emission allowances the partners choose to purchase from the auctioneer (which is the difference between the numbers in column 2 and the numbers in column 4). Column 6 indicates the auction payment for each partner (or the auction revenue collected by the government), which is the product of the numbers in columns 5 and the price of allowances. Column 7 presents the mitigation cost. The last column shows the total net expenditure, which is the sum of the auction payment (column 6) and the mitigation cost (column 7). Note that the auction cost is not a real resource cost (i.e., resources are not being used up), but is rather a transfer from emitters to the government.

Following the simulation results tables, the basic data used in the simulation are summarized. These data tables present the 2020 (or 2025) baseline emissions, the emission budget (capped emissions), the reduction target in percentage terms relative to the 2020 (or 2025) baseline level of the C&T covered sectors, and the internal marginal mitigation cost level for each state/province to meet the emission budget.

Figures G-A1-1 and G-A1-2 show the 2020 and 2025 economy-wide (excluding AFW) marginal cost curves for all the states and province included in this study. Figures G-A1-3 and G-A1-4 show the 2020 and 2025 marginal cost curves of the power sector. This annex presents in detail how we developed the 2025 marginal cost curves for Michigan.

Summarizing the findings from the C&T simulations:

- The factors that have the greatest influence on all simulations are the absolute and relative levels of the marginal mitigation cost curves. The former has the greatest influence on the potential for cost savings, while the latter has the greatest influence on the extent of permit trading across trading states/provinces, including whether each state/province is a permit buyer or seller.
- For some of the MGA partners, the total net cost of achieving the carbon emission caps under the C&T Program is negative. This means that compliance with the caps will result in overall cost savings. In some cases, this result is due to the existence of an extensive range of cost-saving options, such as improvements in energy efficiency. In other cases, this happens to the permit selling partners, which indicates that the revenue the sellers gain in the permit market more than offsets the costs they spend on mitigation activities.
- In general, the power sector-only C&T simulations yield lower equilibrium permit prices than the economy-wide (excluding AFW) C&T simulations. This is mainly because, in the power sector-only analysis, all mitigation options that contribute to the emission reductions from electric power generation are counted, including not only those designed directly for the electricity supply sector, but also those in the residential, commercial, and industrial (RCI) sectors that contribute to the reduction of electricity consumption. Please note although we include both the supply-side and demand-side options in the power sector mitigation cost curve, the MCAC and MGA reduction goals are only applied to the total emissions from the power sector in the power sector-only runs—i.e., the power sector does not have the obligation to reduce emissions generated from the other economic sectors.
- In the C&T simulations for the MGA goals, the permit prices in the trading market are \$21.23/tCO_2e, \$35.35/tCO_2e, and \$50.82/tCO_2e for the economy-wide (excluding AFW) runs, respectively, corresponding to the 15%, 20%, and 25% reduction goals below 2005 levels for 2020. The permit prices for the power sector-only runs are \$13.25/tCO_2e, \$17.25/tCO_2e, and \$22.24/tCO_2e, respectively.
- The MCAC GHG reduction goals are much more stringent compared with the MGA goals. In the simulations for the MCAC goals, with the GHG reduction target increases from 25%, to 30%, and to 35% below the 2002 level, the equilibrium permit price in the trading market increases from \$74.99/tCO_2e to \$93.25/tCO_2e, and to \$113.52/tCO_2e, correspondingly, in the economy-wide (excluding AFW) C&T simulations; and increases from \$38.34/tCO_2e to \$49.03/tCO_2e, and to \$62.39/tCO_2e, correspondingly, in the power sector-only C&T simulations.
- In the economy-wide simulation cases with the MGA reduction goals, Michigan is the biggest permit seller in the market in the first simulation, and the second-biggest seller in the second and third simulations. In the power sector-only simulations, Michigan is the biggest seller in the first simulation, and third-biggest seller in the second and third simulations. Minnesota is the biggest permit purchaser in the market, followed by Wisconsin.
- In the economy-wide simulation cases with the MCAC reduction goals, Michigan is the second-biggest permit seller in the first simulation, and third-biggest seller in the second and third simulations; while in the power sector-only simulations, Michigan is the third-biggest permit seller in all runs. In all the cases, Kansas is the biggest seller. Minnesota is again the biggest permit buyer in the market, followed by Wisconsin.

- In all the simulation cases, if we compare the net cost for each state/province after trading with the before-trading mitigation cost, we find that all states/province are better off as a result of participating in trading, since all the post-trading net costs are smaller than the pre-trading net costs. The gains from trading are shown in the Cost Saving column in the result tables. Compared with the pre-trading situation, Michigan can achieve cost savings of $187–$207 million in 2020 in the economy-wide C&T Program following the MGA reduction goals; and $69–$157 million in the power sector-only C&T Program. Michigan can reduce its net costs (mitigation cost plus permit sales revenue) and achieve savings of $344–$394 million in 2025 in the economy-wide (excluding AFW) C&T Program following the MCAC reduction goals, and $70–$115 million in the power sector-only C&T Program.

In the auction cases, there would be no permit trading among states. In equilibrium, each state would choose to mitigate the same level of emission as it would in a permit trading market, but each partner would buy allowances for its remaining emissions from the auctioneer. The auction price would be the same level as the equilibrium price in a permit trading market. For the economy-wide program, the auction payments range from $16.35 to $34.54 billion in the MGA goal simulations, and from $49.24 to $64.61 billion in the MCAC goal simulations. For the power sector-only program, the auction payments range from $4.20 to $6.22 billion in the MGA goal simulations, and from $9.97 to $14.06 billion in the MCAC goal simulations. These auction costs are not real resource costs to society, but are simply transfer payments from one entity to another. Our analysis does not include the impacts of recycling the auction revenues through government investment in new efficiency technologies, direct efficiency investments, tax relief, or other measures.

Economy-wide Cap-and-Trade Simulations

Table G-A1-1. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2020

(With MGA goal **15% below 2005** levels by 2020, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	–$397	–$289	–$144	–$432	$36	–6.77	41.33	37.44	31.31
IL	–$2,401	–$2,317	–$96	–$2,413	$12	–4.55	89.46	30.15	28.62
KS	–$237	–$76	–$259	–$334	$98	–12.18	39.60	40.07	27.75
MB	–$79	–$200	$47	–$153	$74	2.23	4.98	29.15	42.20
MI	**–$2,263**	**–$2,085**	**–$385**	**–$2,470**	**$207**	**–18.13**	**81.95**	**31.28**	**24.36**
MN	$604	–$1,006	$444	–$562	$1,166	20.93	25.62	16.57	30.11
WI	$345	–$1,013	$392	–$621	$966	18.46	24.83	17.93	31.27
Total	**–$4,427**	**–$6,985**	**$0**	**–$6,985**	**$2,558**	**37.08[b]**	**307.77**	**28.55**	**28.55**

[a] Permit price = $21.23/tCO_2e$.

[b] Represents number of permits bought or sold.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-2. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2020

(With MGA goal **15% below 2005** levels by 2020, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought from Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	110.39	37.44	41.33	69.06	$1,466	–$289	$1,177
IL	296.69	30.15	89.46	207.23	$4,400	–$2,317	$2,083
KS	98.82	40.07	39.60	59.22	$1,257	–$$76	$1,181
MB	17.09	29.15	4.98	12.11	$257	–$200	$57
MI	**261.99**	**31.28**	**81.95**	**180.04**	**$3,822**	**–$2,085**	**$1,738**
MN	154.59	16.57	25.62	128.97	$2,738	–$1,006	$1,732
WI	138.44	17.93	24.83	113.61	$2,412	–$1,013	$1,399
Total	**1,078.01**	**28.55**	**307.77**	**770.24**	**$16,352**	**–$6,985**	**$9,367**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as in a permit trading market.

[b] The auction price would be the same level ($21.23/tCO_2e$) as the equilibrium price in a permit trading market.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-3. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2020

(With MGA goal **20% below 2005** levels by 2020, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	–$334	–$58	–$371	–$429	$96	–10.51	49.53	44.87	35.35
IL	–$2,111	–$1,993	–$126	–$2,119	$8	–3.55	100.93	34.02	32.82
KS	–$202	$183	–$608	–$425	$222	–17.20	48.83	49.41	32.00
MB	–$21	–$186	$82	–$104	$84	2.32	5.48	32.05	45.60
MI	**–$2,195**	**–$1,788**	**–$601**	**–$2,389**	**$193**	**–17.00**	**92.48**	**35.30**	**28.81**
MN	$1,592	–$928	$866	–$61	$1,653	24.51	28.40	18.37	34.22
WI	$1,168	–$939	$758	–$181	$1,349	21.45	27.44	19.82	35.31
Total	**–$2,102**	**–$5,708**	**$0**	**–$5,708**	**$3,606**	**44.71[b]**	**353.08**	**32.75**	**32.75**

[a] Permit price = $35.35/t$CO_2$e.

[b] Represents number of permits bought or sold.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MGA = Midwestern Governors Association; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table G-A1-4. Economy-wide (excluding AFW) cap-and-trade simulation among MGA partners in 2020

(with MGA goal **20% below 2005** levels by 2020, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	110.39	44.87	49.53	60.86	$2,151	–$58	$2,093
IL	296.69	34.02	100.93	195.76	$6,920	–$1,993	$4,927
KS	98.82	49.41	48.83	49.99	$1,767	$183	$1,951
MB	17.09	32.05	5.48	11.61	$410	–$186	$224
MI	**261.99**	**35.30**	**92.48**	**169.51**	**$5,992**	**–$1,788**	**$4,205**
MN	154.59	18.37	28.40	126.19	$4,461	–$928	$3,533
WI	138.44	19.82	27.44	111.00	$3,924	–$939	$2,985
Total	**1,078.01**	**32.75**	**353.08**	**724.93**	**$25,626**	**–$5,708**	**$19,918**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($33.35/t$CO_2$e) as the equilibrium price in a permit trading market.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MGA = Midwestern Governors Association; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table G-A1-5. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2020

(With MGA goal **25% below 2005** levels by 2020, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	–$239	$280	–$708	–$428	$188	–13.93	57.41	52.01	39.39
IL	–$1,627	–$1,483	–$149	–$1,633	$6	–2.94	112.77	38.01	37.02
KS	–$146	$546	–$1,091	–$545	$399	–21.48	57.30	57.98	36.25
MB	$50	–$164	$121	–4$3	$93	2.38	6.00	35.10	49.00
MI	**–$1,957**	**–$1,322**	**–$822**	**–$2,144**	**$187**	**–16.18**	**103.32**	**39.44**	**33.26**
MN	$2,837	–$800	$1,417	$617	$2,220	27.88	31.37	20.29	38.33
WI	$2,207	–$819	$1,233	$414	$1,793	24.26	30.23	21.83	39.36
Total	**$1,125**	**–$3,761**	**$0**	**–$3,761**	**$4,886**	**51.58[b]**	**398.40**	**36.96**	**36.96**

[a] Permit price = $50.82/tCO_2e$.

[b] Represents number of permits bought or sold.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-6. Economy-wide (excluding AFW) cap-and-trade simulation among MGA partners in 2020

(With MGA goal **25% below 2005** levels by 2020, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	110.39	52.01	57.41	52.98	$2,693	$280	$2,973
IL	296.69	38.01	112.77	183.92	$9,347	–$1,483	$7,863
KS	98.82	57.98	57.30	41.52	$2,110	$546	$2,656
MB	17.09	35.10	6.00	11.09	$564	–$164	$400
MI	**261.99**	**39.44**	**103.32**	**158.67**	**$8,064**	**–$1,322**	**$6,742**
MN	154.59	20.29	31.37	123.22	$6,262	–$800	$5,462
WI	138.44	21.83	30.23	108.21	$5,499	–$819	$4,680
Total	**1,078.01**	**36.96**	**398.40**	**679.61**	**$34,538**	**–$3,761**	**$30,777**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($50.82/tCO_2e$) as the equilibrium price in a permit trading market.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Data table G-A1-D1

(Economy-wide C&T with MGA goal 15%, 20%, and 25% below 2005 levels by 2020)

State/ Province	2020 BAU Gross Emissions of the C&T Covered Sectors (Consumption-based) ($MMtCO_2e$)	Emissions Cap for the C&T Covered Sectors in 2020 ($MMtCO_2e$)			GHG Mitigation Goal in 2020 (relative to BAU emissions)			Autarkic Marginal Mitigation Cost ($\$/tCO_2e$)		
		15% below 2005	20% below 2005	25% below 2005	15% below 2005	20% below 2005	25% below 2005	15% below 2005	20% below 2005	25% below 2005
IA	110.4	75.8	71.4	66.9	31.31%	35.35%	39.39%	10.8	17.6	24.8
IL	296.7	211.8	199.3	186.9	28.62%	32.82%	37.02%	15.9	30.9	46.9
KS	98.8	71.4	67.2	63.0	27.75%	32.00%	36.25%	5.6	10.7	16.1
MB	17.1	9.9	9.3	8.7	42.20%	45.60%	49.00%	89.9	110.3	132.1
MI	**262.0**	**198.2**	**186.5**	**174.9**	**24.36%**	**28.81%**	**33.26%**	**–1.2**	**13.0**	**28.1**
MN	154.6	108.0	101.7	95.3	30.11%	34.22%	38.33%	136.0	175.3	217.2
WI	138.4	95.1	89.6	84.0	31.27%	35.31%	39.36%	129.0	165.8	205.1
Total	**1,078.0**	**770.2**	**724.9**	**679.6**	**28.55%**	**32.75%**	**36.96%**			

BAU = business as usual; C&T = cap and trade; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric tons of carbon dioxide equivalent.

Table G-A1-7. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2025

(With MCAC goal **25% below 2002** levels by 2025, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2e$)	($MMtCO_2e$)	(percent from BAU)	(percent from BAU)
IA	–$240	$817	–$1,501	–$684	$444	–20.02	73.71	61.89	45.08
IL	–$843	–$710	–$135	–$845	$2	–1.80	136.89	43.32	42.75
KS	–$200	$1,086	–$2,124	–$1,038	$838	–28.33	72.62	68.39	41.71
MB	$156	–$188	$215	$27	$129	2.87	8.30	41.75	56.18
MI	**–$1,885**	**–$631**	**–$1,597**	**–$2,229**	**$344**	**–21.30**	**126.56**	**46.05**	**38.30**
MN	$6,226	–$686	$2,830	$2,144	$4,082	37.74	39.53	23.72	46.37
WI	$4,461	–$736	$2,313	$1,577	$2,883	30.85	38.18	25.48	46.07
Total	**$7,675**	**–$1,047**	**$0**	**–$1,047**	**$8,722**	**69.65[b]**	**495.79**	**43.02**	**43.02**

[a] Permit price = $74.99/$tCO_2e$.

[b] Represents number of permits bought or sold.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-8. Economy-wide (excluding AFW) cap-and-trade simulation among MGA partners in 2025

(With MCAC goal **25% below 2002** levels by 2025, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	119.11	61.89	73.71	45.40	$3,404	$817	$4,222
IL	315.98	43.32	136.89	179.09	$13,430	–$710	$12,721
KS	106.19	68.39	72.62	33.57	$2,517	$1,086	$3,604
MB	19.88	41.75	8.30	11.58	$868	–$188	$680
MI	**274.82**	**46.05**	**126.56**	**148.26**	**$11,118**	**–$631**	**$10,487**
MN	166.64	23.72	39.53	127.11	$9,532	–$686	$8,846
WI	149.82	25.48	38.18	111.64	$8,372	–$736	$7,636
Total	**1,152.44**	**43.02**	**495.79**	**656.65**	**$49,243**	**–$1,047**	**$48,196**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($74.99/t$CO_2$e) as the equilibrium price in a permit trading market.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table G-A1-9. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2025

(With MCAC goal **30% below 2002** levels by 2025, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	–$78	$1,379	–$2,085	–$706	$627	–22.36	80.41	67.51	48.74
IL	$135	$318	–$186	$132	3	–2.00	149.12	47.19	46.56
KS	–$100	$1,615	–$2,845	–$1,231	$1,131	–30.51	78.93	74.33	45.59
MB	$261	–$136	$264	$128	$133	2.83	8.92	44.87	59.11
MI	**–$1,304**	**$299**	**–$1,966**	**–$1,667**	**$363**	**–21.08**	**137.64**	**50.08**	**42.41**
MN	$8,172	–$391	$3,747	$3,356	$4,816	40.18	43.04	25.83	49.94
WI	$6,043	–$459	$3,073	$2,613	$3,430	32.95	41.46	27.68	49.67
Total	**$13,129**	**$2,626**	**$0**	**$2,626**	**$10,503**	**73.96[b]**	**539.52**	**46.82**	**46.82**

[a] Permit price = $93.25/t$CO_2$e.

[b] Represents number of permits bought or sold.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table G-A1-10. Economy-wide (excluding AFW) cap-and-trade simulation among MGA partners in 2025

(With MCAC goal **30% below 2002** levels by 2025, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	119.11	67.51	80.41	38.70	$3,608	$1,379	$4,988
IL	315.98	47.19	149.12	166.86	$15,560	$318	$15,878
KS	106.19	74.33	78.93	27.26	$2,542	$1,615	$4,157
MB	19.88	44.87	8.92	10.96	$1,022	–$136	$886
MI	**274.82**	**50.08**	**137.64**	**137.18**	**$12,792**	**$299**	**$13,092**
MN	166.64	25.83	43.04	123.60	$11,525	–$391	$11,134
WI	149.82	27.68	41.46	108.36	$10,104	–$459	$9,645
Total	**1,152.44**	**46.82**	**539.52**	**612.92**	**$57,154**	**$2,626**	**$59,780**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($93.25/tCO_2e$) as the equilibrium price in a permit trading market.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-11. Economy-wide (excluding AFW) emission trading simulation among MGA partners in 2025

(With MCAC goal **35% below 2002** levels by 2025, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$119	$2,027	–$2,757	–$730	$849	–24.29	86.70	72.79	52.40
IL	$1,337	$1,620	–$287	$1,332	$5	–2.53	161.72	51.18	50.38
KS	$26	$2,194	–$3,633	–$1,440	$1,465	–32.01	84.55	79.62	49.48
MB	$380	–$69	$313	$245	$135	2.76	9.57	48.14	62.03
MI	**–$531**	**$1,469**	**–$2,394**	**–$925**	**$394**	**–21.09**	**148.97**	**54.20**	**46.53**
MN	$10,401	$0	$4,809	$4,809	$5,592	42.36	46.82	28.10	53.52
WI	$7,856	–$94	$3,950	$3,856	$4,000	34.79	45.00	30.04	53.26
Total	**$19,589**	**$7,147**	**$0**	**$7,147**	**$12,442**	**77.38[b]**	**583.33**	**50.62**	**50.62**

[a] Permit price = $113.52/tCO_2e$.

[b] Represents number of permits bought or sold.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-12. Economy-wide (excluding AFW) cap-and-trade simulation among MGA partners in 2025

(With MCAC goal **35% below 2002** levels by 2025, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	119.11	72.79	86.70	32.41	$3,679	$2,027	$5,706
IL	315.98	51.18	161.72	154.26	$17,511	$1,620	$19,131
KS	106.19	79.62	84.55	21.64	$2,457	$2,194	$4,650
MB	19.88	48.14	9.57	10.31	$1,170	–$69	$1,102
MI	**274.82**	**54.20**	**148.97**	**125.85**	**$14,287**	**$1,469**	**$15,756**
MN	166.64	28.10	46.82	119.82	$13,602	$0	$13,601
WI	149.82	30.04	45.00	104.82	$11,899	–$94	$11,805
Total	**1,152.44**	**50.62**	**583.33**	**569.11**	**$64,605**	**$7,147**	**$71,752**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($113.52/$tCO_2e$) as the equilibrium price in a permit trading market.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Data table G-A1-D2

(Economy-wide C&T with MCAC goal 25%, 30%, and 35% below 2002 levels by 2025)

State/ Province	2025 BAU Gross Emissions of the C&T Covered Sectors (Consumption-based) ($MMtCO_2e$)	Emissions Cap for the C&T Covered Sectors in 2025 ($MMtCO_2e$)			GHG Mitigation Goal in 2025 (relative to BAU emissions)			Autarkic Marginal Mitigation Cost ($/$tCO_2e$)		
		25% below 2002	30% below 2002	35% below 2002	25% below 2002	30% below 2002	35% below 2002	25% below 2002	30% below 2002	35% below 2002
IA	119.1	65.4	61.1	56.7	45.08%	48.74%	52.40%	33.2	41.1	49.6
IL	316.0	180.9	168.9	156.8	42.75%	46.56%	50.38%	72.4	90.2	109.3
KS	106.2	61.9	57.8	53.6	41.71%	45.59%	49.48%	21.3	27.3	33.8
MB	19.9	8.7	8.1	7.5	56.18%	59.11%	62.03%	169.3	192.3	216.8
MI	**274.8**	**169.6**	**158.3**	**146.9**	**38.30%**	**42.41%**	**46.53%**	**43.4**	**59.6**	**77.1**
MN	166.6	89.4	83.4	77.5	46.37%	49.94%	53.52%	304.8	349.8	398.2
WI	149.8	80.8	75.4	70.0	46.07%	49.67%	53.26%	272.6	314.8	360.0
Total	**1,152.4**	**656.7**	**612.9**	**569.1**	**43.02%**	**46.82%**	**50.62%**			

BAU = business as usual; C&T = cap and trade; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric tons of carbon dioxide equivalent.

Power Sector-Only Cap-and-Trade Simulations

Table G-A1-13. Power sector emission trading simulation among MGA partners in 2020

(With MGA goal **15% below 2005** levels by 2020, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$80	$181	–$123	$57	$22	–9.30	21.90	47.13	27.11
IL	–$885	–$947	$50	–$897	$12	3.75	46.95	36.47	39.38
KS	$103	$176	–$82	$94	$9	–6.18	18.52	38.10	25.38
MB	–$38	–$50	–$3	–$53	$15	–0.22	0.57	94.89	57.50
MI	**–$919**	**–$898**	**–$179**	**–$1,076**	**$157**	**–13.48**	**43.89**	**38.98**	**27.01**
MN	$635	–$509	$186	–$322	$957	14.07	12.74	17.05	35.89
WI	$326	–$518	$151	–$367	$693	11.37	12.18	19.72	38.13
Total	**–$700**	**–$2,565**	**$0**	**–$2,565**	**$1,865**	**29.19**[b]	**156.75**	**33.11**	**33.11**

[a] Permit price = $13.25/tCO_2e.

[b] Represents number of permits bought or sold.

BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-14. Power sector emission trading simulation among MGA partners in 2020

(With MGA goal **15% below 2005** levels by 2020, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	46.47	47.13	21.90	24.57	$326	$181	$506
IL	128.76	36.47	46.95	81.81	$1,084	–$947	$137
KS	48.62	38.10	18.52	30.10	$399	$176	$575
MB	0.60	94.89	0.57	0.03	$0	–$50	–$50
MI	**112.57**	**38.98**	**43.89**	**68.68**	**$910**	**–$898**	**$12**
MN	74.68	17.05	12.74	61.94	$821	–$509	$312
WI	61.77	19.72	12.18	49.59	$657	–$518	$139
Total	**473.47**	**33.11**	**156.75**	**316.72**	**$4,197**	**–$2,565**	**$1,631**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($13.25/tCO_2e) as the equilibrium price in a permit trading market.

BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-15. Power sector emission trading simulation among MGA partners in 2020

(With MGA goal **20% below 2005** levels by 2020, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$98	$272	–$230	$42	$56	–13.34	27.93	60.10	31.40
IL	–$776	–$911	$103	–$808	$32	5.99	49.30	38.29	42.94
KS	$126	$286	–$195	$91	$35	–11.30	25.77	53.00	29.77
MB	–$40	–$50	–$4	–$54	$14	–0.21	0.57	95.30	60.00
MI	**–$946**	**–$865**	**–$186**	**–$1,051**	**$105**	**–10.79**	**46.03**	**40.89**	**31.30**
MN	$1,119	–$502	$284	–$218	$1,337	16.44	13.18	17.65	39.66
WI	$676	–$512	$228	–$284	$960	13.21	12.59	20.38	41.77
Total	**$256**	**–$2,283**	**$0**	**–$2,283**	**$2,539**	**35.64[b]**	**175.37**	**37.04**	**37.04**

[a] Permit price = $17.25/t$CO_2$e.

[b] Represents number of permits bought or sold.

BAU = business as usual; MGA = Midwestern Governors Association; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table G-A1-16. Power sector emission trading simulation among MGA partners in 2020

(With MGA goal **20% below 2005** levels by 2020, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	46.47	60.10	27.93	18.54	$320	$272	$592
IL	128.76	38.29	49.30	79.46	$1,371	–$911	$459
KS	48.62	53.00	25.77	22.85	$394	$286	$680
MB	0.60	95.30	0.57	0.03	$0	–$50	–$50
MI	**112.57**	**40.89**	**46.03**	**66.54**	**$1,148**	**–$865**	**–$283**
MN	74.68	17.65	13.18	61.50	$1,061	–$502	$559
WI	61.77	20.38	12.59	49.18	$848	–$512	$337
Total	**473.47**	**37.04**	**175.37**	**298.10**	**$5,142**	**–$2,283**	**$2,860**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($17.25/t$CO_2$e) as the equilibrium price in a permit trading market.

BAU = business as usual; MGA = Midwestern Governors Association; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table G-A1-17. Power sector emission trading simulation among MGA partners in 2020

(With MGA goal **25% below 2005** levels by 2020, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$118	$380	–$375	$5	$113	–16.84	33.43	71.93	35.69
IL	–$628	–$855	$172	–$683	$55	7.74	52.15	40.50	46.51
KS	$151	$416	–$352	$64	$87	–15.82	32.43	66.69	34.16
MB	–$41	–$50	–$4	–$55	$14	–0.20	0.57	95.77	62.50
MI	**–$935**	**–$814**	**–$190**	**–$1,004**	**$69**	**–8.54**	**48.61**	**43.18**	**35.60**
MN	$1,700	–$491	$416	–$75	$1,775	18.70	13.74	18.39	43.43
WI	$1,094	–$502	$333	–$169	$1,263	14.96	13.09	21.18	45.41
Total	**$1,460**	**–$1,916**	**$0**	**–$1,916**	**$3,376**	**41.40[b]**	**194.01**	**40.98**	**40.98**

[a] Permit price = $22.24/tCO_2e.

[b] Represents number of permits bought or sold.

BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-18. Power sector emission trading simulation among MGA partners in 2020

(With MGA goal **25% below 2005** levels by 2020, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	46.47	71.93	33.43	13.04	$290	$380	$670
IL	128.76	40.50	52.15	76.61	$1,704	–$855	$849
KS	48.62	66.69	32.43	16.19	$360	$416	$776
MB	0.60	95.77	0.57	0.03	$1	–$50	–$50
MI	**112.57**	**43.18**	**48.61**	**63.96**	**$1,422**	**–$814**	**$608**
MN	74.68	18.39	13.74	60.94	$1,355	–$491	$865
WI	61.77	21.18	13.09	48.68	$1,083	–$502	$581
Total	**473.47**	**40.98**	**194.01**	**279.46**	**$6,215**	**–$1,916**	**$4,299**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($22.24/tCO_2e) as the equilibrium price in a permit trading market.

BAU = business as usual; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Data table G-A1-D3

(Power sector C&T with MGA goal 15%, 20%, and 25% below 2005 levels by 2020)

State/ Province	2020 BAU Gross Emissions of the C&T Covered Sectors (Consumption-based) ($MMtCO_2e$)	Emissions Cap for the C&T Covered Sectors in 2020 ($MMtCO_2e$)			GHG Mitigation Goal in 2020 (relative to BAU emissions)			Autarkic Marginal Mitigation Cost ($\$/tCO_2e$)		
		15% below 2005	20% below 2005	25% below 2005	15% below 2005	20% below 2005	25% below 2005	15% below 2005	20% below 2005	25% below 2005
IA	46.5	33.9	31.9	29.9	27.11%	31.40%	35.69%	8.7	9.6	10.5
IL	128.8	78.1	73.5	68.9	39.38%	42.94%	46.51%	19.7	28.0	36.8
KS	48.6	36.3	34.1	32.0	25.38%	29.77%	34.16%	10.5	11.4	12.4
MB	0.6	0.3	0.2	0.2	57.50%	60.00%	62.50%	–87.9	–85.0	–81.9
MI	**112.6**	**82.2**	**77.3**	**72.5**	**27.01%**	**31.30%**	**35.60%**	**–9.3**	**–1.7**	**6.4**
MN	74.7	47.9	45.1	42.2	35.89%	39.66%	43.43%	155.4	188.8	224.4
WI	61.8	38.2	36.0	33.7	38.13%	41.77%	45.41%	140.8	170.5	202.1
Total	**473.5**	**316.7**	**298.1**	**279.5**	**33.11%**	**37.04%**	**40.98%**			

BAU = business as usual; C&T = cap and trade; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric tons of carbon dioxide equivalent.

Table G-A1-19. Power sector emission trading simulation among MGA partners in 2025

(With MCAC goal **25% below 2002** levels by 2025, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$116	$604	–$962	–$358	$474	–25.09	47.52	92.60	43.72
IL	–$190	–$747	$434	–$314	$123	11.31	68.47	47.49	55.34
KS	$155	$692	–$986	–$295	$450	–25.72	47.86	91.06	42.12
MB	–$57	–$66	–$9	–$75	$17	–0.22	0.72	95.71	66.07
MI	**–$976**	**–$726**	**–$320**	**–$1,046**	**$70**	**–8.35**	**62.24**	**51.52**	**44.61**
MN	$4,413	–$561	$1,072	$511	$3,902	27.97	17.96	21.53	55.06
WI	$2,414	–$577	$771	$193	$2,220	20.10	16.92	24.65	53.92
Total	**$5,875**	**–$1,382**	**$0**	**–$1,382**	**$7,257**	**59.38**[b]	**261.70**	**50.16**	**50.16**

[a] Permit price = $38.34/$tCO_2e$.

[b] Represents number of permits bought or sold.

BAU = business as usual; MGA = Midwestern Governors Association; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-20. Power sector emission trading simulation among MGA partners in 2025

(With MCAC goal **25% below 2002** levels by 2025, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a] (percent from BAU)	($MMtCO_2$)	Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
IA	51.32	92.60	47.52	3.80	$146	$604	$749
IL	144.17	47.49	68.47	75.70	$2,902	–$747	$2,155
KS	52.56	91.06	47.86	4.70	$180	$692	$872
MB	0.75	95.71	0.72	0.03	$1	–$66	–$65
MI	**120.80**	**51.52**	**62.24**	**58.56**	**$2,245**	**–$726**	**$1,519**
MN	83.41	21.53	17.96	65.45	$2,509	–$561	$1,949
WI	68.67	24.65	16.92	51.75	$1,984	–$577	$1,406
Total	**521.68**	**50.16**	**261.70**	**259.98**	**$9,968**	**–$1,382**	**$8,586**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($38.34/tCO_2e$) as the equilibrium price in a permit trading market.

BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-21. Power sector emission trading simulation among MGA partners in 2025

(With MCAC goal **30% below 2002** levels by 2025, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Payment/ Revenue + Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$136	$690	–$1,234	–$544	$680	–25.17	49.54	96.52	47.47
IL	$91	–$502	$489	–$12	$103	9.98	74.10	51.40	58.32
KS	$179	$797	–$1,282	–$485	$664	–26.15	50.31	95.73	45.97
MB	–$59	–$66	–$10	–$76	$18	–0.21	0.72	96.44	68.33
MI	**–$859**	**–$514**	**–$429**	**–$942**	**$83**	**–8.74**	**67.10**	**55.54**	**48.31**
MN	$5,322	–$506	$1,432	$926	$4,396	29.20	19.21	23.04	58.05
WI	$3,037	–$529	$1,034	$506	$2,531	21.09	18.04	26.27	56.99
Total	**$7,847**	**–$629**	**$0**	**–$629**	**$8,475**	**60.28[b]**	**279.03**	**53.49**	**53.49**

[a] Permit price = $49.03/tonCO_2e$.

[b] Represents number of permits bought or sold.

BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-22. Power sector emission trading simulation among MGA partners in 2025

(With MCAC goal **30% below 2002** levels by 2025, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	51.32	96.52	49.54	1.78	$88	$690	$778
IL	144.17	51.40	74.10	70.07	$3,435	–$502	$2,934
KS	52.56	95.73	50.31	2.25	$110	$797	$907
MB	0.75	96.44	0.72	0.03	$1	–$66	–$65
MI	**120.80**	**55.54**	**67.10**	**53.70**	**$2,633**	**–$514**	**$2,119**
MN	83.41	23.04	19.21	64.20	$3,147	–$506	$2,641
WI	68.67	26.27	18.04	50.63	$2,482	–$529	$1,954
Total	**521.68**	**53.49**	**279.03**	**242.65**	**$11,897**	**–$629**	**$11,268**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($49.03/tCO_2e$) as the equilibrium price in a permit trading market.

BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-23. Power sector emission trading simulation among MGA partners in 2025

(With MCAC goal **35% below 2002** levels by 2025, assuming **free grant** of allowances; million dollars or otherwise specified)

State/ Province	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Payments/ Revenues[a]	Net Cost		($MMtCO_2$)	($MMtCO_2$)	(percent from BAU)	(percent from BAU)
IA	$157	$750	–$1,519	–$769	$926	–24.34	50.63	98.65	51.22
IL	$413	–$143	$487	$344	$69	7.80	80.56	55.88	61.29
KS	$205	$871	–$1,590	–$718	$923	–25.48	51.67	98.30	49.83
MB	–$60	–$66	–$12	–$78	$18	–0.20	0.73	97.18	70.59
MI	**–$703**	**–$208**	**–$611**	**–$819**	**$115**	**–9.79**	**72.61**	**60.11**	**52.00**
MN	$6,333	–$420	$1,882	$1,462	$4,871	30.17	20.75	24.88	61.05
WI	$3,733	–$453	$1,362	$910	$2,824	21.84	19.41	28.26	60.06
Total	**$10,079**	**$332**	**$0**	**$332**	**$9,747**	**59.81**[b]	**296.35**	**56.81**	**56.81**

[a] Permit price = $62.39/tCO_2e$.

[b] Represents number of permits bought or sold.

BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table G-A1-24. Power sector emission trading simulation among MGA partners in 2025

(With MCAC goal **35% below 2002** levels by 2025, assuming **auction** of allowances)

State/ Province	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by Michigan Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (million $)[b]	Mitigation Cost (million $)	Total Payments and Costs (million $)
		(percent from BAU)	($MMtCO_2$)				
IA	51.32	98.65	50.63	0.69	$43	$750	$793
IL	144.17	55.88	80.56	63.61	$3,969	–$143	$3,826
KS	52.56	98.30	51.67	0.89	$56	$871	$927
MB	0.75	97.18	0.73	0.02	$1	–$66	–$64
MI	**120.80**	**60.11**	**72.61**	**48.19**	**$3,007**	**–$208**	**$2,799**
MN	83.41	24.88	20.75	62.66	$3,909	–$420	$3,489
WI	68.67	28.26	19.41	49.26	$3,074	–$453	$2,621
Total	**521.68**	**56.81**	**296.35**	**225.33**	**$14,058**	**$332**	**$14,391**

[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

[b] The auction price would be the same level ($62.39/tCO_2e) as the equilibrium price in a permit trading market.

BAU = business as usual; MCAC = Michigan Climate Action Council; MGA = Midwestern Governors Association; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

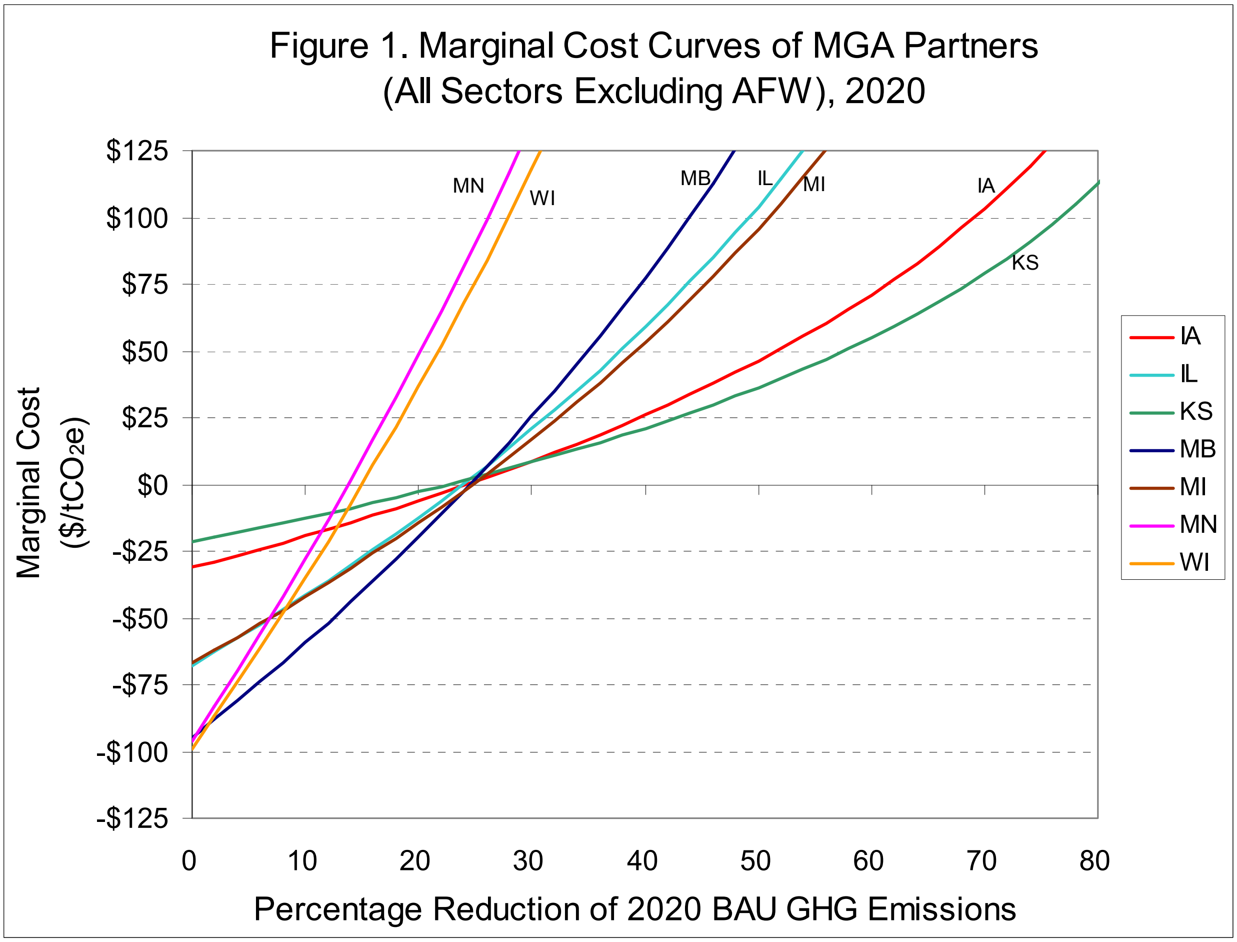
Data table D-A1-D4

(Power sector C&T with MCAC goal 25%, 30%, and 35% below 2002 levels by 2025)

State/ Province	2025 BAU Gross Emissions of the C&T Covered Sectors (Consumption-based) (million tCO_2e)	Emissions Cap for the C&T Covered Sectors in 2025 ($MMtCO_2e$)			GHG Mitigation Goal in 2025 (relative to BAU emissions)			Autarkic Marginal Mitigation Cost ($/tCO_2e$)		
		25% below 2002	30% below 2002	35% below 2002	25% below 2002	30% below 2002	35% below 2002	25% below 2002	30% below 2002	35% below 2002
IA	51.3	28.9	27.0	25.0	43.72%	47.47%	51.22%	9.6	10.6	11.7
IL	144.2	64.4	60.1	55.8	55.34%	58.32%	61.29%	60.7	70.3	80.5
KS	52.6	30.4	28.4	26.4	42.12%	45.97%	49.83%	11.3	12.3	13.4
MB	0.8	0.3	0.2	0.2	66.07%	68.33%	70.59%	-79.5	-75.6	-71.4
MI	120.8	66.9	62.4	58.0	44.61%	48.31%	52.00%	21.9	30.4	39.6
MN	83.4	37.5	35.0	32.5	55.06%	58.05%	61.05%	345.8	383.8	424.7
WI	68.7	31.6	29.5	27.4	53.92%	56.99%	60.06%	278.9	312.6	348.8
Total	**521.7**	**260.0**	**242.7**	**225.3**	**50.16%**	**53.49%**	**56.81%**			

BAU = business as usual; C&T = cap and trade; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO_2e$ = dollars per metric tons of carbon dioxide equivalent.

Figure G-A1-1. Marginal cost curves of MGA partners (all sectors, excluding AFW), 2020



Note:

1. The marginal cost curves of MN and IA are developed based on mitigation options data in the Minnesota (MN) State Climate Change Action Plan and the State Climate Change Action Plan of Iowa (IA), respectively. The marginal cost curve of Michigan (MI) is developed based on the quantification analysis results for individual mitigation options provided by the Energy Supply (ES), Residential, Commercial, and Industrial, and Transportation and Land Use Technical Work Groups.

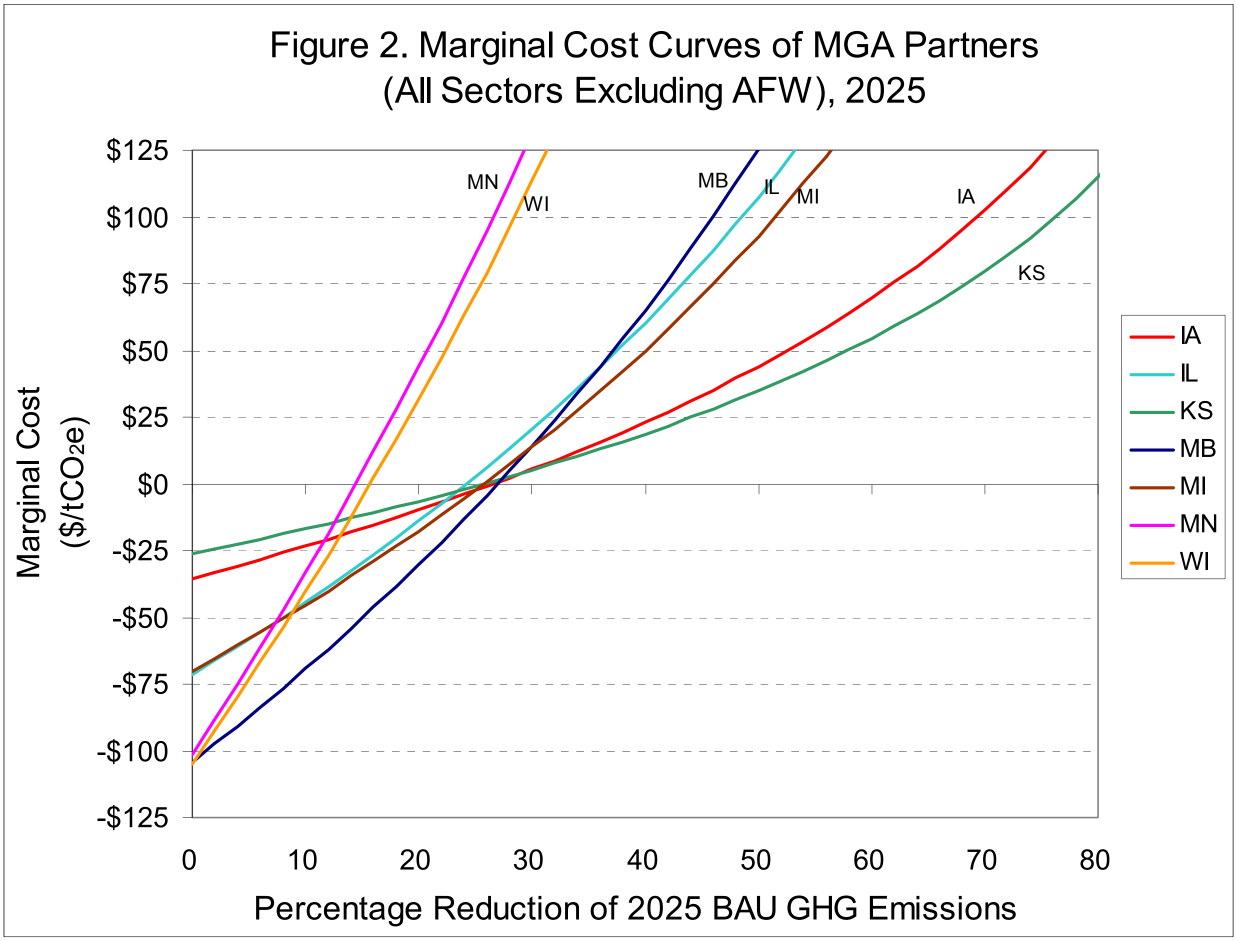
2. The quantification data for MI and MN are for 2025. The mitigation cost data for options of MI and MN are adjusted to 2020 based on the assumption of 2% annual technical improvement or innovation rate. In other words, we use the same reduction potential (in percentage terms) for individual options in 2020 as in 2025, and assume the cost per ton of CO_2e reduction would be about $(1+2\%)^5$ higher in 2020 than in 2025.

3. The marginal cost curves of Manitoba (MB) and Wisconsin (WI) are approximated based on MN data. The cost curve of Kansas (KS) is approximated based on IA data. The cost curve of Illinois (IL) is approximated based on MI data.

4. We adopted the following assumptions when we developed the cost curve for one state based on the data from one of its adjacent states. We assumed that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit of GHG removed for each option is assumed to be at the same level as that of state A. Third, the mitigation potentials of each option are assumed to be proportional to the total mitigation potential in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states. For example, if the emissions from the power sector are 50 $MMtCO_2e$ and 100 $MMtCO_2e$ in state A and state B, respectively, the mitigation potentials of the ES options for state A are multiplied by a factor of 2 (100/50 = 2) for application to state B.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; GHG = greenhouse gas; MGA = Midwestern Governors Association; $/tCO_2e = dollars per metric tons of carbon dioxide equivalent.

Figure G-A1-2. Marginal cost curves of MGA partners (all sectors, excluding AFW), 2025



Note: 1. The marginal cost curves of MN and IA are developed based on mitigation options data in the Minnesota State Climate Change Action Plan and the State Climate Change Action Plan of Iowa, respectively. The marginal cost curve of MI is developed based on the quantification analysis results for individual mitigation options provided by the ES, RCI, and TLU TWGs.

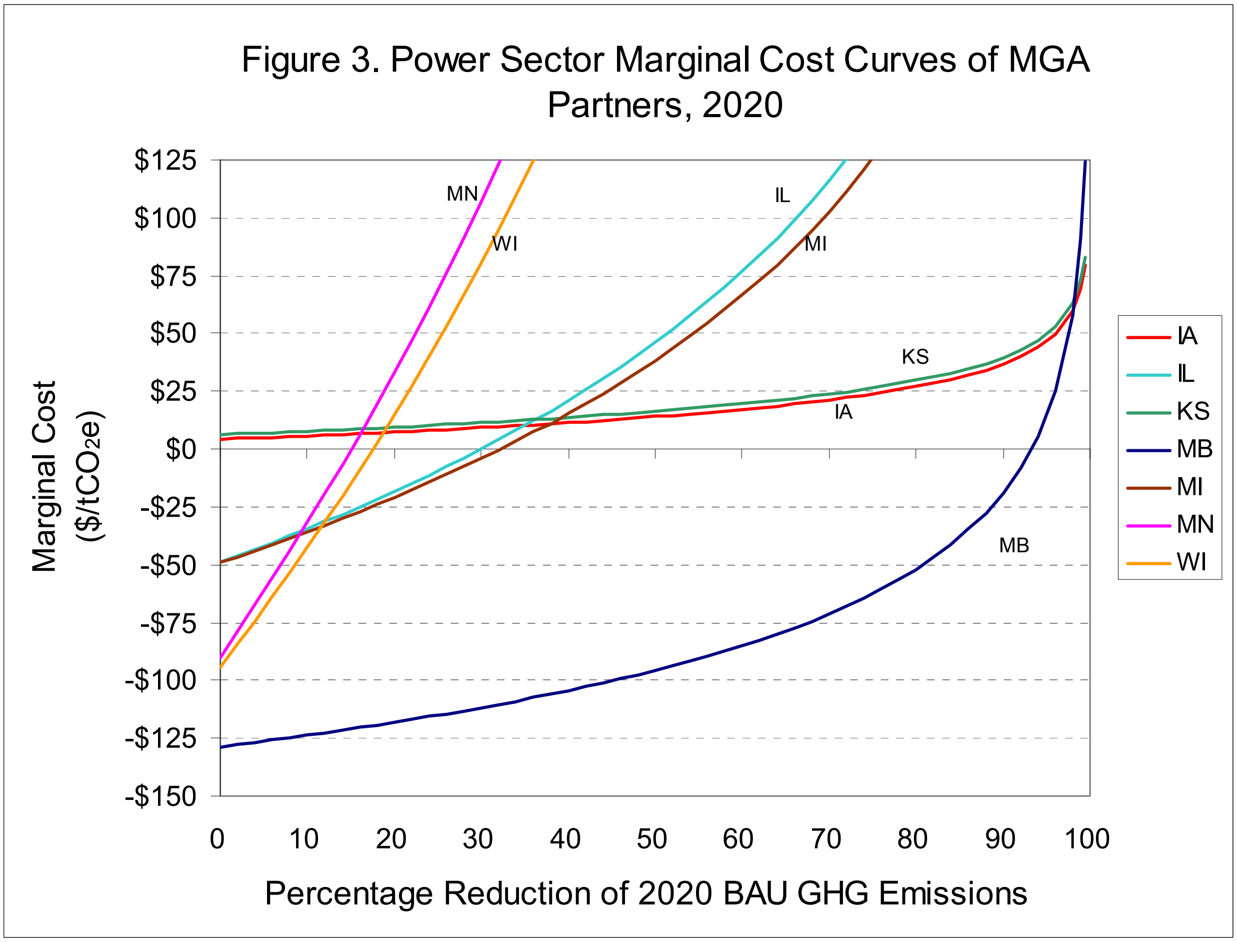
2. The quantification data for Iowa are for the Year 2020. The mitigation cost data for options of IA are adjusted to the Year 2025 based on the assumption of 2% annual technical improvement or innovation rate. In other words, we use the same reduction potential (in percentage terms) for individual options in year 2025 as in year 2020, and assumed the cost per ton of CO_2e reduction would be about $(1+2\%)^5$ lower in year 2025 than in year 2020.

3. The marginal cost curves of MB and WI are approximated based on MN data. The cost curve of KS is approximated based on IA data. The cost curve of IL is approximated based on MI data.

4. The following assumptions are adopted when we develop the cost curve for one state based on the data from one of its adjacent states. We assume that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit GHG removed for each option is assumed to be at the same level as that of state A. Third, the mitigation potentials of each option are assumed to be proportional to the total mitigation potential in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states. For example, if the emissions from the power sector are 50 MMtCO2e and 100 MMtCO2e in state A and state B, respectively, the mitigation potentials of the ES options for state A are multiplied by a factor of 2 (100/50=2) for application to state B.

AFW = agriculture, forestry, and waste management sectors; BAU = business as usual; GHG = greenhouse gas; MGA = Midwestern Governors Association; $/tCO_2e = dollars per metric tons of carbon dioxide equivalent.

Figure G-A1-3. Power sector marginal cost curves of MGA partners, 2020



Note: 1. The power sector marginal cost curves of the states are developed based on the reduction potential and mitigation cost/saving data of individual options that contribute to the emission reductions from power sector. These options not only include those designed directly for the electricity supply sector (such as promotion of renewable energy utilization, repowering existing plants, etc.), but also include options in RCI sectors that contribute to the reduction of electricity consumption (e.g., energy efficiency appliances, building codes, etc.). Also, for those options that apply to the use of both electricity and other fuel types, the emission reduction potentials are adjusted by multiplying the percentage of electricity consumption to total energy consumption in the RCI sector. RCI options that relate entirely to reduction of other fossil fuels consumption (such as gas, oil) are not included in the power sector cost curve development.

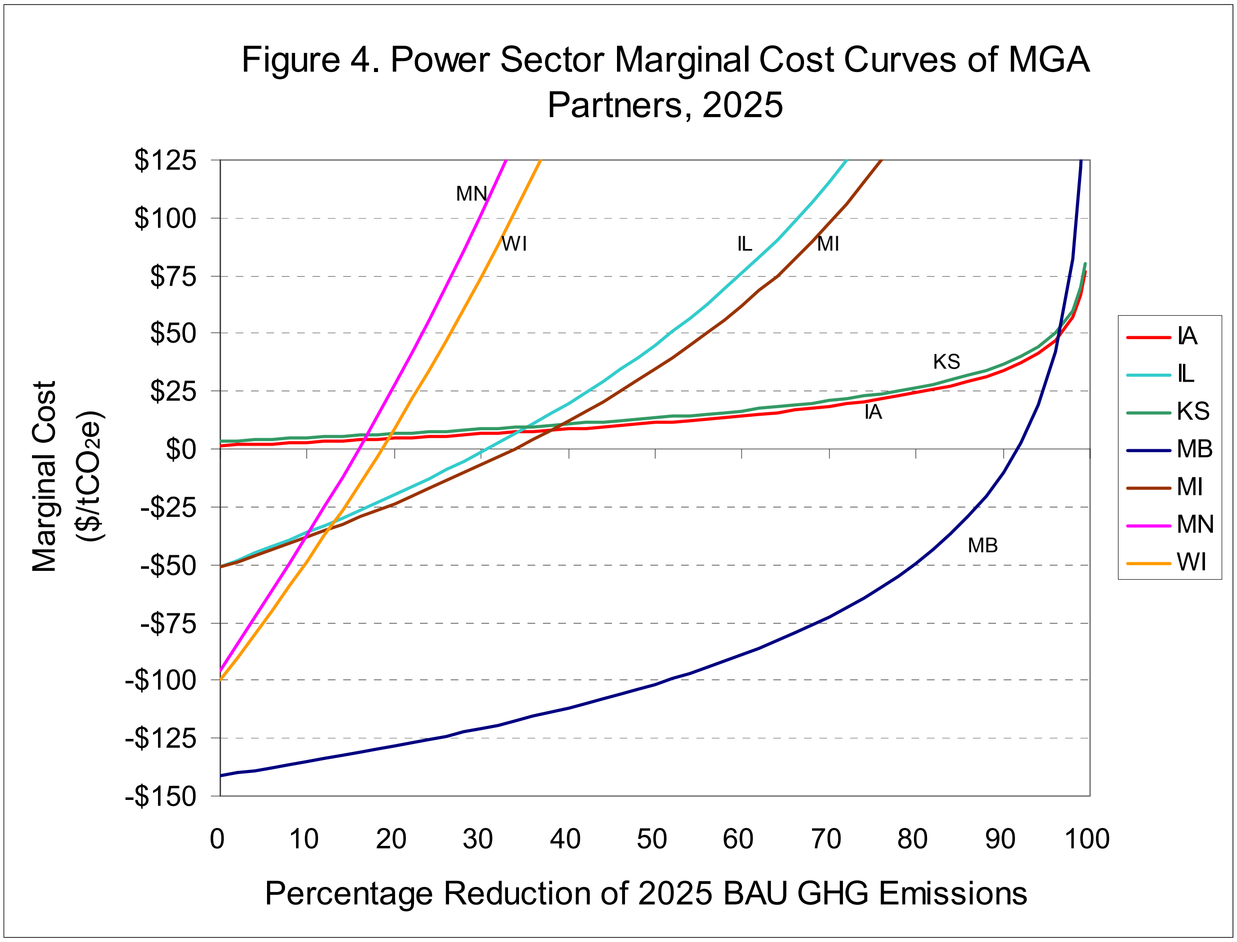
2. The marginal cost curves of MN and IA are developed based on mitigation options data in the Minnesota State Climate Change Action Plan and the State Climate Change Action Plan of Iowa, respectively. The marginal cost curve of MI is developed based on the quantification analysis results for individual mitigation options provided by the ES and RCI TWGs.

3. The marginal cost curves of MB and WI are approximated based on MN data. The cost curve of KS is approximated based on IA data. The cost curve of IL is approximated based on MI data.

4. The following assumptions are adopted when we develop the cost curve for one state based on the data from one of its adjacent states. We assume that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit GHG removed for each option is assumed to be at the same level as that of state A. Third, the mitigation potentials of each option are assumed to be proportional to the total mitigation potential in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states.

BAU = business as usual; GHG = greenhouse gas; MGA = Midwestern Governors Association; $/tCO_2e$ = dollars per metric tons of carbon dioxide equivalent.

Figure G-A1-4. Power sector marginal cost curves of MGA partners, 2025



Note: 1. The power sector marginal cost curves of the states are developed based on the reduction potential and mitigation cost/saving data of individual options that contribute to the emission reductions from power sector. These options not only include those designed directly for the electricity supply sector (such as promotion of renewable energy utilization, repowering existing plants, etc.), but also include options in RCI sectors that contribute to the reduction of electricity consumption (e.g., energy efficiency appliances, building codes, etc.). Also, for those options that apply to the use of both electricity and other fuel types, the emission reduction potentials are adjusted by multiplying the percentage of electricity consumption to total energy consumption in the RCI sector. RCI options that relate entirely to reduction of other fossil fuels consumption (such as gas, oil) are not included in the power sector cost curve development.

2. The marginal cost curves of MN and IA are developed based on mitigation options data in the Minnesota State Climate Change Action Plan and the State Climate Change Action Plan of Iowa, respectively. The marginal cost curve of MI is developed based on the quantification analysis results for individual mitigation options provided by the ES and RCI TWGs.

3. The marginal cost curves of MB and WI are approximated based on MN data. The cost curve of KS is approximated based on IA data. The cost curve of IL is approximated based on MI data.

4. The following assumptions are adopted when we develop the cost curve for one state based on the data from one of its adjacent states. We assume that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit GHG removed for each option is assumed to be at the same level as that of state A. Third, the mitigation potentials of each option are assumed to be proportional to the total mitigation potential in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states.

BAU = business as usual; GHG = greenhouse gas; MGA = Midwestern Governors Association; $/tCO_2e$ = dollars per metric tons of carbon dioxide equivalent.

References

GHG Mitigation Options Data

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Annex G-2

Development of Marginal Cost Curves for Michigan

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Economy-wide (Excluding AFW) Marginal Cost Curve

The marginal cost curve of Michigan is developed based on the reduction potential and mitigation cost/saving data of individual options that are quantitatively analyzed by the Energy Supply (ES), Residential, Commercial, and Industrial (RCI), and Transportation and Land Use (TLU) Technical Work Groups (TWGs). Table G-A2-1 presents the list of options that have been quantitatively analyzed by the TWGs.

Table G-A2-1. GHG mitigation options of Michigan (all sectors excluding AFW)

Recommendation No.	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per Ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
TLU-6	Land Use Planning and Incentives	0.430	–$189.00	0.16%	0.16%	0.38
TLU-2	Eco-Driver Program	2.200	–$176.00	0.80%	0.96%	1.96
TLU-3	Truck Idling Policies	0.760	–$85.00	0.28%	1.23%	0.68
TLU-5	Congestion Mitigation	0.180	–$81.00	0.07%	1.30%	0.16
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	9.700	–$35.00	3.53%	4.83%	8.64
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	0.000	–$31.00	0.00%	4.83%	0.00
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	53.800	–$28.00	19.58%	24.40%	47.94
ES-3	Energy Efficiency Portfolio Standard	14.600	–$19.00	5.31%	29.72%	13.01
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0.000	–$19.00	0.00%	29.72%	0.00
ES-13	Combined Heat and Power (CHP) Standards, Incentives	0.500	$4.09	0.18%	29.90%	0.45

Recommendation No.	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per Ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
	and/or Barrier Removal					
ES-11	Power Plant Replacement, EE, and Repowering	2.000	$9.40	0.73%	30.63%	1.78
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration--Co-firing at 10%	0.500	$10.70	0.18%	30.81%	0.45
TLU-1	Promote Low-Carbon Fuel Use in Transportation	5.900	$16.00	2.15%	32.96%	5.26
ES-6	New Nuclear Power	6.300	$25.98	2.29%	35.25%	5.61
RCI-6	Incentives To Promote Renewable Energy Systems Implementation	0.000	$27.00	0.00%	35.25%	0.00
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.190	$35.00	0.07%	35.32%	0.17
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	14.600	$48.00	5.31%	40.63%	13.01
TLU-7	Transit and Travel Options	0.540	$185.00	0.20%	40.83%	0.48
TLU-4	Advanced Vehicle Technology	0.030	$1,458.00	0.01%	40.84%	0.03

[1] Michigan 2025 projected consumption-based gross GHG emission level excluding the AFW sector is 274.82 $MMtCO_2e$.

Note: The emission reduction potentials shown in the table are the values after overlap adjustment (both within sectors and across sectors).

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; EE = energy efficiency; ES = Energy Supply; GHG = greenhouse gas; RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use.

In Table G-A2-1, Column 3 of the table presents the estimated 2025 annual greenhouse gas (GHG) reduction potential for each option, with reduction potentials translated into percentages of the 2025 business as usual (BAU) emissions level of the cap and trade (C&T) covered sectors in Column 5. The estimated cost or cost saving per ton of GHG removed by each option in 2025 is presented in Column 4. The options are listed in ascending order in terms of cost, beginning with the lowest-cost (including cost-savings) option. Column 6 lists the cumulative GHG reduction potentials of the policy options. The last column presents the proportion of GHG mitigation contributed by each option.

Based on the data presented in Table G-A2-1, the stepwise marginal cost function of Michigan in 2025 is first drawn in Figure G-A2-1. The horizontal axis represents the percentage of GHG emission reduction, and the vertical axis represents the marginal cost or savings of mitigation. In the figure, each horizontal segment represents an individual mitigation option. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost (saving) of reducing one metric ton of GHG with the application of the option. The figure indicates that, collectively, the reduction potential of options from all economic sectors can avoid about 40% of 2025 baseline emissions in Michigan.

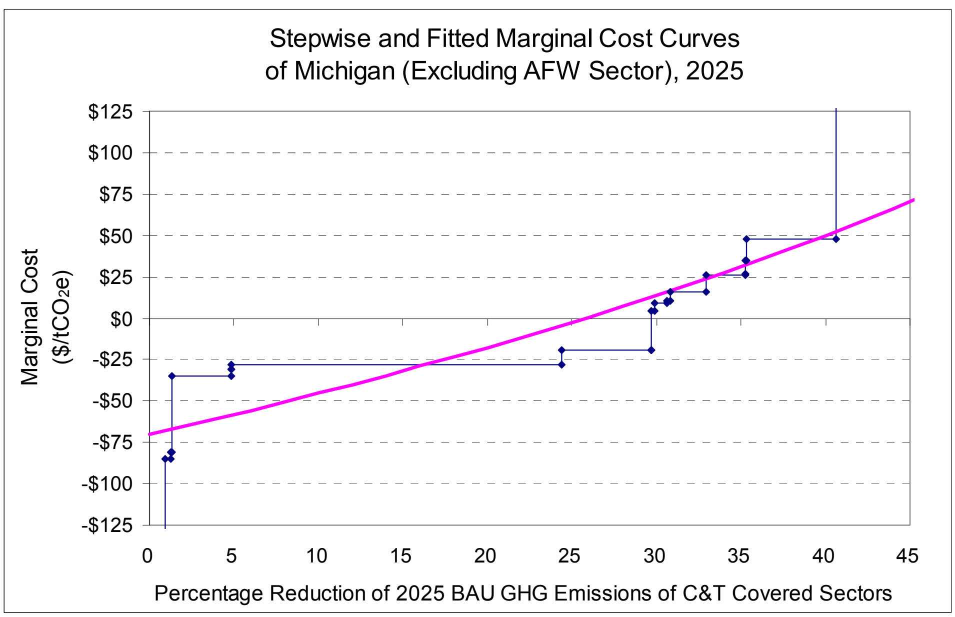
Next, we fit a smooth curve through the data using regression analysis (also see Figure G-A2-1). We weight each policy option based on its GHG mitigation potential to give relatively greater influence to options that have the potential for higher levels of application, and thereby should improve the accuracy of the estimation. This fitted curve is then used in our C&T analysis model.

The fitted curve shown in Figure G-A2-1 has the following functional form:

$$MC = a + b \times \ln(1 - R)$$

where *MC* is the marginal cost; *R* is the percentage reduction of GHG emissions; and *a* and *b* are parameters.

Figure G-A2-1. Stepwise and fitted marginal cost curve of Michigan (excluding AFW sector), 2025



AFW = Agriculture, Forestry, and Waste Management; BAU = business as usual; C&T = cap and trade; GHG = greenhouse gas.

The logarithmic functional form utilized here is consistent with theoretical expectations and empirical findings on diminishing returns of emission control (Nordhaus, 1994). As the emission reductions increase along the x-axis, the cost to reduce one additional unit of emission increases at an accelerating rate; in other words, it exhibits diminishing returns.

The economy-wide (excluding AFW) marginal cost curve of Michigan has the following specification:

$$MC = -70.13 - 235.15 \times \ln(1 - R)$$

The fitted curve has an intercept with the y-axis at MC = –$70.13. The curve increases to MC = 0 at the emission reduction level of 25.8%, which indicates that Michigan has cost-saving mitigation potentials (such as energy efficiency) up to that level of the 2025 BAU emissions of the C&T covered sectors.

Power Sector-Only Marginal Cost Curve

The policy options we used to develop the power sector marginal cost curve include not only those designed directly for the electricity supply sector, but also those in the RCI sectors that contribute to the reduction of electricity consumption. The emission reduction potentials of these options are adjusted by multiplying the percentage of electricity consumption by total energy consumption in the RCI sectors. RCI options that relate entirely to reduction of other fossil fuel consumption (e.g., gas, oil) are not included in the cost curve development. Table G-A2-2 presents the list of options Michigan used to develop the power sector cost curve.

Table G-A2-2. GHG mitigation options of Michigan (for power sector)

RecommendationsNo.	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	4.949	–$35.00	4.10%	4.10%	6.98
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	0.000	–$31.00	0.00%	4.10%	0.00
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	27.452	–$28.00	22.72%	26.82%	38.72
ES-3	Energy Efficiency Portfolio Standard	14.600	–$19.00	12.09%	38.91%	20.59
RCI-1	Utility Demand-Side Management for Electricity and	0.000	–$19.00	0.00%	38.91%	0.00

RecommendationsNo.	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
	Natural Gas					
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.500	$4.09	0.41%	39.32%	0.71
ES-11	Power Plant Replacement, EE, and Repowering	2.000	$9.40	1.66%	40.98%	2.82
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration--Co-firing at 10%	0.500	$10.70	0.41%	41.39%	0.71
ES-6	New Nuclear Power	6.300	$25.98	5.22%	46.61%	8.89
RCI-6	Incentives To Promote Renewable Energy Systems Implementation	0.000	$27.00	0.00%	46.61%	0.00
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	14.600	$48.00	12.09%	58.69%	20.59

[1] Michigan 2025 projected consumption-based power sector gross CO_2 emission level is 120.8 $MMtCO_2e$.

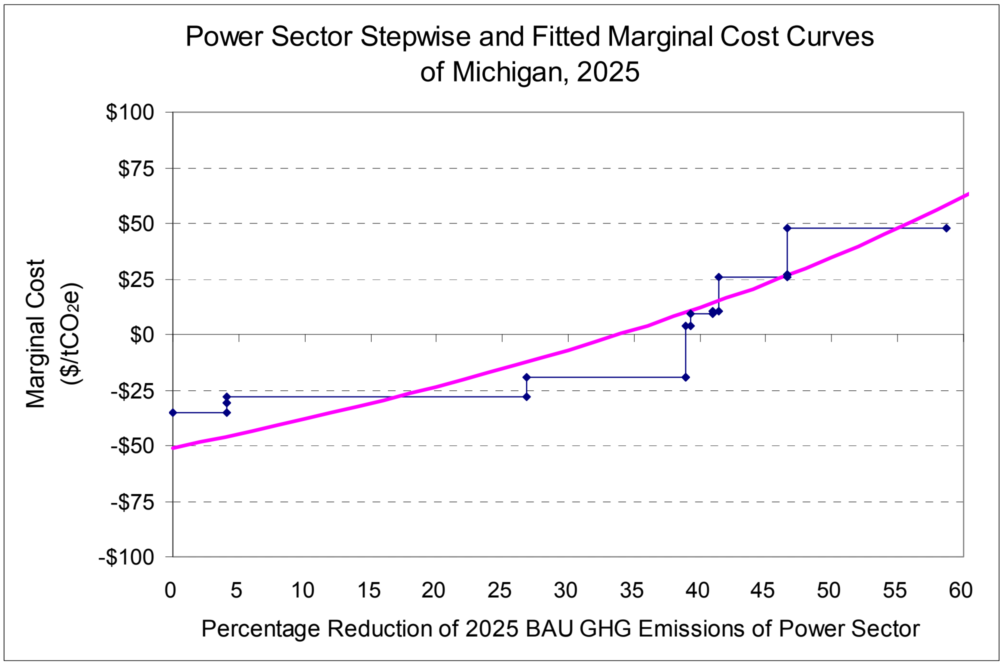
Note: The emission reduction potentials shown in the table are the values after overlap adjustment (both within sectors and across sectors).

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; EE = energy efficiency; ES = Energy Supply; GHG = greenhouse gas; RCI = Residential, Commercial, and Industrial.

Following the same methodology as described above, the power sector stepwise and fitted marginal cost curves of Michigan for 2025 are developed and presented in Figure G-A2-2. The specification of the power sector fitted marginal cost curve is:

$$MC = -50.98 - 123.36 \times \ln(1 - R)$$

Figure G-A2-2. Power sector stepwise and fitted marginal cost curve of Michigan, 2025



$/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent; BAU = business as usual; GHG = greenhouse gas.

Reference

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Annex G-3

Modeling of Cap-and-Trade Programs

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November 2008

Introduction of the Cap-and-Trade Model

A cap-and-trade (C&T) system has many desirable features for implementing pollution emission reductions. The cap limits emissions, while the trading ensures that the reduction will be achieved at the lowest possible cost (economic efficiency). The initial allocation of permits can be used to address issues of fairness (equity).

The model we use for the C&T analysis has been previously developed and successfully applied to simulate the workings of interregional (and international) C&T systems. It is based on established economic principles (equilibrium and optimization). The model can be solved either as a system of simultaneous equations or as a nonlinear programming model. It has been applied to the analysis of C&T associated with the Kyoto Protocol, emissions trading within the European Union, the Regional Greenhouse Gas Initiative (RGGI), 10 U.S. Environmental Protection Agency EPA regions covering all U.S. states, the Midwestern Governors Association (MGA) region, Minnesota internal state trading, the Western Climate Initiative (WCI), and Pacific Rim states and countries (see Rose et al., 1998 and 2006; Rose and Zhang, 2004; Center for Climate Strategies (CCS), 2008; Rose and Wei, 2008).

This model is based on the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities (see, e.g., Tietenberg, 2007). For permit purchasing states (or sectors), compliance costs are equal to their own abatement plus the cost of permits, whereas for selling states (or sectors), compliance costs are equal to their own abatement cost minus the revenues from selling permits. The model can readily be adapted to include such alternative design features as variations in sector and source coverage, implications of the cap on emission reduction requirements over time, offsets, variations on auctioning, upstream versus downstream application, borrowing and banking, and any explicit constraints on the permit price or trading (see Stevens and Rose, 2002; CCS, 2008). With a few modifications, the same model can also be used to simulate a carbon tax.

The model yields the following general results:

- Greenhouse gas (GHG) emission reductions (abatement and sequestration) for each entity (sector and/or state) before and after permit trading.
- Cost (or cost savings) of GHG emission reductions for each trading entity before and after trading.
- Number of permits traded (bought and sold) by each entity.
- Equilibrium permit price.
- Cost savings for each entity of joining the C&T program.

- Auction revenues if the allowances are auctioned among trading entities instead of grandfathered.

The model uses the following inputs (all the input data are collected from the state's climate change action plans):

- Projections of baseline GHG emissions for each trading entity.
- Caps on GHG emissions for each entity (translated from the state reduction goals in target years).
- Marginal cost curve of GHG emission reduction for each entity based on the cost of all relevant mitigation/sequestration options.

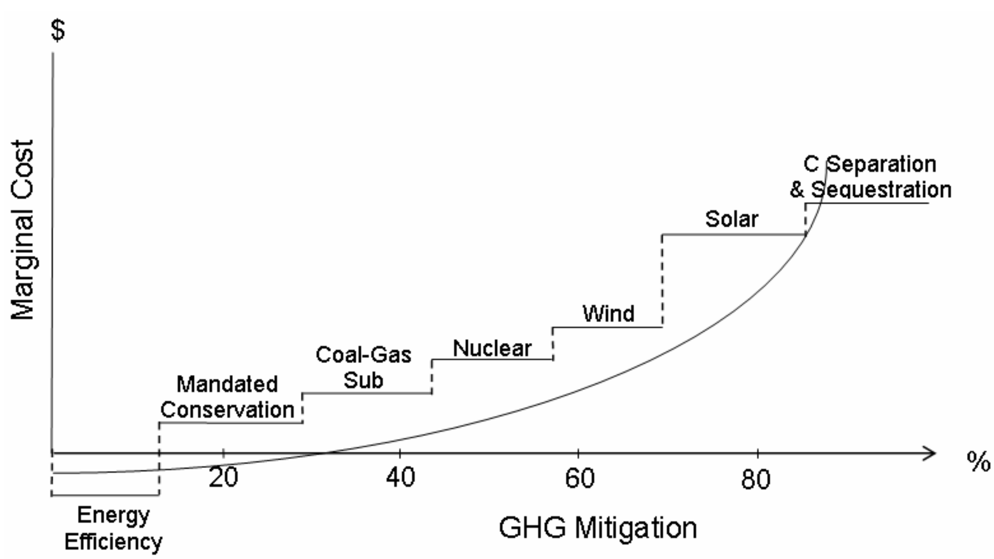
Development of Marginal Cost Curves

Many states have developed climate change action plans. The following data are collected for each applicable mitigation option (that has been quantitatively analyzed) in these states:

- The range of the mitigation option's application (maximum percentage of total emissions that can be reduced by the option).
- The cost per ton of carbon dioxide (CO_2) that can be reduced (this is specified in terms of a cost-effectiveness, including the possibility of cost savings per unit of GHG removed).

For each state, the mitigation options are then ordered from lowest cost to highest cost. A step function is developed based on the mitigation potential and cost per ton of CO_2 reduction for each policy option. Such a step function is illustrated in Figure G-A3-1. Next, a smooth curve is developed to fit the step function, which would be used as the marginal cost curve of the state in C&T policy analysis.

Figure G-A3-1. Illustrative marginal cost step function and curve for GHG mitigation



C = carbon; GHG = greenhouse gas.

Prior CCS analysis for Minnesota can serve as an example of the construction of the mitigation marginal cost curve. Table G-A3-1 presents 8 example climate mitigation options out of the 37 options analyzed quantitatively for Minnesota by CCS. Column 2 of the table presents the estimated 2025 annual GHG reduction potential for each option, with reduction potentials translated into percentages of the 2025 business as usual (BAU) emission level in Column 4. The estimated cost or cost saving per ton of GHG removed by each option in 2025 is presented in Column 3. The options are listed in ascending order in terms of cost, beginning with the cheapest option. Column 5 lists the cumulative GHG reduction potentials of the policy options listed in the table. The last column presents the proportion of GHG mitigation contributed by each option.

Table G-A3-1. GHG mitigation options of Minnesota

Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
RCI-6. Non-Utility Strategies and Incentives To Encourage Energy Efficiency and Reduce GHG Emissions	1.3	–$37.00	0.65%	9.91%	1.48
AFW-1. Agricultural Crop Management--A. Soil Carbon Management	1.3	–$2.00	0.65%	15.42%	1.48
TLU-5. Climate-Friendly Transportation Pricing/Pay as You Drive	2.1	–$1.00	1.05%	16.46%	2.39
AFW-8. End of Life Waste Management Practices--A. Landfilled Waste Methane	0.73	$1.00	0.36%	16.98%	0.83
AFW-4. Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	3.8	$3.00	1.90%	18.87%	4.32
ES-3. Efficiency Improvements, Repowering and other Upgrades to Existing Plants--Biomass co-firing	0.4	$12.00	0.20%	29.38%	0.46
AFW-5. Forestry Management Programs to Enhance GHG Benefits--A. Forestation	2.2	$13.00	1.11%	30.48%	2.50
ES-5. Renewable and/or Environmental Portfolio Standard	15.7	$56.40	7.83%	43.53%	17.86

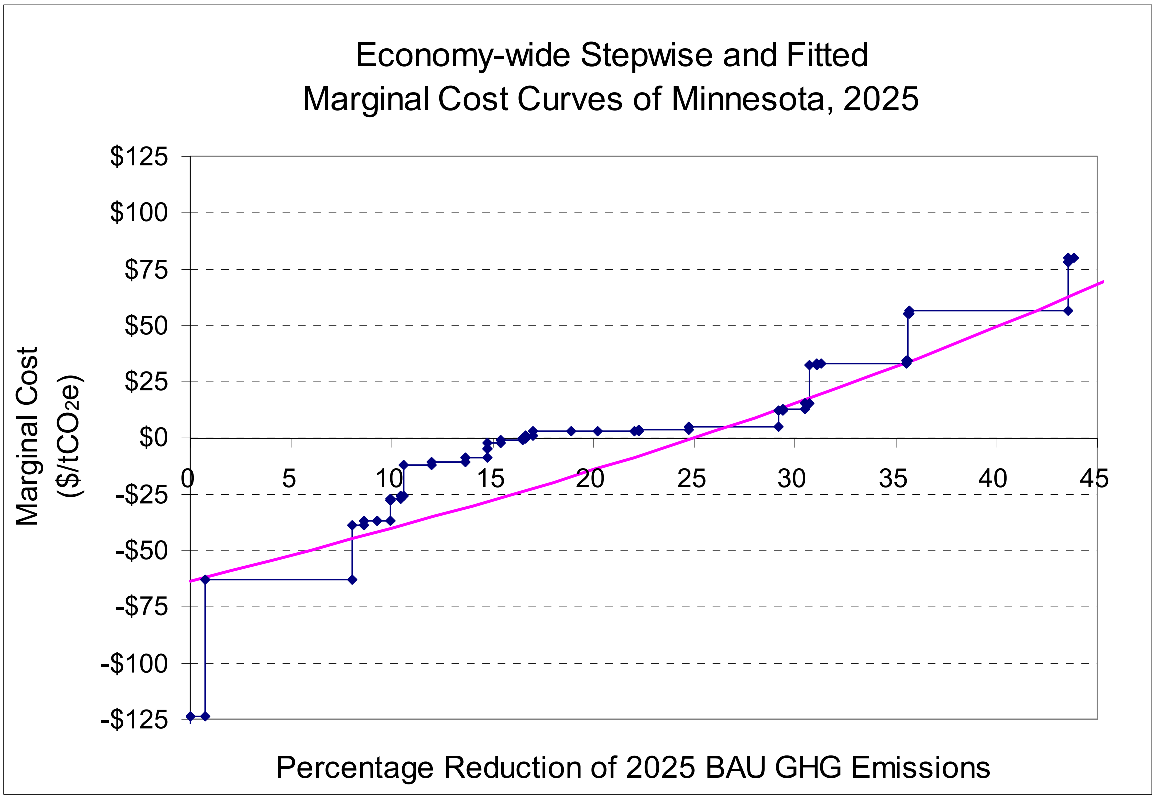
[1] Minnesota 2025 projected consumption-based gross GHG emission level is 200.46 Million Metric Tons of CO_2e.

AFW = Agriculture, Forestry, and Waste Management; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; EE = energy efficiency; ES = Energy Supply; GHG = greenhouse gas; RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use.

Based on the data presented in Table G-A3-1, the stepwise marginal cost function for Minnesota in 2025 is first drawn in Figure G-A3-2. The horizontal axis represents the percentage of GHG emission reduction, and the vertical axis represents the marginal cost or cost savings of mitigation. In the figure, each horizontal segment represents an individual mitigation option. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost (saving) of reducing one metric ton of GHG with the application of the option. The figure indicates that, collectively, the reduction potential of options from all economic sectors can avoid about 44% of 2025 baseline emissions in Minnesota. Our approach to develop the marginal cost curve based on state-specific climate change action plans directly includes any introduction of new emission reduction technologies (such as carbon capture and storage) of the state. Furthermore, sensitivity analyses of mitigation options, for example, to account for different learning and penetration effects or technological innovations, can be readily reflected in the cost curve by variations in the width (usually lengthening) and height (usually lowering), as well as the sequencing of the corresponding segments of the options.

Next, we fit a smooth curve through the data using statistical analysis (see Figure G-A3-2). We weight each policy option based on its GHG mitigation potential to give relatively greater influence to options that have the potential for higher levels of application, and thereby should improve the accuracy of the estimation. This fitted curve will then be used in our C&T analysis model.

Figure G-A3-2. Economy-wide and stepwise and fitted marginal cost curves of Minnesota, 2025



$/tCO₂e = dollars per metric ton of carbon dioxide equivalent; BAU = business as usual; GHG = greenhouse gas.

The fitted curve shown in Figure G-A3-2 has the following functional form:

$$MC = a + b \times \ln(1 - R)$$

where *MC* is the marginal cost; *R* is the percentage reduction of GHG emissions; and *a* and *b* are parameters.

The logarithmic functional form utilized here is consistent with theoretical expectations and empirical findings on diminishing returns of emission control (Nordhaus, 1991 and 1994). As the emission reductions increase along the x-axis, the cost to reduce one additional unit of emission increases at an accelerating rate; in other words, it exhibits diminishing returns.

The marginal cost curve for Minnesota has the following specification:

$$MC = -63.37 - 220.25 \times \ln(1 - R)$$

The fitted curve has an intercept with the y-axis at MC = –$63.37. The curve increases to MC = 0 at the emission reduction level of 25%, which indicates that Minnesota has cost-saving mitigation potentials (such as energy efficiency) up to that level of the 2025 BAU emissions.

General Assumptions Adopted in the Analysis

The general assumptions we adopted in the C&T analysis and our modeling can be summarized as follows:

Emissions:

- All six GHGs—CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride—from the covered sectors are included in the analysis.
- The gross emissions (excluding forestry and agriculture soils sinks) are considered.

Marginal Cost Curves:

- Marginal cost curves embody direct mitigation costs only.
- Marginal cost curves do not include various transactions costs.
- Marginal cost curves do not distinguish between producer versus consumer allocation of permits.
- For analysis of C&T among power sectors, the power sector marginal cost curves of the states are developed based on the reduction potential and mitigation cost/saving data of individual options that contribute to the emission reductions from the power sector. These options not only include those designed directly for the electricity supply sector (such as promotion of renewable energy utilization, repowering existing plants, generation performance standards), but also include options in residential, commercial, and industrial (RCI) sectors that contribute to the reduction of electricity consumption (e.g., demand-side management, energy efficiency appliances, building codes). Also, for those options that apply to the use of both electricity and other fuel types, the emission reduction potentials are adjusted by multiplying the percentage of electricity consumption by total energy consumption in the RCI sectors. RCI options that relate entirely to reduction of other fossil fuels consumption (such as gas, oil) are not included in the power sector cost curve development.
- The target year we used for the Midwestern Governors Association C&T analysis is 2025. The mitigation policy options of Iowa are analyzed for 2020. Therefore, we adjusted the mitigation cost data of Iowa to 2025, based on the assumption of a 2% annual technical improvement or innovation rate. In other words, we used the same reduction potential

numbers for individual options in 2025 as in 2020 for Iowa, and assumed the cost per metric ton of CO_2 equivalent (CO_2e) reduction being about $(1\% + 2\%)^5$ lower in 2025 than in 2020.

- For state that lacks direct cost data, the cost curve is approximated based on the data of one of its adjacent states that has quantified cost data available. We assume that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit of GHG removed for each option is assumed to be at the same level as of state A. Third, the mitigation potentials of each option are assumed to be proportional in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states. For example, if the emissions from the power sector are 50 million metric tons of CO_2 equivalent (MMtCO_2e) and 100 MMtCO_2e in state A and state B, respectively, the mitigation potentials of the Energy Supply (ES) options for state A are multiplied by a factor of 2 (100/50=2) for application to state B.

Basic Model (can be included in advanced versions):

- Offsets are not included.
- No safety valve (permit price limit) is included.
- Recycling of auction revenues (or tax revenues in the carbon tax cases) is not analyzed in the simulations.
- Banking and borrowing are not considered.

Specification of the Cap-and-Trade Model

The C&T model is based on well-established principles of the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities (see, e.g., Tietenberg, 2007). Where a strict cap implies unique GHG emission reduction requirements, the individual state and overall regional optimization can be accomplished without explicit consideration of the benefits side of the ledger (i.e., it yields "efficiency without optimality"). Therefore, the model simply requires equalization of marginal costs of all entities with the equilibrium permit price (see Zhang, 2000; Loeschel and Zhang, 2002; Rose and Zhang, 2004). This ensures minimization of both total net compliance costs for each state and total abatement costs for the region as a whole. Purchasing (high-cost) states will reduce emissions up to the point where their marginal cost equals the prevailing market permit price, and will accomplish their remaining reduction responsibility by purchasing available permits in the market. Selling (low-cost) states have the incentive to do more than their reduction targets indicate, so that they can sell their surplus permits on the open market for a profit. For the region as a whole, permit sales and purchases cancel out, simplifying the overall objective functions.

We assume that the marginal abatement cost function for state *i* is of the logarithmic form, similar to Nordhaus (1994):[15]

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[15] The shape of the cost function for mitigating CO_2 emissions has been studied extensively. For example, Nordhaus (1994) found that the logarithmic functional form provided the best fit for the estimates of the marginal costs of mitigating a specific amount of CO_2 emissions among a number of economic modeling studies that he surveyed (a type of meta-analysis). He used an analytical model to further derive a logarithmic relationship between the marginal costs and the percentage reduction.

$$MC_i = a_i + b_i \times \ln(1 - R_i) \qquad i = 1\ ,\ \ldots\ ,n \qquad (1)$$

where MC_i is the marginal cost of abatement for state i, R_i is the percentage of GHG abatement undertaken by state i in $MMtCO_2e$, and a_i and b_i are cost parameters. This functional form has the desired property of positive and increasing marginal cost for $b_i < 0$. When $a_i = 0$, the cost curve starts from the origin. When $a_i < 0$, the curve can show the cost-saving mitigation range of the state. These cost parameters also capture technological and other distinctions that cause mitigation costs to differ across regions. By integration, the total cost of abatement for region i, TC_i, is:

$$TC_i = \int_0^{R_i} \left[a_i \cdot R_i - b_i \cdot (1 - R_i) \cdot \ln(1 - R_i) - b_i \cdot R_i\right] \cdot E_i \qquad i = 1\ ,\ \ldots\ ,n \qquad (2)$$

where E_i is each state's gross (unabated) emissions in $MMtCO_2e$. Denoting the total required percentage reduction of emissions in region i in the absence of emissions trading as $\overline{R}_i$, the total abatement cost for each state in the absence of trading, $TC\overline{R}_i$, is calculated as:

$$TC\overline{R}_i = \int_0^{\overline{R}_i} \left[\left(a_i + b_i \cdot \ln(1 - r_i)\right) dr_i E_i\right] = \left[a_i \cdot \overline{R}_i - b_i \cdot (1 - \overline{R}_i) \cdot \ln(1 - \overline{R}_i) - b_i \cdot \overline{R}_i\right] \cdot E_i$$

$$i = 1\ ,\ \ldots\ ,n \qquad (3)$$

Emissions trading helps a region with relatively high marginal abatement cost to lower its compliance cost by avoiding the undertaking of their own actions. To minimize compliance costs, a purchasing state undertakes only some of its abatement requirement itself, $R_i E_i$, $\left(R_i E_i < \overline{R}_i E_i\right)$, up to the point where the marginal cost of doing so is equal to the endogenously determined permit price, P:

$$MC_i = a_i + b_i \times \ln(1 - R_i) = P \qquad i \in N \qquad (4)$$

where N is the set of all states.

The state meets the remaining demand, $\left(\overline{R}_i E_i - R_i E_i\right)$, via purchasing the "right to emit" at the regional market price, P. So, the total demand for emission permits of all purchasing states, TD, is:

$$TD = \sum_i \left(\overline{R}_i E_i - R_i E_i\right) \qquad i \in N \qquad (5)$$

On the other hand, for state j, with relatively low marginal cost, emissions trading provides an incentive to undertake abatement and sell permits to higher-cost states at the equilibrium permit price, P:

$$MC_j = a_j + b_j \times \ln(1 - R_j) = P \qquad j \in N \qquad (6)$$

The total amount of emission permits available for sale in a given regional trading coalition TS, is:

$$TS = \sum_j \left(R_j E_j - \overline{R}_j E_j \right) \qquad j \in N \qquad (7)$$

The sum of total number of purchasing states *i* and total number of selling states *j* will be equal to *n*. At the equilibrium, the total demand for emission permits in the region is equal to the total supply:

$$TD = TS \qquad (8)$$

Substituting Equation (Eq.) (5) and Eq. (7) into Eq. (8) and rearranging terms yields the condition that the total emissions actually abated equal the total emission abatement requirement:

$$\sum_i R_i E_i = \sum_i \overline{R}_i E_i \qquad i = 1, \ldots, n \qquad (9)$$

We solve the model by minimizing total abatement costs of all states $\sum_i TC_i$ subject to Eqs. (4), (6), and (9), using GAMS (General Algebraic Modeling System), an algebraic modeling system for linear, nonlinear, and integer programming problems (Brooke et al., 1996).[16] The solution yields the equilibrium permit price (*P*), each state's own abatement after trading $(R_i E_i)$, and each state's marginal abatement cost (MC_i). Because we focus on unrestricted emissions trading, in equilibrium the marginal cost of abatement for each region is the same and is equal to the permit price, indicated in Eq. (4) and Eq. (6).

This completes the description of the general model by which the permit price, MC_i, and $R_i E_i$ are determined endogenously in a competitive market. In the case where the permit price is set exogenously, as in the case of some auction-based C&T or the carbon tax cases, the situation becomes simpler because MC_i and hence $R_i E_i$ follow suit. There is no need for Eqs. (5), (7), (8), and (9) because the total sales of selling states to purchasing states are not equal to the total purchases, except by chance (when the specified permit price equals the equilibrium price).

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[16] The market equilibrium solution of our model is unique, so the same solution could be obtained without optimizing. The reason why we specify an objective function is that we use GAMS/MINOS, a solver mainly for optimization problems. The minimization of the total cost is a logical choice for an objective in the case of "cost-effectiveness" analysis here (i.e., when a policy target is set and decision units seek to attain it at least cost). Had we used a software package that is specifically designed to solve a simultaneous equation system, then there would have been no need for an objective function.

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Appendix H
Transportation and Land Use Policy Recommendations

Summary List of MCAC Recommendations

Policy No.	Policy Recommendations	GHG Reductions ($MMtCO_2e$) 2015	2025	Total 2009–2025	Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
TLU-1	Promote Low-Carbon Fuel Use in Transportation	2.6	5.9	53	$820	$16	Unanimous
TLU-2	Eco-Driver Program	1.1	2.2	22	–$3,921	–$176	Unanimous
TLU-3	Truck Idling Policies	0.36	0.76	7.0	–$596	–$85	Unanimous
TLU-4	Advanced Vehicle Technology	0.01	0.03	0.19	$281	$1,458	Unanimous
TLU-5	Congestion Mitigation	0.08	0.18	1.7	–$135	–$81	Unanimous
TLU-6	Land Use Planning and Incentives	0.14	0.43	3.2	–$598	–$189	Unanimous
TLU-7	Transit and Travel Options	0.13	0.54	3.5	$655	$185	Unanimous
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.10	0.19	2.0	$69	$35	Unanimous
TLU-9	Great Lakes Shipping	0.24	0.27	2.5	NQ	NQ	Unanimous
	Sector Totals	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**
	Sector Total After Adjusting for Overlaps	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**
	Reductions From Recent Actions	**0**	**0**	**0**	**$0**	**$0**	**N/A**
	Sector Total Plus Recent Actions	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**	**N/A**

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

Note: Negative numbers indicate cost savings.

TLU-1. Promote Low-Carbon Fuel Use in Transportation

Policy Description

Reduce the greenhouse gas (GHG) emissions from the use of transportation fuels through a package of incentives, education, and standards, including recommendations by the Michigan Renewable Fuels Commission (RFC). Renewable fuels and electric propulsion provide significant opportunities to reduce GHG emissions from the transportation sector if promoted in a way that emphasizes the reduction of GHG emissions on a life cycle basis.

Policy Design

Goals: Reduce GHG emissions from the transportation sector by reducing the average carbon "intensity" of on-road transportation fuels sold within the state, measured on a life cycle basis. Achieve 5% reduction of GHG emissions on a life cycle carbon dioxide (CO_2) basis by 2015 and 10% reduction by 2025 compared with business as usual (BAU) forecasts.

Timing: See Goals, Above

Parties Involved: Michigan legislature, Michigan Department of Environmental Quality (MDEQ), Michigan Department of Agriculture (MDA), Michigan Department of Natural Resources (MDNR), fuel providers, agricultural producers, utilities, and auto companies.

Other: None identified.

Implementation Mechanisms

In its June 2007 report, the Michigan RFC recommended a variety of actions to stimulate the production and use of renewable, low-carbon fuels within the state. These include:

Low Carbon Fuels Policy:
While a federal low-carbon fuel policy could make further action in Michigan unnecessary, there is no clear time frame for such action or any guarantee that Congress will act. Michigan should encourage federal policy in this area, and should also consider taking the lead and establishing its own state policy.

If implemented at the state level, the governor should initiate the development of a strategy to enact a low-carbon emission transportation fuels program in Michigan. This strategy should be integrated into and be consistent with an overall carbon reduction strategy for the state, as well as development of a regional model standard through the Midwestern Governors Association Climate Initiative. Policymakers should consider the likelihood of near-term federal policy action, as well as the potential competitive advantage to the state in encouraging a low-carbon fuels industry by providing policy leadership, when deciding on the appropriate course of action.

The implementation recommendations of the MCAC are subject to further economic analysis, which would be expected to provide more information about the costs and benefits of alternative ways to pursue this policy.

Establish a Next-Generation Renewable Fuels Feedstock Program:
This would encourage the sustainable production of next-generation bioenergy and biomass materials while reducing risk to landowners. For more information on the production of biofuels, see AFW-2. In addition, the state will achieve 10% use of renewable fuels with lower GHG emissions than petroleum-based fuels by 2012 and 25% by 2025.[1] A goal of achieving a minimum of 10% alternative fuel use in the transportation sector is a critical first step towards significant biofuel consumption. This goal is considered on a volumetric level, and includes starch-based ethanol production already in place as of 2008.

Create a Green Fuels Retailers Program (Tax Incentives for E85 and Biodiesel Sales): The state should establish a Green Fuels Retailers Program that rewards retail and wholesale outlets that attain benchmarks in the sale of biofuels. This would provide state recognition for achievement and provide important cost savings to both the seller and the consumer of biofuels. (To provide alternative fuel choice to consumers, promote state energy security needs and reduce GHG emissions.) Access to alternative fuels should address both gasoline and diesel fuels. A Green Fuels Retailer designation would be provided by the state to any retail outlet that sells a minimum level of gasoline biofuel (E85). Note: The notations E85 and E100 are used to show the percentage of ethanol in a gallon of fuel. E85 contains 85% ethanol and 15% gasoline. B20 contains 20% biodiesel and 80% conventional diesel fuel.

A Green Fuels Retailer will receive incentives to support the infrastructure development needed for E85 and to help ensure that the retailer is able to provide value-based pricing (ethanol's lower energy content requires a lower price per gallon to offset the fuel economy reduction) for sustainable consumer use. The applicable incentive will be a reduction in the payment of motor fuel tax on all gasoline sold at the facility. These incentives are needed in the early stages of E85 growth to accelerate the development of new production, distribution, and retail channels.

The same incentives should apply to diesel transportation fuels. A Green Fuels Retailer designation would apply for similar minimum levels of B20 biofuel sales.

As an alternative to the application of incentives to the Green Fuesl Retailer described above, a feebate approach could be considered where increases to the motor fuel tax (fee) are used to create a fund that would provide Green Retailers with an incentive (rebate) amount for each gallon of E85 or B20 sold. Such a public–private partnership is critically needed to accelerate consumer access to alternative fuels and to support consumer value, setting the stage for increased use of renewable fuels in the transportation sector beyond low-level blends.

Related Policies/Programs in Place

Motor Fuels Tax program.

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[1] The goals of 10% by 2012 and 25% by 2025 are both included in the Michigan Renewable Fuels Commission final report. The goal of 25% by 2025 is included in the Midwestern Governors Association Energy Platform.

Type(s) of GHG Reductions

Carbon Dioxide (CO_2)

Estimated GHG Reductions and Net Costs or Cost Savings

Quantification Methods:

This analysis looks specifically at how biofuels could reduce the carbon content of fuel and therefore reduce overall transportation emissions. The included quantification does not model the recommendations by the RFC. Electric propulsion was also not considered in this analysis, although it could potentially reduce the carbon content associated with fuels. Expanded use of hybrid electric vehicles is considered in TLU-4.

The gallons of diesel fuel and gasoline forecast to be used in Michigan vehicles comes from the Michigan Inventory and Forecast (I&F). The goal is to reduce the life cycle emissions of these fuels by 5% by 2015 and by 10% by 2025. Please note that the implementation path outlined here only achieves part of these reductions (4.3% reduction in 2015 and 9.9% in 2025). This implementation path is based on the maximum feasible quantity of biofuels that could be produced in the state of Michigan, as found in the Agriculture, Forestry, and Waste Management (AFW) option AFW-2 (see Appendix J).

Table H-1-1 shows the gallons of gasoline and diesel fuel that are forecast to be Michigan's on-road consumption. The life cycle emissions factors used for gasoline (11.26 kilograms of carbon dioxide equivalent per gallon [kg CO_2e/gal]) and for diesel (11.25 kg CO_2e/gal) are from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (Argonne National Laboratory [ANL], 2008). The life cycle emissions of these fuels are also shown in Table H-1-1. These Green Fuels Retailer life cycle emissions are higher than the emissions estimates for transportation in the I&F because the emissions figures in the I&F are direct emissions from combustion of fuel, rather than the life cycle emissions (which include refining and transporting the fuel). The difference between direct combustion emissions and life cycle emissions is typically around 20%–25% for petroleum-based fuel.

Table H-1-1. Life cycle emissions of fuel consumption in Michigan

Year	Gasoline Gallons (million)	Diesel Gallons (million)	Total Life Cycle Gasoline Emissions (MMtCO_2e)	Total Life Cycle Diesel Emissions (MMtCO_2e)
2008	4,554	1,095	51.3	12.3
2009	4,563	1,118	51.4	12.6
2010	4,557	1,138	51.3	12.8
2011	4,514	1,143	50.8	12.9
2012	4,448	1,142	50.1	12.8
2013	4,380	1,140	49.3	12.8
2014	4,322	1,141	48.7	12.8
2015	4,272	1,144	48.1	12.9

Year	Gasoline Gallons (million)	Diesel Gallons (million)	Total Life Cycle Gasoline Emissions ($MMtCO_2e$)	Total Life Cycle Diesel Emissions ($MMtCO_2e$)
2016	4,233	1,146	47.7	12.9
2017	4,194	1,148	47.2	12.9
2018	4,156	1,150	46.8	12.9
2019	4,119	1,152	46.4	13.0
2020	4,088	1,156	46.0	13.0
2021	4,073	1,167	45.9	13.1
2022	4,068	1,180	45.8	13.3
2023	4,071	1,195	45.8	13.4
2024	4,079	1,213	45.9	13.6
2025	4,059	1,222	45.7	13.7

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

The level of biofuel consumption used in this analysis is set to match the achievable levels of production found by AFW-2. This will serve to reduce the life cycle emissions of GHGs by 5% by 2015 and by 10% by 2025. The three fuels being considered in this analysis are biodiesel, cellulosic ethanol, and corn ethanol. The implementation path of the goal and the goal for the consumption of each individual fuel is shown in Table H-1-2. The implementation path indicates the percentage reduction in CO_2e emissions compared to conventional fuel consumption. Cellulosic ethanol production does not begin until 2011 and increases steadily from then on. Corn ethanol makes up the remaining portion of the total biofuels.

The figure for gasoline/diesel gallons replaced is determined based on the different heat contents of the biofuels (e.g., the heat content for gasoline is higher than that of ethanol but lower than that of diesel fuel) (Energy Information Administration [EIA], 2007). This means that in order to replace 1 gallon of gasoline, more than 1 gallon of ethanol is needed to provide the same energy. The life cycle emissions per British thermal unit (Btu) are shown in Table H-1-2.

Table H-1-2. Life cycle CO_2e emissions per million Btu

Type of Fuel	kg CO_2e/Million Btu
Gasoline	90.01
Diesel	81.11
Corn ethanol (E100)	72.66
Cellulosic ethanol (E100)	12.07
Biodiesel (B100)	48.26

kg CO_2e = kilograms of carbon dioxide equivalent; Btu = British thermal unit; E100 = 100% ethanol; B100 = 100% biodiesel.

The amount of each biofuel required in the policy is shown in Table H-1-3. The emissions reductions of these biofuels are calculated by multiplying the gallons of fuel being replaced by the difference in GHG emission factors between the conventional fuel and the biofuel. Only gallons of corn-based ethanol beyond current levels of production are considered towards the emissions reductions. Therefore, the emissions reduction in 2010 only accounts for the reductions from 18 million gallons of corn ethanol.

Table H-1-3. Biofuel quantities and the associated emissions reductions from the implementation path

Year	Million Gallons of Biodiesel (B100)	Million Gallons of Cellulosic Ethanol (E100)	Million Gallons of Corn Ethanol (E100)	Total Life Cycle Emissions Savings ($MMtCO_2e$)	Life-Cycle Emissions Reduction
2009	0	0	267	0.00	0.0%
2010	0	0	285	0.03	0.0%
2011	1	98	325	0.73	1.2%
2012	2	230	326	1.61	2.6%
2013	3	280	333	1.95	3.1%
2014	4	334	334	2.31	3.8%
2015	6	379	345	2.63	4.3%
2016	7	406	374	2.85	4.7%
2017	8	454	380	3.18	5.3%
2018	9	503	386	3.52	5.9%
2019	10	552	391	3.85	6.5%
2020	11	600	397	4.18	7.1%
2021	12	649	407	4.52	7.7%
2022	13	698	419	4.86	8.2%
2023	14	747	434	5.21	8.8%
2024	16	795	451	5.56	9.3%
2025	18	844	458	5.90	9.9%
Total				52.9	

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

The costs of this option are calculated on the basis of the difference in cost between conventional fuels and biofuels. The cost estimates for gasoline, diesel, corn ethanol, and biodiesel come from the Annual Energy Outlook (AEO) 2008, High Price Case. The cost estimates for cellulosic ethanol come from the analysis of the cost of producing cellulosic ethanol done for AFW-2. This break-even cost for cellulosic producers ranges from $1.87 to $1.60 per gallon. Added to this cost is the profit margin for the producers and distributors, which also comes from AEO 2008. The difference in cost between the wholesale and retail price of corn ethanol found in the AEO was applied to cellulosic ethanol for each year. This resulted in a cost for cellulosic ethanol ranging between $2.05 and $2.42 per gallon. The total costs of each biofuel are shown in Table H-1-4.

Table H-1-4. Cost of biofuels in TLU-1

Year	Additional Cost of Biodiesel (Million $)	Additional Cost of Cellulosic Ethanol (Million $)	Additional Cost of Corn Ethanol (Million $)	Additional Cost of all Biofuels (Million $)
2009	0	0	0	0
2010	0	0	5	5
2011	0	40	18	58
2012	1	59	18	78
2013	1	60	-3	58
2014	2	39	-6	35
2015	2	–21	–22	–41
2016	3	68	–1	70
2017	3	93	0	97
2018	4	69	1	74
2019	4	41	0	45
2020	5	–32	–1	–28
2021	5	–110	–5	–109
2022	6	–105	-15	–114
2023	6	–31	–12	–37
2024	7	31	–13	24
2025	8	16	–13	12

Numbers may not sum due to rounding errors.
Negative numbers indicate costs savings.

The prices of cellulosic and corn ethanol are lower on a per gallon basis than that of gasoline for the entire policy period. However, because more gallons of ethanol are needed to provide the same amount of energy as a gallon of gasoline, this price difference is significantly reduced. In years where the price of ethanol is predicted to be low (such as 2015), then both cellulosic and corn ethanol are cost-effective when compared with the predicted price of gasoline. On the other hand, in years (such as 2012) where the price of ethanol is higher compared with that of gasoline (on a per Btu basis), then there is a net cost for using ethanol compared with using gasoline. Biodiesel has a lower energy content than traditional diesel fuel and is estimated to have slightly higher costs than traditional diesel fuel throughout the policy period. The costs of fuel in 2015 and 2025 are shown in Table H-1-5.

Table H-1-5: Fuel Costs in 2015 and 2025

Year	Gasoline ($/gal)	Diesel ($/gal)	Biodiesel (B100) ($/gal)	Corn Ethanol E100 ($/gal)	Cellulosic Ethanol (E100) ($/gal)
2015	3.12	3.09	3.26	1.82	2.05
2025	3.52	3.57	3.74	2.31	2.39

If this policy were implemented as written, it would exceed the amount of ethanol that could be consumed through the use of E10 in gasoline. It would therefore require the introduction of additional flex-fuel vehicles capable of running on E85. According to AEO 2008, the additional cost of a mid-sized vehicle that can run on flex-fuel is $400. The number of vehicles that would be required to run on flex-fuel is calculated by assessing the amount of ethanol produced beyond 10% (which can be burned in all gasoline engines as E10), and the number of new vehicles that would have to be sold to burn the additional quantities of ethanol. The estimate for new vehicle sales is calculated in TLU-4. The total costs of the TLU-1, in terms of biofuels and vehicle costs are shown in Table H-1-6. It is possible that the cost of these vehicles is being overestimated, because Michigan already has a significant number of flex-fuel vehicles on the road. More than 272,000 flex-fuel vehicles were registered in Michigan in 2007, and this number is estimated to increase by 52,000 every year. At that rate, there would be sufficient flex-fuel vehicles on the road for the entire policy period.

Table H-1-6. Costs of Vehicle Modifications in TLU-1

Year	Estimated New Vehicle Sales	% Gasoline Replaced (volumetrically)	% of Cars Needed to be Flex-Fuel Vehicles	Number of Cars Needed to be Flex-Fuel Vehicles	Additional Cost of Flex-Fuel Vehicles (MM$)
2009	627,795	5.84%	0.00%	0	$0
2010	630,493	6.24%	0.00%	0	$0
2011	632,541	9.35%	0.00%	0	$0
2012	634,595	12.48%	2.48%	18,527	$7
2013	636,656	13.94%	3.94%	29,488	$12
2014	638,723	15.40%	5.40%	40,576	$16
2015	640,798	16.87%	6.87%	51,792	$21
2016	641,965	18.34%	8.34%	62,965	$25
2017	643,134	19.81%	9.81%	74,223	$30
2018	644,305	21.29%	11.29%	85,567	$34
2019	645,479	22.77%	12.77%	96,997	$39
2020	646,654	24.26%	14.26%	108,520	$43
2021	646,869	25.77%	15.77%	120,022	$48
2022	647,083	27.29%	17.29%	131,597	$53
2023	647,297	28.81%	18.81%	143,247	$57
2024	647,512	30.34%	20.34%	154,970	$62
2025	647,727	31.85%	21.85%	166,540	$67
Total				**1,285,032**	**$514**

To sell these higher quantities of gasoline, more service stations must provide E85 pumps. E85 pumps are different from traditional gasoline pumps, because ethanol is more susceptible to contamination by mixing with water. Therefore, pumps must be modified to avoid any possible condensation/contamination. The cost of these pumps is estimated to be an additional $75,000 for each service station. Table H-1-7 shows the costs of these modifications for the State of Michigan.

Table H-1-7. Costs of service station equipment to sell E-85

Year	% of Service Stations That Need to Sell E85	Stations in Michigan That Need to Sell E85	Cost of Service Station Upgrades (Million $)
2009	0.00%	0	$0.0
2010	0.00%	0	$0.0
2011	0.00%	0	$0.0
2012	2.92%	122	$9.2
2013	4.63%	194	$5.4
2014	6.35%	266	$5.4
2015	8.08%	339	$5.4
2016	9.81%	411	$5.4
2017	11.54%	484	$5.4
2018	13.28%	557	$5.5
2019	15.03%	630	$5.5
2020	16.78%	703	$5.5
2021	18.55%	778	$5.6
2022	20.34%	852	$5.6
2023	22.13%	927	$5.6
2024	23.93%	1,003	$5.7
2025	25.71%	1,078	$5.6
Total			**$80.8**

Table H-1-8 shows the total costs of TLU-1, including the additional cost of using biofuels compared with using conventional gasoline/diesel fuel, as well as the additional cost of flex-fuel vehicles and additional costs for service stations to enable them to sell biofuels.

Table H-1-8. Total costs of TLU-1

Year	Additional Cost of all Biofuels ($MM)	Additional Cost of Vehicles ($MM)	Additional Cost of Gas Stations ($MM)	Total Cost of TLU-1 ($MM)
2009	0	0	0	0
2010	5	0	0	5
2011	58	0	0	58
2012	78	7	9	95
2013	58	12	5	75
2014	35	16	5	56
2015	-41	21	5	-15
2016	70	25	5	100

Year	Additional Cost of all Biofuels ($MM)	Additional Cost of Vehicles ($MM)	Additional Cost of Gas Stations ($MM)	Total Cost of TLU-1 ($MM)
2017	97	30	5	132
2018	74	34	5	114
2019	45	39	5	89
2020	–28	43	6	21
2021	–109	48	6	–56
2022	–114	53	6	–56
2023	–37	57	6	26
2024	24	62	6	92
2025	12	67	6	84
Total				**$820**

Numbers may not sum due to rounding.
Negative numbers indicate costs savings.

Table H-1-9 shows the overall costs and GHG savings estimated in the TLU-1 analysis.

Table H-1-9. Summary of TLU-1

	2015	2025	Units
GHG emission reductions	2.6	5.9	$MMtCO_2e$
Net present value (2009–2025)		$820	$ Million
Cumulative emissions reductions (2009–2025)		53	$MMtCO_2e$
Cost-effectiveness (2009–2025)		$16	$/tCO_2e$

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

Data Sources:

U.S. EIA, February 2007. "Biofuels in the U.S. Transportation Sector," available at: http://www.eia.doe.gov/oiaf/analysispaper/pdf/tbl12.pdf (accessed August 11, 2008).

U.S. EIA, 2008. "The New World of Biofuels: Implications for Agriculture and Energy" Available at: http://www.eia.doe.gov/oiaf/aeo/conf/collins/collins.ppt (accessed on August 14, 2008).

U.S. EIA, June 2008. "Annual Energy Outlook High Price Estimate," available at: http://www.eia.doe.gov/oiaf/aeo/aeohighprice.html (accessed on September 17, 2008).

ANL. 2008, "GREET Model 1.8" available at: http://www.transportation.anl.gov/modeling_simulation/GREET/index.html

Key Assumptions:

Key Uncertainties

There are significant uncertainties in predicting the cost of fuel over a long period of time. Depending on the cost difference between conventional gasoline/diesel fuel and biofuels, the cost figures for this option could change significantly. The price of cellulosic ethanol is particularly difficult to estimate, because it is not currently available on a commercial scale; thus, fuel cost estimates are largely speculative.

Emissions factors for these fuels come from national estimates. Depending on the blending, components, and production practices, emissions factors can be significantly affected.

Some service stations have had difficulties installing E85 pumps. Issues such as the potential for leakage, fire safety concerns, and uncertain fuel quality make some station operators uneasy with installing the new technology. Improved standardization/certification of E85 pumps might help reduce these concerns.

There is considerable uncertainty in modeling the indirect effects (land use changes) of biofuels production.

Additional Benefits and Costs

Other benefits or costs of a low carbon fuel standard that are not quantified here include:

- impact (positive or negative) on other air pollutants of concern
- sustainability of production
- flexibility to adjust based on the emergence of other technologies that might result in greater or more cost-effective GHG reductions
- impact on food prices
- impact on fuel tax revenue
- impact on the cost of goods delivery (i.e. fuel prices)
- other environmental impacts such as water quality and quantity, and conservation of land.

Feasibility Issues

Implementation of TLU-1 relies heavily upon cellulosic ethanol. Uncertainties exist concerning cellulosic ethanol's feedstock availability, logistics, and conversion technology.

According to the National Biofuels Action Plan (October, 2008):

> "Although R&D [research and development] on cellulosic ethanol has made progress in reducing estimated conversion costs, production costs remain too high for biomass-based fuels to compete in the

> marketplace. Transformational breakthroughs in basic and applied science will be necessary to make plant fiber-based biofuels economically viable."[2]

Cellulosic ethanol technology and production capacity have not yet been proven on a commercial scale, and this raises concerns about the viability for volumes of cellulosic and biodiesel fuel.

Status of Group Approval

Approved

Level of Group Support

Unanimous

Barriers to Consensus

None

[2] U.S. Department of Energy and U.S. Department of Agriculture, National Biofuels Action Plan, October, 2008. (Available at: http://www.afdc.energy.gov/afdc/pdfs/nbap.pdf)

TLU-2. Eco-Driver Program

Policy Description

Driving behavior can significantly influence a vehicle's fuel economy performance. Eco-driving principles incorporate a wide range of initiatives that can help drivers maximize the fuel efficiency from their existing vehicles by better understanding the direct impact that driving style, driving patterns, vehicle technologies, and vehicle maintenance have on a vehicle's fuel economy. A properly designed eco-driving program not only enhances driver awareness and understanding in the short term but also provides a systematic program framework that can alter driver behavior and yield tangible environmental and consumer cost benefits.

Eco-driving programs leverage driver behavior across the entire fleet of existing vehicles in use. The primary focus of an eco-driving campaign would target light-duty vehicles where driver education on eco-driving principles would have the greatest benefit. Michigan drivers consume more than 5 billion gallons of gasoline per year, which generates more than 44 million metric tons of CO_2 ($MMtCO_2$) emissions. Eco-driving training programs in Europe and Canada have documented reductions in fuel consumption ranging from 16% to 25% for individual drivers. An integrated eco-driving program in Michigan can be designed to achieve a fuel-economy increase (and corresponding GHG reduction) of at least 10% in the mid-term with long-term benefit potential of up to 20%.

Policy Design

A properly designed eco-driving program must move beyond a list of driver "tips" and focus on providing the appropriate tools and programs to systematically change driver behavior.

Key eco-driving principles must cover

- Driving style
  - *Acceleration*—accounts for 50% of a vehicle's fuel consumption in city driving
  - *Speed limits*—driving at 65 miles per hour (mph) requires 15% more fuel than driving at 55 mph
  - *Safe driving distances*—20% less fuel is required to accelerate from 5 mph than from a full stop
- Starting and idling
- Trip planning
- Vehicle drag/weight
  - *Excess cargo*—fuel economy drops 1% for every 25–50 lbs of additional weight
  - *Vehicle drag*—Open windows/truck bed covers/vehicle add-ons
- Proper maintenance

- Engine tuning
- Correctly inflated tires

- Vehicle technology applications
  - Use of instantaneous fuel economy readouts
  - Use of navigation/direction systems

A Michigan eco-driving program must consider the following program initiatives:

Direct Driver Training Initiatives

- **Scope:** Provide direct, hands-on training from professional eco-driving instructors who provide a credible real-world basis for individual drivers to understand the direct impact their driving decisions have on fuel consumption and costs. This direct interaction could start with new drivers who need to pass a driver education course. In addition, eco-driving seminars and training can be linked with corporate/coalition initiatives to highlight specific eco-driving benefits.
- **Key Enablers:**
  - Development of an eco-driving module to be incorporated into all new driver course instruction. Module must include both written (online materials) and hands-on driving practice with the driving instructor.
  - Eco-driving course instruction and hands on training for all instructors licensed to train new drivers. Training can be provided by professional eco-drivers in a series of state-sponsored training courses.
  - State support for eco-driving training seminars in partnership with key auto coalition sponsors (e.g., American Automobile Association [AAA] and automakers). The goal is to document average savings for typical drivers that could be used in a media event that highlights the impact of eco-driving habits. A typical training package used in Europe and Canada targets drivers age 50 and older and includes (1) fuel economy monitoring during a 20-mile course (city/highway), (2) eco-driving instruction and discussion, and (3) repeat of the 20-mile course with the eco-driving instructor to define improvement.
- **Goal:** Newly trained drivers will gradually pass along what they learn to friends and neighbors, extending the impact of the program beyond the formal participants. Full implementation for new drivers programs by 2010. State-supported training in partnership with corporate/coalition members should target 5–10 regional events per year to leverage media focus.

General Eco-Driving Education

- **Scope:** Highlight the importance of ongoing eco-driving education by incorporating the review of an eco-driving training module as part of the state’s driver’s license renewal requirement.
- **Key Enablers:** Development of an interactive, online eco-driving module. Development of this module can leverage existing resources provided by automakers and other auto-related groups.

- **Goal:** Statewide implementation by 2010.

Vehicle Maintenance

- **Scope:** Proper inflation of tires is one of the most direct eco-driving actions that can be taken, and it can increase fuel economy by 2%–5%.
- **Key Enablers:**
  - Encourage all fuel stations to provide free air and accurate tire pressure gauges by providing a tax credit for up to 50% of the equipment cost. By 2010, require that all fuel stations (exempting low-volume operators) have a tire pressure gauge in place.
  - Encourage all repair and oil-change facilities to adjust tire pressure as part of their service—along with an eco-driving checklist—and create a state-sponsored "eco-star" program that highlights repair and oil-change facilities that incorporate eco-driving initiatives.
  - Require aftermarket tire manufacturers to display fuel economy ratings (rolling resistance standards) from tire manufacturers.
- **Goal:** Full customer access to tire pumps by 2010. Ensure that by 2012, 90% of all service stations follow a repair and oil-change checklist that includes a tire pressure check.

Vehicle Applications

- **Scope:** Real-time fuel economy indicators on vehicle instrument panels are one of the best means for encouraging eco-friendly driving because they provide prompt, quantitative feedback to drivers. Unfortunately, the State of Michigan acting alone cannot require manufacturers to offer such indicators on all vehicles, and it does not seem to be practical at present to install such indicators as after-market devices. Therefore, we have not included a goal relating to fuel-economy indicators.
- **Key Enablers:** Pursue a resolution with the governor and state officials to encourage manufacturers to offer real-time fuel economy indicators more widely.
- **Goal:** 90% of new vehicles have real-time fuel economy indicators by 2015.

Implementation Mechanisms

The low-rolling-resistance (LRR) tire program should include an information campaign aimed at making people more aware (at the point of sale) of the potential for fuel savings from LRR tires.

There may be difficulties in compelling currently licensed drivers to undergo additional driver training, but if the costs of such a program were low (or completely state funded), then it is possible that some people would participate to save money on fuel.

It may be possible to incorporate direct eco-driver training to the process of commercial truck licensing. Because the process for getting a commercial truck license is much more stringent than that for getting a regular driver's license, adding an eco-driver program would be less difficult.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

The GHG reductions from various eco-driver actions and the costs and cost saving are shown in Tables 2-1 through Table H-2-9, below.

Quantification Methods:

Four methods of improving Michigan's driving and vehicle maintenance habits were considered in this analysis: (1) LRR tires, (2) proper tire inflation, (3) direct eco-driver training, and (4) general eco-driver training. While the benefits of these programs have a definite potential for overlap, other eco-driving initiatives that are not considered in this analysis will likely have further savings that are not quantified. Other potential eco-driver initiatives include in-car vehicle readouts to show fuel efficiency and general vehicle maintenance to ensure optimal efficiency.

Low-Rolling-Resistance Tires

Rolling resistance reduces the amount of engine power that can be transferred to moving a vehicle along the road. This policy is intended to encourage the use of LRR tires as replacement tires, because new vehicles often use LRR tires to achieve their corporate average fuel economy (CAFÉ) requirements. The fuel efficiency savings possible from installing LRR tires was estimated at 3% according to the California Energy Commission (CEC, 2003). The fuel efficiency savings from trucks is even more significant, with an average savings of 3.9% (Ang-Olson and Schroeer, 2001).[3] Life cycle gasoline emissions for passenger cars were estimated to be 11.74 kg CO_2e/gal, while life cycle diesel fuel emissions for freight trucks were estimated to be 12.69 kg CO_2e/gal (ANL, 2008). Both of these emissions factors come from the GREET model. The implementation path represents the percentage of vehicles that will have LRR tires that otherwise would not have them. The path chosen can have a dramatic impact on the savings possible with an LRR tire program. The implementation path used and the GHG savings from LRR tires is shown in Table H-2-1.

[3] The 3.9% figure is an average of the Bridgestone and Michelin Study on LRR tires.

Table H-2-1. Implementation path and greenhouse gas savings of low-rolling-resistance tires

Year	Implementation Path (tire improvements)	Reduction in Fuel Use, LRR Tires, Passenger Cars	Reduction in Fuel Use, LRR Tires, Freight Trucks	GHG reduction, LRR Tires ($MMtCO_2e$)
2008	0%	0.00%	0.00%	0.00
2009	1.2%	0.04%	0.05%	0.03
2010	2.4%	0.07%	0.09%	0.05
2011	3.5%	0.11%	0.14%	0.08
2012	4.7%	0.14%	0.18%	0.10
2013	5.9%	0.18%	0.23%	0.12
2014	7.1%	0.21%	0.28%	0.15
2015	8.2%	0.25%	0.32%	0.17
2016	9.4%	0.28%	0.37%	0.19
2017	10.6%	0.32%	0.41%	0.22
2018	11.8%	0.35%	0.46%	0.24
2019	12.9%	0.39%	0.50%	0.26
2020	14.1%	0.42%	0.55%	0.28
2021	15.3%	0.46%	0.60%	0.31
2022	16.5%	0.49%	0.64%	0.33
2023	17.6%	0.53%	0.69%	0.36
2024	18.8%	0.56%	0.73%	0.38
2025	20%	0.60%	0.78%	0.41

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

Estimates of the number of vehicles in the program were made by multiplying the passenger vehicles or commercial trucks registered in Michigan by the implementation path (Bureau of Transportation Statistics [BTS], 2008). The costs of this policy were based on the additional cost of four LRR tires, estimated to be $100 (Snyder, 2008). These costs were applied to all vehicles in the program in their first year and then every 3 years after that. For trucks, the same cost factor was used, but was applied to 18 wheels rather than 4. The costs of this policy are shown in Table H-2-2. Taking into account the fuel savings over the course of the policy period, the use of LRR tires is a net cost savings.

Table H-2-2. Costs and cost savings from low-rolling -resistance tires

Year	Cost, LRR Tires, Passenger Cars (Million $)	Cost, LRR Tires, Freight Trucks (Million $)	Cost Savings, Passenger Cars (Million $)	Cost Savings, Diesel Freight Trucks (Million $)	Total Cost, LRR Tires (Million $)
2008	$0	$0	$0.0	$0.0	$0.0
2009	$9.5	$0.4	$4.6	$1.5	$3.9
2010	$12.7	$0.5	$9.5	$2.9	$0.9
2011	$15.9	$0.7	$14.3	$4.6	–$2.3
2012	$19.1	$0.8	$18.9	$6.1	–$5.1
2013	$22.2	$1.0	$23.6	$7.8	–$8.3
2014	$25.4	$1.1	$28.5	$9.6	–$11.6
2015	$28.6	$1.2	$33.0	$11.4	–$14.5
2016	$31.8	$1.4	$37.9	$13.2	–$18.0
2017	$34.9	$1.5	$43.1	$15.3	–$21.9
2018	$38.1	$1.6	$48.0	$17.3	–$25.6
2019	$41.3	$1.8	$53.3	$19.5	–$29.7
2020	$44.5	$1.9	$58.8	$21.7	–$34.2
2021	$47.6	$2.0	$65.2	$24.4	–$39.8
2022	$50.8	$2.2	$70.9	$26.9	–$44.8
2023	$54.0	$2.3	$76.1	$29.2	–$49.0
2024	$57.2	$2.4	$81.8	$31.8	–$53.9
2025	$60.4	$2.6	$85.8	$34.0	–$56.9

LRR = low-rolling-resistance [tires]. Negative numbers indicate costs savings.

Proper Tire Inflation

The General Accounting Office (GAO) estimated that 25% of vehicles have tires that are 8 pounds per square inch (psi) or more underinflated (GAO, 2008). In passenger cars, tires at 1 psi below optimal inflation reduce fuel efficiency by 0.4% (Carcare, 2008). Freight trucks with underinflated tires are estimated to have a reduced fuel efficiency of 0.6% (Ang-Olson and Schroeer, 2001). This policy involves modeling a tire inflation campaign for the State of Michigan after a similar program adopted in Sarasota, Florida. The implementation path used for this policy approaches 20%, and therefore 20% of drivers that otherwise would have had underinflated tires are assumed to now be practicing proper tire maintenance. The implementation path of the policy can be seen in Table H-2-3. The reduction in fuel consumption from the proper tire inflation campaign is determined by multiplying the percent of fuel improvement possible for both passenger cars and trucks by the amount of fuel consumed in the state by the emissions factor for a gallon of each fuel. The total GHG reductions possible with this policy are shown in Table H-2-3.

Table H-2-3. Implementation path and greenhouse gas reduction from proper tire inflation

Year	Implementation Path (tire improvements)	Fuel Improvement Possible, Tire Inflation, Passenger Cars	Fuel Improvement Possible, Tire Inflation, Commercial Trucks	GHG reduction, Tire Inflation ($MMtCO_2e$)
2008	0%	0.00%	0.00%	0.00
2009	1.2%	0.01%	0.01%	0.01
2010	2.4%	0.02%	0.01%	0.01
2011	3.5%	0.03%	0.02%	0.02
2012	4.7%	0.04%	0.03%	0.02
2013	5.9%	0.05%	0.04%	0.03
2014	7.1%	0.06%	0.04%	0.03
2015	8.2%	0.07%	0.05%	0.04
2016	9.4%	0.08%	0.06%	0.05
2017	10.6%	0.08%	0.06%	0.05
2018	11.8%	0.09%	0.07%	0.06
2019	12.9%	0.10%	0.08%	0.06
2020	14.1%	0.11%	0.08%	0.07
2021	15.3%	0.12%	0.09%	0.07
2022	16.5%	0.13%	0.10%	0.08
2023	17.6%	0.14%	0.11%	0.08
2024	18.8%	0.15%	0.11%	0.09
2025	20%	0.16%	0.12%	0.09

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

The costs of the tire inflation campaign were modeled after the Sarasota, Florida, tire information campaign (Florida, 2008).[4] These costs were adjusted to Michigan's population relative to that of Sarasota and scaled to an annual cost of $2.7 million. The cost savings come from reduced fuel use. The costs and cost savings are shown in Table H-2-4.

[4] This program aims to reduce tire waste and promote better tire care and maintenance. It is possible that a campaign aimed only at improving tire maintenance and inflation could be run at a lower cost.

Table H-2-4. Costs and cost savings from proper tire inflation program

Year	Cost of Tire Inflation Campaign (Million $)	Cost Savings, Tire Inflation (Million $)	Net Costs, Tire Inflation (Million $)
2008	$0.0	$0.0	$0.0
2009	$2.7	$1.4	$1.3
2010	$2.7	$3.0	–$0.2
2011	$2.7	$4.5	–$1.8
2012	$2.7	$6.0	–$3.2
2013	$2.7	$7.5	–$4.8
2014	$2.7	$9.1	–$6.3
2015	$2.7	$10.5	–$7.8
2016	$2.7	$12.1	–$9.4
2017	$2.7	$13.8	–$11.1
2018	$2.7	$15.5	–$12.7
2019	$2.7	$17.2	–$14.5
2020	$2.7	$19.0	–$16.3
2021	$2.7	$21.1	–$18.4
2022	$2.7	$23.0	–$20.3
2023	$2.7	$24.8	–$22.0
2024	$2.7	$26.7	–$24.0
2025	$2.7	$28.1	–$25.4

Negative numbers indicate costs savings.

Eco-Driver Training

Direct eco-driver training encourages driving habits that reduce fuel consumption. These habits include shifting to a higher gear earlier, using cruise control, coasting to stoplights, and accelerating more gradually. Habits such as these have both environmental and economic benefits to the driver. An eco-driving course in Europe found that reductions in fuel consumption of 15%–25% were quite possible for drivers in the first year (Ecodrive, 2007). This improvement typically decreases as old driving habits return, so subsequent years had an average of 6.3% reduction in fuel consumption (Ecodrive, 2007). This policy was applied only to drivers of passenger vehicles, because it is assumed that while eco-driving techniques could save fuel in freight trucks, they are likely to have costs and benefits different from a program aimed at cars. The reduction in fuel consumption and GHG benefits are shown in Table H-2-5.

Table H-2-5. Implementation path and greenhouse gas savings of direct eco-driver training

Year	Implementation Path (behavior changes)	Percentage Fuel Reduction From Driver Training (passenger cars only)	GHG Reduction, Direct Driver Education
2008	0.00%	0.00%	0.00
2009	2.94%	0.59%	0.32
2010	5.88%	0.76%	0.41
2011	8.82%	0.93%	0.49
2012	11.76%	1.10%	0.58
2013	14.71%	1.28%	0.66
2014	17.65%	1.45%	0.73
2015	20.59%	1.62%	0.81
2016	23.53%	1.79%	0.89
2017	26.47%	1.96%	0.97
2018	29.41%	2.13%	1.04
2019	32.35%	2.31%	1.12
2020	35.29%	2.48%	1.19
2021	38.24%	2.65%	1.27
2022	41.18%	2.82%	1.35
2023	44.12%	2.99%	1.43
2024	47.06%	3.17%	1.52
2025	50.00%	3.34%	1.59

GHG = greenhouse gas.

The costs for direct eco-driver training for Michigan were estimated based on a cost of 2 million Euros to train 6,500 driving instructors in a similar program in the Netherlands (Wilbers et al., 2006). Ninety-two percent of these driving instructors said that they would take into account the methods taught in the course, and therefore it is assumed that 92% of driving instructors will begin teaching eco-driving methods (Wilbers et al., 2006). These training costs were multiplied to the number of drivers assumed to be taking an eco-driving course, as shown in the implementation path, reaching 50% of the population by 2025. The costs of direct eco-driver training are shown in Table H-2-6.

Table H-2-6. Costs of direct eco-driver training

Year	Cost of Driver Training (Passenger Cars) (Million $)	Cost Savings, Driver Training (Passenger Cars) (Million $)	Net Costs, Driver Training (Million $)
2008	$0.0	$0.0	$0.0
2009	$93.3	$76.6	$16.7
2010	$93.3	$101.8	–$8.5
2011	$93.3	$125.4	–$32.2
2012	$93.3	$147.5	–$54.2
2013	$93.3	$170.7	–$77.4
2014	$93.3	$194.5	–$101.2
2015	$93.3	$216.1	–$122.9
2016	$93.3	$240.3	–$147.0
2017	$93.3	$266.0	–$172.7
2018	$93.3	$290.4	–$197.2
2019	$93.3	$316.7	–$223.4
2020	$93.3	$344.3	–$251.0
2021	$93.3	$376.4	–$283.1
2022	$93.3	$405.0	–$311.8
2023	$93.3	$430.4	–$337.1
2024	$93.3	$458.3	–$365.0
2025	$93.3	$477.4	–$384.1

Negative numbers indicate costs savings.

General Eco-Driving Initiative

The general eco-driving initiative seeks to encourage all drivers to operate their vehicles in a safer manner, with the emphasis on reduced highway speeds. The implementation path used for this program assumes that 5% of drivers will modify their driving habits and thus reduce their typical highway speed from 70 to 60 mph. It is likely that the true benefits of this program will be different: more than 5% of the population is likely to change their driving habits in some small way, and some drivers will reduce their highway speed, but only some of the time or only by a few miles per hour. However, this estimate should serve as an example of the fuel reductions that can come from a general eco-driver initiative aimed at encouraging reduced highway speeds.

The fuel savings of this program were estimated by multiplying the implementation path by the average amount of high speed (>55 mph) driving for both cars (24%) (Federal Highway Administration [FHWA], 2008) and trucks (50%) (Ang-Olson and Schroeer, 2001). The result was then multiplied by the reduction in fuel efficiency that comes with driving at 70 mph rather than at 60 mph. This fuel efficiency improvement for cars was estimated to be 16% (Speed

Figure, 2007),[5] while the improvement for freight trucks is 14% (Ang-Olson and Schroeer, 2001). The GHG benefits of the General Eco-Driver Initiative are shown in Table H-2-7.

Table H-2-7. Implementation path and GHG benefits of General Eco-Driver Initiative

Implementation Path (behavior changes)	General Eco-Driver Initiative (passenger cars)	General Eco-Driver Initiative (freight trucks)	GHG Reduction, General Eco-Driver Initiative
0.00%	0.00%	0.00%	0.00
0.29%	0.01%	0.02%	0.01
0.59%	0.02%	0.04%	0.02
0.88%	0.03%	0.06%	0.03
1.18%	0.05%	0.08%	0.04
1.47%	0.06%	0.10%	0.04
1.76%	0.07%	0.12%	0.05
2.06%	0.08%	0.14%	0.06
2.35%	0.09%	0.16%	0.07
2.65%	0.10%	0.19%	0.08
2.94%	0.11%	0.21%	0.09
3.24%	0.13%	0.23%	0.09
3.53%	0.14%	0.25%	0.10
3.82%	0.15%	0.27%	0.11
4.12%	0.16%	0.29%	0.12
4.41%	0.17%	0.31%	0.13
4.71%	0.18%	0.33%	0.14
5.00%	0.20%	0.35%	0.15

The costs of this eco-driver initiative were based on a similar eco-driver initiative in the Netherlands (Senternovem, 2004).[6] The cost savings of this policy come from the reduced cost of fuel over the policy period. The costs of the eco-driver program are shown in Table H-2-8.

[5] The average of these seven different efficiencies was used in this analysis.

[6] The largest year for this policy was 2002 which had a budget of 7 million Euros. This amount was used for our costs, and then adjusted according to differences in the Netherlands/Michigan population and exchange rates. The result is an investment of $6.3 million annually.

Table H-2-8. Costs and cost savings of eco-driver initiative

Year	Cost of Eco-Driver Information Program (Million $)	Cost Savings of Eco-Driver Program (Million $)	Net Costs, Eco-Driver Program (Million $)
2008	$0.0	$0.0	$0.0
2009	$6.3	$2.1	$4.2
2010	$6.3	$4.4	$1.9
2011	$6.3	$6.7	–$0.3
2012	$6.3	$8.9	–$2.5
2013	$6.3	$11.2	–$4.9
2014	$6.3	$13.6	–$7.2
2015	$6.3	$15.8	–$9.5
2016	$6.3	$18.3	–$11.9
2017	$6.3	$20.9	–$14.5
2018	$6.3	$23.4	–$17.0
2019	$6.3	$26.1	–$19.7
2020	$6.3	$28.9	–$22.5
2021	$6.3	$32.1	–$25.8
2022	$6.3	$35.2	–$28.8
2023	$6.3	$37.9	–$31.5
2024	$6.3	$40.9	–$34.5
2025	$6.3	$43.2	–$36.9

Negative numbers indicate costs savings.

The entire Eco-Driver policy requires a significant investment on the part of the state of Michigan, but these investments all reap significant rewards in terms of fuel savings. The combined costs, cost savings and GHG benefits of the four eco-driver initiatives considered are shown in Table H-2-9.

Table H-2-9. Total costs, cost savings, and GHG reductions from TLU-2

Year	Total Costs (Million $)	Total Savings (Million $)	Net Costs, TLU-2 (Million $)	Gas Gallons Saved (Million)	Diesel Gallons Saved (Million)	Emissions Savings ($MMtCO_2e$)
2008	$0.0	$0	$0.0	0.0	0.0	0.00
2009	$112.3	$86	$26.0	29.4	0.8	0.36
2010	$115.6	$122	–$6.0	39.8	1.7	0.49
2011	$118.9	$155	–$36.6	49.7	2.5	0.62
2012	$122.2	$187	–$65.1	59.1	3.4	0.74
2013	$125.5	$221	–$95.3	68.2	4.2	0.85
2014	$128.9	$255	–$126.3	77.1	5.0	0.97
2015	$132.2	$287	–$154.7	86.0	5.9	1.08
2016	$135.5	$322	–$186.3	94.8	6.7	1.20
2017	$138.8	$359	–$220.3	103.5	7.6	1.31
2018	$142.1	$395	–$252.5	112.1	8.5	1.42
2019	$145.4	$433	–$287	120.5	9.3	1.53
2020	$148.7	$473	–$324	128.9	10.2	1.64
2021	$152.0	$519	–$367	137.7	11.2	1.76
2022	$155.4	$561	–$406	146.8	12.1	1.88
2023	$158.7	$598	–$440	156.2	13.2	2.00
2024	$162.0	$639	–$477	165.8	14.3	2.13
2025	$165.3	$669	–$503	174.3	15.3	2.24
Total			**–$3,921**			**22.2**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent. Negative numbers indicate costs savings.

Data Sources:

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ANL. 2008. GREET Model 1.8, available at: http://www.transportation.anl.gov/modeling_simulation/GREET/index.html

Wilbers et al. 2006. "Monitoring and evaluation of behavioral programmes," available at: http://www.iapsc.org.uk/presentations/0606_Kroon_combined.pdf (accessed on August 14, 2008).

Ecodrive. April 11, 2007. "CIECA internal project on 'Eco-driving' in category B driver training & the driving test," available at: http://www.ecodrive.org/fileadmin/dam/ecodrive/Downloads/CIECA_Eco-driving_project_final_report_EN.pdf (accessed on August 12, 2008).

Florida. 2008. "Waste Tire Source Reduction and Public Awareness Program," available at: http://www.dep.state.fl.us/waste/quick_topics/publications/shw/recycling/InnovativeGrants/IGyear5/fullprop/SarasotaCounty.pdf (accessed on August 12, 2008).

GAO. 2008. http://www.gao.gov/new.items/d07246r.pdf (accessed on August 10, 2008).

Carcare. 2008. http://www.carcare.org/tires_wheels/inflation.shtml (accessed on August 12, 2008).

Ang-Olson, J. and W. Schroeer. 2001. "Energy Efficiency Strategies for Freight Trucking: Potential Impact on Fuel Use and Greenhouse Gas Emissions." The 3.9% figure is an average of the Bridgestone and Michelin Study on LRR tires.

BTS. 2008. http://www.bts.gov/publications/state_transportation_statistics/michigan/html/fast_facts.html

Snyder, J. "A big fuel saver: Easy-rolling tires (but watch braking)," *Automotive News,* July 21, 2008.

Senternovem. 2004. http://www.senternovem.nl/mmfiles/Engelse%20folder%20april%202004_tcm24-192328.pdf. The largest year for this policy was 2002 which had a budget of 7 million Euros. This amount was used to calculate the costs of an eco-driver program, and then adjusted according to differences between the Netherlands and Michigan populations and exchange rates. The result is an investment of $6.3 million annually.

FHWA. 2008. http://www.fhwa.dot.gov/ohim/tvtw/08juntvt/08juntvt.pdf. Assumes that speed on interstate highways is above 55 mph and speed on non-interstate highways is below 55 mph.

Speed Figure. 2007. http://bioage.typepad.com/.shared/image.html?/photos/uncategorized/2007/05/01/fordspeed1.png (accessed August 14, 2008). This figure shows seven different vehicles, and the efficiency reductions that came with travelling at higher speeds. The average of these seven different efficiencies was used in this analysis.

Key Assumptions: Noted in discussion.

Key Uncertainties

None cited.

Additional Benefits and Costs

LRR tires can require additional stopping distance at highway speeds, thus creating safety concerns.

Conversely, encouraging reduced speeds through the general eco-driving program can help improve highway safety.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-3. Truck Idling Policies

Policy Description

This policy option aims to reduce GHG and other emissions from unnecessary idling of heavy-duty vehicles, including trucks and buses. The U.S. Environmental Protection Agency (EPA) estimates that truck idling consumes 1 billion gallons of fuel annually, emitting 11 $MMtCO_2$. Michigan has 3.66% of the total U.S. truck and bus registrations, so the Michigan estimates are 36.6 million gallons and 0.4 million metric tons of CO_2. Much of this idling takes place during mandatory rest periods to provide heating or cooling of the truck's cabin air. Substantial reductions in fuel consumption and GHG emissions could be realized by providing alternate means for cabin air conditioning.

Additional idling occurs during vehicle operation, for example, when loading and unloading buses and trucks. The implementation of public and private fleet anti-idling policies and ordinances, targeted education of bus and truck operators, and creation of low-cost means to access available EPA-verified technologies could help encourage emissions reductions from heavy-duty diesel engines.

Policy Design

Goals:

Reduce heavy-duty engine idling by providing increased availability of electrification at privately owned truck stops or encouraging greater use of auxiliary power units (APUs; on-board generators) for heating, cooling, and other creature comforts on heavy-duty vehicles. Provide financial assistance (e.g., low-interest revolving loans) to truck-stop operators and truck owners/operators for infrastructure development or equipment purchase. Undertake targeted educational activities as appropriate with truck, bus, and truck-stop owners and operators. Achieve diesel idling reductions from heavy-duty diesel engines of 40% by 2015 and 80% by 2025, relative to baseline.

Adopt a Michigan anti-idling law based on the EPA Model State Idling Law (http://www.epa.gov/SmartwayLogistics/documents/420s06001.pdf) and/or encourage adoption of local ordinances to address idling during operation of buses and heavy trucks.

Timing:

Parties Involved: Truck and bus fleet owners and operators, Michigan Department of Transportation (MDOT), truck-stop owners and operators, school districts (for school buses), and state police (enforcement).

Other: Issues to be resolved include the choice of implementing one EPA-verified technology over another (e.g., electrification versus APUs), costs and benefits associated with providing anti-idling infrastructure and facilities at public rest areas versus private truck stops, costs and benefits to fleet operators and to the state, and enforcement mechanisms that would be required.

Potential funding sources include funding from the gas tax and from Congestion Mitigation and Air Quality (CMAQ) and other federal agency grants.

Implementation Mechanisms

Adopt a Michigan anti-idling law based on the EPA Model State Idling Law (http://www.epa.gov/SmartwayLogistics/documents/420s06001.pdf) and/or encourage adoption of local ordinances to address idling during operation of buses and heavy trucks.

Many other states have low-interest loans to finance idling reduction technology, but this is not the case in Michigan. Such a program would help provide the capital necessary to defray the up-front costs of investing in these efficiency improvements.

There are also difficulties in this program that come from misplaced incentives for efficiency improvement. For example, if the truck owner is responsible for truck maintenance (and therefore any upgrades to the truck) but the truck driver is responsible for fuel costs, then there is no incentive for either to make an investment toward efficiency improvement. Any implementation of this policy should try to account for this potential barrier to implementation.

Clean School Bus USA's newly launched National Idle Reduction Campaign is a public information campaign that recognizes the important role of the school bus driver as a professional who is responsible for the safety and security of children. The National Idle Reduction Campaign provides an opportunity for bus drivers, transportation managers, teachers, and children to learn about air quality and diesel emissions. It recognizes the positive contributions being made by school bus drivers. In addition, this program promotes idle reduction as an easy way to save money by saving fuel, reducing wear and tear on engines, protecting driver's health and the health of children, and improving air quality.

Related Policies/Programs in Place

No state programs exist for truck stop anti-idling. Numerous trucking firms have encouraged reducing idling through grants from EPA and other sources. The City of Ann Arbor has a draft policy on truck idling reduction based on EPA recommendations.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-3-1. Estimated GHG reductions and cost-effectiveness

	2015	2025	Units
GHG emission savings	0.36	0.76	$MMtCO_2e$
Net present value (2009–2025)		–$596	$million
Cumulative emissions reductions (2009–2025)		7.0	$MMtCO_2e$
Cost-effectiveness		–$85	$/tCO_2e$

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

Data Sources:

American Transportation Research Institute (ATRI). February 2006. "Idle Reduction Technology: Fleet Preferences Survey." Source for technology and maintenance costs.

EPA SmartWay Transportation Partnership. http://www.epa.gov/otaq/smartway/transport/what-smartway/idling-reduction.htm. Source for average idling hours and technology costs.

ANL. June 2000. "Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks," ANL/ESD-43, Transportation Technology R&D Center. Source for information on technology impacts.

Data from EPA's MOBILE6 model to estimate the proportion of CO_2 emissions attributable to Class 8 trucks. http://www.epa.gov/otaq/m6.htm

Data from AEO 2008 to estimate the amount of fuel consumed annually per truck.

Truck-Stop Electrification data based on a study done by ANTARES Group Inc. for the DeWitt Service Area facility in New York state, available at: http://www.epa.gov/smartway/documents/dewitt-study.pdf.

Ang-Olson, J. and W. Schroeer. 2001. "Energy Efficiency Strategies for Freight Trucking: Potential Impact on Fuel Use and Greenhouse Gas Emissions," Transportation Research Board. Data for APU diesel consumption.

ATRI. August 2007. "Fuel Savings/Emissions Reducing Technologies and Incentives: Use and Preferences Among Diesel Truck Owners in the Baltimore Region."

U.S. EPA. National Idle Reduction Campaign and Idle Reduction Calculator. Used to estimate costs and GHG savings for Michigan school bus retrofits, available at: http://www.epa.gov/cleanschoolbus/antiidling.htm

Quantification Methods:

The estimated reduction in CO_2 emissions from reduced idling was calculated by first estimating the portion of emissions and fuel consumption in the Michigan transportation inventory that were attributable to Class 8 diesel trucks. Class 8 trucks are defined by the Federal Highway Administration as heavy duty trucks with less than five axles, used for medium-haul delivery. Then, the portion of the total fuel consumption that would be consumed during idling was estimated. Idle reduction percentages for each year was interpolated from 2010 to 2025 based on the Michigan reduction targets of 40% by 2015 and 80% by 2025 (Table 3-2).

Table H-3-2. Truck idling activities, idling reduction percentages, and diesel savings

Year	Estimated Number of Class 8 Trucks in Michigan	Diesel Consumption in Class 8 Truck Idling (million gallons)	Idling Reduction Percentage Applied	Diesel Saved From Idling Reduction (million gallons)
2009	124,617	92.2	0%	0
2010	124,551	93.9	7%	6.3
2011	124,357	94.3	13%	12.6
2012	125,482	94.2	20%	18.8
2013	127,274	94.1	27%	25.1
2014	128,805	94.1	33%	31.4
2015	130,037	94.4	40%	37.7
2016	131,254	94.5	44%	41.6
2017	132,932	94.7	48%	45.5
2018	134,267	94.9	52%	49.3
2019	135,414	95.1	56%	53.2
2020	136,509	95.4	60%	57.3
2021	138,226	96.3	64%	61.6
2022	140,376	97.4	68%	66.2
2023	142,648	98.6	72%	71.0
2024	145,028	100.1	76%	76.0
2025	146,407	100.8	80%	80.7
Total Reductions				**734**

For the purpose of this analysis, emissions from the usage of APUs for truck idling were quantified. Specifically, it was assumed that auxiliary diesel engines burn 0.2 gallons of fuel per hour of idling (Ang-Olson and Schroeer, 2001). The CO_2 emissions saved from idle reduction were then netted against the CO_2 emitted from APU usage. The emissions for all gallons of diesel fuel consumed used the life cycle emissions factor of 11.25 tCO_2e/1,000 gal consumed. Table H-3-3 shows the APU diesel consumption and the net CO_2 reduced from idling.

Table H-3-3. APU emissions and net CO_2 savings from truck idle reduction

Year	Diesel Consumed From APU Usage (million gallons)	CO_2 Emissions From APU Usage ($MMtCO_2e$)	Net CO_2 Saved From Idle Reduction ($MMtCO_2e$)
2009	0.00	0.00	0.00
2010	1.1	0.01	0.06
2011	2.3	0.03	0.12
2012	3.4	0.04	0.17
2013	4.5	0.05	0.23
2014	5.6	0.06	0.29
2015	6.8	0.08	0.35
2016	7.5	0.08	0.38
2017	8.1	0.09	0.42
2018	8.8	0.10	0.46
2019	9.5	0.11	0.49
2020	10.3	0.12	0.53
2021	11.0	0.12	0.57
2022	11.9	0.13	0.61
2023	12.7	0.14	0.66
2024	13.6	0.15	0.70
2025	14.4	0.16	0.74
Total Reductions	**131**	**1.48**	**6.78**

The cost analysis assumes a 5-year lifetime for idling technology equipment, applied to an incremental percentage of Class 8 vehicles starting in 2010, at a cost of $6,000 per vehicle.[7] The AEO 2008 diesel fuel prices for the High Energy Price Case were used for estimating fuel savings. APU operating costs were based on the cost of burning 0.2 gallons of fuel per hour of idling. APU annual maintenance costs were not included in this analysis, because these costs were not adequately reported in surveys. However, ATRI indicated in a study that $300 per year can be saved in truck engine maintenance when using APU for idling. Table H-3-4 shows the costs and savings from idle reduction on a year-to-year basis.

[7] ATRI. February 2006. "Idle Reduction Technology: Fleet Preferences Survey," for idle-reduction technology costs.

Table H-3-4. Costs estimated from truck anti-idling policies

Year	Fuel Cost ($/gallon) High Energy Price Scenario	Annualized Capital Cost of Idle Retrofits (million $)	Direct Fuel Savings Using APU (million $)	Total Annual Capital Cost + Fuel Savings (million $)
2009	$2.83	$0.00	$0	$0
2010	$2.82	$11.51	$18	–$3
2011	$2.92	$22.98	$37	–$7
2012	$2.92	$34.78	$55	–$10
2013	$3.00	$47.04	$75	–$15
2014	$3.06	$59.50	$96	–$19
2015	$3.09	$72.08	$117	–$24
2016	$3.14	$80.04	$131	–$27
2017	$3.23	$88.43	$147	–$32
2018	$3.28	$96.76	$162	–$36
2019	$3.34	$105.09	$178	–$41
2020	$3.41	$113.51	$195	–$47
2021	$3.50	$122.60	$216	–$54
2022	$3.55	$132.29	$235	–$61
2023	$3.55	$142.34	$252	–$65
2024	$3.57	$152.75	$271	–$70
2025	$3.57	$162.32	$288	–$74

APU = auxiliary power unit. Negative numbers indicate cost savings.

Reduced School Bus Idling

There are approximately 18,000 school buses in Michigan based on estimates provided by the Michigan State Police, who inspect all Michigan school buses annually. EPA's National Idle-Reduction Campaign calculator was used to estimate the potential fuel savings and fuel costs for a school bus idle reduction campaign. Based on a 30-minute reduction in idling each school day, it was estimated that 45 gallons per year in diesel fuel would be saved (Table H-3-5). The buses were assumed to have installed engine block preheaters to be used in cold weather. These preheaters cost approximately $1,500; fuel costs are one-sixteenth those of traditional engine idling. Engine costs are considered as an annualized cost over 20 years, with a 5% discount rate. Because reduced engine idling also reduces engine wear, there would likely be savings in the cost of maintenance. These savings are not considered in this analysis.

Table H-3-5. Cost savings and greenhouse gas benefits from reduced school bus idling

	Michigan Total, Diesel Gallons (million)	Bus Savings, Diesel Gallons (thousand)	Emissions Reduction ($MMtCO_2e$)	Cost Savings From Reduced Fuel Use (million $)	Installation Costs (million $)	Net Costs (million $)
2008	1,095	810	0.010	2.5	$2.2	–$0.4
2009	1,118	827	0.010	2.3	$2.2	–$0.2
2010	1,138	842	0.011	2.4	$2.2	–$0.2
2011	1,143	845	0.011	2.5	$2.2	–$0.3
2012	1,142	845	0.011	2.5	$2.2	–$0.3
2013	1,140	843	0.011	2.5	$2.2	–$0.4
2014	1,141	844	0.011	2.6	$2.2	–$0.4
2015	1,144	846	0.011	2.6	$2.2	–$0.4
2016	1,146	847	0.011	2.7	$2.2	–$0.5
2017	1,148	849	0.011	2.7	$2.2	–$0.6
2018	1,150	851	0.011	2.8	$2.2	–$0.6
2019	1,152	852	0.011	2.9	$2.2	–$0.7
2020	1,156	855	0.011	2.9	$2.2	–$0.8
2021	1,167	863	0.011	3.0	$2.2	–$0.9
2022	1,180	873	0.011	3.1	$2.2	–$0.9
2023	1,195	884	0.011	3.1	$2.2	–$1.0
2024	1,213	897	0.011	3.2	$2.2	–$1.0
2025	1,222	904	0.011	3.2	$2.2	–$1.1
			0.195			**–$10.6**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent. Negative numbers indicate cost savings.

Table H-3-6 shows the total costs and the total GHG reductions that come from reduced school bus idling and reduced commercial truck idling.

Table H-3-6. Costs and GHG savings of TLU-3

Year	GHG Savings, Reduced Truck Idling ($MMtCO_2e$)	GHG Savings, Reduced School Bus Idling ($MMtCO_2e$)	Total GHG Savings ($MMtCO_2e$)	Net Costs, Reduced Truck Idling (million $)	Net Costs, Reduced School Bus Idling (million $)	Net Costs, Total (million $)
2008	0.00	0.010	0.01	$0	–$0.4	–$0.4
2009	0.00	0.010	0.01	$0	–$0.2	–$0.2
2010	0.06	0.011	0.07	–$3	–$0.2	–$3.2
2011	0.12	0.011	0.13	–$7	–$0.3	–$7.5
2012	0.17	0.011	0.18	–$10	–$0.3	–$10.7
2013	0.23	0.011	0.24	–$15	–$0.4	–$15.1
2014	0.29	0.011	0.30	–$19	–$0.4	–$19.7
2015	0.35	0.011	0.36	–$24	–$0.4	–$24.1
2016	0.38	0.011	0.39	–$27	–$0.5	–$27.7

Year	GHG Savings, Reduced Truck Idling ($MMtCO_2e$)	GHG Savings, Reduced School Bus Idling ($MMtCO_2e$)	Total GHG Savings ($MMtCO_2e$)	Net Costs, Reduced Truck Idling (million $)	Net Costs, Reduced School Bus Idling (million $)	Net Costs, Total (million $)
2017	0.42	0.011	0.43	–$32	–$0.6	–$32.7
2018	0.46	0.011	0.47	–$36	–$0.6	–$36.7
2019	0.49	0.011	0.50	–$41	–$0.7	–$41.6
2020	0.53	0.011	0.54	–$47	–$0.8	–$47.5
2021	0.57	0.011	0.58	–$54	–$0.9	–$55.3
2022	0.61	0.011	0.62	–$61	–$0.9	–$61.6
2023	0.66	0.011	0.67	–$65	–$1.0	–$65.6
2024	0.70	0.011	0.71	–$70	–$1.0	–$71.1
2025	0.74	0.011	0.76	–$74	–$1.1	–$75.1
Total			**7.0**			**–$596**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.
Negative numbers indicate cost savings.

Key Assumptions: This analysis assumes that idle reductions are achieved only by the Class 8 diesel truck population, that these trucks idle for an average of 6 hours per day, that they consume 1 gallon of diesel per hour during idling,[8] and that a 40% (by 2015) or 80% (by 2025) reduction of diesel idling from these Class 8 trucks will be achieved.

Program administration costs, enforcement costs, and fines have not been factored into the cost analysis. Reduced vehicle maintenance costs have also not been factored into the analysis.

Key Uncertainties

Buses, as well as other diesel trucks that have not been quantified here, could achieve a small additional reduction in idling emissions. The distribution of technologies that would be selected by these trucks or fleets to reduce their emissions is highly uncertain, which would have a significant impact on the overall cost/cost savings of this measure.

Use of these technologies would also cause a slight decrease in the CO_2 and fuel consumption reductions achieved. For example, the use of truck stop electrification (TSE) would increase emissions from electricity generation. Based on a study done at a TSE service area near Syracuse, New York, about 2,670 kilowatt-hours (kWh) of electricity was consumed using TSE each year for each parking space.[9] Using Michigan electricity CO_2 emission factors,[10] this equals about 2.1 tCO_2 emitted per year per electrified space. If Michigan were to have 1,000 TSE

[8] EPA SmartWay Transportation Partnership, available at: http://www.epa.gov/otaq/smartway/transport/what-smartway/idling-reduction.htm. Source for idle assumption.

[9] Truck-Stop Electrification data based on a study done by ANTARES Group Inc. for the DeWitt Service Area facility in New York state, available at: http://www.epa.gov/smartway/documents/dewitt-study.pdf.

[10] MI electric emission factors from Appendix F of "Instructions for Form EIA-1605 Voluntary Reporting of Greenhouse Gases," available at: http://www.eia.doe.gov/oiaf/1605/pdf/EIA1605_Instructions_10-23-07.pdf

spaces by 2025, the CO_2 emissions from electric consumption would be 0.002 $MMtCO_2$, a negligible number.

Equipment cost and lifetime will also vary by technology employed. The cost value selected was based on cost data summarized by ATRI, and it represents the capital costs of a variety of idle reduction technologies. The cost of $6,000 per vehicle represents a mix of costs for higher and lower technologies. The cost analysis does not take into account the number of vehicles that have already installed idle reduction technologies. The fuel cost assumed here is based on long-term projected fuel costs. Increases in this assumed fuel cost will lead to greater cost savings for this measure.

Additional Benefits and Costs

Reductions in idling will also reduce emissions of toxics, nitrogen oxides (NO_x), and particulate matter (PM). The primary co-benefits for Michigan of this policy will be in reducing PM-2.5 [particulate matter 2.5 micrometers in diameter and smaller] precursor emissions, such as PM-2.5 and NO_x emissions in the state's PM-2.5 non-attainment areas. The currently designated PM-2.5 non-attainment area in Michigan is Detroit–Ann Arbor. Therefore, initial implementation of this policy option should be in that non-attainment area.

Reducing fine particle pollution, according to EPA studies, will mean improved health due to fewer cases of asthma, lost workdays, hospital visits, and premature deaths. Idle emission reductions will reduce wear from engine operation, thus leading to a cost savings from reduced maintenance costs.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-4. Advanced Vehicle Technology

Policy Description

Create a policy that will expand the development and use of more efficient vehicle design and/or hybrid propulsion systems.

Policy Design

Goals:

- Make loans and subsidies available to municipalities, local governments, and waste management organizations to encourage more rapid adoption of advanced vehicles by public fleets (transit agencies and schools) with a goal of achieving the use of advanced vehicle technologies (hybrid or hydrogen technology) in 10% of the fleet by 2025.

Timing: The timing for advanced vehicle technology improvements will have a direct correlation with the consumer market based on fuel prices and a desire for Michigan and the United States to become more energy independent.

Parties Involved: Public utilities, consumers, original equipment manufacturers (OEMs; battery manufacturers, automakers), municipalities, local governments, waste management, and the freight industry.

Other: Incentives will build a market that encourages OEMs to produce more efficient vehicle and propulsion designs. This will stimulate the ancillary manufactures to further improve the efficiency of products to support the OEMs. The majority of the subsidies and incentives will come at the inception of approval of these policies to encourage the market. Subsidies and incentives will slowly taper off until the full potential of market penetration has been realized and the technologies have become economically competitive.

Implementation Mechanisms

The Michigan at a Climate Crossroads study considered an alternative vehicle technology incentive measure that was designed to provide tax credits to consumers for purchasing alternative vehicle technologies. However, the models that they had available for examining such an implementation mechanism were unable to consistently capture the market pull effect of providing a tax credit to consumers for advanced vehicle technology purchases. The state tax credit that they modeled was estimated to be $1,500 per vehicle, on average.

This policy option does not include specifics about recommended state actions or about the amounts that might be invested by the state to increase the probability that low-GHG-emitting advanced vehicle technologies could be sold and operated in Michigan. Funding might be used for state tax credits or other incentives that would induce fleet managers to purchase more expensive (in initial purchase cost) advanced technology vehicles. This investment might need to be on the order of a few thousand dollars per light-duty vehicle sold until the market penetration of advanced technology vehicles is sufficient to provide the economies of scale associated with large production volumes.

Related Policies/Programs in Place

Michigan hybrid electric vehicle laws and incentives include the following:

Hybrid Electric Vehicle Research and Development Tax Credit: For tax years beginning on or after January 1, 2008, and ending before January 1, 2016, a manufacturer engaged in R&D on a qualified hybrid system primarily for propelling a motor vehicle may claim a tax credit under the Michigan Business Tax law. This tax credit is equal to 3.9% of all wages, salaries, fees, bonuses, commissions, or other payments made in the taxable year for the benefit of employees for services performed in a qualified facility.

Alternative Fuel Research and Development Tax Exemption: The Michigan Strategic Fund has designated an alternative energy zone (AEZ) within Wayne State University's Research and Technology Park in Detroit to promote the research, development, and manufacturing of alternative energy technologies, including alternative fuel vehicles (AFVs). Businesses located within the AEZ that are engaged in qualified activities are eligible for exemption from state and local taxes, which would be determined by the Michigan NextEnergy Authority (MNEA). Alternative energy technology companies located in the AEZ may also be eligible for a refundable payroll credit under the Michigan Business Tax law.

Alternative Fuel Development Property Tax Exemption: A tax exemption may apply to industrial property that is used for high-technology activities or for the creation or synthesis of biodiesel fuel. High-technology activities include those related to advanced vehicle technologies such as electric, hybrid, or AFVs and their components.

Acquisition and Alternative Fuel Use Requirement: The Department of Management and Budget (DMB) is required to continue to comply with the requirements of the federal Energy Policy Act of 1992. The DMB must include hybrid electric vehicles within the state's fleet if the vehicles are determined to be cost-effective and capable of meeting the state's transportation needs. In addition, as the state's public fueling infrastructure for alternative fuel continues to develop, state motor fleet AFVs are required to fuel with alternative fuels to the extent possible. The DMB will develop rules to encourage or require the use of diesel fuel with the highest percentage of biodiesel content available for diesel-powered vehicles in the state fleet.

Electric Smart Grid collaborative expansion to include Plug-in Electric Hybrid Vehicle (PHEV) pilot projects: On April 24, 2007, a Commission Order was issued in Case No. U-15278 commencing a Smart Grid collaborative. In this collaborative, all Commission regulated electric distribution companies are required to participate in the investigation of technologies that will help the grid to become more flexible, efficient, and reliable.

On March 11, 2008, pursuant to the April 24, 2007 Commission Order, an Order was issued that required all Commission regulated electric distribution companies to expand the scope of their collaborative participation to include PHEV pilot projects. Commission staff shall draft annual reports on PHEV advancements regarding the smart grid collaborative with the first report scheduled to be filed by June 30, 2009.

The order contained the following tasks for the PHEV aspect of the collaborative:

- Technology pilot programs using actual vehicles, some of which incorporate Vehicle to Grid systems, if and when available.
- An analysis of the environmental effects in Michigan of PHEVs at low, medium, and, high levels of adoption, with and without Vehicle to Grid capability.
- A comprehensive analysis of the effect of PHEVs on Michigan utility and regional electric system load duration curves and the effect of PHEV market penetration on generation mix and capacity requirements.
- An analysis of metering and time-based pricing policies for electricity used to charge electric vehicles.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

Quantification Methods:

GHG Benefits of Advanced Vehicle Technology

Light Duty Vehicles

While this analysis considers only two vehicle technologies—plug-in hybrid vehicles and hydrogen fuel cell vehicles—it should be recognized that other technologies (e.g., battery-electric vehicles) can also provide benefits. To determine the number of vehicles in the program, the number of fleet vehicles (cars, trucks, and buses) in Michigan in a given year were estimated (Wards, 2007),[11] and then multiplied by the implementation path in order to achieve 10% of fleet vehicles by 2025. The implementation path and advanced vehicle purchases in the policy are shown in Table H-4-1. There were just over 46,000 cars in Michigan's fleet, as well as 70,000 trucks and 16,000 buses. Trucks were not included in this analysis, due to the significant difference in the size, fuel economy and cost of different truck types. Fleet buses (both school and transit buses were included) are considered in this analysis, and that information is provided in the next section. The AEO 2008 forecast did not have plug-in hybrids available to the mass market until 2012 and did not have hydrogen fuel cell vehicles available on a large scale until 2013. Thus, those are the first years that those vehicle types are considered in this analysis.

[11] The estimate was made on the basis of the retail sales of new vehicles in the country, multiplied by the percentage of vehicle registrations that take place in Michigan. This figure was increased according to growth factors within the Michigan I&F.

Table H-4-1. Implementation path of advanced light-duty vehicles

Year	Estimated Fleet Vehicles	VMT per Vehicle	Percent of fleet from advanced vehicles	Total fleet plug-in hybrids	Total fleet hydrogen vehicles
2008	47,269	12,221	0.00%	0	
2009	47,472	12,273	0.00%	0	
2010	47,677	12,326	0.00%	0	
2011	47,831	12,366	0.00%	0	
2012	47,987	12,406	0.7%	343	
2013	48,143	12,447	1.4%	550	138
2014	48,299	12,487	2.1%	758	277
2015	48,456	12,528	2.9%	968	417
2016	48,544	12,550	3.6%	1,177	556
2017	48,632	12,573	4.3%	1,388	697
2018	48,721	12,596	5.0%	1,599	837
2019	48,810	12,619	5.7%	1,811	979
2020	48,899	12,642	6.4%	2,023	1,120
2021	48,915	12,646	7.1%	2,233	1,260
2022	48,931	12,650	7.9%	2,444	1,401
2023	48,947	12,655	8.6%	2,654	1,541
2024	48,963	12,659	9.3%	2,865	1,682
2025	48,980	12,663	10%	3,076	1,822

Numbers may not sum due to rounding errors. VMT = vehicle miles traveled.

The costs (except for plug-in hybrids) and miles per gallon efficiency of these two advanced vehicle technologies as well as for conventional gasoline vehicles come from the AEO 2008. The estimate of the price difference between plug-in hybrids and traditional vehicles comes from the California Air Resources Board for the years 2012–2017. The cost difference is estimated to be $10,000 for the years 2018–2025, based on personal communication with the TWG on September 24, 2008. The average VMT per vehicle for 2005 was estimated to be 12,013 (Wards, 2007) and that figure was estimated to increase according to VMT growth factors from the Michigan I&F. The gasoline used in a conventional vehicle in a typical year is determined by dividing VMT per vehicle by average miles per gallon (mpg) from the AEO 2008. The gasoline used in a hydrogen fuel cell vehicle or plug-in hybrid is calculated in the same way, and the difference between the conventional and advanced vehicle is the gallons of fuel saved. For this analysis, it was assumed that these vehicles will be on the road for an average of 10 years. The gallons of fuel saved was then multiplied by the emissions factor for gasoline (11.74 metric tons/1,000 gal) to determine the CO_2e savings from the advanced vehicles (ANL, 2008). The GHG benefits of the policy are shown in Table H-4-2.

Table H-4-2. GHG benefits of advanced light-duty vehicle technologies

Year	Million Gallons of Fuel Saved, All Plug-Ins	Million Gallons of Fuel Saved, Hydrogen Fuel Cell	$MMtCO_2e$ Reduced, Plug-Ins	$MMtCO_2e$ Reduced, Hydrogen Fuel Cell	$MMtCO_2e$ Reduced, Total
2008	0.00	0.00	0.000	0.000	0.00
2009	0.00	0.00	0.000	0.000	0.00
2010	0.00	0.00	0.000	0.000	0.00
2011	0.00	0.00	0.000	0.000	0.00
2012	0.06	0.00	0.001	0.000	0.00
2013	0.09	0.02	0.001	0.000	0.00
2014	0.11	0.04	0.001	0.000	0.01
2015	0.15	0.05	0.002	0.001	0.01
2016	0.17	0.06	0.002	0.001	0.01
2017	0.19	0.06	0.002	0.001	0.01
2018	0.22	0.07	0.002	0.001	0.01
2019	0.25	0.08	0.003	0.001	0.01
2020	0.28	0.09	0.003	0.001	0.02
2021	0.31	0.10	0.003	0.001	0.02
2022	0.34	0.11	0.004	0.001	0.02
2023	0.37	0.12	0.004	0.001	0.02
2024	0.40	0.13	0.004	0.002	0.02
2025	0.43	0.15	0.005	0.002	0.03
Totals			**0.04**	**0.01**	**0.19**

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

Cost of Advanced Light-Duty Vehicle Technologies

The difference between the cost of a conventional vehicle and an advanced vehicle was calculated for all years in the policy. There are also cost savings that come from reduced fuel use. The initial analysis considers 50% of the advanced vehicles sold to be compact and 50% of them to be mid-sized. In years where only compact or mid-sized vehicles are available, then 100% of sales are in those categories. While the price difference between the advanced and conventional vehicles is declining from year to year, the additional cost is between $25,000 and $45,000 for hydrogen fuel cell vehicles and between $10,000 and $25,000 for plug-in hybrids. The additional cost of hydrogen fuel cell vehicle technologies comes from the AEO 2008. PHEV costs are those estimated by the California Air Resources Board (2008). The price of gasoline comes from the AEO 2008 and is shown in Tables 4-3 and 4-4. The cost savings and total costs for plug-in hybrids are shown in Table H-4-3 and those for hydrogen fuel cell vehicles are shown in Table H-4-4.

Hydrogen fuel cell vehicles will also come with additional infrastructure costs, because separate hydrogen refueling stations will be required. It was assumed that these stations would be centralized in Southeast Michigan, and that the cost of a hydrogen fueling station would be $4 million. The number of fueling stations required was determined based on the number of vehicles registered in the state (8.1 million) divided by the number of fueling stations required to fuel conventional vehicles in the state (50,000). This gave a figure of 162 vehicles per fueling station. The number of new hydrogen fueling stations is estimated to be the number of new hydrogen fuel cell vehicles divided by this figure (162). These costs were then discounted back to 2005 dollars. One advantage of plug-in hybrid electric vehicles is that the necessary electricity infrastructure is already in place.

Table H-4-3. Costs and cost savings of plug-in hybrids

Year	Additional Cost, Plug-In Hybrids (MM$)	Million Gallons of Fuel Saved, All Plug-In Hybrids	Gasoline ($/gal)	Cost Savings (Fuel), Plug-In Hybrids (MM$)	Net Cost, Plug-In Hybrids (MM$)
2008	0.0	0.00	3.05	0.0	0.0
2009	0.0	0.00	2.85	0.0	0.0
2010	0.0	0.00	2.94	0.0	0.0
2011	0.0	0.00	2.98	0.0	0.0
2012	8.6	0.06	3.00	0.2	8.4
2013	5.2	0.09	3.05	0.3	4.9
2014	2.6	0.11	3.11	0.4	2.2
2015	2.6	0.15	3.12	0.5	2.2
2016	2.6	0.17	3.17	0.5	2.1
2017	2.1	0.19	3.23	0.6	1.5
2018	2.1	0.22	3.27	0.7	1.4
2019	2.1	0.25	3.33	0.8	1.3
2020	2.1	0.28	3.40	1.0	1.2
2021	2.1	0.31	3.49	1.1	1.0
2022	4.2	0.34	3.53	1.2	3.0
2023	4.2	0.37	3.53	1.3	2.9
2024	4.2	0.40	3.55	1.4	2.8
2025	4.2	0.43	3.52	1.5	2.7
Total					$37
$/ton					$986

Table H-4-4. Costs and cost savings of hydrogen fuel cell vehicles

Year	Additional Cost, Hydrogen Fuel Cell Vehicles (MM$)	Discounted Hydrogen Infrastructure Costs ($MM)	Million Gallons of Fuel Saved, Hydrogen Fuel Cell Vehicles	Gasoline ($/gal)	Cost Savings (Fuel), Hydrogen Fuel Cell Vehicles	Net Cost, Hydrogen Fuel Cell Vehicles ($MM)
2008	0.0	0.0	0.00	3.05	0.0	0.0
2009	0.0	0.0	0.00	2.85	0.0	0.0
2010	0.0	0.0	0.00	2.94	0.0	0.0
2011	0.0	0.0	0.00	2.98	0.0	0.0
2012	0.0	0.0	0.00	3.00	0.0	0.0
2013	6.3	1.2	0.02	3.05	0.1	7.4
2014	6.0	1.1	0.04	3.11	0.1	7.0
2015	5.8	1.1	0.05	3.12	0.2	6.7
2016	5.5	1.0	0.06	3.17	0.2	6.3
2017	5.1	1.0	0.06	3.23	0.2	5.9
2018	4.9	0.9	0.07	3.27	0.2	5.6
2019	4.7	0.9	0.08	3.33	0.3	5.3
2020	4.6	0.8	0.09	3.40	0.3	5.1
2021	4.4	0.8	0.10	3.49	0.4	4.8
2022	8.4	1.5	0.11	3.53	0.4	9.5
2023	8.2	1.4	0.12	3.53	0.4	9.2
2024	7.9	1.4	0.13	3.55	0.5	8.8
2025	7.7	1.3	0.15	3.52	0.5	8.5
Total						**$90**
$/ton						**$7,338**

GHG Benefits of Hybrid Buses

The potential GHG savings from hybrid school buses was also considered in this analysis. Both transit and school buses could take advantage of this technology. This analysis focuses on school buses because there are many more school buses than there are transit buses in Michigan. First, the number of school buses was estimated based on the Ward's Motor Vehicle Facts and Figures 2007 publication and increased out through 2025 based on the VMT growth rate for each year after 2005. The number of hybrid buses in Michigan is predicted to increase steadily starting in 2012 (the same year as the other hybrid vehicles), and to increase to make up 10% of the vehicle fleet in 2025. The number of hybrid buses purchased is shown in Table H-4-5. The GHG savings were determined by dividing the average VMT for a Michigan school bus (Wards, 2007) by the fuel efficiency figure for a conventional bus (2.5 mpg) compared to a hybrid bus, which gets 3.2 mpg (Chandler and Walkowitz, 2006). These fuel savings are then multiplied by the life cycle emissions factor for diesel fuel (11.25 mtCO2e/1000 gals). The total MMtCO2e saved from Hybrid Buses is shown in Table H-4-5.

Table H-4-5. Greenhouse gas savings from hybrid school buses

	Estimated School Bus Fleet	Total New Buses	Million Gallons Saved	MMtCO2e Saved
2008	18,031	0	0.0	0.000
2009	18,108	0	0.0	0.000
2010	18,186	0	0.0	0.000
2011	18,245	0	0.0	0.000
2012	18,304	131	0.1	0.001
2013	18,364	262	0.2	0.003
2014	18,423	395	0.4	0.004
2015	18,483	528	0.5	0.005
2016	18,517	661	0.6	0.007
2017	18,550	795	0.7	0.008
2018	18,584	929	0.8	0.009
2019	18,618	1,064	1.0	0.011
2020	18,652	1,199	1.1	0.012
2021	18,658	1,333	1.2	0.014
2022	18,664	1,466	1.3	0.015
2023	18,671	1,600	1.5	0.016
2024	18,677	1,734	1.6	0.018
2025	18,683	1,868	1.7	0.019
Total				0.143

Cost of Hybrid Bus Technology

The costs of the hybrid bus program were estimated based on the cost differential between conventional buses and hybrid buses, estimated to be $200,000 (Chandler and Walkowitz, 2006). Fuel savings are also taken into account. The gallons of diesel saved are multiplied by the estimated diesel cost, from AEO 2008. All of these costs are shown in Table H-4-6.

Table H-4-6. Total Costs of Hybrid Bus Technology

	Total New Buses	Million Gallons Saved	Diesel ($/gal)	Diesel Costs Reduced ($MM)	Discounted Hybrid Vehicle Cost (MM$)	Net Cost
2008	0	0.0	3.14	0.0	0.0	0.0
2009	0	0.0	2.83	0.0	0.0	0.0
2010	0	0.0	2.82	0.0	0.0	0.0
2011	0	0.0	2.92	0.0	0.0	0.0
2012	131	0.1	2.92	0.3	18.6	18.2
2013	262	0.2	3.00	0.7	17.8	17.1
2014	395	0.4	3.06	1.1	17.1	16.0
2015	528	0.5	3.09	1.5	16.4	14.9

	Total New Buses	Million Gallons Saved	Diesel ($/gal)	Diesel Costs Reduced ($MM)	Discounted Hybrid Vehicle Cost (MM$)	Net Cost
2016	661	0.6	3.14	1.9	15.6	13.7
2017	795	0.7	3.23	2.3	14.9	12.6
2018	929	0.8	3.28	2.8	14.2	11.5
2019	1,064	1.0	3.34	3.2	13.6	10.4
2020	1,199	1.1	3.41	3.7	13.0	9.3
2021	1,333	1.2	3.50	4.2	12.2	8.0
2022	1,466	1.3	3.55	4.7	11.7	7.0
2023	1,600	1.5	3.55	5.1	11.1	6.0
2024	1,734	1.6	3.57	5.6	10.6	5.0
2025	1,868	1.7	3.57	6.1	10.1	4.0
					Total Cost	**$154**
					$/ton	**$1,077**

The total costs of the advanced vehicle technologies considered in this analysis are shown in Table H-4-7.

Table H-4-7. Total costs of TLU-4

Year	Total Cost, Plug-Ins	Total Cost, Hydrogen Fuel Cell Vehicles	Total Cost, Hybrid Buses	Total Cost TLU-4
2008	0.0	0.0	$0	0.0
2009	0.0	0.0	$0	0.0
2010	0.0	0.0	$0	0.0
2011	0.0	0.0	$0	0.0
2012	21.1	0.0	$18	39.4
2013	12.3	18.5	$17	48.0
2014	5.7	17.6	$16	39.3
2015	5.4	16.8	$15	37.1
2016	5.2	15.9	$14	34.9
2017	3.7	14.7	$13	31.0
2018	3.5	14.0	$11	29.0
2019	3.2	13.4	$10	27.0
2020	2.9	12.8	$9	25.1
2021	2.6	12.1	$8	22.7
2022	7.4	23.9	$7	38.2
2023	7.2	23.0	$6	36.2
2024	7.0	22.2	$5	34.1

Year	Total Cost, Plug-Ins	Total Cost, Hydrogen Fuel Cell Vehicles	Total Cost, Hybrid Buses	Total Cost TLU-4
2025	6.8	21.4	$4	32.3
Total	$94	$226	$154	$474
$/Ton	$986	$7,338	$1,077	$1,763

Table H-4-8 summarizes the GHG savings and costs of TLU-4.

Table H-4-8. Summary of TLU-4

	2015	2025	Units
GHG emission reductions	0.01	0.03	$MMtCO_2e$
Net present value (2009–2025)		$281	$ Million
Cumulative emissions reductions (2009–2025)		0.19	$MMtCO_2e$
Cost-effectiveness (2009–2025)		$1,458	$/t CO_2e

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

Data Sources:

U.S. EIA. Annual Energy Outlook 2008 Supplement. Table 59. New Light-Duty Vehicle Fuel Economy and Table 60. New Light-Duty Vehicle Prices. http://www.eia.doe.gov/oiaf/aeo/supplement/index.html (accessed August 27, 2008).

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Key Assumptions: While the light-duty vehicle quantification analysis above focuses on plug-in hybrid and hydrogen fuel cell technologies, there are other alternative light-duty vehicle technologies that are expected to be introduced to the marketplace in the near future that also are expected to provide GHG emissions reductions. These include battery electric vehicles and clean diesel. Some of the attributes of these technologies are summarized below.

On September 23, 2008, Chrysler unveiled three electric vehicles and said that it would bring one of them to market by 2010. In at least the near-term, battery electric vehicles are expected to be limited in their range (100 miles or fewer on a charge). Automakers say the following factors may make electric cars mainstream products: (1) government incentives for zero emission vehicles, (2) help from power companies in creating a recharging infrastructure, (3) financial and social pressure for consumers to buy greener cars, (4) lower long-term cost of operating electric vehicles, and (5) progress in cutting battery costs and improving performance. Having the ability to recharge batteries at home and via charging stations in long-term parking areas is part of the needed infrastructure for the success of this technology. In addition, some manufacturers suggest that batteries be leased to customers so that during long trips, drivers will be able to stop at service stations to swap a depleted battery for a fresh one.

Clean diesel technology is currently available in a limited number of light-duty vehicle models, with more models to be available in the next 1–2 years. Diesel-powered highway engines and vehicles for 2007 and later model years are designed to operate only with ultra-low-sulfur diesel fuel. Today's clean diesels can offer better fuel economy and produce fewer GHGs than some gas–electric hybrids. During 2008, diesel is selling for a premium relative to gasoline, but AEO projections show expected long-term gasoline and diesel prices to be comparable. Diesel fuel economy is about 25% better than that for a comparable gasoline model, and diesel engines have longer lifetimes than spark-ignited engines.

Key Uncertainties

The direct costs of the advanced vehicle technologies are uncertain in advance of vehicles reaching the production stage. The cost of these technologies may change as technology advances occur and production volumes increase to a high enough level to produce economies of scale.

The mpg figure from the AEO is not entirely clear with regard to plug-in hybrid and hydrogen vehicles. Plug-in hybrid vehicles consume both gasoline and electricity, so it is not certain how the electricity consumption calculated in the AEO is converted into an mpg figure. There is a figure for mpg in the AEO 2008 for both plug-in hybrid and hydrogen technologies, and that is used as a stand-in for the energy consumption of these vehicles. It is assumed that the AEO 2008 mpg values are an attempt to compute fuel cost equivalent.

In addition, the electricity generation mix for Michigan includes more coal than the national average. This could contribute to an underestimation of the emissions that come from a plug-in hybrid vehicle, if the AEO 2008 information accounts for electricity emissions on a national level.

Additional Benefits and Costs

This policy could serve to reestablish Detroit as a leader of automotive research, which would have benefits across the state. In addition, progress on advanced vehicle technology can have benefits far beyond the borders of Michigan in terms of energy security, economic growth, and environmental quality.

The impact of increased use of plug-in electric technology on Michigan's electricity supply is not considered in this analysis. Because the number of plug-in hybrid electric vehicles (PHEVs) is relatively small, the impact is not likely to be dramatic, but it could nonetheless have an impact on the overall demand or load profile for the state. Through advances in advanced metering infrastructure and Smart Grid technologies, increase in demand can be delayed to take advantage of the underutilized off-peak capacity and allow for a much cheaper fuel price and far lower emissions when compared to conventional combustion engine fuel.

It is likely that there will be CO_2 emissions that result from charging PHEVs at night. These emissions were not considered in this analysis because of difficulty in estimating the associated electricity demand and emissions factor.

Feasibility Issues

The primary feasibility issue with advanced technologies is whether they can be produced at a cost that will be attractive to consumers. Some technologies may also need supporting re-fueling or re-charging infrastructure.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-5. Congestion Mitigation

Policy Description

Improve traffic flow and travel time through expanding the use of intelligent transportation systems (ITS). In conjunction with expanding ITS, the following actions should also be considered: identifying and improving key bottlenecks, constructing modern roundabouts at appropriate intersections, and continuing the use of the MDOT courtesy patrol on congested roadways. A four-day workweek and flex-time should be encouraged to reduce congestion. All of these elements contribute to reducing travel delay for both recurring and nonrecurring congestion.

Promoting the development of intermodal freight terminals will facilitate freight shipment on rail and air thus reducing the volume of freight on Michigan roadways. By supporting these efforts, the congestion mitigation policy option will allow for more efficient travel and increased economic output.

Policy Design

Goals: The goals for this policy are as follows:

- Reduce travel time delay from recurring and nonrecurring congestion in Michigan's major urban areas (metro Detroit and Grand Rapids) by 10% by 2025.
- Reduce travel time related to nonrecurring congestion (i.e., road construction) by continuing to implement and refine the Michigan Work Zone Safety and Mobility Policy. This policy sets a 10-minute threshold for congestion related to road work. If a vehicle is delayed more than 10 minutes the department is notified to review and modify its standards.

Timing: 2010–2025.

Parties Involved: MDOT, FHWA, and metropolitan planning organizations (MPOs).

Implementation Mechanisms

Congestion reduction in the major metropolitan areas can be achieved through implementing an appropriate combination of the methods described in the policy description. In 2005, metro Detroit drivers had 54 hours of delay annually and Grand Rapids drivers had 24 hours of delay annually. (Delay estimates are for one driver versus free-flow conditions for a single year.)

Funding for intermodal freight initiatives such as the Detroit Intermodal Freight Terminal (DIFT) and the West Detroit Rail Junction will be provided to increase rail efficiency and reduce the number of long-haul shipments on Michigan roadways. (This measure is addressed in TLU-8.)

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-5-1. Summary of TLU-5 congestion mitigation

	2015	2025	Units
GHG emission savings	0.08	0.18	$MMtCO_2e$
Net present value (2006–2025)		–$135	$ Million
Cumulative emissions reductions (2006–2025)		1.68	$MMtCO_2e$
Cost-effectiveness		–$80.63	$/$tCO_2e$

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

Table H-5-2. Summary of Detroit and Grand Rapids congestion mitigation

	2015	2025	Units
GHG emission savings	0.05	0.12	$MMtCO_2e$
Net present value (2006–2025)		–$21	$ Million
Cumulative emissions reductions (2006–2025)		1.12	$MMtCO_2e$
Cost-effectiveness		–$21.56	$/$MtCO_2e$

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

Table H-5-3. Summary of statewide nonrecurring congestion mitigation

	2015	2025	Units
GHG emission savings	0.03	0.06	$MMtCO_2e$
Net present value (2006–2025)		–$114	$ Million
Cumulative emissions reductions (2006–2025)		0.56	$MMtCO_2e$
Cost-effectiveness		–$204.67	$/$MtCO_2e$

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

Data Sources:

D.L. Schrank, T. J. Lomax, Texas Transportation Institute (TTI), 2007.*Urban Mobility Report.* *http://tti.tamu.edu/publications/catalog/record_detail.htm?id=32636*

FHWA. *Highway Economic Requirements System* model. http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.cfm

Quantification Methods: Analysis of congestion mitigation was undertaken by applying the stated goals of a 10% reduction in travel time delay from congestion in metro Detroit and Grand Rapids by 2025 using fuel savings and congestion delay equations from the TTI 2007 Urban Mobility Report. The amount of delay for each metro area was forecast using historical data from

TTI going back to 1982. The quantity of fuel wasted was then calculated for each year using the TTI equation relating fuel loss due to various congestion levels from time delays in traffic (a nonlinear relationship). Then the analysis calculates the amount of fuel wasted if delay were to be reduced 10% in 2025 and by proportionally less during the phase-in period of 2010–2025. The difference represents the fuel savings due to the Detroit/Grand Rapids congestion reduction program. The statewide program to reduce delays from nonrecurring congestion (e.g., road work and traffic incidents) was estimated to provide approximately half the benefits of the program for recurring and nonrecurring congestion.

Costs were estimated using a methodology derived from the federal Highway Economic Reporting System model, which examines the range of bottleneck relief, capacity expansion, and operational improvements (e.g., ramp-metering and ITS applications) that can be cost-effectively implemented and selects the most cost-effective measures as those to be implemented. Benefits from the congestion reduction are based on savings from reduced fuel consumption using a value of $3.82 per gallon (the average price of fuel year-to-date for 2008) along with other vehicle operating costs. A 1.1 to 1.0 ratio of benefit to cost was estimated (i.e., improvements would be undertaken to the point where an overall 1.1 benefit-to-cost ratio was maintained) for the investments needed to generate the desired 10% congestion relief in Detroit and Grand Rapids, with a respective cost of $208 million and benefit of $229 million. For the statewide nonrecurring congestion effort (centered on the Michigan Work Zone Safety and Mobility Policy, but also including real-time traveler information, incident management, variable message signs, and other operational deployments potentially available through 2025), a net benefit of $114 million was estimated.

It should be noted that benefits of $2,043 million were estimated in travel time savings using the TTI Urban Mobility Report methodology. Because these savings are an indirect benefit, they were not included in our estimate of direct benefits, but they are very important to bear in mind.

Key Uncertainties

The effects of the statewide nonrecurring congestion reduction measures are somewhat speculative because there is not much data on congestion and delays on roads and highways outside of metropolitan areas.

Additional Benefits and Costs

As mentioned above, the most important co-benefit is reduced travel times and improved travel reliability. These congestion mitigation measures also provide benefits from energy savings, reduced air pollution, and public health.

Feasibility Issues

Funding for the ITS and capacity expansion/bottleneck relief measures is dependent on state budget and fiscal status and policymakers' approval.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-6. Land Use Planning and Incentives

Policy Description

Implement state policies and programs that encourage local and regional planning and development strategies in order to reduce the projected growth of VMT and corresponding GHG emissions. The state will enable each region to adopt a unique mixture of policies to reach reduction goals in its own manner. Strategies include

- Promoting and expanding regional growth management options that result in more compact mixed-use, transit-oriented, walkable development;
- Transportation system management and pricing that allows for greater investment in alternatives to the single-occupancy vehicle, such as public transit; and
- Use of other land-use–related economic development tools as recommended in the Michigan Land Use Leadership Council's Report (2003)[12].

Policy Design

Goals:

- To reduce low density development and the conversion of greenfield open land to development 25% by 2015, 50% by 2025, and 80% by 2050 compared with Michigan's land use growth pattern of 2000–2005.
- To encourage communities to utilize an "infill" approach for both new and redevelopment projects by focusing on areas where infrastructure already exists. On a local and regional basis, track and compare private and public percentage of investments of infill development/redevelopment versus greenfield development.
- Beginning in 2009, work to ensure that at least 60% of new/future statewide growth utilizes more compact development or transit-oriented development design.

These goals can be accomplished through

- Multi-jurisdictional land use planning and zoning policies, tax base sharing, and providing state and local incentives.
- Market-based approaches in future land development and housing policies that focus public and private investments toward achieving higher density, transit-oriented, and compact or mixed-use development (where appropriate), while conserving natural resources and protecting our land-resource–based industries.
- Integrated transportation policies, investments, system management, and pricing to offer Michigan residents and visitors access to an energy-efficient and cost-effective variety of travel options.

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[12] Michigan's Land, Michigan's Future: Final Report of the Michigan Land Use Leadership Council, August 15, 2003. http://www.mighicanlanduse.org/finalreport.htm

- Enactment of a new Statewide Comprehensive Planning Law. This could be focused on public participation in creating a locally driven comprehensive planning process for local units of government to follow in meeting key statewide goals for economic, social, and environmental priorities. If plans are enacted by a certain date, those communities would qualify for priority funding from state government programs.

Timing: Governor and appropriate Cabinet members should initiate planning and administrative activities in 2009 to shape transportation and land development plans and policies that support this goal in 2010 and beyond. Prepare additional enabling legislation for the 2009–2010 legislative session supporting the goal.

Parties Involved: MDOT, MDEQ, MDNR, and Michigan Departments of Labor and Economic Growth and Agriculture; local governments and MPOs; transportation planning regions; real estate development and homebuilding industry; economic development interests; and environmental, conservation, and community interest groups.

Implementation Mechanisms

To achieve these land use goals, the state and local communities will need to use some or all of the following strategies, which have been used in other states and regions.

Priority Areas Designated for Planned Growth

Establish a process to designate types of priority growth areas within the state. Priority growth areas could include town centers, downtowns, regional centers, neighborhood centers, transit corridors, and transit station areas. Establish a process to encourage higher density housing and employment growth; mixed-use and mixed-income development; and bicycle, pedestrian, and transit-friendly development within these areas. Priority growth areas could include brownfields (old commercial or industrial sites), as appropriate in the context of the study of redevelopment of contaminated sites in Michigan. Development and redevelopment within these areas would be promoted through incentives, technical assistance, and/or regulation.

School Siting and Accessibility

Review and revise school siting laws in Michigan to remove excessive acreage requirements that drive schools into undeveloped areas. Encourage the development or rehabilitation of schools in priority growth areas to make it easier for children, teachers, and parents to get to school on foot, by bicycle, or by transit.

Jobs–Housing Balance

Plan and zone for new housing development to be prioritized near existing jobs and plan and zone for new commercial development near existing housing. Implement financial incentives and/or regulation to encourage a range of housing types and affordability levels that support a community's local work force, which will create a stronger jobs–housing balance and reduce the length and number of vehicle trips.

Smart Growth Planning, Modeling, and Tools

Institute statewide and municipal planning requirements and/or incentives to implement TLU-6. Provide technical assistance to communities on best practices in zoning, parking, and street design to increase walking, bicycling, and transit use; to encourage higher density transit and walking-oriented development; and to balance regional residential, commercial, and industrial needs. (See Oregon's Transportation and Growth Management technical assistance program for Oregon communities, available at: http://www.lcd.state.or.us/LCD/TGM/index.shtml.)

Create an integrated transportation and land-use forecasting model for use statewide. This tool would enable communities to predict increased VMT and GHG emissions based on proposed developments.

Targeted Open Space Protection

Establish programs and/or requirements to preserve key forestlands, natural areas, agricultural land, and parkland, which will help guide development and redevelopment into targeted/priority growth areas.

Transportation Investments for Transit- and Pedestrian-Oriented Development

Plan for and invest in transit- and pedestrian-oriented corridors that will draw and support higher density, mixed-use development along public transit corridors.

Complete Streets and Well-Connected Streets

Develop statewide guidance and technical support for complete streets and well-connected streets to shorten trip distances, to make walking in general and walking to transit safer and more convenient, to reduce the need for overly large urban arterial roads, and to support higher density development.

Development Characteristics

Incorporate principles such as Creative Cities—green accounting that identifies natural features and functions as assets—and Leadership in Energy and Environmental Design–Neighborhood Development (LEED-ND) for their potential to reduce CO_2 emissions into development standards.

Identification and mapping of all natural assets within a geographical area should be completed and incorporated within the planning process to promote better and more efficient land use planning within a community destined for growth or redevelopment. Green infrastructure has quantifiable economic, environmental, and aesthetic values. A typical asset/liability budget approach for development/redevelopment should be used, whereby biological and environmental (assets) should be preserved and growth should be shifted to more suitable low-cost (liability) areas. By preserving green infrastructure within a community, more GHGs can be sequestered while providing a broader more comprehensive planning approach to achieving higher standards of environmental quality. These assets may be mapped onto geographic information system (GIS) layers and used as an overlay with other base layers (e.g., infrastructure, commercial, and residential) to determine the most effective land use budget for development/redevelopment of an urban/suburban/exurban neighborhood.

The LEED-ND rating system integrates the principles of smart growth, urbanism, and green building into the first national system for neighborhood design. LEED certification provides independent, third-party verification that a development's location and design meet accepted high levels of environmentally responsible, sustainable development. Currently in its pilot period, LEED-ND is a collaboration of the U.S. Green Building Council, the Congress for the New Urbanism, and the Natural Resources Defense Council.

Funding

Target new and existing environmental bond, tax credit, tax increment financing, transportation, and housing dollars from regional, state, and federal sources to those projects that help meet these land use and development goals.

The implementation of various transportation demand management (TDM) measures (e.g., carpools, parking cash-out) and provision of transit will facilitate the land use and VMT reduction goals of other related TLU policy options presented here. The TDM measures are not quantified here, although the costs for transit service necessary to support more compact development are included here (transit is analyzed separately as a stand-alone measure in TLU-7).

Related Policies/Programs in Place

TBD

Type(s) of GHG Reductions

CO_2:

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-6-1. Summary of TLU-6 land use planning and incentives

	2015	2025	Units
GHG emission savings	0.14	0.43	$MMtCO_2e$
Net present value (2006–2025)		–$598	$ Million
Cumulative emissions reductions (2006–2025)		3.16	$MMtCO_2e$
Cost-effectiveness		–$189	$/t$CO_2e$

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

Table H-6-2. Speculative projection of TLU-6 land use planning and incentives for 2050

	2050	Units
GHG emission savings	1.15	$MMtCO_2e$
Net present value (2006–2025)	Net savings	$ Million
Cumulative emissions reductions (2006–2025)	23.02	$MMtCO_2e$
Cost-effectiveness	Net savings	$/t$CO_2e$

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

Data Sources:

Total population and population density by Census tract, 1990 and 2000.

Per-capita VMT by Census tract population density in Michigan, from Center for Urban Transportation Research (CUTR) VMT forecasting model.

Forecast statewide population growth.

Transit Cooperative Research Program (TCRP). 2000. "The Costs of Sprawl," TCRP Report 74, National Academy of Sciences.

Growing Cooler, Urban Land Institute, 2007.

Quantification Methods:

The State of Michigan will help growth and development efforts achieve land use goals through a series of policies that includes implementation mechanisms identified below. Scientific research shows that VMT reduction in urban areas is quantifiable through improved planning software. Michigan agencies will assist local and/or regional governments in using the latest planning technology that measures VMT impacts to assist with decision making on future growth and development. The more aggressively the policies are pursued, the greater the potential reduction in VMT.

The quantification effort was most suited to using the parameters stated in the third goal of this measure ("at least 60% of new/future statewide growth utilizes more compact development"), and so the parameters stated in the other goals (e.g., "reduce the conversion of greenfield open land to development 25% by 2015, 50% by 2025, and 80% by 2050") were considered but not explicitly quantified. For example, the percent of growth to occur in low-density development (less than 500 persons/square mile—a proxy for greenfield development) was reduced for 2025 from 34% in the BAU case to 11% in the case of implementing this measure.

This analysis considers potential GHG reductions from fewer personal (noncommercial) VMT as a result of a shift toward more compact development patterns. The analysis relies on estimates of per capita VMT by Census tract population density range, as developed by Polzin, et al. for the Center for Urban Transportation Research (CUTR) VMT forecasting model. The CUTR model is based on analysis of 2001 Nationwide Household Travel Survey data. The model provides estimates of per capita VMT by state for five density ranges. The model is currently set up for years 2005, 2035, and 2055; for this analysis, results were interpolated for Center for Climate Strategies (CCS) analysis years.

The observed relationship between per capita VMT and population density is a rough proxy for the effects of Smart Growth development, as described above. Higher levels of population density are associated with overall shorter trips because destinations are closer together. In addition, areas with higher population densities are more likely to have pedestrian-friendly design (e.g., walkability and mixed-use development) and to support transit service. It is difficult to separate the individual effects of the various Smart Growth strategies at this aggregate level of analysis, but the analysis should provide an indicator of what can be achieved through a combined set of Smart Growth policies.

The specific method used to estimate GHG benefits of Smart Growth strategies is as follows:

- Total population in 2000 is identified by five Census tract density ranges as identified in the CUTR model (<500, 500–1,999, 2000–3,999, 4,000–9,999, and 10,000 or more persons per square mile).
- The change in population from 1990 to 2000, and associated share of change by density range, is identified from Census data.
- For the Baseline scenario, new population growth between 2000 and 2020 (as determined from CCS baseline assumptions) is allocated to tract density ranges based on the share of growth in the 1990–2000 time frame.
- The proportion of existing housing stock (population) that would be redeveloped over this time frame is estimated at 15%, of which two-thirds is redeveloped in place and one-third is redeveloped elsewhere, with this redevelopment allocated to tract density ranges based on the 1990–2000 share of population growth. (The 15% and two-thirds figures come from the 2007 Growing Cooler report, Section 1.7.3, citing analysis of Census data by Nelson [2006][13]. For the Climate Action scenario, a significant shift in the proportion of new development and relocated redevelopment is assumed to take place, with higher density tracts (>2,000 persons per square mile) receiving 60% of new development under this scenario compared with –17% (a flight from denser areas) under the Baseline scenario. Total population by tract density under this scenario is then calculated.
- Total personal-travel VMT is calculated under the Baseline and Climate Action scenarios, based on VMT per capita (from the CUTR model) and total 2025 population by tract density range, and the percent reduction in personal-travel VMT is also calculated.
- The percent reduction in VMT is adjusted by 90% to estimate the percent reduction in GHG emissions. This factor is the same as that used in the Growing Cooler report to account for the fact that higher density areas may experience somewhat lower travel speeds and therefore slightly reduced fuel economy.

Costs for implementing land use planning processes ($79 million) were estimated based on a $62 million cost for implementing visioning/planning programs in 15 Michigan metropolitan areas/cities for 2010–2025, $4 million for state policy/code revision and implementation, and $13 million for municipal policy/code revisions across the state. The provision of additional transit services necessary to support and facilitate land use changes was estimated at $798 million, assuming a 20% mode share for transit in compact development and transit-oriented development (TOD) locations by using the same cost methodology as applied in TLU-7.

Cost savings for avoided infrastructure provision (roads, water, and sewer) were estimated at $546 million based on density-derived cost estimates from TCRP Report 74. Fuel cost savings of $930 million were estimated based on the VMT reductions, a fuel cost of $3.82 per gallon, and fuel economy projections from the AEO 2007. The net result of the costs and savings was approximately $600 million in net savings.

[13] Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen. "Growing Cooler: The Evidence on Urban Development and Climate Change." Urban Land Institute. 2008.

Key Assumptions:

- Fraction of new population growth and redevelopment by Census tract density, under Baseline scenario.
- Assumed shift in the fraction of new population growth and redevelopment from lower-density to higher density Census tracts under Climate Action versus Baseline scenarios.
- Percent of residential building stock redeveloped (off-site) over the analysis time frame.

Key Uncertainties

Smart Growth scenario analysis depends on patterns of development that involve decisions of many individual property owners and private capital investors. As result, the scenarios show what is possible under a development scenario but should not be considered as predicted outcomes.

VMT has remained relatively flat in Michigan since 2002. A variety of factors may be contributing to this, in particular, the economic slowdown seen in Michigan and increases in fuel prices. Changes in local economic conditions and fuel prices could both have significant impacts on VMT in the state.

Advancement in alternative fuel technology and the corresponding use of new fuel sources that either reduce or eliminate GHG emissions by vehicles in Michigan could alter the priority to reduce VMT. Therefore, more holistic and comprehensive land use development patterns that protect Michigan farmland and other natural resources will provide more carbon sinks rather than sources, and thereby further help reduce net GHGs.

The estimates developed using this methodology are consistent with results found in meta-analysis in the published literature, such as the recent *Growing Cooler* report from the Urban Land Institute (ULI). Table H-6-3 shows estimates calculated by using the methodology provided in *Growing Cooler*.

Table H-6-3. Growing Cooler methodology for TLU-6 land use planning and incentives

	2015	2025	Units
GHG emission reductions	0.14	0.41	$MMtCO_2e$
Net present value (2006–2025)		Net savings	$ Million
Cumulative emissions reductions (2006–2025)		3.08	$MMtCO_2e$
Cost-effectiveness		Net savings	$/tCO_2e

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

Additional Benefits and Costs

Smart growth generally has very low direct costs to implement, such as cost to the government of altering regulations and zoning and the costs of providing education and technical assistance. Tax incentives are an income transfer that results in a public sector cost but offsets developer revenue. As most smart growth policies (e.g., allowing higher density and mixed use, reducing parking requirements) are deregulatory, they are opening the development market and have significant indirect benefits. An exception is growth boundaries, which restrict the land use market and have an indirect cost.

Alternative patterns of development have a large number of additional impacts, which may provide both benefits and costs. Smart growth provides a range of co-benefits that are well documented elsewhere. Prominent among these is the reduced cost of providing utilities and infrastructure because smart growth makes better use of existing facilities and infrastructure and, on average, has lower demand. Improved air quality, public health (e.g., due to walking), and quality of life are also notable co-benefits.

VMT is considered by some economists to be a leading economic indicator—one that foreshadows the greater economic trend. In the current economic climate, Michigan cannot afford to impose strict cap limits on VMT. The focus must remain on encouraging infill development and more compact or transit-oriented land use patterns, which will in turn lead to reductions in the growth of VMT.

Feasibility Issues

Smart growth policies are being considered and implemented around the country in a wide range of communities. Because most policies are deregulatory in nature, this significantly lowers political barriers.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-7. Transit and Travel Options

Policy Description

Reduce the number of single-occupant vehicle trips and improve the efficiency of daily travel by

- Creating, enhancing, and promoting public transit options such as commuter rail, light rail, streetcars, and bus rapid transit;
- Enhancing transit service through route expansion, increased service frequency, longer service hours, and/or better system coordination; and
- Facilitating increased carpooling, vanpooling, biking, and walking.

These actions will reduce GHG emissions by decreasing or slowing the growth of VMT, thus reducing fuel consumption.

Policy Design

Goals: Goals for this policy are as follows (from a 2002 baseline);

- Double transit ridership by 2015 and double it again by 2025 (line-haul systems).
- Double the number of carpool and vanpool participants by 2015 and double again by 2025.

Timing: 2009–2025

Parties Involved: Michigan legislature, MDOT, regional transit operators, local governments, Amtrak, freight railroads, and schools.

Implementation Mechanisms

The following are several actions that would be necessary to achieve the goals listed above.

- Amend the Michigan Constitution to provide a broader range of funding mechanisms for public transit. The section of the Constitution that needs to be addressed is Article IX, section 9. This is the section that dictates the divide between road and transit funding.
- Build additional park-and-ride lots to encourage and enable increased transit ridership. Ensure that these lots have bicycle storage facilities. Also construct carpool lots to provide more opportunity for ridesharing in Michigan.
- Provide incentives for TOD and focus growth in areas already served by transit.
- Incorporate bike lanes into roadway construction and reconstruction plans wherever possible.
- Encourage/require sidewalks in new developments and encourage their addition in areas where they are now absent.

- Implement metropolitan transit plans, including Southeast Michigan's Transit Vision, Grand Rapids' Great Transit, Grand Tomorrows study, and other existing plans throughout the state.

- Pursue implementation of inter-city transit service where it is cost-effective and provides the greatest GHG benefits in relation to other transit options.

- Undertake a public education campaign to identify, quantify, and effectively communicate the benefits of public transit to people who don't currently use it. Such a campaign will be necessary to generate the support needed for local tax initiatives to fund transit improvements.

Related Policies/Programs in Place

Existing transit systems have experienced a 15% increase in urban ridership between 2005 and 2008.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-7-1. Summary of reductions from TLU-7

	2015	2025	Units
GHG emission savings	0.13	0.50	$MMtCO_2e$
Net present value (2009–2025)		$655	$ Million
Cumulative emissions reductions (2009–2025)		3.54	$MMtCO_2e$
Cost-effectiveness (2009–2025)		$185	$/tCO_2e$

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

Data Sources:

Transportation Research Board. 2001. "Making Transit Work: Insight From Western Europe, Canada, and the United States—Special Report 257," Washington, DC.

Current and historical transit ridership, by mode type (urban/rural, bus, or paratransit) from National Transit Database.

Marginal Greenhouse Gas Reduction Benefits of Transit, Cambridge Systematics, 2008.

Improving Transportation Choices, Natural Resources Defense Council, 2007.

The Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction, ICF International, 2008.

Table H-7-2. Michigan Transit System Data

2006 Michigan Transit Data (NTD)	Mode	Vehicle Or Train Revenue Miles	Unlinked Passenger Trips	Passenger Miles	Operating cost	Fare Revenue	Capital cost	Federal cost share	Total cost	Net Cost/VRM
Detroit Transportation Corporation	Automated Guideway	608,222	2,307,909	3,231,073	12,295,052	991,814				$ 20.21
Bay Metropolitan Transit Authority	Bus	1,001,407	518,490	2,736,135	4,615,650	612,597				$ 4.61
Battle Creek Transit	Bus	457,586	517,949	1,854,257	2,578,862	295,541				$ 5.64
Suburban Mobility Authority for Regional Transportation	Bus	11,437,915	10,684,202	87,025,343	79,829,748	10,121,712				$ 6.98
Suburban Mobility Authority for Regional Transportation	Bus	337,192	233,537	499,340	0	0				$ -
Mass Transportation Authority	Bus	2,798,210	4,584,462	15,766,906	11,917,500	1,981,690				$ 4.26
Interurban Transit Partnership	Bus	3,911,464	7,048,057	26,289,253	21,622,993	3,392,574				$ 5.53
City of Jackson Transportation Authority	Bus	336,643	559,435	1,622,397	1,550,841	263,011				$ 4.61
Kalamazoo Metro Transit System	Bus	1,546,154	2,782,397	7,948,428	9,029,419	1,502,367				$ 5.84
Capital Area Transportation Authority	Bus	2,968,101	9,572,798	25,998,915	22,513,206	3,328,804				$ 7.59
Muskegon Area Transit System	Bus	432,497	478,873	2,236,337	2,282,930	245,831				$ 5.28
Saginaw Transit Authority Regional Service	Bus	681,292	687,694	2,730,145	4,690,854	459,237				$ 6.89
Ann Arbor Transportation Authority	Bus	2,403,730	5,338,018	17,401,939	18,529,134	2,907,408				$ 7.71
City of Detroit Department of Transportation	Bus	14,949,745	37,083,344	200,196,964	174,619,203	23,444,999				$ 11.68
Twin Cities Area Transportation Authority	Bus	53,294	17,132	56,394	177,667	6,826				$ 3.33
City of Holland Macatawa Area Express	Bus	275,870	92,090	328,128	1,007,404	72,434				$ 3.65
Blue Water Area Transportation Commission	Bus	375,248	495,069	1,286,931	1,715,093	75,515				$ 4.57
University of Michigan Parking and Transportation Services	Bus	956,788	5,682,304	13,906,872	5,284,619	1,327,051				$ 5.52
Interurban Transit Partnership	Vanpool	17,821	1,800	62,942	46,824	15,518				$ 2.63
Interurban Transit Partnership	Vanpool	26,145	921	64,839	46,824	15,518				$ 1.79
Kalamazoo Metro Transit System	Vanpool	24,531	12,178	197,066	74,254	47,864				$ 3.03
Total	**Total**	**45,599,855**	**88,698,659**	**411,440,604**	**374,428,077**	**51,108,311**	**78,192,296**	**96,284,513**	**305,227,548**	**$ 6.69**

Operating cost per passenger and per passenger-mile, by mode type (urban/rural, bus, or paratransit) from National Transit Database.

Revenue per passenger and per passenger-mile, by mode type (urban/rural, bus, or paratransit) from National Transit Database.

Quantification Methods:
This analysis examines the reductions in GHGs possible by shifting from personal motor vehicles to transit, which emits fewer GHGs per passenger mile. The calculation of GHG reductions must account for the reduction in the number of private VMT and also account for the partially offsetting increase in transit VMT. In addition to these direct reductions from individuals' shift of modes, two more long-term, indirect effects are estimated: (1) the shifting of trips from personal vehicles to transit can reduce the number of vehicles on the road and thus the amount of congestion in urban areas, and (2) reducing congestion improves traffic flow and can improve actual average vehicle fuel economy. Studies have also demonstrated that increased transit service can help shape land use patterns, enabling densities and proximity to the center of urban areas. This has been shown to result in reduced VMT by those living in transit corridors, even if they never use transit.

Direct quantification was undertaken for improvements in service frequency, reductions in travel time, and the introduction of new routes and the expansion of existing routes and services for bus, bus rapid transit (BRT), commuter rail, and vanpools.

Travel time improvements provide a well-documented means of improving transit service and ridership. There is a direct benefit to riders because the improved service reduces the "generalized cost" (time cost plus financial cost) of their trip. In addition to co-benefits in improving service frequency, there is about a –0.4 elasticity for transit travel time.

Service frequency increases ridership by existing riders and attracts new riders. As waiting time between vehicles has been shown to be valued about two times more strongly on average than actual travel time, this mechanism can prove very effective. There is a reported 0.5 elasticity for service frequency alone (time between buses), while the aggregate impacts for service improvements in time between vehicles and travel time have shown an elasticity of between 0.6 and 1.0, incorporating the time and frequency impacts of aggregate increases in service miles provided. The aggregate elasticity, using a value of 1.0, was applied to the total increase in vehicle revenue service miles to capture both factors together.

For service expansions and introduction, both the literature and a first-order statistical analysis show a long-run elasticity for service expansion of between 0.6 and 1.0. An elasticity of 1.0 was applied to service increases.

The total operations and capital costs for providing the additional transit services were totaled and then reduced by the federal cost share for these expenditures. Operating costs, which are very highly correlated with the amount of service being provided, were obtained from the National Transit Database (NTD) for 2006, and average costs per vehicle-mile of service were calculated. Because both capital costs and federal cost sharing are somewhat more volatile from year to year based on current needs, data were obtained for each of these for the 5-year period of

2002–2006 and then averaged to determine typical annual amounts. Based on the historical trends between the provision of service and costs, the latter were calculated to increase proportionately with service (see Key Assumptions).

The cost savings for avoided provision of roads and highways and for vehicle operating cost savings (at the Internal Revenue Service [IRS] reimbursement rate of $0.505, which incorporates fuel, tires, oil, maintenance, repairs, and depreciation) were then subtracted to provide the above result of approximately $655 million in net costs.

Key Assumptions:

Transit services can be expanded and introduced at the same average operating cost as current services. A mix in transit modes that includes BRT, commuter rail, and vanpools decreases the average net operating cost of bus service, which is almost the only service being offered.

New or improved services will be able to attract ridership in a manner consistent with service improvements in other similar areas of the country (i.e., the transit market is not at saturation). Current fuel price increases provide a strong argument for this assumption. An elasticity of 1.0 (i.e., that ridership increases proportionately to new service), which is at the high end of the range found in the literature, was selected to model the effects of service expansion. This was selected as the goal of this strategy is to maximize ridership increases. Alternative transit service goals for might include increasing mobility and accessibility to given areas, improving transportation equity, congestion reduction, etc.

Key Uncertainties

Funding availability for the provision of additional transit service is uncertain, especially for the dramatic increases proposed here.

Additional Benefits and Costs

The provision of transit service provides other benefits and cost impacts. The ability of transit to encourage and facilitate land use changes toward more compact development is very important. This benefit is strongest with fixed guideway (rail and BRT) routes but is associated with all transit service. Related to this is the role transit plays in helping to improve the quality of life and attractiveness of cities and to maintain urban populations.

Transit services have a large number of additional impacts which provide additional benefits. Transit service provides mobility, accessibility, and safety benefits that are not included in the analysis above. Important other co-benefits include improved air quality, public health (e.g., due to walking), and quality of life. Transit benefits in reducing congestion and those in facilitating land use patterns such as transit-oriented development and smart growth are very significant and as noted are partially reflected in the analysis above.

Typically, transit service (dominated by bus services, but also for light rail) averages slower travel times for users than personal vehicles.

Feasibility Issues

Funding availability for the provision of additional transit service is uncertain, especially for the dramatic increases proposed here. To a significant extent, the ability to implement this measure depends on the budget and financial condition of the state, and the willingness of state and local policy-makers to provide dedicated, long-term funding for services. The rapid implementation envisioned here may also have barriers in the ability to procure vehicles and build infrastructure rapidly enough.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-8. Increase Rail Capacity and Address Rail Freight System Bottlenecks

Policy Description

Michigan can reduce GHG emissions in the transportation sector by encouraging more energy efficient freight movement. Making or facilitating transportation infrastructure improvements that increase rail capacity, support connectivity, and reduce rail freight system bottlenecks will help accomplish this shift.

Most freight shipment is undertaken by the private sector. Truck transportation is the most common means of moving freight in Michigan, but rail transport is more energy efficient. Whether goods move by rail, truck or other modes, private sector shipping decisions are based on the need to ship those goods at the lowest possible cost within an appropriate time frame.

For short hauls, truck freight is, and will likely continue to be, the mode of choice; intermodal rail freight tends to be most effective for trips of 700-800 miles or longer. As the price of diesel fuel continues to increase, however, rail freight will become more cost-competitive, perhaps at shorter distances. Michigan should be prepared to take advantage of this opportunity for both environmental and economic reasons.

Policy Design

Goals: To reduce transportation sector GHG emissions from freight movement by making system improvements with the goal of increasing tonnage of rail freight traveling to, through and from Michigan an additional 50% by 2020.

The most recent data available from the U.S. Department of Transportation (USDOT)[14] indicates that freight tonnage for shipments to, through, and from Michigan is expected to increase from 752 million tons in 2002 to 1540 million tons in 2035, an increase of 105%. Tonnage is expected to increase on all freight modes, but by far the majority of this increase is anticipated to be truck freight, with a projected 576 million ton increase between 2002 and 2035. In the same period, rail freight tonnage is projected to increase by 67.4 million tons.

Increasing the projected tonnage of rail freight an additional 50% by 2020 potentially shifts a projected 17 million tons of cargo that would otherwise travel by truck. Using the national standard of 80,000 pounds[15] as the upper weight limit for trucks, this would potentially remove an estimated 200,000 trucks from the roads.

It is important to recognize that shipping decisions are made by the private sector, and are not under the control of government. Investment to encourage greater use of rail lines and intermodal shipping must be made with that reality in mind.

[14] USDOT State by State Freight Analysis Framework 2.2

[15] Michigan's legal truck weight limits allow for 164,000-pound trucks, but fewer than 5% of the trucks on Michigan's roads travel at that weight.

A variety of approaches will be necessary to accomplish this:

- **Construct Intermodal Terminals:** The use of intermodal containers and intermodal shipping allows many goods to travel by either truck or rail, depending on the length of the trip. Construction or improvement of intermodal terminals in Michigan offers a real opportunity to improve connectivity and encourage the timely and cost-effective shipment of goods by rail rather than truck.
- **Preserve Existing Service:** Michigan's peninsular geography is an obstacle, not only to increasing the capacity of freight rail service but also to preserving existing rail service, particularly in the northern reaches of the state. As part of any policy to improve rail freight service, attention must also be focused on preserving existing rail lines. In the short term, this will require continued state investment in these lines, which often do not generate sufficient revenues for the private sector operator to make adequate investments of its own.
- **Preserve Right-of-Way for Future New Service:** It is unlikely that additional rail freight lines will be constructed in Michigan on new rights-of-way, but for the long term, it is important to keep the option of future rail service available on existing rights-of-way. One means of preserving right-of-way for future rail service, whether freight or passenger, is for the state to continue to expand present efforts to develop abandoned rail lines as trailways.

Timing:
The Detroit Intermodal Freight Terminal project will consolidate and expand a complex of railroad intermodal terminals in the Detroit metropolitan area to accommodate growth through 2025. Improvements will also be made to railroad connections and terminal access roads to improve efficiencies for both trucks and trains. Construction of the project is anticipated to begin in fiscal year 2010 (FY2010) and the full build-out will occur over approximately 10 years. The project is a public–private partnership, with the railroads providing approximately 40% of the estimated $611.7 million total cost.

The West Detroit Junction rail project involves the construction of a new connecting track at one of the busiest rail junctions in Michigan, which handles 50–60 trains per day. The new track will primarily accommodate Amtrak trains and allow significant improvements in on-time performance. Engineering work for the estimated $12 million project will begin in summer 2008, with construction beginning in 2009.

Parties Involved: Private sector railroad companies (e.g., Canadian National, CSX Railways, and Norfolk Southern), auto manufacturers, MDOT, Federal Railroad Administration (FRA), Michigan Trails and Greenways Alliance (MTGA), MDNR, and nonmotorized stakeholders

Implementation Mechanisms

As described under "Timing:"

- The Detroit Intermodal Freight Terminal project;
- The West Detroit Junction rail project;
- An additional intermodal terminal outside of the Detroit area; and,

- 250 miles of additional track improvements.
- Preservation of existing system and rights-of-way.

Related Policies/Programs in Place

The Detroit Intermodal Freight Terminal project.

The West Detroit Junction rail project.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-8-1. Summary of TLU-8 Analysis

	2015	2025	Units
GHG emission reductions	0.10	0.19	$MMtCO_2e$
Net present value (2009–2025)		$69	$ Million
Cumulative emissions reductions (2009–2025)		2.01	$MMtCO_2e$
Cost-effectiveness (2009–2025)		$35	$/tCO_2e$

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

Data Sources:

US Department of Transportation. Highway Statistics, 2006, Federal Highway Administration, Washington DC. http://www.fhwa.dot.gov/policy/ohim/hs06/index.htm

U.S. EPA. SmartWay Partnership, available at: http://www.epa.gov/smartway/

American Association of Railroads (AAR). September 2007. "National Rail Freight Infrastructure Capacity and Investment Study," available at: http://www.aar.org/IndustryInformation/National_Capacity_Study/~/media/Files/National_CAP_Study_docs/natl_freight_capacity_study.ashx

American Association of State Highway and Transportation Officials (AASHTO). December 2007. "Freight Demand and Logistics Bottom Line Report," available at: http://downloads.transportation.org/DR_3%20Freight%20Demand_Report-12-07.pdf

American Trucking Association (ATA). October 2007. "Strategies for Further Reduction of the Trucking Industry's Carbon Footprint." Sustainability Task Force.

North American Commission for Environmental Cooperation. August 2001. "North American Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies," available at: http://www.tam.cec.org/files/PDF/POLLUTANTS/Trade_Corridors_Final-e1_EN.PDF

Texas Transportation Institute. Center for Ports and Waterways. "A Modal Comparison of Domestic Freight Transportation Effects on the General Public." The Texas A&M University System, College Station, TX. December 2007. http://tti.tamu.edu/documents/TTI-2007-5.pdf

U.S. DOT. Intermodal Transportation and Inventory Cost – State Tool, available at: http://www.fhwa.dot.gov/policy/otps/061012/iticst_info.htm

Quantification Methods:

Quantification involved the following steps:

Existing rail tonnage was increased linearly from 2011 to 2020 to reach the goal of a 50% increase in rail tonnage. Consistent with the freight commodity mix transported to and from Michigan, the preponderance of this growth is expected to occur from intermodal cargo diverted from trucking. In this analysis, all diversion from rail to truck was considered to be intermodal trailers and containers.

Rail fuel consumption was increased proportionally with tonnage. While in reality rail fuel efficiency is improving, the same is true for trucking, and so the ratio between them, which is what is most important for this analysis, was assumed to remain constant.

The ratio of truck fuel consumption to intermodal rail fuel consumption (including both switch locomotive fuel use, railyard activity, and drayage truck fuel use for the portion of the transportation between the railyard and the origin/final destination) was researched in the literature, and a consensus value of 2.62 was used to calculate truck fuel consumption avoided.

The diesel emission factor of 10,802 grams of CO_2/gallon was used to calculate metric tons reduced.

Costs were identified from the implementation measures above, namely The Detroit Intermodal Freight Terminal project and The West Detroit Junction rail project. Additional costs were estimated as including $50 million for the additional intermodal terminal(s); this number is consistent with a single large additional intermodal yard or several smaller yards in multiple locations in the state. An average figure of $2 million/mile was utilized for approximately 250 miles of additional track upgrades. This figure would typically represent signal and train control upgrades but would also include the addition of some rail sidings, double-tracking, system and right-of-way preservation, and/or the alleviation of rail system bottlenecks. These capital costs were then allocated evenly over the years 2011–2020 and discounted to 2005 dollars.

Key Assumptions:

The rate of fuel efficiency improvements for rail and trucks will be similar in future years.

All diversion comes from intermodal rail traffic.

Key Uncertainties

Whether sufficient appropriate cargo exists to allow this increase is uncertain. Because intermodal rail cargo is only a portion of all rail cargo, the rate of increase for this area would actually be significantly higher than 50%.

Additional Benefits and Costs

Modal shifts from truck to rail also provide benefits in congestion reduction, safety, and air quality.

Feasibility Issues

Whether sufficient appropriate cargo exists to allow this increase is uncertain. As intermodal rail cargo is only a portion of all rail cargo, the rate of increase for this area would actually be significantly higher than 50%.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-9. Great Lakes Shipping

Policy Description

Marine transportation is the most energy-efficient form of surface transportation to move cargo over long distances (150 miles or more). Michigan's commercial ports typically accommodate 85–95 million tons of cargo annually, most of which are bulk materials including stone, iron ore, coal, and cement. While Great Lakes shipping decisions and services are private sector responsibilities, the public sector has a role in providing navigation channels and related infrastructure.

Policy Design

Goals:

- Reduce transportation sector GHG emissions by maintaining the existing marine infrastructure, including maintaining federal navigation channels to their congressionally authorized depths. Without adequate maintenance of infrastructure, continued operation of some ports or marine terminals is in jeopardy, with a resultant shift of traffic from marine to truck transportation.
- Improve the marine infrastructure by deepening commercial navigation channels at selected commercial ports to Seaway standard depths. This will allow greater cargo volumes to be carried on each vessel and reduce the number of trips needed.
- Encourage the development or expansion of "short sea shipping" (also known as "marine highway") within the Great Lakes. This could include carrying truck trailers or containers on specialized Great Lakes vessels, which would decrease the number of truck miles driven on the highways. The focus of this policy is on increased shipping within the Great Lakes—not on increasing traffic through the St. Lawrence Seaway.
- Consider the use of ferry boats to move people and cars.
- Consider a biodiesel program at Michigan ports if it is feasible to burn this fuel in marine diesel engines. Other alternative fuels might include wood biomass and garbage.

Timing:

Parties Involved: U.S. Army Corps of Engineers (USACE), Lake Carriers Association.

Other:

Implementation Mechanisms

For infrastructure maintenance, the Governor's office should lobby Congress to appropriate money from the Harbor Maintenance Trust Fund surplus to meet urgent needs in Michigan.

Related Policies/Programs in Place

Federal Harbor Maintenance Trust Fund

Great Lakes policy is shaped in part by the Lake Carriers Association, which represents the shipping companies. This group strongly supports the Jones Act and keeping foreign vessels out of the Great Lakes. The Jones Act prohibits Canadian vessels from picking up and delivering in the United States.

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

The binational Great Lakes St. Lawrence Seaway (GLSLS) system, which includes the St. Lawrence Seaway, stretches over 2,300 miles. The 1959 opening of the Montreal–Lake Ontario (MLO) section of the Seaway was the final step in establishing a navigation system that allows deep draft ocean vessels to move between the Atlantic Ocean and Great Lakes ports. Although traffic volumes in recent years have been about half the peak levels of the 1970s and early 1980s, the Seaway continues to play a key role in the shipment of grain, iron ore, and steel. Seaway trade is particularly important for Canada, which paid more than 70% of the total cost of the original seaway navigation project and continues to play a greater role than its U.S. partner in financing and operating the waterway.

Forecasting future Seaway traffic has historically been problematic because of the multitude of economic and political forces affecting trade, both within the Great Lakes region and beyond.

As the Seaway enters its sixth decade of service, its future role within the Great Lakes transportation system is unclear. This observation does not imply that the waterway has no future role, but rather that this role remains difficult to anticipate because of numerous uncertainties. On one hand, the Seaway's infrastructure is in need of major renovation to ensure its continuing reliability, and the waterway's locks can accommodate only a decreasing fraction of world vessel capacity as the growth of container shipping leads to the building of ever larger vessels. However, the Seaway offers an alternative to increasingly congested land-based routes, particularly for cargo movements, where the relatively long transit times and seasonality of the navigation season can be accommodated. Furthermore, the growth of hub ports for container shipping on North America's eastern seaboard may provide opportunities to develop feeder services into the Great Lakes through the Seaway. The overall influence of global climate change on Seaway navigation is also uncertain, with the possibility that the adverse effects of lower water levels may be offset to some extent by a longer navigation season.

Maintaining navigation channels through the GLSLS depends, in part, on ensuring that all channels in the system have a minimum navigable depth. In addition to dredging, there is also a need to maintain aids to navigation such as buoys, channel markers, and range markers.

Maintenance dredging is needed only in limited sections of the system—proportionally less than is required for other North American navigational systems. Sedimentation is minimal in the majority of the navigation channels and generally consists of recirculation of local sediments. On average, maintaining channel depth costs the equivalent of $20 million/year for dredging itself and for managing the dredged material. Funding for this work is contingent on congressional approval. To put these statistics in perspective, an average of about 185 million tons annually is shipped through the GLSLS upstream of Montreal. Dredging 3 million m^3/year represents roughly one ton of dredged material for every 40 tons of goods passing through the system.

Of the 2–4 million m^3 of annual maintenance dredging, some 10% consists of contaminated sediments. USACE records indicate that some 32% of sediments from maintenance dredging are clean enough to allow for open water disposal, and 12% of the sediments dredged are reintroduced into the coastal zone as beach nourishment. Where containment is required, the development of approved sediment containment sites is both lengthy and costly. As a result, dredging costs in the Great Lakes average \$8/yd^3, considerably higher than the average of \$3/yd^3 across North America. The capacity of contaminated sediment disposal sites is an ongoing concern for port operators throughout the system. Dredging costs in the St. Lawrence River typically run significantly higher because of a lack of dredging contractors and the higher mobilization costs associated with use of contractors from the Great Lakes. In addition, contaminated upland spoiling of dredged materials is typically required in this area and, if it is contaminated, the dredged material has to be transported to a special landfill.

The annual maintenance dredging needed in Michigan each year is approximately 1 million yd^3. The estimated annual cost to do this is \$7.5 million. Shippers pay a tax to recover the costs of such maintenance. This money goes into the Federal Harbor Maintenance Trust Fund, which currently has a \$3–\$4 billion surplus. There is a dredging backlog because these monies are not being appropriated.

Any analysis of the cost of deeper dredging would need to be port-specific. This would involve borings and channel surveys to estimate the cubic yards of material that would have to be dredged. In addition, the dredging cost would vary according to the type of material that would need to be dredged in each port.

Data Sources:

Transportation Research Board. 2008. "Great Lakes Shipping, Trade, and Aquatic Invasive Species," TRB Special Report 291, Washington, DC.

Winebrake J.J., J.J. Corbett, A. Falzarano, et al. 2008. "Assessing Energy, Environmental, and Economic Trade in Intermodal Freight Transportation," *Journal of the Air & Waste Management Association (JAWMA),* 58(08):1004–13.

Great Lakes St. Lawrence Seaway Study. Fall 2007. Transport Canada, U.S. Army Corps of Engineers, U.S. Department of Transportation, The St. Lawrence Seaway Management Corporation, Saint Lawrence Seaway Development Corporation, Environment Canada, U.S. Fish and Wildlife Service. http://www.glsls-study.com

Quantification Methods:

The initial analysis of the GHG benefit of providing deeper channels for marine vessel cargo transport is based on a 10% change in the number of trips (and associated fuel consumption) by marine vessels. Based on the 2015 and 2025 Commercial Marine Vessel (CMV) CO_2e emissions, a 10% efficiency improvement in each year from 2015 on would reduce associated GHG emissions by 0.24 MMt in 2015 and 0.27 MMt in 2025.

Table H-9-1 provides CO_2 emission factors from the recent Winebrake et al. JAWMA paper for the three primary freight transport modes. These factors can be used to estimate how shifting 100,000 20-foot equivalent units (TEUs)/shipping containers from rail and truck to ships in Michigan might affect GHG emissions.

Table H-9-1. Data for transport modes for case studies

Mode of Transport	Cost ($/TEU-mile)	Energy (Btu/TEU-mile)	CO_2 (g/TEU-mile)	PM-10 (g/TEU-mile)	SO_X (g/TEU-mile)
Truck	0.87	10,704	1,001	0.12	0.22
Rail	0.55	2,590	201	0.09	0.04
Ship	0.50	13,040	1,094	0.98	3.33

$/TEU-mile = dollars per 20-ft equivalent units-mile; Btu = British thermal unit; CO_2 = carbon dioxide; g/TEU-mile = grams per 20-ft equivalent units-mile; PM10 = particulate matter 10 microns in diameter or smaller; SO_x = sulfur oxides.

Recognize that ships vary significantly in their sizes, speeds and installed power, which means that their energy and emission characteristics vary. The information in Table H-9-1 is based on ship characteristics that have been highlighted favorably in recent Short Sea Shipping reports, because this policy option was intended to represent a short movement of freight. The ship used in this analysis is a roll-on/roll-off vessel capable of speeds up to about 25 knots with about 11,000 kilowatts (kW) of power, which carries about 200 TEUs. Using the characteristics of other vessel groups would produce different results than the comparison shown in Table H-9-1.

The Rochester Institute of Technology and the University of Delaware through the Sustainable Intermodal Freight Transportation Research Program are developing a model that could be used to evaluate the advantages and disadvantages of increased shipping on the Great Lakes. A report on that model should be available in September 2008. The overall approach in this project is the integration of three modal networks (road, rail, and water) in a single geographic information system (GIS) intermodal network. The decision tool that is developed will allow users to conduct route analyses based on various network attributes, including cost, time-of-delivery, distance, energy use, and emissions. The initial work phase will involve constructing the network model for the Great Lakes region and collecting data to characterize cargo flows and their energy and environmental impacts along that network.

Key Assumptions: Noted in discussion.

Key Uncertainties

None cited.

Additional Benefits and Costs

Because of the potential harm of further spreading of aquatic invasive species populations within the Great Lakes near Michigan, increased intra-lake shipping has potential ecosystem costs. These costs include the potential to reduce fish populations and reduce the catch of Michigan's commercial fishing operations. However, if the ships involved do not leave the Great Lakes and enter the ocean, the potential for harming the commercial fishing industry may be limited.

Shifting freight traffic from truck or rail to marine vessels could increase PM-10 and sulfur dioxide (SO_2) emissions.

Feasibility Issues

Any policy option affecting Great Lakes Shipping needs to consider the effect on aquatic invasive species (AIS). The Transportation Research Board just released Special Report 291: Great Lakes Shipping, Trade, and Aquatic Invasive Species (see Data Sources section). This report evaluates the issues regarding invasive species in the Great Lakes and proposes some recommended actions. The committee's recommendations include a comprehensive technology-based AIS program targeting all vessels transiting the seaway, a requirement for all transoceanic and coastal vessels transiting the seaway to conduct ballast water exchange (BWE) or salt water flushing, the adoption of a single set of ballast water standards for the Great Lakes equivalent to the proposed International Maritime Organization (IMO) ballast water management (BWM) standards, and a binational surveillance program to monitor for the presence of new AIS in the Great Lakes.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Unanimous Barriers to Consensus

None cited.

Appendix I
Residential, Commercial, and Industrial Policy Recommendations

Summary List of MCAC Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0.0	13.6	86.3	–$1,632	–$19	Unanimous
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	17.6	53.8	428.6	–$12,107	–$28	Unanimous
RCI-3	Regulatory (PSC) Changes to Remove Disincentives and Encourage Energy Efficiency Investments by IOUs	*Not Quantifiable*					Unanimous
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	3.6	9.8	82	–$2,865	–$35	Unanimous
RCI-5	MI Climate Challenge & Related Consumer Education Programs	*Not Quantifiable*					Unanimous
RCI-6	Incentives to Promote Renewable Energy Systems Implementation	0.7	1.5	14.0	$1,958	140	Unanimous
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	15.6	47.6	380	–$11,693	–$31	Unanimous
RCI-8	Net Metering for Distributed Generation	Fully incorporated into RCI-6					Unanimous
RCI-9	Training & Education for Bldg. Design, Construction, and Operation	*Not Quantifiable*					Unanimous
RCI-10	Water Use and Management	*Not Quantifiable*					Unanimous
	Sector Total After Adjusting for Overlaps*	**21.8**	**64.9**	**523.9**	***–$13,014***	***–$24.8***	
	Reductions From Recent Actions	**Figures adjusted include recent actions**					
	Sector Total Plus Recent Actions	**21.8**	***64.9***	***523.9***	***–$13,014***	***–$24.8***	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; PSC = Public Service Commission; IOU = investor-owned utility.

Note: The numbering is for reference purposes only; it does not reflect prioritization among these policy options. Negative net present values and cost effectiveness numbers above reflect “negative costs” or net savings.

*The figures listed show totals for the options net of recent legislation.

RCI-1. Utility Demand-Side Management (DSM) for Electricity, Natural Gas

Policy Description

This option focuses on increasing investment in electricity and natural gas demand-side management (DSM) programs through programs run by the investor owned, municipal and co-operative utilities, as well as energy service companies (ESCOs), large customers, or others, in order to meet the goal of overall reduction in energy consumption. Decreasing consumption will have immediate impacts on greenhouse gas emissions. DSM activities may be designed to work in tandem with other recommended strategies that can also encourage efficiency gains.

This policy recommendation focuses on improving energy efficiency through increased investment in demand-side management programs including energy efficiency, energy conservation and peak demand reduction efforts. Energy efficiency and conservation are the lowest cost resources for reductions in electricity and natural gas use by the residential, commercial and industrial sectors and thus for reduction of greenhouse gasses. There is a long track record of cost effective energy efficiency initiatives, typically called demand side management (DSM), at the local, state and regional levels in areas around the country and in Michigan. There is vast potential for improving the energy efficiency of homes, appliances, businesses and industry in Michigan. A number of DSM efforts are already underway or mandated in Michigan, and important new energy efficiency legislation – Public Act 295 of 2008 – was adopted as the MCAC was concluding its efforts.

This policy option considers energy savings goals for electricity and natural gas, and the policy, program, and funding mechanisms that might be used to achieve these goals. These are intended to work in tandem with other strategies under consideration by the RCI and ES TWGs.

Policy Design

Goals and Timing: The goal of this policy is to bring the *total overall* demand reduction of existing actions, recent actions including notably newly-adopted Public Act 295 of 2008, plus new, additional DSM activities in Michigan to save in each year 2% of the prior year's electricity use and 0.75% of the prior year's natural gas use by the residential, commercial, institutional, municipal, and industrial sectors, compared to a three-year, weather-normalized Business-As-Usual (BAU) forecast that does not incorporate these goals. This goal derives in part from the efficiency goal identified in the Midwestern Governors Association's November 15, 2007 Energy Security and Climate Stewardship Platform.

This goal is phased in as follows:

Tier 1: 2008-2012 Electricity Energy Optimization Program Savings

- Biennial incremental electricity savings in 2008–2009 equivalent to 0.3% of total annual retail electricity sales in MWh in 2007.
- Annual incremental electricity savings in 2010 equivalent to 0.5% of total annual retail electricity sales in MWh in 2009.

- Annual incremental electricity savings in 2011 equivalent to 0.75% of annual retail electricity sales in MWh in 2010.
- Annual incremental electricity savings in 2012 of 1.0% of annual retail electricity sales in MWh in 2011.

Tier 1: 2008-2012 Natural Gas Energy Optimization Program Savings

- Biennial natural gas savings in 2008–-2009 equivalent to 0.1% of total annual retail natural gas sales in decatherms or equivalent MCF in 2007.
- Annual incremental natural gas savings in 2010 equivalent to 0.25% of total annual retail natural gas sales in decatherms or equivalent MCF on 2009.
- Annual incremental natural gas savings in 2011 equivalent to 0.5% of total annual retail natural gas sales in decatherms or equivalent MCF in 2010.
- Annual incremental natural gas savings in 2012 of 0.75% of total annual retail natural gas sales in 2011.

Tier 2 (2013-2015):

- Annual gross savings for electricity equal to 1.33% in 2013, 1.66% in 2014 and 2.0% in 2015.
- 0.75% annual gross savings for natural gas by 2015 and each year thereafter based upon prior year sales; and

Tier 3 (long term):

- Annual incremental electricity savings in 2016 and each year thereafter through 2025 equivalent to 2.0% of total annual retail electricity sales in MWh in the preceding year.
- Annual incremental natural gas savings in 2016 and each year thereafter through 2025, equivalent to 0.75% of total annual retail natural gas sales in decatherms or equivalent MCF in the preceding year.

Parties Involved: All of the state's gas and electric distribution companies and by extension, all customers.

Implementation Mechanisms

As reflected in Public Act 295 of 2008, implementation of this policy option is envisioned to be – at least initially – through traditional utility-based DSM programs. Implementation may also be enhanced through integrated resource planning (IRP) processes regarding future demand.

Related Policies/Programs in Place

Few related policies are in place at this time, although constructive new legislation – Public Act 295 of 2008 – was adopted as the MCAC process neared its conclusion. The quantitative goals and results of this Act are shown below:

Electric providers must achieve the following collective minimum energy savings:

- Biennial incremental energy savings in 2008-2009 equivalent to 0.3% of total annual retail electricity sales in megawatt hours in 2007.
- Annual incremental energy savings in 2010 equivalent to 0.5% of total annual retail electricity sales in megawatt hours in 2009.
- Annual incremental energy savings in 2011 equivalent to 0.75% of total annual retail electricity sales in megawatt hours in 2010.
- Annual incremental energy savings in 2012, 2013, 2014, and 2015 and each year thereafter equivalent to 1.0% of total annual retail sales in megawatt hours in the preceding year.

A natural gas provider shall meet the following minimum energy savings:

- Biennial incremental energy savings in 2008-2009 equivalent to 0.1% of total annual retail natural gas sales in decatherms (Dth)[*] or equivalent thousand cubic feet (MCF) in 2007.
- Annual incremental energy savings in 2010 equivalent to 0.25% of total annual retail natural gas sales in Dth or equivalent MCF in 2007.
- Annual incremental energy savings in 2011 equivalent to 0.5% of total annual retail natural gas sales in Dth or equivalent MCF in 2007.
- Annual incremental energy savings in 2012, 2013, 2014, and 2015 equivalent to 0.75% of total annual retail natural gas sales in Dth or equivalent MCF in the preceding year.

These legislated actions will result in the effects on energy consumption and greenhouse gas emissions shown in Table RCI-1 A, below.

Table RCI-1 A. Estimated DSM legislated actions GHG reductions and cumulative cost savings

Legislated Actions: Utility Demand Side Management for Electricity and Natural Gas	2015	2025	Units
GHG emission reductions	3.3	24.6	Million tons of CO_2
Cumulative net costs (present value) (2009-2025)		–$4,415	Million $
Cumulative emissions reductions (2009-2025)		193.9	Million tons of CO_2
Cost-effectiveness		–$23	$/ton of CO_2

Note: Negative numbers represent costs savings.

Also, the Customer Choice and Electricity Reliability Act of 2000 authorized the creation of a Low-Income and Energy Efficiency Fund (LIEEF), administered by the Michigan Public Service Commission via grants to qualifying organizations. The purpose of the fund is to provide shut-off and other protection for low-income customers and to promote energy efficiency by all

[*] Decatherm (Dth): A measurement of the heat equivalent to one million BTUs

customer classes. Since 2002, approximately $89 million (24% of available funds) has been used for efficiency-related grants.

Type(s) of GHG Reductions

Primarily CO2 reductions resulting from avoided electricity generation, but could reduce to some degree all six statutory GHGs (CO2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

Estimated GHG Reductions and Costs or Cost Savings

The estimated GHG reductions and cost savings from this Policy Option that are additional to the results of the legislation portrayed in Table RCI-1 A above are as follows;

Table RCI-1 B. Estimated DSM electricity and natural gas GHG reductions and cost savings

RCI-1: Utility Demand Side Management for Electricity and Natural Gas	2015	2025	Units
GHG emission reductions	0.0	13.6	Million tons of CO_2
Cumulative net costs (present value) (2009-2025)		–$1,632	Million $
Cumulative emissions reductions (2009-2025)		86.3	Million tons of CO_2
Cost-effectiveness		–$19	$/ton of CO_2

Note: Negative numbers represent costs savings.

Data Sources: Projections for energy sales are based on the most recent U.S. DOE Energy Information Annual Energy Outlook projections for energy sales in Michigan. The cost of energy is based on the most recent data from the Energy Information Administration. The levelized cost of natural gas savings is based on an estimate provided (September, 2008) from the American Council for an Energy Efficient Economy. The levelized cost of electricity savings is also based on data that the American Council for an Energy Efficient Economy provided, base don its survey of numerous electricity efficiency programs across the country. Primary data source is Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies, American Council for an Energy Efficient Economy.

Quantification Methods: Energy savings for both electricity and natural gas are calculated by multiplying the percentage of energy to be saved by the amount of energy projected to be sold in the baseline year. Those electricity or natural gas savings are then multiplied by the cost of electricity and natural gas savings and by the avoided electricity and gas cost to produce a net total cost of the policy option. In the case of these energy efficiency measures, the total cost is negative – meaning the energy efficiency measures produce net savings.

Key Assumptions: All emissions reductions shown are incremental to any energy savings required by existing Michigan legislation. The goal of this policy option is 2% electricity savings and 0.75% natural gas savings, phased in between 2009-2015. The savings targets continue through the year 2025. The analysis also assumes that residential, commercial and industrial sectors meet the same energy savings goals and that all energy sales in all three sectors must meet the same energy savings targets.

The other key cost assumptions, based on the data sources described above, are as follows:

Table RCI-1 C. Electricity and natural gas costs & savings assumptions

Levelized Cost of Electricity Savings	$30/MWh
Avoided Electricity Delivery Cost	$60/MWh
Levelized Cost of Natural Gas Savings	$2.5/MMBtu
Avoided Delivered Natural Gas Cost	$7.7/MMBtu

$/MWh = Cost per megawatt hour; $MMBtu = Cost per million British thermal units

Key Uncertainties

Key uncertainties are related to the assumed avoided cost of energy; if the assumed avoided costs of the energy (the energy that consumers do not need to purchase, as a result of energy efficiency measures) rises, then cost per ton of the policy option decreases. If the avoided cost of energy falls, then the cost, per ton of CO_2 reduced, increases.

Additional Benefits and Costs

Energy efficiency measures that reduce the use of fossil fuels often reduce emissions of criteria pollutants and air toxics in addition to GHGs. These reductions offer indirect public health and related economic benefits, none of which are quantified or included here.

Feasibility Issues

The requirements for electricity recommended here are more ambitious than the one recently enacted by Michigan, and the one recommended for natural gas is less stringent than the one enacted. There are therefore no feasibility issues associated with the natural gas recommendation. Whether a future Legislature will strengthen the electricity requirements will likely depend upon the experience with the relatively modest one now on the books.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-2. Existing Building Energy Efficiency Incentives, Assistance, Certification and Financing

Policy Description

The intent of this policy option is to improve the energy efficiency of existing buildings. Because Michigan has one of the weakest energy codes in the nation, and currently utilizes many of its World War II-era industrial buildings, energy efficiency improvements provide a significant opportunity to reduce Michigan's carbon footprint. This policy sets a goal for reducing energy usage in existing buildings by encouraging energy efficiency upgrades and operating improvements in existing institutional, municipal, commercial, residential and industrial buildings. Incentives, rebates and property tax abatements are imperative to foster state-wide participation in implementing energy efficient measures to reduce future energy generation and greenhouse gas emissions. This policy is intended to support and work in conjunction with other policies (e.g., RCI-1) to help create a sustainable and cost-effective energy efficiency program for Michigan.

Policy Design

Goals:

- Reduce energy consumption per square foot of floor space in existing residential, commercial, institutional, and municipal buildings by 50% from 2002 levels by 2030. Reduce energy consumption in the industrial sector, where building systems and process systems are often intertwined, by 20% by 2030.

Timing: Program begins in 2010.

Parties Involved: All parties involved in owning, operating, renovating, occupying, or other activities associated with Michigan's existing residential, commercial, institutional, municipal, and industrial building stock.

Implementation Mechanisms

Further development and implementation of this policy should take into account changes in building use and utilization, especially that which is brought about by the economic recovery of Michigan. This is particularly pertinent to the industrial sector.

The following are proposed mechanisms:

- **Energy survey and audit programs to encompass all facilities, including residential:** The proposed programs will provide funding or partial funding for energy audits for existing buildings and homes, allowing for a free or reduced-cost residential energy survey or a reduced cost technical energy audit for each commercial, industrial or institutional customer through qualified energy service companies, i.e., Rebuild MI-approved providers. Funding will be based on total square footage of building and will require documentation of recommendations, return on investment (ROI) calculations if investment is required and calculated reductions in GHG emissions. Audit program will incorporate free energy assessments for industries through Industrial Energy Assessment Centers & Department of Energy (DOE) Save Energy Now Program. Incentives and assistance will be available for follow up and implementation of audit recommendations. It may also be appropriate to target existing buildings through time-of-sale and/or change-of-occupancy energy efficiency audits. Such audits can be implemented on a voluntary or mandatory basis, and can be applied toward several purposes (e.g., as a threshold to qualify for incentives, as a screening tool for utility DSM investments, or simply for disclosure in buyer-seller transactions).

- **Incentives and rebates for energy efficiency measures and improvements:** This program will provide financial incentives for all state energy consumers to install energy efficient equipment in their homes and businesses. Residential customers will have a separate rebate program to include common and largest energy consuming equipment such as clothes washers/dryers, refrigerators, furnaces and compact fluorescent lamps. All equipment must be EnergyStar rated. For all other customer classes the rebate basis will be for prescriptive technologies such as lighting, HVAC and motors including agricultural technologies. Rebates only apply to full time Michigan residents and businesses.
- **Property tax abatement for achieving Leadership in Energy and Environmental Design (LEED) certification[*] for existing buildings (LEED) by the U.S. Green Building Council (USBGC) and/or other tax incentives for energy efficiency:** This program will provide property tax abatement by achieving LEED Certification. Abatements will be scaled to the level of certification achieved. Governmental facilities and operations are excluded from these incentives however should be encouraged or required to comply with minimum ranking through existing executive order. (Covered in more detail in RCI-7.) In addition, tax credits could be made available to homeowners and residential rental property owners for energy-efficiency upgrades.
- **Short-term, low- or no-interest loans:** Applies to businesses or energy service companies (ESCO's) that implement energy savings measures with verification & monitoring activities. Loans are secured and bound by purchased equipment and distributed directly to customer or to third party energy service provider. This program will have established ROI terms and is available to all residential and small businesses (SBA members). This program will also complement and promote all other initiatives considered in this policy. Loans will be prioritized and quantified by customer class and applicable to qualified prescriptive technology measures only. Low income class customers may also utilize Michigan's LIEEF for supplemental or full funding of energy improvements.
- **Energy efficiency reinvestment funds:** Establish a fund which will act as a bank for guaranteed performance based energy improvement projects by issuing internal unsecured loans. Applies to businesses or energy service companies (ESCO's) that implement energy savings measures with verification & monitoring activities. This program will have established ROI terms and is available to all customer classes excluding residential. Projects are approved on short term simple payback basis as long as the debt service from savings does not exceed existing utility costs. Loans will be prioritized and quantified by customer class and applicable to qualified prescriptive technology measures only. Interest on loans to

[*] Leadership in Energy and Environmental Design (LEED) is a third-party certification program and nationally accepted benchmark for the design, construction and operation of high performance green buildings.

be fixed with portion appropriated for administrative fees and profit (to be used to increase fund size).

Related Policies/Programs in Place

From www.michigan.gov website:

- Rebuild Michigan

  The Rebuild Michigan Program fosters partnerships that promote increased energy efficiency within a community. Partners may include local governments, schools, universities, businesses, non-profit organizations and public housing authorities. With assistance from state government and other partners each community can determine energy saving opportunities and goals and work to implement an energy action plan.

- State Facility Energy Savings Plan

  On November 14, 2007, the MI Department of Management & Budget (DMB) began its compliance of Executive Directive 2007-22; an energy reduction strategy to reduce utility expenditures by 10% by the end of fiscal year 2008 (September 30, 2008), based on 2002 utility expenditures of approximately $16 million on DMB managed and owned buildings. Additionally, energy consumption must be reduced by another 10% by the end of fiscal year 2015 (September 30, 2015), compared to a 2006 baseline. This strategy incorporates benchmarking state-owned facilities through ENERGY STAR in partnership with the MI Department of Labor & Economic Growth/Energy Office.

- Energy Cost Avoidance Certification (P.A. 122)

  Public Act 122 (P.A. 122) of 1987 encourages ongoing energy management in state-owned facilities by offering a financial incentive to departments that have taken energy-saving actions and can document the energy cost savings. Departments may retain seventy-five percent (75%) of their certified energy cost avoidance to fund additional energy efficiency projects during the next fiscal year.

- ENERGY STAR Building Label Incentive

  The ENERGY STAR Building Label is awarded to buildings that exhibit high energy efficiency without sacrificing occupant safety and comfort. These buildings are given national recognition for their energy performance. Also, each recognized building is presented with a plaque that can be mounted in the building visible to occupants, visitors and community members. To receive the ENERGY STAR Building Label the building owner must:
    - benchmark their building(s)
    - have a professional engineer verify and prepare a statement of energy performance
    - submit a completed application

- The Energy Office staff is available to assist with the benchmarking and application processes. This Office is also offering a limited time incentive to help public agencies pay for the statement of energy performance.

From DSIRE website (www.dsireusa.org):

- Low-Income and Energy Efficiency Fund (LIEEF)

  Michigan's statewide public benefits fund, the Low-Income and Energy Efficiency Fund (LIEEF), was authorized by the state's restructuring legislation (Act 141), enacted in June 2000. The purpose of the LIEEF is to provide energy assistance for low-income customers, to provide conservation and efficiency measures to reduce energy use and energy bills of low-income customers, and to promote energy efficiency among all customer classes.

  The LIEEF is administered by the Michigan Public Service Commission (PSC), which issues periodic requests for proposals (RFPs) for prospective projects. The most recent RFPs include $55 million for low-income energy assistance, $10 million for low-income energy efficiency, and $15 million for energy efficiency in all customer classes. The deadline for proposal submissions on all three RFPs was May 1, 2008.

- Nonrefundable Business Activity Credit

  Businesses certified by the NextEnergy Authority that locate in the NextEnergy Zone may claim a nonrefundable credit for the tax year equal to the lesser of (1) the amount by which a business's "tax liability attributable to qualified business activity" for the tax year exceeds the business's "baseline tax liability attributable to qualified business activity," or (2) 10% of the amount by which the business's "adjusted qualified business activity" performed in Michigan, outside of a "Renaissance Zone," for a tax year exceeds such activity for the 2001 tax year under former Michigan Compiled Laws (MCL) § 208.39e. Under either formula, a business may not claim the credit for any tax year in which its "tax liability attributable to qualified business activity" did not exceed the "baseline tax liability attributable to qualified business activity" in 2001. These credits initially took effect beginning in 2003 and were scheduled to expire at the end of 2007 with the repeal of MCL § 208.39e. In 2007 however, they were renewed without substantive alteration as part of a larger reworking of state business taxing policy.

- Refundable Payroll Credit

  Businesses certified by the NextEnergy Authority that locate in the NextEnergy Zone to develop "alternative energy technologies," as defined by the Michigan Next Energy Authority Act, may claim a credit for the their qualified payroll amount. If the credit exceeds the tax liability of the business for the tax year, the portion of the credit exceeding the tax liability will be refunded. This credit initially took effect beginning in 2003 and was scheduled to expire at the end of 2007 with the repeal of MCL § 208.39e. In 2007 however, it was renewed as part of a larger reworking of state business taxing policy.

- Wisconsin Public Power, Inc. - Renewable Energy Rebate

  Rebates for renewable-energy systems are available to residential and small commercial customers of all Wisconsin Public Power, Inc. (WPPI) utilities, including these Michigan utilities: Alger Delta CEA, Baraga Electric Utility, Gladstone Power & Light, L'Anse Electric Utility, Negaunee Electric Department, and Norway Power & Light. Customers must reside in the service territory of the participating utility, and the system must be installed on the customer's property. Projects must be approved by the utility before installation.

- DTE Energy

  DTE Energy launched a small energy efficiency pilot program in May 2008 offering rebates of up to $5,000 to customers of its natural gas utility, MichCon, for products and services that help conserve energy. Under the pilot program, a limited number of $250 rebates are available to customers who purchase a high efficiency furnace or have a professional energy audit performed on their home. The company also is offering six rebates of $5,000 to builders who construct new energy efficient homes.

Financial Assistance Programs offered through the Department of Environmental Quality:

- Retired Engineers Technical Assistance Program (RETAP) (www.michigan.gov/deq/0,1607,7-135-3585_4848---,00.html)

  Retired professionals are available through the Retired Engineer Technical Assistance Program (RETAP) to assist businesses and institutions in Michigan with pollution prevention. Each assessor has thirty to forty years of experience with Michigan industries. Businesses of 500 employees or fewer in the state and institutions of any size are eligible. This program provides confidential and non-regulatory on-site pollution prevention/ energy assessments for Michigan businesses and institutions, free of charge. Teams of RETAP professionals review operations for potential waste reduction strategies and opportunities; including source reduction, reuse, recycling, and energy efficiency.

- Small Business Pollution Prevention Loan Program (P2 Loans)

  This program provides loans of up to $400,000 at an interest rate of 5% or less to existing independently owned businesses with 500 or fewer full time employees. Projects that qualify for P2 loan funding include those that either eliminate or reduce waste at the business location (source reduction), result in environmentally sound reuse and recycling for the loan applicant's generated wastes, conserve energy or water on-site, or are a qualified agricultural energy production system. Funding for the P2 Loan Program comes from a revolving loan fund, made possible through passage of the Clean Michigan Initiative in November of 1998. Low interest loans are available to all Michigan businesses including manufacturing, farming, retail and service.

- Energy Research and Demonstration Centers (www.warmtraining.org/medc/)

  Michigan's Energy Office supports the Michigan Energy Demonstration Centers located throughout the State. The Michigan Energy Demonstration Centers promote energy efficiency, renewable energy, green building and sustainable living solutions for Michigan residents and businesses.

- Other Grants and Loans (www.michigan.gov/deq/0,1607,7-135-3307_3515---,00.html)

  Other grant and loan programs include Brownfield grants and loans; the State Revolving Loan Fund; and Nonpoint Source Grant Funds. Additional information can be found at the above website.

Other Outreach Websites and Information

- Sustainability (www.michigan.gov/deq/0,1607,7-135-3585_30068_48393---,00.html)
- Energy Efficiency Resources (www.michigan.gov/deq/0,1607,7-135-3585_30068_27504---,00.html)

Type(s) of GHG Reductions

Primarily CO2 reductions resulting from avoided electricity generation, but could reduce to some degree all six statutory GHGs (CO2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

Estimated GHG Reductions and Costs or Cost Savings

The estimated GHG reductions and cost savings are as follows;

Table RCI-2 A. Estimated energy efficiency measures GHG reductions and cost savings

RCI-2: Energy Efficiency Incentives, Assistance, Certification and Financing	2015	2025	Units
GHG emission reductions	17.6	53.8	Million tons of CO_2
Cumulative net costs (net present value) (2009-2025)		–$12,107	Million $
Cumulative emissions reductions (2009-2025)		428.6	Million tons of CO_2
Cost-effectiveness		–$28	$/ton of CO_2

Note: Negative numbers represent costs savings.

Data Sources: As laid out in quantification memo. Primary data sources are US Department of Energy price and fuel projections as well as data on residential, commercial and industrial energy use, the Michigan 21st Century Energy Plan and Midwest Independent System Operator. In addition, the cost of energy efficiency measures for electricity and natural gas is derived from the

American Council for an Energy Efficient Economy. US Census Bureau data is used for projections of population growth in Michigan.

Quantification Methods: The first step in the quantification was to use Energy Information Administration (EIA) data to project industrial, commercial and residential energy consumption over the period through 2025. The second step was to calculate a percentage reduction in energy use for each year, based on the phase in of the 20% and 50% energy use reduction goal for industrial and residential/commercial energy use respectively. Growth factors for residential, commercial, institutional, and municipal floor space came from the EIA and from the Michigan 21st Century Energy Plan, and the next step was to calculate the reduction in energy use for the overall residential, commercial, institutional, and municipal sectors on a per square foot basis. Industrial energy use reductions were calculated for each of the major industrial fuels – fuel oil, natural gas, electricity, liquefied petroleum gas (LPG) and coal. Finally, based on these annual reductions in energy use, the cost, per year, of these reductions was calculated. The net present value (NPV) of these figures, along with cumulative greenhouse gas emissions as well as emissions reductions in 2015 and 2025 is shown in Table RCI-2 A, above and in the Summary Table of all options on page 1.

Key Assumptions: The key assumptions for this analysis are as follows:

Table RCI-2 B. Electricity and natural gas cost assumptions

Levelized Cost of Electricity Savings	$30.00	$/MWh
Levelized Cost of Natural Gas Savings	$2.50	$/MMBtu
Avoided Electricity Cost	$60.00	$/MWh
Avoided Natural Gas Cost	$7.70	$/MMBtu

$/MWh = Cost per megawatt hour; $MMBtu = Cost per million British thermal units

The quantification model is also based on assumed growth rates for housing that take into account growth in Michigan population as projected by the U.S. Census Bureau. For example, population growth is projected to be 1.02% for 2008-2009. Based on the 21st Century Energy Plan, commercial floor space is expected to grow by 40 million square feet per year.

Key Uncertainties

Significant uncertainty exists with respect to baseline (2002) levels of energy consumption per square foot, particularly at any high-resolution level like building-specific figures at the residential or commercial level.

One key uncertainty relates to the ability to reach the goals as stated in this policy option. The ability to reach these goals will depend heavily on design and level of incentives that the State of Michigan adopts. While it is possible to achieve 50% savings in an individual building, it may not be possible to achieve such savings across the entire existing building stock in the residential and commercial sectors. High penetrations may also affect the cost of achieving such savings. If, for instance, the State achieved only 50% of this goal, the results would be as follows in Table RCI-2-C.

Table RCI-2 C. Estimated cumulative cost savings and GHG reductions from energy efficiency measures, 2015-2025

RCI-2: Energy Efficiency Incentives, Assistance, Certification and Financing	2015	2025	Units
GHG emission reductions	10.8	35.5	Million tons of CO_2
Cumulative net costs (net present value) (2009-2025)		–$7,268	Million $
Cumulative emissions reductions (2009-2025)		272.5	Million tons of CO_2
Cost-effectiveness		–$26.7	$/ton of CO_2

Note: Negative numbers represent costs savings.

Additional Benefits and Costs

"Green" buildings promote ecological health and well-being while reinforcing positive social and environmental ramifications by increasing the efficiency of the building that uses energy, water and materials in a way that reduces impacts to human health and the environment over its lifetime.

As co-benefit of improving building stock efficiency, healthier "green" building environments provide added societal and economic benefits to the state in terms of reduced worker sick leave, improved worker performance and direct and indirect jobs related to the energy sectors associated with this particular policy option.

Additional benefits of "green" buildings (as noted on the USGBC LEED web site) include the following.

- Environmental benefits:
    - Enhance and protect ecosystems and biodiversity
    - Improve air and water quality
    - Reduce solid waste
    - Conserve natural resources

- Economic benefits:
    - Reduce operating costs
    - Enhance asset value and profits
    - Improve employee productivity and satisfaction
    - Optimize life-cycle economic performance

- Health and community benefits:
    - Improve air, thermal, and acoustic environments
    - Enhance occupant comfort and health
    - Minimize strain on local infrastructure

- Contribute to overall quality of life

Feasibility Issues

Characterization and generalization will almost certainly be needed due to the widespread lack of building-specific baseline data for 2002.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-3. Regulatory (PSC) Changes to Remove Disincentives and Encourage Energy Efficiency Investments by Investor-Owned Utilities (IOUs)

Policy Description

Economic regulation of investor-owned utility rates by the Michigan Public Service Commission (MPSC) limits the company's earnings potential by determining an authorized level of earnings and by establishing the allowed earnings as a percentage of the utility rate base – meaning the value of assets (e.g. power plants and distribution networks) used in the business. In designing the rates charged to customers to recover the utility's "revenue requirement" (expenses plus return on the rate base), the regulator typically assigns most of the revenue requirement to a predicted level of sales of units of gas or electricity. This method creates financial incentives for the utility to increase, not decrease, its unit sales and make investments in the physical assets of the business.

Successful energy conservation and efficiency programs will reduce unit sales and could cut into the utility's recovery of revenues associated with the costs of doing business, including a reasonable return. If the program costs are expensed, there can be no incremental earnings on the program investment no matter how successful it is. Thus there is limited "upside" potential and a significant risk of harming profitability associated with an energy efficiency program. Cooperative and municipal systems may run the risk of diminished cash flow from reduced sales, even absent the same earnings model as the investor-owned utilities. The financial incentives are to maximize unit sales, consistent with existing production capability, not reduce them.

The natural financial disincentive can be offset by: (1) providing a possible incentive financial benefit for a successful efficiency program; (2) changing the rate method so that expenses and earnings are recovered by a fixed rate charge developed based on the number of customers rather than units sold; (3) allow updating of the sales figure in between rate cases; and (4) utilize a system benefits charge applicable to all distribution service customers for the efficiency program. Items (2) and (3) are alternatives sometimes referred to as "decoupling" of the revenue requirement from a projected sales level determined in the rate case. Item (4) ensures that all customers receiving deliveries from the local distribution utility contribute to the program costs, since the benefits are societal.

Decoupling utility unit sales from profits in rate setting while providing the opportunity to earn profits from successful program outcomes can realign incentives to encourage effective utility investment in DSM, energy efficiency and conservation and reduce the incentive to maximize unit sales.

A public benefits charge (sometimes call systems benefits charge) is a fee attributed to utility customers for the purpose of accomplishing a public good, such as reducing emissions. The fee is a non-by passable charge on electric or natural gas utility bills and may be set on a per-meter, per month or volumetric (per kWh) basis. The funds collected are used to provide energy efficiency, conservation and peak demand reduction programming. This programming can be operated by the distribution utilities or by a commission-supervised third party.

Policy Design

Goals: This policy option is not quantifiable at this time. However, the MPSC should undertake and complete as soon as possible a comprehensive study identifying disincentives to energy efficiency investments by utilities and ways to remove them, as well as opportunities to encourage additional energy efficiency investment by utilities. MPSC should implement the recommendations of this study by December 2010. This should be done in close coordination with the MCAC's Energy Supply recommendations, and in keeping with the provisions of Public Act 295 of 2008, Michigan's newly adopted energy legislation.

Timing: As noted above.

Parties Involved: MPSC, investor-owned utilities, and others as the study's recommendations may indicate.

Implementation Mechanisms

- To have the Commission issue an order on its own motion to address guidelines on decoupling mechanisms by the 1st quarter of 2009, providing opportunity for comments with a staff report due by the end of the 3rd quarter of 2009 and a commission order out the 1st quarter of 2010. Utilities will have the opportunity to file a rate case on decoupling mechanisms that correspond with the guidelines issued by the commission.
- Other implementation mechanisms for this policy option will derive from the conclusions and recommendations of the identified study.

Related Policies/Programs in Place

Newly adopted Public Act 295 of 2008 allows utilities to contribute to a centrally administered program at a level of 2% of revenue, creating an attractive option for utilities lacking staff to administer their own programs.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Costs or Cost Savings

Not applicable; this policy option was not quantified.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-4. Adopt More Stringent Building Codes for Energy Efficiency

Policy Description

Newly constructed buildings today become the energy-consuming building stock of tomorrow. In an effort to reduce the largest operations and maintenance cost for newly constructed buildings (energy costs), a higher energy standard should be required in Michigan. Stronger building energy codes can be an effective way to eliminate the least efficient energy approaches in new or renovated buildings. The "2030 Challenge" is a global initiative that targets all new buildings and major renovations to reduce their fossil-fuel GHG-emitting consumption by 50% by 2010, incrementally increasing the reduction for new buildings to carbon neutral by 2030. The 2030 challenge has been adopted by the U.S. Conference of Mayors, National Association of Counties, American Institute of Architects, U.S. Green Building Council, International Council for Local Environmental Initiatives, Congress for the New Urbanism, states of Illinois, Minnesota, California & New Mexico, numerous counties and cities, and supported by the American Society of Heating, Refrigerating & Air-Conditioning Engineers (ASHRAE). New building standards that meet the 2030 Challenge are currently being developed. To meet or exceed the 2030 Challenge for a 50% GHG reduction by 2010, it would require Michigan to achieve a 30% improvement beyond the requirements of the IECC 2006 Code.

Policy Design

Goals:

- Strengthen the Michigan energy building codes for residential, commercial, institutional, municipal, and covered industrial construction to match those of the 2030 Challenge.
- To meet the initial 2030 Challenge goal of 50% GHG reduction by 2010, Michigan should adopt an energy code that requires 30% energy performance improvement beyond the requirements of the IECC 2006 Code.
- Implement mandatory thermal envelope inspections for all new building construction to assure that "as designed" thermal envelope details match "as implemented" thermal envelope details. This will assure that energy efficiency performance objectives are met in the completed structures.
- Energy savings can be measured by using the current Michigan Uniform Energy Code (MUEC), the IECC 2006, and ASHRAE 90.1 2004 standards as baseline references to the requirements of the 2030 Challenge. Assuming that the earliest new codes could be implemented would be 2009, the baseline year for energy saving comparisons should be 2008.
- Implementing the 2030 Challenge standards will result in reductions in electrical consumption far exceeding the 25% reduction achievable by meeting the 2006 IECC or ASHRAE 90.1 2004 standard
- Adhere to periodic upgrades of the national standards for new residential, commercial, institutional, municipal, and industrial buildings, and review and upgrade existing state and local building codes accordingly.

Timing: The above provisions should take effect immediately in order to effectively meet the requirement of a 50% GHG reduction by 2010, and a carbon neutral goal by 2030.

Parties Involved: All parties involved in designing, constructing, owning and occupying new residential, commercial, institutional, municipal, or industrial facilities.

Implementation Mechanisms

The full implementation of the 2030 Challenge in Michigan would require legislation that repeals the Stille-Derossette-Hale Single State Construction Act, allowing a revised energy code to be established.

In order to support increasing energy efficiency standards for new construction, it would be necessary to implement training for code officials as well as building trade professionals and facility managers to ensure consistent quality control and enforcement measures (see RCI-9).

Related Policies/Programs in Place

Background: Michigan is currently bound by the language of the State Construction Code Act regarding any changes to the Energy Code. Attempts to update the Residential Energy Code within the confines of the State Construction Code Act were met by litigation from the Michigan Association of Home Builders (MAHB) in February, 2005. The Circuit Court issued an injunction halting the implementation of the revised Michigan Uniform Energy Code (MUEC). This litigation is still unresolved. On June 25, 2008, however, the Michigan Supreme Court ruled that the MAHB would not be allowed to introduce new information at the Circuit Court trial that had not been developed or shared during the public rulemaking process and further clarified the State's rule making authority under the Administrative Procedures Act of Michigan State Agencies. With the Appeals Court and Supreme Court cases resolved, it is expected that the Circuit Court will now hear the case. It is expected that the State will request the injunction be lifted and the revised MUEC be implemented.

Concurrently, the Bureau of Construction Codes conducted ad hoc committee meetings through June of 2008 to discuss possible commercial and residential energy code updates. The ad hoc committee consisted of representatives from the building, manufacturing, building code, government and public sectors. The ad hoc committee's suggestions for commercial and residential energy code updates will be guided by the State Construction Code Act. The suggestions generated from the ad hoc committee have been presented to the Department of Labor and Economic Growth for consideration to update the current energy code. Any changes to the code will follow the normal notice-and-comment rulemaking process. Members of the public are encouraged to submit comments for the record addressing the proposed change to the residential energy code.

The ad hoc committee recommendations include suggestions for the commercial code to reflect the 2006 edition to the International Energy Conservation Code (IECC), and the residential code to reflect portions of the IECC as well as the International Residential Code (IRC).

In 2007, a proposed House Bill (HB 4812) recommended that the Michigan Uniform Energy Code be replaced by the 2004 supplement version of IECC. Similarly, a 2007 Senate Bill (SB

597) recommended that the Michigan Uniform Energy Code be replaced by the 2006 edition of the IECC.

There is a voluntary Michigan Greenbuilt program sponsored by the Michigan Association of Homebuilders that includes an energy performance standard for residential homes that exceeds the minimal Michigan Uniform Energy Code standard.

Numerous colleges and universities in Michigan and throughout the country have set long-term carbon neutral goals for their campuses.

Elsewhere, for example, California recently adopted "Zero net energy" building codes calling for residential coverage by 2020 and commercial buildings by 2030.

Type(s) of GHG Reductions

CO_2 and energy-related GHG equivalents.

Estimated GHG Reductions and Costs or Cost Savings

The projected GHG reductions and cost savings are as follows:

Table RCI-4 A. Estimated GHG reductions and costs savings from building codes

RCI-4: Building Codes	2015	2025	Units
GHG emission reductions	3.55	9.82	Million tons of CO_2
Cumulative net cost savings (present value) (2009-2025)		–$2,865	Million $
Cumulative emissions reductions (2009-2025)		82	Million tons of CO_2
Cost-effectiveness		–$34.95	$/ton of CO_2

Note: Negative numbers represent costs saving.

Data Sources: Primary data sources are the US Department of Energy EIA Annual Energy Outlook, the Michigan 21st Century Energy Plan and Midwest Independent System Operator as well as the Building Codes Assistance Project.

Quantification Methods: The first step in this calculation was to determine the difference between the current Michigan codes and the most up to date national model codes. According to the Building Codes Assistance Project, the 2006 residential code is 30% more stringent (resulting in 30% lower energy use) than the existing Michigan code. The most recent commercial model code is 25% more stringent than the existing code. The second step was to determine the energy savings if a new Michigan code required savings 30% greater than these model codes. This involved using an estimate of total energy use in the residential, commercial, institutional, and municipal sectors, and estimating the amount of industrial energy use that would be covered by building codes, using an EIA breakdown of industrial energy consumption, by end use. Finally, these figures were adjusted to account for an estimate of any new residential, commercial, institutional, or municipal substantial renovations that would be covered by energy codes.

Key Assumptions:

The key assumptions are as follows:

Table RCI-4 B. Electricity and natural gas cost assumptions

Levelized Cost of Electricity Savings	$30.00	$/MWh
Levelized Cost of Natural Gas Savings	$2.50	$/MMBtu
Avoided Electricity Cost	$60.00	$/MWh
Avoided Natural Gas Cost	$7.70	$/MMBtu

$/MWh = cost per megawatt hours; $MMBtu = cost per million British thermal units

- Per analysis provided by the Building Codes Assistance Project, the IECC 2006 energy code is assumed to result in 30% greater energy efficiency than the MUEC. The existing ASHRAE standard for commercial space is assumed to be 25% less efficient than the 2004 ASHRAE standard.

- An adjustment for inclusion of renovated residential, commercial, institutional, and municipal space of 1.3 and 1.2 respectively is included, however additional data to confirm this is requested. This adjustment means that for every 1 unit of commercial space built in Michigan an additional 0.3 units of commercial space and 0.2 units of residential space will be renovated and covered by code.

- Enforcement and compliance with Building Codes is assumed to be at 75 percent. In other words, it is assumed that 75 percent of buildings constructed will fully comply with the relevant code. This figure is consistent with compliance rates in other jurisdictions.

- Emissions factors assumed are as follows:

Table RCI-4 C. Emissions factors of fuels

Fuel	tCO_2e/billion BTU
LPG - RCI	61.978
Coal - RCI	93.103
Natural Gas - RCI	52.909
Biomass - RCI	2.500
Oil - RCI	68.171
Landfill Gas - RCI	0.260
Biogas - RCI	5.000

LPF = liquid petroleum gas;
tCO_2e/billion BTU = tons of CO_2 equivalent per billion British thermal units

Key Uncertainties

The key uncertainties in this area are (1) inclusion of renovated space under code and (2) enforcement and compliance with the energy codes.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-5. Michigan Climate Challenge and Related Consumer Education Programs

Policy Description

Each and every local government official, small business owner and citizen plays an integral part in recognizing climate change risks and committing to specific actions to reverse those changes. Together these individual actions will reduce the risks to the environment now and in the future. The Michigan Climate Challenge (MCC) provides the opportunity and resources for communities, organizations, businesses, and individuals to make those commitments allowing Michigan to move forward in addressing climate change.

Policy Design

The state should lead by example (i.e., walk the talk) regarding education and outreach. Implementation of the Michigan Climate Challenge will be one of the key elements of the state's effort in this area. A summary of this program follows:

Establish the MCC to encourage Michigan businesses, institutions, local and regional governments, and the general public to make a voluntary public commitment to undertake actions to reduce GHG emissions in their communities. The Department of Environmental Quality, working in conjunction and consultation with other state agencies, will develop and launch the MCC and include a web-based "Online Pledge" to encourage voluntary GHG reductions throughout Michigan.

The MCC will provide web-based resources and information in the form of a "Climate Action Toolkit" for individuals and organizations to consider implementing as part of their voluntary pledge to reduce GHG emissions. The "Climate Action Toolkit" will contain specific recommendations for reducing GHG emissions and will also identify measures that can be undertaken to minimize the impacts of climate change so Michigan can be better prepared to adapt to its effects.

Information and education should include training and education programs – and certification – for state officials, building planners, builders and contractors, energy managers and operators, and local code enforcement officials on certification that buildings and building subsystems have met program requirements. It should also include programs for consumer education and public education at the elementary and secondary levels.

Goals: Establish and implement the Michigan Climate Challenge.

Timing: The MCC website is currently under development. A demonstration of the website is scheduled for the November MCAC meeting. The website is scheduled to be fully implemented by December 31, 2009.

Parties Involved: Individual citizens, organizations, cities, townships, counties, metropolitan districts, regional metro councils, school districts, and other jurisdictions as appropriate.

Implementation Mechanisms

Prior to the MCC website going live, a marketing plan must be developed to ensure broad notice and participation. A mechanism to track participation in the MCC with the ability to register progress as part of the website design is being explored.

Related Policies/Programs in Place

The policies recommended by the Michigan Climate Action Council can be integrated into the Michigan Climate Challenge or stand alone as complementary actions to increase awareness and reduce emissions.

Mayors Climate Protection Agreement
(www.usmayors.org/climateprotection/agreement.htm)

As of August 2008, at least 23 Michigan cities have become signatories to the Mayors Climate Protection Agreement. These municipalities include Ann Arbor, Battle Creek, Berkley, Dearborn Heights, East Lansing, Ferndale, Grand Rapids, Holland, Kalamazoo, Lansing, Marquette, Meridian Township, Pittsfield Charter Township, Portage, Royal Oak, Saline, Southfield, Southgate, Sturgis, Sutton Bay, Taylor, Traverse City, and Warren.

American College & University Presidents Climate Commitment
(www.presidentsclimatecommitment.org/html/commitment.php)

As of late 2008, at least 12 colleges and universities in Michigan have signed on to the American College & University Presidents Climate Commitment. These institutions include Albion College, Aquinas College, Concordia University, Delta College, Grand Rapids Community College, Grand Valley State University, Jackson Community College, Lake Michigan College, Lansing Community College, Monroe Community College, North Central Michigan College, and St. Clair Community College.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Costs or Cost Savings

Not applicable; this policy option was not quantified.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Note: The RCI TWG recognized that this policy option is parallel with and nearly identical to the policy option CCI-5. RCI-5 is retained here to reinforce the importance of public and professional education and outreach, specifically training, education, and certification programs for professionals as well as programs for consumer education and public education.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-6. Incentives to Promote Renewable Energy Systems Implementation

Policy Description

Customer-sited distributed generation powered by renewable energy sources provides electricity system benefits such as avoided capital investment and avoided transmission and distribution losses, while also displacing fossil-fueled generation and thus reducing greenhouse gas emissions. Increasing the use of renewable distributed generation in Michigan can be achieved through a combination of regulatory changes and incentives.

Distributed generation technologies exist across the spectrum of residential, commercial and industrial facilities. Customer-sited renewable distributed generation can include solar photovoltaic systems, wind power systems, biogas and landfill gas-fired systems, geothermal generation systems, and systems fueled by biomass wastes or biomass collected or grown as fuel. Policies to encourage and accelerate the implementation of customer-sited renewable distributed generation can include direct incentives or requirements for power purchases, market incentives related to the pricing of electricity output by renewable distributed generation, state goals or directives, and favorable rules for interconnecting renewable generation systems with the electricity grid. Incentives for non-electric renewable energy applications should also be included.

Other potential technologies or elements that could be encouraged under this policy option include:

- Solar roofs (roofing materials with built-in solar photovoltaic cells, or solar PV panels erected on roofs).
- Solar water heating and solar space heating systems.
- Wind powered systems, particularly for rural areas.
- Biomass-fired generation, space, or water heating systems.
- Programs targeted at specific customer sectors (e.g., residential, commercial, industrial), or specific markets within sectors.
- Tax credits, and/or utility or other incentives to lower the initial cost of distributed energy systems to users.

Potential supporting measures for this option include training and certification of installers and contractors, net metering and other pricing arrangements, interconnection standards, and the creation or support of markets for biomass fuels. Through an educational campaign (see policy options RCI-5 and CCI-5), individuals and businesses can also gain a better understanding of renewable energy options and of the requirements of the program ultimately adopted in Michigan.

Policy Design

The TWG recommends that Michigan set as a minimum target the addition of small-scale customer-sited distributed renewable generation consistent with its overall annual goals for renewable generation. Renewable generation in Michigan at this time is recognized to be ~3-4%, but most of this is large-scale, centralized renewable generation.

Goals: Increase total annual electrical generation from small-scale customer-sited distributed renewable sources in Michigan by 2% by 2025. This policy option is designed to be accomplished as an addition to the 25% Renewable Portfolio Standards (RPS) goal set out in the Energy Supply policy #1. Total renewable supply as a result of these two policies would be 27% from renewable energy.

Timing: As noted above.

Parties Involved: MPSC, utilities, small-scale renewable generators, and others depending on implementation mechanisms selected.

Implementation Mechanisms

- One approach that has proven effective in encouraging renewable generation is renewable energy payments such as “feed-in-tariffs” (FITs), also known as “Fixed-Rate” or “Advanced” tariffs. Renewable energy payments typically obligate utilities to pay an incrementally higher (above market) price to distributed generators reflecting the cost disadvantages of investing in renewable resources. There could be a single renewable energy payment for a set of renewable sources, or a series of renewable energy payments for specified types of renewable resources. Utilities typically purchase renewable energy from an independent generator at a fixed price over a long-term period. The price is set so the independent generator can earn a return sufficient to cover capital costs and a reasonable profit. Prices vary by technology type (e.g., solar photovoltaic generators typically receive a higher price than utility-scale wind generators) and by location (e.g., wind turbines in regions with lower wind resources may receive a higher price than wind turbines in higher wind resource areas). Renewable energy payments are reviewed on an on-going basis with the goal of reducing the power purchase price as markets for renewable energy generation mature. The widespread use of solar photovoltaics and other renewables in Germany is widely attributed to that country’s adoption of a renewable energy payments policies.
- Information and education: Would include training and education programs and certification for building planners, builders/contractors, energy managers and operators, renewable energy contractors, and state and local officials on the incorporation of distributed renewable generation and solar space/water heat in building projects. Would also include programs for consumer and elementary/secondary education.
- Technical assistance: Assistance in siting, designing, planning renewable systems.
- Funding mechanisms and or incentives: These might include low-interest loan programs, rebates on capital costs, tax incentives, attractive rates for power purchases/net metering, and other incentives.
- Voluntary and or negotiated agreements
- Codes and standards: Common interconnection rules and standards are needed. A national IEEE standard, IEEE #1547, has been adopted to facilitate distributed generation (DG) installations.

- Market based mechanisms: Net metering for some renewable distributed generation systems, and possibly avoided-cost pricing rules for others.
- Pilots and demonstration projects, such as renewable systems in government buildings
- Research and development: Support for development of distributed renewable generation systems research.
- Regulatory: Complete Environmental Portfolio Standard (EPS) process at the State level and complete Sustainable Energy process for the State.
- The Governor's Energy Office could set up an audit program (with audits to be outsourced). Wisconsin's performance-based system could serve as a model for implementation of this policy.

Related Policies/Programs in Place

- A voluntary statewide net-metering policy is in effect (MPSC Case No. U-14346). A commission is currently looking at net-metering, fossil fuel plant efficiencies (generation), and fuel sources, and additional legislation is currently pending (SB 1246).
- Voluntary green energy programs through municipal and major utilities. According to MPSC, there are eight utilities in Michigan that offer green pricing programs.

Type(s) of GHG Reductions

- CO2 reduction from avoided fossil-fueled electricity production.
- Modest reduction in emissions of CH4 from avoided fuel combustion in electricity generation and avoided natural gas pipeline leakage. Likely small reductions in N2O and Black Carbon emissions from avoided fuel combustion in electricity generation.

Estimated GHG Reductions and Costs or Cost Savings

Table RCI-6-A shows the greenhouse gas emissions and costs resulting from this policy option.

Table RCI-6 A: RCI-6 2% distributed renewable energy estimated GHG reductions and costs

RCI-6: Incentives to Promote Renewable Energy Systems Implementation	2015	2025	Units
GHG emission reductions	0.72	1.49	Million tons of CO_2
Cumulative net costs (present value) (2009-2025)		$1,958	Million $
Cumulative emissions reductions (2009-2025)		14	Million tons of CO_2
Cost-effectiveness		$140	$/ton of CO_2

The capacity for distributed and non-distributed renewable energy capacity under this RCI scenario are as follows in Table RCI-6-B.

Table RCI-6-B: RCI-6 distributed generation RPS additional capacity

	2010	2015	2025
Total additional capacity of distributed generation (Megawatts)		392	1,344

Data Sources:

- EIA Annual Energy Outlook
- http://www.windpoweringamerica.gov/pdfs/economic_development/2008/mi_wind_benefits_factsheet.pdf
- Conversation with Recovered Energy Inc. (for plasma gasification)

Quantification Methods: New renewables were assumed to displace primarily coal-fired power, as reflected in the inventory and forecast. The values presented above reflect the minimum amounts specified in the recent RPS legislation.

In order to quantify this option, the first step was to identify the phase-in dates and percentages for the DG RPS. The second step identified the allocation among specific technologies that would fulfill the RPS obligation. These are presented below under Key Assumptions. The next step identified capacity factors and total energy generation from each of these renewable generation sources in order meet the RPS goals. In order to estimate costs, capital, Operation and Maintenance as well as fuel costs where relevant were incorporated into the model. These element combined to produce the estimate of costs for meeting the DG RPS.

The TWG first determined the magnitude of the carve-out, as a percent of total electrical energy consumption in the state, set at 2% in 2025, phased in beginning in 2010. This quantity of energy generated by distributed sources was spread across wind, solar PV and biogas based on the assumptions shown below. Based on the capacity factors determined by the TWG, the total required capacity was calculated. Costs are based on levelized cost of electricity from the various sources. The avoided cost of electricity is consistent with all other options.

Key Assumptions:

- The following portfolio of new renewables was used, based on input from the TWG.

Table RCI-6 B. Renewable electricity generation assumptions

Type of electricity generation	2015	2025	Units
Wind	40%	40%	of RPS
Biomass	35%	35%	of RPS
Solar PV	25%	25%	of RPS

RPS = Renewable Portfolio Standard; PV = photovoltaic

- The following assumptions were used for each type of generation:

Table RCI-6 C. Assumptions on Renewable Costs and Capacity Factors

	2015	2025
Wind		
Capital cost ($/kW)	$6,000	$5,000
Capacity factor	18%	18%
Biogas		
Capital cost ($/kW)	$3,250	3,250
Capacity factor	65%	65%
Solar PV		
Capital cost ($/kW)	$8,131	$6,756
Capacity factor	15%	15%

$/kW = cost per kilowatt hour; PV = photovoltaic

Key Uncertainties

It is unclear at this time how many customers would be interested in installing customer-sited, distributed renewable energy generation. Cost estimates are based on the best data available, but will vary as a result of many factors.

Additional Benefits and Costs

- Reducing dependence on imported fuel sources
- Reducing energy price increases and volatility
- Reducing peak demand and improving the utilization of the electricity system
- Reducing the risk of power shortages
- Supporting local businesses and stimulating economic development
- Enabling avoidance of energy supply projects
- Reducing water consumption by power plants
- Reducing pollutant emissions by power plants and improving public health
- Increased flexibility of electricity supply for consumers hosting generation.
- Central-station power plant cooling water savings
- Potential local air quality impacts (may be positive or negative, depending on technology)
- Saving consumers and businesses money on their energy bills (and/or offering a new income stream)
- Reducing dependence on imported fuel sources, and reducing vulnerability to energy price spikes
- Where waste biomass fuels are used, possible reduction in disposal cost, reduction in environmental impacts related to disposal
- Electricity (grid) system benefits, including reduced peak demand, reduced capital and operating costs, improved utilization and performance of the electricity system, reduced pollutant emissions from power plants and related health improvements

- Supporting local businesses (related to renewable system sales, installation, and service, and possibly biomass fuel supply) and stimulating economic development.

Feasibility Issues

- Costs could be very high for monitoring and verification.
- This effort is contingent upon state approval and appropriation of funding and/or funding mechanisms.

Status of Group Approval

Approved.

Note: The RCI TWG recognized that this policy option is parallel with and has substantial overlap with policy option ES-1. RCI and ES TWGs believed it appropriate to consolidate RCI-6 and ES-1 by considering the RCI emphasis on small-scale, customer-cited distributed generation as a "carve out" within the broader overall goal of ES-1.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-7. Promotion and Incentives for Improved Design and Construction in the Private Sector

Policy Description

Revolving loan funds are proven and effective tools for promoting energy efficiency in state and local government facilities. This tool should be utilized in the private sector. This policy would facilitate investment in energy efficiency improvements by providing zero interest loans to local governments that provide the program to private entities. Utility cost savings for the private sector would provide cash flow for repaying principal, with the cost of program for the local government limited to interest payments and loan administration.

Policy Design

Incentives, such as permitting and fee advantages, tax credits, financing incentives (such as "green mortgages"), or other inducements should be used to encourage retrofit of existing residential, commercial, institutional, municipal, and industrial buildings or for the development of non-traditional off-grid low- carbon and carbon-neutral energy sources. The state can work with financial institutions to develop loan tools for these programs. Eligibility for the loans would be factored upon the selection of standards.

Michigan jurisdictions that have adopted enforceable standards will be eligible for managing the loans. The IECC, or alternative standard, must be enforced.

This policy assumes a gradually increasing energy efficiency code for new construction, backed up by strong, consistent enforcement measures.

- Providing incentives, such as permitting and fee advantages, tax credits, financing incentives (such as "green mortgages"), or other inducements to encourage retrofit of existing residential, commercial, institutional, municipal, and industrial buildings or for the development of non-traditional off-grid low and carbon neutral energy sources. The state can work with financial institutions to develop loan tools for these programs.
- Targeting existing buildings for efficiency improvements during both major and minor renovation, through application and enforcement of building codes and/or with tax rebates or other incentives. It may also be appropriate to target existing buildings through time-of-sale and/or change-of-occupancy energy efficiency audits. Such audits can be implemented on a voluntary or mandatory basis, and can be applied toward several purposes (e.g., as a threshold to qualify for incentives, as a screening tool for utility DSM investments, or simply for disclosure in buyer-seller transactions).
- Energy-reduction targets should be periodically reassessed. Potential measures supporting this policy can include outreach and public education, public recognition programs, improved enforcement of building codes, encouraging or providing incentives for energy tracking and benchmarking, performance contracting/shared savings arrangements, technical support resources for implementation, development of a clearinghouse for information on and access

to software tools to calculate the impact of energy efficiency and solar technologies on building energy performance.

- An important piece of any incentive structure for energy efficiency improvements is to include property tax abatements to help offset the immediate raises in property value likely to occur. Examples of proposed tax abatements for USGBC LEED-certified projects are shown in the table below.

Table RCI-7 A. Examples of tax abatements for green building certification levels

Real Property Tax Abatement				
LEED	Certified	Silver	Gold	Platinum
Abatement Amount	20%	30%	40%	50%
Personal Property Tax Abatement				
LEED	Certified	Silver	Gold	Platinum
Abatement Amount	20%	30%	40%	50%

LEED = Leadership in Energy & Environmental Design Source: DeLong & Bazzani.

- Adhere to periodic upgrades of the national standards applicable to retrofits of residential, commercial, and industrial buildings that are subject to building energy codes; review and upgrade existing state and local building codes accordingly.

Goals: Encouraged by the incentives offered, all residential, commercial, institutional, municipal, and industrial buildings will achieve 15% better energy efficiency than that required by IECC 2006 by 2015 and 30% better efficiency than that required by IECC 2006 by 2025.

Timing: As noted above.

Parties Involved: All parties involved with residential, commercial, institutional, municipal, and industrial buildings.

Implementation Mechanisms

- Technical assistance: Assistance to building planners, engineers, and others in energy-efficient design and in building energy efficiency analysis, possibly including reference materials, performance/design guidelines, and assistance with energy performance analysis software.

- Funding mechanisms and or incentives: Tax credits and/or incentives related to the rate of amortization of expenses related to buildings or renovation. State grants to help cover additional costs of energy performance enhancements for municipal government buildings.

- Voluntary and or negotiated agreements: Agreements by municipal governments, builders to meet higher energy performance standards in exchange for special certification and/or financial incentives.

- Codes and standards: For state-owned or state-leased space, requirements to exceed codes in force (as noted in RCI-4).

- Pilots and demos: Applications of building energy performance improvements (possibly including demonstration of construction of buildings and renovations leading to LEED or other relevant standards) and urban landscaping for government buildings.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO_2 and other energy-related GHGs.

Estimated GHG Reductions and Costs or Cost Savings

The estimated GHG reductions and cost savings are show in the table below

Table RCI-7 B. Reductions and cost savings from promotions and incentives

RCI-7 Summary: Promotion and Incentives for Improved Design and Construction in the Private Sector	**2015**	**2025**	**Units**
GHG emission reductions	15.63	47.57	Million tons of CO_2
Cumulative net cost savings (present value) (2009-2025)		–$11,693	Million $
Cumulative emissions reductions (2009-2025)		379.9	Million tons of CO_2
Cost-effectiveness		–$30.8	$/ton of CO_2

Note: Negative numbers represent costs savings in all tables.

The RCI-7 is made up of two components, one reflecting a change in building codes to affect new construction and the second affecting renovations to existing buildings. The separate results for these two portions of RCI-7 are laid out in the two tables below.

Table RCI-7 C, Reductions and cost savings from building codes

RCI-7: Building Code Portion	**2015**	**2025**	**Units**
GHG emission reductions	0.45	7.1	Million tons of CO_2
Cumulative net cost savings (present value) (2009-2025)		–$1,389	Million $
Cumulative emissions reductions (2009-2025)		35.9	Million tons of CO_2
Cost-effectiveness		–$38.7	$/ton of CO_2

Table RCI-7 D. Reductions and cost savings from facility retrofits

RCI-7: Existing Facility Portion	2015	2025	Units
GHG emission reductions	15.18	40.48	Million tons of CO_2
Cumulative net cost savings (present value) (2009-2025)		–$10,304	Million $
Cumulative emissions reductions (2009-2025)		344	Million tons of CO_2
Cost-effectiveness		–$29.9	$/ton of CO_2

Data Sources: As laid out in quantification memo. Primary data sources are US Department of Energy price and fuel projections as well as data on residential, commercial, institutional, municipal, and industrial energy use, the Michigan 21st Century Energy Plan and Midwest Independent System Operator. In addition, the cost of energy efficiency measures for electricity and natural gas is derived from the American Council for an Energy Efficient Economy. US Census Bureau data is used for projections of population growth in Michigan.

Quantification Methods: This quantification took place in two steps in order to accommodate the goals laid out in this option. These goals require a percentage reduction in energy use for all buildings, for both existing and new buildings. This quantification approach, therefore, examined a scenario for an overall reduction in building energy use in the existing building sector and also examined an overall reduction in energy use (based on an increment above the newest model residential and commercial energy codes) for new buildings. We approached these two scenarios as follows:

For existing buildings: The first step in the quantification was to use EIA data to project industrial, commercial and residential energy consumption over the period through 2025. The second step was to calculate a percentage reduction in energy use for each year, based on the phase in of the 20% and 50% energy use reduction goal for industrial and residential/commercial energy use respectively. Growth factors for residential and commercial floor space came from the EIA and from the Michigan 21st Century Energy Plan, and the next step was to calculate the reduction in energy use for residential and commercial sectors on a per square foot basis. Industrial energy use reductions were calculated for each of the major industrial fuels – fuel oil, natural gas, electricity, LPG and coal. Finally, based on these annual reductions in energy use, the cost, per year, of these reductions was calculated. The net present value of these figures is shown in the summary chart above, along with cumulative greenhouse gas emissions as well as emissions reductions in 2015 and 2025.

For new buildings: The first step in this calculation was to determine the difference between the current Michigan codes and the most up to date national model codes. According to the Building Codes Assistance Project, the 2006 residential code is 30% more stringent (resulting in 30% lower energy use) than the existing Michigan code. The most recent commercial model code is 25% more stringent than the existing code. The second step was to determine the energy savings if a new Michigan code required savings 15% and then 30% greater than these model codes. This involved using an estimate of total energy use in the residential and commercial sectors, and estimating the amount of industrial energy use that would be covered by building codes, using an

EIA breakdown of industrial energy consumption, by end use. Finally, these figures were adjusted to account for an estimate of any new commercial or residential substantial renovations that would be covered by energy codes.

Key Assumptions: The key assumptions for this analysis are as follows:

Table RCI-7 E. Cost assumptions for electricity and natural gas

Levelized Cost of Electricity Savings	$30.00	$/MWh
Levelized Cost of Natural Gas Savings	$2.50	$/MMBtu
Avoided Electricity Cost	$60.00	$/MWh
Avoided Natural Gas Cost	$7.70	$/MMBtu

$/MWh = Cost per megawatt hour; $MMBtu = Cost per million British thermal units

Emissions factors assumed are as follows:

Table RCI-7 F. Emission factors for fuels

Fuel	tCO_2e/billion BTU
LPG – RCI	61.978
Coal – RCI	93.103
Natural Gas – RCI	52.909
Biomass – RCI	2.500
Oil – RCI	68.171
Landfill Gas – RCI	0.260
Biogas – RCI	5.000

LPG = liquefied petroleum gas
tCO_2e/billion BTU = tons of carbon dioxide equivalent per billion British thermal units

The quantification model is also based on assumed growth rates for housing that take into account growth in Michigan population as projected by the U.S. Census Bureau. For example, population growth is projected to be 1.02% for 2008-2009. Based on the 21st Century Energy Plan, commercial floor space is expected to grow by 40 million square feet per year.

The following key assumptions related to building codes are as follows:

- Per analysis provided by the Building Codes Assistance Project, the IECC 2006 energy code is assumed to result in 30% greater energy efficiency than the MUEC. The existing ASHRAE standard for commercial space is assumed to be 25% less efficient than the 2004 ASHRAE standard.

- An adjustment for inclusion of renovated commercial and residential space of 1.3 and 1.2 respectively is included, however additional data to confirm this is requested – meaning that for every 1 unit of commercial space built in Michigan and additional 0.3 units of commercial space and 0.2 units of residential space will be renovated and covered by code.

- Enforcement and compliance with Building Codes is assumed to be at 75 percent – in other words, it is assumed that 75 percent of buildings constructed will comply with the relevant code. This figure is consistent with compliance rates in other jurisdictions.

Data Sources: As laid out in quantification memo. Primary data sources are US Department of Energy, the Michigan 21st Century Energy Plan and Midwest Independent System Operator as well as Building Codes Assistance Project.

Quantification Methods: This quantification approach is set out in two parts: (1) an assumption that building codes for new and substantially renovated commercial and residential space (as well as affected industrial space) are made more stringent compared to IECC 2006 by 15% by 2015 and 30% by 2025; and (2) that there is an overall, phased-in reduction in electricity and gas use in existing buildings of 15% by 2015 and 30% by 2025. The overall reduction from these two sets of measures are summed to produce a reduction for the full measure. Phase in of goals is assumed to happen on a straight line basis according to the timeline laid out in the goals and timing section.

Key Assumptions: As in RCI-4 and per analysis provided by the Building Codes Assistance Project, the IECC 2006 energy code is assumed to result in 30% greater energy efficiency than the MUEC. The existing ASHRAE standard for commercial space is assumed to be 25 less efficient than the 2004 ASHRAE standard. As noted above, an adjustment for inclusion of renovated commercial and residential space of 1.3 and 1.2 respectively is included.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-8. Net Metering For Distributed Generation

Policy Description

Net metering in a broad sense refers to policies that provide the opportunity for individuals or businesses to obtain financial benefits from small electricity generators installed at their home or business location. A basic form of net metering allows the consumer to deliver any excess generation from its small generator to the utility through the standard energy meter, which runs both forward and backward during the billing period. The customer is charged by the utility only for the net amount of energy taken from the utility during the period, which provides a financial benefit at the utility's retail charge for all electricity produced by the customer generator (i.e., the displaced utility kWh's plus credit on future bills for power beyond the customer's usage delivered to the grid). Variations on the basic form of net metering include: (i) limiting the benefit to the value of grid power offset by customer generation during the billing period (no carryover); (ii) a net purchase and sale method that measures flow separately in each direction, with customers paying the utility retail rate and receiving a wholesale rate for the excess generation; and (iii) one or more methods combined with a separate charge to maintain the customer's contribution for distribution and any transmission related costs.

Whatever form it takes, the purpose of a net metering arrangement is to provide financial benefits to the customer which can offset part of the cost of the small generator.

Distributed generation (DG) refers to small electric generation sources dispersed throughout the grid on the premises of utility customers. It is sometimes referred to as on-site, dispersed or decentralized generation. Benefits of DG can include reduced transmission losses because the power is generated near the point of use, a reduction in the size of distribution power lines, and environmental benefits where renewable or cleaner fuel sources are used. Examples include rooftop solar panels, small wind turbines, natural gas fueled micro-turbines, or micro-hydroelectric generators.

Policy Design

A voluntary, statewide net metering program was adopted by the MPSC in March, 2005 (Case No. U-14346) limited to renewable energy facilities with capacity under 30 kW and capped at the greater of 100 kW or 0.1% of a utility's peak load. Qualifying facilities must be sized no larger than necessary to meet the customer's needs. Several billing configurations are permitted at the option of the utility starting with the basic net metering form, with credits for excess generation being for allowed up to 1 year. Any excess credits after one year go to the utility to offset program costs. All regulated investor-owned and cooperative electric utilities are participating.

The Federal Energy Policy Act of 2005 requires the state to consider adopting a new standard whereby all public utilities would have to offer net metering service to their customers. The MPSC is considering whether to adopt this standard and is also considering possible changes to the voluntary program described above.

The Michigan Legislature is considering measures that would establish a statewide program requirement with larger size limits on the facilities and total program, a mandate to use the basic net metering format, and related measures on interconnection of facilities.

Goals: Install 392 MW of electric generation capacity from distributed generation sources by 2015, increasing to 1,344 MW by 2025.

Timing: As noted above.

Parties Involved: MPSC, utilities, distributed generation sources.

Implementation Mechanisms

Not applicable.

Related Policies/Programs in Place

- Newly passed legislation (Public Act 295 of 2008) requires a statewide net metering program to be developed and implemented. Specifically, the legislation includes the following provisions: (1) MPSC order and rule promulgation in 180 days; program applies to regulated electric utilities and AESs; all classes eligible; 10 year minimum program life; capacity limited to customer need; (2) program limit at 1% of in-state peak load for prior year; allocated 50% to systems < 20 kW, 25% to systems from 20 kW-150 kW and 25% above 150 kW; notify MPSC when program reaches limit; (3) select eligibility in the order applications are received (where eligibility means renewable energy systems < 150 kW or methane digesters < 550 kW); (4) no retaliatory electric service denials; (5) program to include uniform interconnection, code compliance (e.g. IEEE 1547), uniform application, true net metering for systems ≤ 20 kW (single meter), modified net metering above 20 kW (power supply component of retail rate); (6) records maintained by utility/AES.

- Michigan 21st Century Energy Plan

- A voluntary, statewide net metering program was adopted by the MPSC in March, 2005 (Case No. U-14346) as noted above.

Note: With the August 6, 2008 MPSC order in U-15316, the discussion might shift to unspecified maximum net metering potential up to the total amount of utility generation. (Net metering is defined as available to all customers to offset up to 100% of utility supplied energy during a billing period.) The uncertainty lies with what level of subsidy is needed to have customers will be willing to incur the capital costs and other duties of operating their own generation. This order may end discussion around currently pending legislation SB 1246. Net metering could be considered as available, with further decisions/filings coming by the end of 2009.

Type(s) of GHG Reductions

Carbon dioxide (CO_2)

Estimated GHG Reductions and Costs or Cost Savings

The MCAC requested that RCI-6 and RCI-8 be coordinated such that a distributed renewable energy capacity goal be expressed in RCI-8 and the same goal be expressed in terms of energy in RCI-6. Because the two goals for RCI-6 and RCI-8 are thus identical, although expressed in energy and capacity terms respectively, all quantification calculations for greenhouse gas emissions reductions, net present value and cost per ton of GHG reductions are presented in RCI-6.

Key Uncertainties

- Future capital costs

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-9. Training and Education for Building Design, Operation, and Construction

Policy Description

Policy option RCI-4 addresses the establishment of more stringent energy codes for energy efficiency in new construction. However, pro-active education programs for building trade professionals are a necessary component to successfully improving energy efficient construction practices. Improved construction standards resulting in energy efficient buildings can only be accomplished if building code officials and building trade contractors, sub-contractors and facility operators are properly educated in building envelope and mechanical performance building and maintenance techniques. Properly trained building code officials, building trade professionals and facility operators will help assure consistent quality control and enforcement of Michigan's enhanced building codes and market-based building performance practices.

Training programs are also needed to respond to periodic upgrades of the national standards, as well as to changes in state and local building codes. Training should cover new residential, commercial, and industrial buildings plus retrofits that are subject to building energy codes.

Policy Design

Goals: Provide up-to-date building performance, code compliance, and mechanical equipment training to building code officials, homebuilders, commercial construction contractors, heating/ventilation & air conditioning contractors, electricians, plumbers, carpenters, remodelers, other construction trade professionals, and facility operators.

Training programs should focus on (1) Proper construction and maintenance practices with building envelope and mechanical performance standards as established in revised Michigan building energy codes (see RCI-4 and RCI-7); (2) Proper construction and maintenance practices with building envelope and mechanical performance standards as identified in "beyond code" building programs.

Develop a certification program for code officials, builders, and contractors and facility operators who successfully complete energy efficiency and related "green building" training programs

Timing: Begin funding in 2009, with initial training to begin in 2009.

Parties Involved: Building code officials, homebuilders, commercial construction contractors, heating/ventilation & air conditioning contractors, electricians, plumbers, carpenters, remodelers, other construction trade professionals, and facility operators, as well as representatives of colleges, vocational/technical colleges, professional societies, and training providers and professionals.

Implementation Mechanisms

- Establish training and education programs for code officials. Training will cover compliance methods for Michigan energy codes. Code official training should be made available in all areas of the State for maximum coverage of code officials. Provide certification for successful completion of code compliance training.

- Establish training and education programs for building professionals including but not limited to homebuilders, commercial construction contractors, heating/ventilation & air conditioning contractors, electricians, plumbers, carpenters, remodelers, other construction trade professionals. Training will cover compliance methods for Michigan energy codes. Building trade training should be made available in all areas of the State for maximum coverage of building professionals. Provide certification for successful completion of code compliance training.

- Establish training and education programs for facility operators. Training will cover compliance methods for Michigan energy codes. Facility operator training should be made available in all areas of the State for maximum coverage. Provide certification for successful completion of code compliance training.

- Establish "beyond code" training and education programs for building professionals including but not limited to homebuilders, commercial construction contractors, heating/ventilation & air conditioning contractors, electricians, plumbers, carpenters, remodelers, other construction trade professionals. This training should be made available in all areas of the State for maximum coverage of building professionals. Provide certification for successful completion of "beyond code" compliance training. "Beyond code" programs could include but are not limited to Energy Star, Leadership in Energy and Environmental Design (LEED), Environments for Living, SystemVision and GreenBuilt.

- Refer to RCI-5 for recommendations addressing related consumer education programs.

- If not covered under RCI-5, consider establishing training and education for municipal, county and regional planning officials. Training will cover general compliance methods for Michigan energy codes as well as general "beyond code" principles. Investigate implementing such programs by developing sections in to MSU's online "Citizen Planner" online training used across the state.

- Funding sources for all training and education programs could originate from utility sponsored demand side management programs, legislatively designated funding programs (system benefit charges), and future Department of Energy funds as allocated though the State Energy Office.

Related Policies/Programs in Place

- Limited code official and building trades training has been offered in the past in Michigan. Some of location specific programs have been funded by the Department of Energy through the State Energy Office. This includes "Rebuild Michigan" training offered through DOE grants sand facilitated through MI Energy Office.

- The Michigan Association of Home Builders' "GreenBuilt" program is available for a fee to homebuilders desiring to build beyond code and incorporate green building principles.

- Various "beyond code" performance seminars have been offered by the Energy and Environmental Building Association (EEBA) for a fee to participants.

- None of these past programs have comprehensively addressed the education and training needed to transform the practices of building code officials, building trade professionals, and facility operators resulting in considerable energy savings with residential, commercial and industrial buildings.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Costs or Cost Savings

Not applicable; this policy option was not quantified.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

- Funding must be adequate to provide training at all levels: building code officials, building construction professionals, facility operators, etc.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-10. Water Use and Management

Policy Description

A considerable amount of energy is used to pump, treat, and deliver water across the state. This policy options aims to reduce energy consumption by reducing overall water use and improving the efficiency and management of the State water supply and water management facilities (i.e. wastewater treatment, potable water, irrigation, etc.).

Policy Design

The State's primary users of water are currently agricultural consumers, municipal consumers, and industrial users. Significant amounts of energy are used to pump this water from underground aquifers and open water sources to users, and to treat it in wastewater facilities after it is used. Improved water use and handling efficiencies will reduce the amount of electricity used for water distribution. A reduction in electricity use will reduce energy costs for users and associated GHG emissions from power plants.

Five specific recommendations are provided:

1. Accelerate investment in water use efficiency: Implement best management practices and efficient water management practices, and provide incentives for implementation of water management improvement measures. Coordinate with the investments in energy efficiency methods of water handling. Start in the areas of the state with most energy-intensive water use cycles. Consider developing a statewide water and wastewater savings plan, based on a thorough assessment of water and wastewater options in all water using sectors.

2. Increase the energy efficiency of all water and wastewater treatment operations. Develop long-term programs to better mesh with the long-term investments in water and wastewater infrastructure. For example, for water pumping, in particular, two specific options are worth considering:

    - Pump Testing Program. A large amount of energy is likely expended by a small number of older well pumps that are often run until they failure, many years after it would be economic to replace them. Incentives combined with the provision of energy efficiency information through the existing pump testing program could lead to significant energy savings.
    - Encouraging Pump Design/Planning/Maintenance Best Practices Study in Rapidly Growing Areas. Many municipalities, especially small but rapidly growing cities, lack the experience or resources to optimize the specifications of new pumps to reduce energy consumption. An effort to benchmark effective pump specification, management, and maintenance procedures across municipalities and to share best practices with emerging cities could yield large savings.

3. Increase energy production by water and wastewater agencies from renewable sources such as in-conduit hydropower and biogas. Add generation from solar and wind resources to water and wastewater projects where applicable.

4. Encourage and create incentives for technologies with the capability to reduce water use associated with power generation. Included would be zero or low-water-use technologies and renewable energy technologies, as well as energy efficiency technologies that reduce electricity consumption.

5. Ensure that power plants use the best management practices and economically feasible technology available to conserve water (via siting, evaluation, permitting or other processes).

Goals:

• Require that water utilities track and report energy usage, and conduct a comprehensive study of potential improvements in energy efficiency by water utilities.

• Improve the average energy efficiency of water utilities in the state (in terms of kWh used per gallon pumped) by 20% over the course of three years.

• Achieve a 10% overall water savings by 2025.

Timing: Implement program in 2010, complete in 2013.

Parties Involved: Water systems and utilities, MDEQ and other state officials.

Implementation Mechanisms

• Specific implementation strategies are to be determined based on the completion of a thorough assessment of water and wastewater options in all water-using sectors.

Related Policies/Programs in Place

• The MDEQ Water Bureau maintains a number of water management programs and policies.

Type(s) of GHG Reductions

GHG reductions (primarily CO_2) would result from avoided fuel and electricity consumption for pumping, treating, and delivering water.

Estimated GHG Reductions and Costs or Cost Savings

The RCI TWG was unable to quantify this option due to an absence of data, and accordingly recommended the tracking and reporting requirement incorporated into the policy design goals. Assuming implementation of this recommendation, or that water utilities' energy use data is otherwise made available, the link between water conservation and utility energy savings – and associated GHG reductions – can then be assessed.

Key Uncertainties

None cited beyond data availability.

Additional Benefits and Costs

- All ancillary benefits and costs associated with other energy efficiency options.
- Reduced cost of electricity for water pumping and displaced fuels costs for users of gas captured from waste treatment facilities.
- Central station power plant cooling water savings
- Reducing dependence on imported fuel sources, and reducing vulnerability to energy price spikes

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Appendix J
Agriculture, Forestry, and Waste Management Policy Recommendations

Summary List of MCAC Policy Recommendations

Policy No.	Policy Recommendation		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
			2015	2025	Total 2009–2025			
AFW-1	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production		3.3	10	79	$1,649	$21	Unanimous
AFW-2*	In-State Liquid Biofuels Production		*Included in the Results of TLU-1*					Unanimous
AFW-3	Methane Capture and Utilization From Manure and Other Biological Waste		0.09	0.14	1.5	$4.7	$3	Unanimous
AFW-4	Expanded Use of Bio-based Materials	A. Use of Bio-based Products	.08	.21	1.7	–$108	–$62	Unanimous
		B. Utilization of Solid Wood Residues	*Not Quantified*					Unanimous
AFW-5	Land Use Management That Promotes Permanent Cover	A. Increase in Permanent Cover Area	0.08	0.21	1.8	$63	$34	Unanimous
		B. Retention of Lands in Conservation Programs†	0.05	0.11	1.1	$24	$23	Unanimous
		C. Retention/ Enhancement of Wetlands	*Not Quantified*					Unanimous
AFW-6	Forestry and Agricultural Land Protection	A. Agricultural Land Protection	0.46	1.1	10	$864	$85	Unanimous
		B. Forested Land Protection	*Not Quantified*					Unanimous
		C. Peatlands/ Wetlands Protection	*Not Quantified*					Unanimous
AFW-7**	Promotion of Farming Practices That Achieve GHG Benefits	A. Soil Carbon Management	0.7	1.7	15	–$200	–$13	Unanimous
		B. Nutrient Efficiency	0.05	0.12	1.1	–$27	–$26	Unanimous
		C. Energy Efficiency	0.13	0.32	2.9	–$102	–$35	Unanimous
		D. Local Food	*Not Quantified*					Unanimous

Policy No.	Policy Recommendation		GHG Reductions (MMtCO$_2$e) 2015	2025	Total 2009–2025	Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
AFW-8	Forest Management for Carbon Sequestration and Biodiversity	A. Enhanced Forestland Management	0.53	1.42	12.05	$800	$66	Unanimous
		B. Urban Forest Canopy	1.2	2.9	26	–$346	–$13	Unanimous
		C. Reduce Wildfire	*Not Quantified*					Unanimous
AFW-9**	Source Reduction, Advanced Recycling, and Organics Management							Unanimous
	In-State GHG Reductions		1.4	3.0	28	–$3,136	–$112	
	Full Life-Cycle Reductions		14.5	35.3	314	–$3,136	–$10	
AFW-10	Landfill Methane Energy Programs		0.91	2.7	22	–$35	–$2	Unanimous
	Sector Totals†		**9**	**23**	**201**	**–$548**	**–$3**	
	Sector Total After Adjusting for Overlaps††		**6**	**17**	**147**	**–$1,634**	**–$11**	
	Reductions From Recent Actions		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
	Sector Total Plus Recent Actions		6	17	147	-$1,634	-$11	

GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalent; $/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; TLU = Transportation and Land Use; N/A = not applicable.

Note that negative costs represent a monetary savings.

* The quantification results for AFW-2 (biofuel production volumes and costs) were used as inputs to the quantification of the results of TLU-1, which covers consumption of biofuels in Michigan.

** The analyses for AFW-5, AFW-7, and AFW-9 include the full life-cycle costs of the policies. In the case of AFW-9, it is estimated that a significant fraction of the reductions will occur out of state. In-state reductions refer only to those occurring from reduced landfilling and waste combustion (these are broken out separately in the table above).

† The reductions from AFW-5B (Retention of Lands in Conservation Programs) have been left out of the sector totals, since they relate to a soil carbon protection measure where the estimated emissions (from conservation acres being returned to active cultivation) are not included in the business as usual (BAU) inventory and forecast (I&F). The costs have been included in the sector totals, since these will be incurred in order to retain the level of emissions in the BAU I&F. For AFW-5, AFW-7, and AFW-9, these include the reductions that are expected to occur within the state.

†† See the section below for discussion of overlap adjustments.

Overlap Discussion

The amount of greenhouse gas (GHG) emissions reduced or sequestered and the costs of a policy recommendation within the agriculture, forestry, and waste management (AFW) sectors in some cases overlap with other AFW recommendations. For the Michigan Climate Action Council (MCAC) recommendations, overlap occurs between AFW-9 and AFW-10 in the waste management sector. One of the policy elements of AFW-9 covers enhanced management of organic waste in the municipal solid waste sector. To the extent that these wastes are being diverted from landfills to other waste management facilities (e.g., composting facilities), less organic waste is available to generate landfill methane. This effect has been accounted for in the quantification of AFW-10; hence, the values shown for AFW-10 above assume successful implementation of AFW-9.

Overlap also occurs with some of the quantified benefits and costs of policy recommendations within other sectors. Every effort has been made to determine where those overlaps occur and to eliminate double counting. As displayed in the table above, the AFW sector totals have been adjusted accordingly, as follows:

- AFW-1 outlines how biomass may be utilized for energy production. The Energy Supply (ES) Technical Work Group (TWG) also quantified the use of biomass for energy production (specifically ES-1 and ES-10). AFW-1 utilizes a greater amount of biomass than the ES options post-2011. The biomass demand requirements for ES (in millions of British thermal units [MMBtu]) and the GHG reductions and costs associated with its use were removed from the AFW sector totals in the table above, as these were considered to be accounted for under the ES analyses.
- AFW-2 outlines how biofuels could be produced in-state to offset GHG emissions from fossil-based fuels (primarily in the transportation sector). The Transportation and Land Use (TLU) TWG also quantified the benefits and costs of increased use of biofuels in TLU-1. To avoid double counting, the goals of biofuel production in AFW-2 and biofuel consumption in TLU-1 were aligned, and then the estimated AFW-2 biofuel production volumes and costs were used as input to the analysis of biofuel consumption under TLU-1. Hence, the benefits and costs of AFW-2 are captured in the overall results of TLU-1. To avoid confusion, those results are left out of the summary table above; however, the quantification of production volumes and costs has been left in the AFW-2 documentation in this appendix .

Biomass Resource Supply and Demand Assessment

An assessment of biomass resources available to meet the feedstock requirements of the MCAC policies is presented in Table 1 below. The table presents a total estimated potential availability of biomass in dry tons based on business as usual (BAU) in Michigan across the AFW sectors. Potential availability is defined as the amount available if the resource were managed according to its current demonstrated productive capacity, and if social, ecological, administrative, and technical constraints were managed to minimize their impact on utilization.[1] For the purpose of defining a reference point, the stated potential assumes all constraints can be lifted and does not consider economic considerations limiting supply (e.g., distance to end user). The only item that is not based on BAU is energy crops, which assumes production of these crops on 2.1 million acres of currently idle land. The estimated availability for unharvested annual above-ground biomass on timberland acres is adjusted downward by 30% to account for biomass that needs to be left in the forest to promote sustainable biomass supply. The value for sawtimber is further reduced by 90% to account for higher-value uses for this material (e.g., durable wood products).

After determining the available supply, the TWG then provided assumptions about the likely end use for each of the feedstocks. This was done to inform the setting of goals under AFW-1 and

[1] Robert Froese, Version 1.0, August 18, 2008. "Biomass for Bioenergy in Michigan: Actual Versus Potential Availability," unpublished.

AFW-2, although the TWG recognizes that each of these feedstock sources has the potential to be used interchangeably between each option. The results were that 8.4 million (MM) dry tons/year are estimated to be available for cellulosic biofuel production, and 14.1 MM dry tons/yr are available for use in electricity or heat/steam production.

Table 2 provides the estimated biomass resource requirements to satisfy each of the MCAC recommendations within the AFW and other sectors. The results of this supply/demand assessment assisted the AFW TWG in adjusting the goals of options with biomass feedstock requirements. The overall biomass demand of the MCAC recommendations is estimated to be about 78% of the available sustainable supply for the state. Given the uncertainties associated with these initial state-level assessments, the TWG was comfortable with biomass utilization at these estimated levels.

Table J-1. Potential annual biomass resource availability

Biomass Resource	Estimated Inventory (dry tons/year)	With Sustainability Accommodation Reduction[1] of 30% (dry tons/year)	With Reduction Due to Potential Competition for Other Uses, Including Higher-Value Uses Than Energy [2] (dry tons/year)	Percentage Considered for Potential Use for Cellulosic Fuel Production[5]	Percentage Considered for Potential Use for Electric Generation/ Heat/Steam	Notes
Unharvested annual above-ground biomass growth on timberland[3] acres						Estimated Inventory Source: Potential New Woody Biomass Feedstock Availability in Michigan, Estimates compiled by Ray O. Miller, Michigan State University, February 2007. Unpublished and updated with data from the USFS Draft Publication "Michigan's Forest Resources 2007." Percentage breakdown by product class estimated from 2005 FIA data. See Key Uncertainties section.
✓ Tops/limbs/stumps/saplings less than 5"	8,036,093	5,625,265	5,625,265	0%	100%	
✓ Pulpwood	5,665,446	3,965,812	2,776,068	100%	0%	
✓ Sawtimber	6,388,694	4,472,086	447,209	100%	0%	
Totals	20,090,233	14,063,163	8,848,542			
Energy Crops						Estimated Inventory Source: Potential New Woody Biomass Feedstock Availability in Michigan, Estimates compiled by Ray O. Miller, Michigan State University, February 2007, Unpublished. Assumes 2.1 million acres of idle land with a productivity of 3 dry tons per acre. See Key Uncertainties section.[2]
✓ Potential acres: 2,100,000	6,300,000	N/A	6,300,000	75%	25%	
✓ Growth rate (dry tons/acre): 3						
Unutilized logging residue from current timberland harvests	869,468	N/A	608,628	0%	100%	Estimated Inventory Source: Biomass, Biofuels and Bioenergy: Feedstock Opportunities in Michigan, Robert E. Froese, February 2007. Includes residue that is currently available and unutilized.

2 Note that AFW-8 describes an additional 333,333 acres of short-rotation woody crops (SRWC) that would add an additional 1,000,000 dry tons of biomass in this category.

Biomass Resource	Estimated Inventory (dry tons/year)	With Sustainability Accommodation Reduction[1] of 30% (dry tons/year)	With Reduction Due to Potential Competition for Other Uses, Including Higher-Value Uses Than Energy [2] (dry tons/year)	Percentage Considered for Potential Use for Cellulosic Fuel Production[5]	Percentage Considered for Potential Use for Electric Generation/ Heat/Steam	Notes
Unutilized residues from current other removals (road building clearings, rights of way, and precommercial thinnings)	96,268	N/A	67,388	50%	50%	Estimated Inventory Source: Biomass for Bioenergy in Michigan: Actual Versus Potential Availability, Robert E. Froese, Michigan Technological University, August 2008, Unpublished.
Urban Wood Waste	1,311,382	N/A	917,967	50%	50%	Estimated Inventory Source: Biomass, Biofuels and Bioenergy: Feedstock Opportunities in Michigan, Robert E. Froese, February 2007. Includes residue that is currently available and unutilized.
Primary Mill Residue (unused)	45,000	N/A	31,500	0%	100%	Estimated Inventory Source: 2005 NREL Report. Derived from the USDA Forest Service's Timber Product Output database for 2002, includes mill residues burned as waste or landfilled.
Secondary Mill Residue	95,000	N/A	66,500	0%	100%	Estimated Inventory Source: 2005 NREL Report. Includes wood scraps and sawdust from woodworking shops, furniture factories, wood container and pallet mills, and wholesale lumberyards. Estimated using number of businesses from the U.S. Census Bureau, 2002 County Business Patterns, and assumptions on the wood waste generated.
Agriculture Residue	3,953,000	N/A	3,953,000	0%	100%	Estimated Inventory Source: 2005 NREL Report. Estimated using 2002 total grain production, crop-to-residue ratio and moisture content, and taking into consideration the amount of residue left on the field for

Biomass Resource	Estimated Inventory (dry tons/year)	With Sustainability Accommodation Reduction[1] of 30% (dry tons/year)	With Reduction Due to Potential Competition for Other Uses, Including Higher-Value Uses Than Energy [2] (dry tons/year)	Percentage Considered for Potential Use for Cellulosic Fuel Production[5]	Percentage Considered for Potential Use for Electric Generation/ Heat/Steam	Notes
						soil protection, grazing, and other agricultural activities.
Municipal Solid Waste (MSW) fiber[4]	1,763,854	N/A	1,763,854	0%	100%	Estimated Inventory Source: Estimated 2025 Biomass by MSW Component.
Totals (dry tons/year)	**34,524,205**	**28,497,135**	**22,557,379**	**8,440,954**	**14,116,424**	

NREL = National Renewable Energy Laboratory; USDA = U.S. Department of Agriculture; USFS = U.S. Forest Service; CRP = Conservation Reserve Program; FIA = Forest Inventory and Analysis; MSW = municipal solid waste; N/A = not applicable.

[1] Assumed a 30% reduction on potential fiber utilization to accommodate the broad range of sustainability issues outlined in the sustainable forest management definition provided in footnote #3 on Page 9.

[2] Current manufacturers will compete for incremental tops/limbs/stumps/saplings less than 5 inches for power generation; however a competitive reduction has not been made because use of this material will lead to incremental renewable energy production from current manufacturers. Assumed a 30% reduction in pulpwood due to competition for unharvested pulpwood growth by current pulpwood using manufacturers. Assumed 90% of sawtimber will be utilized for higher-value products, such as veneer and lumber, with 10% having potential for energy production due to smaller size, quality, or species that are not suitable for higher-value sawtimber markets. Assumed a 30% reduction due to competition from current manufacturers for incremental wood fiber-based residues and waste categories (e.g., logging/other removal residues, urban wood waste, and primary/secondary mill residues).

[3] Timberland: Forestland producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization (formerly known as commercial forestland), USDA Forest Service Northeastern Forest Inventory and Analysis: http://www.fs.fed.us/ne/fia/methodology/def_qz.htm.

[4] These estimates are based on the results of waste characterization and generation projections completed by the Center for Climate Strategies (CCS) (see AFW-9). Composition of available AFW biomass may vary, depending on baseline waste characterization assumptions made.

[5] Assumed that cellulosic ethanol will be generated from material that produces a clean wood chip (e.g., a chip without bark).

Table J-2. Biomass demands of MCAC policies

Policy Requiring Biomass	Annual Biomass Demand (dry tons)	% of Estimated Resource	Notes
AFW-1 Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	9,108,501	40%	Produce 10% of total in-state electric generation from sustainable biomass feedstock by 2025.
AFW-2 In-State Liquid Biofuels Production	8,440,954	37%	Achieve 10% use of renewable fuels by 2012 and 25% by 2025. *It is possible that new technologies will allow for biofuels to be produced aside from ethanol. These may require additional types of feedstocks.*
Incremental TLU Demand	0	0%	The TLU demand-side policy has demand for 683 million gallons of cellulosic ethanol. This is approximately 3/4 the supply that is provided in the AFW option. Because all of the demand in TLU is met through the AFW option, there are no additional biomass supply requirements from TLU-1.
Incremental ES and RCI Demand	0	0%	While there is no additional demand from ES and RCI options that require in-state biomass that is incremental to AFW-1, there is demand that is considered to overlap (e.g., biomass component of a renewable portfolio standard, biomass co-firing).
Existing Biomass Demand	0	0%	Existing demand is already accounted for in the biomass supply estimate.
Total Annual Biomass Demand	**17,549,455**	**78%**	

AFW = Agriculture, Forestry, and Waste Management; TLU = Transportation and Land Use; TBD = to be determined; ES = Energy Supply; RCI = Residential, Commercial, and Industrial.

AFW-1. Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production

Policy Description

Increase the amount of agriculture and forest biomass available on a sustainable[3] basis for generating electricity and displacing the use of fossil energy sources. Expand the utilization of biomass feedstock in production systems that:

- Utilize high-efficiency conversion processes (including promoting co-location with heat- and steam-using facilities);
- Generate useful forms of energy that displace maximum quantities of fossil fuel use;
- Minimize net GHG emissions, and achieve net reductions of all harmful emissions using best available control technologies;
- Maintain the sustainability of feedstock supply and other natural resources; and
- Utilize integrated feedstocks via integrated manufacturing (including co-location of manufacturing facilities) to capture higher-value products, along with GHG emission reductions and energy efficiencies.

Clarify life-cycle analysis expectations and definitions of carbon neutrality/carbon balance to support decision making related to investments in biomass for electricity, heat, and steam production.

Policy goals should be evaluated hand-in-hand with the impact of other GHG policy options and their cumulative impact on the sustainability of feedstock, food and other commodity supplies, and other natural resources.

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[3] Sustainable forest management: "Stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and potential to fulfill now and in the future relevant ecological, economic, and social functions at local, national, and global levels, and does not cause damage to other ecosystems" (The Ministerial Conference on the Protection of Forest in Europe, Helsinki, 1993).

Sustainable agriculture: "Sustainable agriculture" was addressed by Congress in the 1990 "Farm Bill" [Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), Public Law 101-624, Title XVI, Subtitle A, Section 1603 (Government Printing Office, Washington, DC, 1990) NAL Call # KF1692.A31 1990]. Under that law, "the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term, satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole." [*Subchapter I: Findings, Purposes, and Definitions*, U.S. Code, Title 7, Chapter 64-Agricultural Research, Extension and Teaching. Available at GPO Access: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+7USC3103 (August 23, 2007)] (National Agricultural Library www.nal.usda.gov/afsic/pubs/terms/srb9902.shtml#toc2).

Note that this policy has linkages and potential overlaps with ES-1: Renewable Portfolio Standard (RPS); ES-7: Integrated Resource Planning (IRP), Including CHP; ES-10: Technology-Focused Initiatives; and ES-13: Combined Heat and Power (CHP). This AFW policy recommendation focuses on biomass supply.

Policy Design

Goals: Produce 10% of total in-state electric generation from sustainable biomass feedstock by 2025.

Timing: See Goals, above.

Parties Involved: Agricultural interests; forestry interests; public utilities; environmental/ sustainability interests; food processing industries; primary and secondary forest products industries; utility customers/host facilities capable of utilizing combined heat and power outputs of biomass-fueled energy conversion systems; Michigan manufacturers of biomass-fueled energy conversion systems; municipalities; relevant state regulatory authorities (Michigan Department of Environmental Quality [MDEQ], Michigan Public Service Commission [MPSC]; the Michigan Departments of Agriculture [MDA], Natural Resources [MDNR], and Labor and Economic Growth [MDLEG]; and the Michigan Economic Development Corporation [MEDC]).

Other: Co-benefits include production of heat and steam from biomass that can be utilized through co-location of facilities. Growth in the use of biomass fuels needs to be linked to the health of Michigan's agricultural, food processing, and forest products industries, and to sustainable agricultural and forest management practices.

Implementation Mechanisms

Increase permanent forestland cover (including improved stocking of understocked stands) across the state on 1 million acres through afforestation and reforestation by 2025.

Enhance investments in mechanisms with clear points of entry for non-industrial private forest landowners to increase participation in forest management.

Promote local, state, and regional markets so private and public landowners have outlets for a variety of products (traditional and/or ecosystem service-based) that will provide income streams and incentives to manage forestlands, promote carbon sequestration, and reduce GHG emissions (for example, promote enrollment in agriculture and forest carbon trading markets).

Look for opportunities and provide necessary resources to improve forest health and productivity on state-owned forests, as described in Michigan's State Forest Management Plan[4] and supporting projects identified by the Michigan Forest Finance Authority.

[4] See http://www.michigan.gov/dnr/0,1607,7-153-30301_30505_31025---,00.html for more detail. Michigan's State Forest Management Strategy is available at http://www.michigan.gov/documents/dnr/MichigansStateForestMgtStrategy_215508_7.pdf.

Develop, implement, and promote the use of woody biomass harvesting guidelines, best management practices for water quality, and other generally accepted management practices for forestry and agriculture.

Carefully design policies to promote only sustainable agricultural and forestry practices that maintain and improve soil productivity and result in the greatest net reductions in GHG emissions. Available biomass should be used for its highest-value purposes, which, in addition to energy, may include food, fiber, and chemical feedstocks. Financial incentives, if any, should be carefully targeted to reward uses that achieve the maximum value from biomass consumed and also achieve market transformation goals.[5]

Michigan does not presently have a comprehensive inventory of biomass resources. Preliminary indications show a potential for doubling the contribution of biomass resources in providing useful electricity and thermal energy.[6] Accompanying any policies intended to promote the additional use of biomass for energy, adequate resources should be dedicated for completing and maintaining a comprehensive biomass inventory for Michigan; in addition, appropriate sustainability indicators[7] should be used to track changes in the inventory over time. The feedstock portfolio should also include an analysis and inventory of potential lands for energy plantations, and an assessment of the potential impact of using identified lands for this purpose on current food and fiber production.

Promote the development of cost-efficient systems for short-rotation crop establishment and biomass harvesting, processing, and transportation.

Related Policies/Programs in Place

Senate Bill 213 includes a renewable portfolio standard (RPS), creates the Energy Conservation Fund, and requires utility energy optimization plans, wind energy resource zones, and net metering. The RPS, which will be 10% of energy generated by 2015, will be comprised of renewable sources of energy. Energy optimization credits and advanced cleaner energy credits can be used to partly meet the RPS requirement. Detroit Edison is required to have at least 300 megawatts (MW) of renewable energy by 2013 and 600 MW by 2015, and Consumers Energy is required to have 200 MW by 2013 and 500 MW by 2015. The enrolled version of Senate Bill 213 is now available on the Michigan legislature's Web site at: http://www.legislature.mi.gov/documents/2007-2008/billenrolled/Senate/pdf/2007-SNB-0213.pdf.

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[5] "Market transformation" incentives are designed to engender permanent changes in specific target markets, so that financial incentives can be removed in a reasonably short time, and the market will maintain the new higher-efficiency behavior. See http://www.cee1.org/cee/mt-primer.php3.

[6] See *Michigan's 21st Century Electric Energy Plan,* Appendix II – Chapter 4 (January 2007). Available at: http://www.dleg.state.mi.us/mpsc/electric/capacity/energyplan.

[7] "Sustainability indicators" are measures of "stocks, inventories or qualities of economic, social, ecological or institutional assets over time." They are typically developed using "dynamic iterative processes and dialogue among non-expert citizen participants, government bureaucrats and technical experts [which] … allows participants to define locally-relevant aspects of sustainability from their unique perspectives, anchored by their own values" (László Pintér, Peter Hardi, Peter Bartelmus, International Institute for Sustainable Development, 2005, pp. 2, 5; http://www.iisd.org/measure/). See also http://www.sustainabilityindicators.org/.

MDLEG's Energy Office has created a Biomass Energy Program to encourage increased production and use of energy derived from Michigan's biomass resources through program policies, public and private partnerships, information dissemination, and state project grants. For more information on this program, go to http://www.michigan.gov/cis/0,1607,7-154-25676_25753---,00.html.

MDA has provided outreach to expand awareness and availability of renewable energy-generating treatment technologies.

MDEQ promotes renewable energy through education and outreach programs, pollution prevention programs, loans, and annual AgriEnergy conferences.

MPSC establishes rates, terms, and conditions of service for electric generators interconnected with the public utility grid. See http://www.michigan.gov/customergeneration.

Agricultural biomass producers should be encouraged to obtain MAEAP (Michigan Agriculture Environmental Assurance Program) certification. Forestry biomass producers should be encouraged to participate in appropriate certification programs (e.g., sustainable forestry certifications, such as the Sustainable Forestry Initiative® or the Forest Stewardship Council). For details on MAEAP, see: www.michigan.gov/mda/0,1607,7-125-1567_1599_25432-12819--,00.html.

MPSC has commenced a formal rulemaking proceeding in Case No. U-15239 to revise the state's Electric Interconnection Standards Rules. The intention is to make the interconnection procedures more predictable and smoother. A revised set of rules is being filed as a starting point for the formal rulemaking process. Also, utility rates, terms, and conditions of service for interconnected generators are being reviewed by the MPSC staff. Any concerns, issues, or barriers that might affect such facilities will be addressed in the rate case process.

Similar processes are underway at the Federal Energy Regulatory Commission (FERC) for improving the interconnection process for larger generators seeking interconnection with the electric transmission grid.

Type(s) of GHG Reductions

CO_2, N_2O, CH_4: Displaces emissions from fossil fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$): 3.3 and 10, respectively.

Net Cost per tCO_2e: $21.

Data Sources: As indicated in the Quantification Methods section, below.

Quantification Methods:

The goal was determined using baseline data from the Center for Climate Strategies (CCS) Inventory and Forecast.[8] BAU electricity generation grows over the policy period from about 93 terawatt-hours (TWh) in 2009 to approximately 120 TWh in 2025. Biomass usage over the period is based on the existing biomass generation capacity. The forecast is therefore based on the 5-year (2001–2005) average biomass gross generation level in the forecast years through 2025, which is 1,124 gigawatt-hours (GWh) per year out to 2025. In 2009, this represents just over 1% of total generation. This baseline information, along with the projected target, is illustrated in Table J-1-1. To meet this generation, approximately 936,667 dry tons per year of biomass are required.[9]

Table J-1-1. Expanded use of biomass goal determination

Year	Total BAU Generation Required To Meet Demand (GWh)	BAU Electricity Generation From Biomass (GWh)	Policy Goal Proportion of Total in-State Electricity Generation (%)	Additional Biomass Generation To Meet Policy Goals (GWh)	Estimated Biomass Required (MMBtu)[10]
2009	92,798	1,124	1.2%	—	—
2010	94,290	1,124	1.8%	536	5,360,141
2011	95,832	1,124	2.3%	1,090	10,895,686
2012	97,639	1,124	2.9%	1,668	16,676,329
2013	99,080	1,124	3.4%	2,253	22,530,780
2014	100,793	1,124	4.0%	2,865	28,651,087
2015	102,424	1,124	4.5%	3,492	34,922,831
2016	104,216	1,124	5.1%	4,145	41,454,961
2017	105,589	1,124	5.6%	4,795	47,949,159
2018	107,397	1,124	6.2%	5,486	54,862,055
2019	109,196	1,124	6.7%	6,197	61,967,273
2020	111,146	1,124	7.3%	6,938	69,380,208
2021	112,885	1,124	7.8%	7,684	76,841,906
2022	114,759	1,124	8.4%	8,461	84,607,747
2023	116,659	1,124	8.9%	9,260	92,602,737
2024	118,706	1,124	9.5%	10,095	100,945,123
2025	120,542	1,124	10.0%	10,930	109,302,012

BAU = business as usual; GWh = gigawatt-hours; MMBtu = millions of British thermal units.

[8] The CCS Michigan Energy Supply Inventory and Forecast (Appendix A) includes assumptions and data sourced from *EIA-906/920 Monthly Time Series Data*. This is a database file available from the Energy Information Administration (EIA) of the United States (U.S.) Department of Energy (DOE); *Michigan's 21st Century Electric Energy Plan*; and the EIA *Annual Energy Outlook 2007.*

[9] Assuming a heat rate of 10,000 British thermal units per kilowatt-hour (Btu/kWh) for a biomass plant and an energy content of 12 million Btu/metric ton for biomass.

[10] The assumed heat rate for a biomass plant is 10,000 Btu/kWh, based on advice from the AFW Technical Work Group (TWG).

This analysis focuses on the incremental GHG benefits associated with the utilization of additional biomass to offset the consumption of fossil fuels. The analysis assumes biomass will be used to replace electricity.[11] It is also assumed that of this additional biomass generation, 25% will be from small-scale facilities utilizing combined heat and power (CHP) at a local level. As a result, there are two types of GHG benefits from this option. The first is offsetting electricity, and the second is offsetting other fossil fuels that would have otherwise been used for heating and/or steam (e.g., natural gas or oil).

The GHG benefits from electricity were calculated by assuming that using biomass reduces emissions (in carbon dioxide equivalents [CO_2e]) by the Michigan-specific emissions factor. The CO_2e associated with this amount of electricity in each year is estimated by multiplying the megawatt-hours (MWh) produced by the Michigan-specific emission factor for electricity production from the Michigan GHG inventory and forecast (I&F) (these values in metric tons (t) of CO_2e/MWh vary in each year of the forecast).[12]

To quantify the cogeneration component, it is assumed that 25% of generation under the policy utilizes waste heat at the local level. For these CHP plants, it is assumed that in addition to the electricity generation, 40% of the biomass feedstock energy is converted into usable steam/heat (in MMBtu).[13] It is also assumed that this waste heat is used to offset energy that would have otherwise been generated from natural gas. The GHG benefits were calculated by the difference in emissions associated with each of the input fuels (0.0539 tCO_2e/MMBtu for natural gas, and 0.0019 tCO_2e/MMBtu for biomass, including non-methane (CH_4) and non-nitrous oxide (N_2O) emissions).[14]

Table J-1-2 illustrates the GHG benefits and the amount of biomass utilized under this option, and indicates the approximate amount of biomass required to meet the goal.

Energy From Biomass Costs

The breakdown of biomass being utilized will influence the costs for AFW-1, as the costs are dependent on the feedstock being utilized. The proportion of each biomass feedstock used to meet the goal was based on the proportion of availability for each feedstock. The relative proportion of feedstocks is indicated in Table J-1-3.

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[11] Based on eGRID data for Michigan: Coal, 58%; Nuclear, 26%; Oil, 0.8%; Natural Gas ,13%; Wind, 0%; and Biomass, 2% (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html).

[12] Total electricity emissions per MWh were provided by the ES TWG, and range from 0.91 tCO_2e/MWh in 2009 to 0.84 tCO_2e/MWh in 2025.

[13] The assumed thermal efficiency rate of a biomass cogeneration facility is 80%, with 40% being converted into electricity and 40% being derived from the waste heat. This assumption is based on advice from the AFW TWG.

[14] Emission factors obtained from the Michigan I&F.

Table J-1-2. Expanded use of biomass GHG benefits and approximate biomass demand

Year	Policy Goal Proportion of Total In-State Electricity Generation (%)	Additional Biomass Generation To Meet Policy Goals (GWh)	Avoided Emissions From Electricity Production ($MMtCO_2e$)	Avoided Emissions From Offsetting Heat/Steam ($MMtCO_2e$)	Avoided Emissions ($MMtCO_2e$)	Approximate Amount of Biomass Required To Meet Goal[15] (dry tons)
2009	1.2%	—			0.00	—
2010	1.8%	536	0.49	0.03	0.52	446,678
2011	2.3%	1,090	0.99	0.06	1.05	907,974
2012	2.9%	1,668	1.51	0.09	1.60	1,389,694
2013	3.4%	2,253	2.05	0.12	2.17	1,877,565
2014	4.0%	2,865	2.61	0.15	2.76	2,387,591
2015	4.5%	3,492	3.12	0.18	3.30	2,910,236
2016	5.1%	4,145	3.71	0.22	3.92	3,454,580
2017	5.6%	4,795	4.21	0.25	4.46	3,995,763
2018	6.2%	5,486	4.76	0.28	5.04	4,571,838
2019	6.7%	6,197	5.38	0.32	5.71	5,163,939
2020	7.3%	6,938	6.01	0.36	6.37	5,781,684
2021	7.8%	7,684	6.68	0.40	7.08	6,403,492
2022	8.4%	8,461	7.32	0.44	7.76	7,050,646
2023	8.9%	9,260	7.85	0.48	8.33	7,716,895
2024	9.5%	10,095	8.43	0.52	9.00	8,412,094
2025	10.0%	10,930	9.13	0.57	9.70	9,108,501
Cumulative			**74**	**4.46**	**79**	

GWh = gigawatt-hours; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table J-1-3. Relative proportion of feedstocks assumed to meet the goal based on availability

Biomass Fuel Type	Proportion
Total Agriculture Residue	32%
Energy Crop	13%
Forest Feedstocks	55%

The cost calculation has two main components: fuel costs and capital/operational/maintenance costs. The fuel component is based on the difference in costs between supply of biomass fuel and the assumed fossil fuel that it is replacing. The assumed biomass fuel cost used in this analysis is indicated in Table J-1-4, and the assumed fossil fuel costs are indicated in Table J-1-5. While municipal solid waste (MSW) has been identified as a potential feedstock, it has not been included in the cost analysis. It is possible that MSW energy feedstocks have a very low or negative cost. This is because in the current market, waste haulers pay a tipping fee to the landfill

[15] Assumes 12 MMBtu/metric ton.

or transfer station that receives the waste, and haulers could forego this payment through delivery as an energy feedstock. However, currently there is not an established market in Michigan for utilizing MSW as an energy feedstock, and there is significant uncertainty regarding the processing costs (e.g., uncertain separation, processing, storage, and transportation costs).

Table J-1-4. Assumed costs of biomass feedstocks

Biomass Fuel Type	Cost ($/dry ton delivered)	Heat Content (MMBtu/ton)	Cost ($/MMBtu delivered)	Source
Total agriculture residue	42.50	12.9	3.29	"The Economics of Biomass Collection, Transportation, and Supply to Indiana Cellulosic and Electric Utility Facilities," Sarah C. Brechbill and Wallace E. Tyner, Department of Agricultural Economics, Purdue University (April 2008). Total per-ton costs for transporting biomass 30 miles range between $39 and $46 for corn stover and $57 and $63 for switchgrass. Heat content taken from "Bioenergy Feedstock Characteristics," Jonathan Scurlock, Oak Ridge National Laboratory low end of range 6,450–7,300 Btu/lb.[16]
Energy crop (switchgrass)	60.00	14.7	4.09	"The Economics of Biomass Collection, Transportation, and Supply to Indiana Cellulosic and Electric Utility Facilities," Sarah C. Brechbill and Wallace E. Tyner, Department of Agricultural Economics, Purdue University (April 2008). Total per-ton costs for transporting biomass 30 miles range between $39 and $46 for corn stover and $57 and $63 for switchgrass. Heat Content of Selected Fuels, ORNL (7,341 Btu per pound).[17]
Forest feedstocks	65.00	15.4	4.23	The basis for the cost per ton comes from summaries on Michigan pulpwood costs in a document titled: *Michigan Timber Market Analysis. Final Report* Prepared for the Michigan Department of Natural Resources by Prentiss and Carlisle, March 10, 2008. The Climate Registry's Wood and Wood Waste biomass heat rate of 15.38 MMBtu/short ton of biomass (The Climate Registry, General Reporting Protocol Version 1.1, May 2008, Table 12.2). The Climate Registry bases a dry ton on a 12% moisture content instead of a standard of 15%, and may overestimate the Btu content.

lb = pound; MMBtu = millions of British thermal units.

Note: The above cost information is consistent with the information produced for the Wolverine Clean Energy Venture study.[18]

[16] See: http://bioenergy.ornl.gov/papers/misc/biochar_factsheet.html.

[17] See: http://cta.ornl.gov/bedb/appendix_a/Approximate_Heat_Content_of_Selected_Fuels_for_Electric_Power_Generation.xls.

[18] Froese, R., and Miller, C., *Biomass Co-Firing for the Wolverine Clean Energy Venture: An Assessment of Potential Supply, Environmental Limitations, and Co-Benefits Through Carbon Sequestration*, School of Forest Resources and Environmental Science, Michigan Technological University, January 30, 2008.

The cost of implementing this policy is estimated by assuming the replacement of fossil fuel-generated electricity with biomass-generated electricity. In this case, it is the relative proportion of fuel mixes required under the BAU scenario (i.e., coal, natural gas, or oil in MMBtu) as defined by eGRID: i.e., 81% coal, 18% natural gas, and 1% oil (it is assumed that biomass would not replace nuclear), as indicated in Table J-1-5.[19]

Table J-1-5. Assumed costs of fossil fuel feedstocks[20]

Year	Coal ($/MMBtu)	Natural Gas ($/MMBtu)	Residual Fuel Oil ($/MMBtu)
2009	$2.04	$8.29	$11.1
2010	$2.47	$9.28	$16.5
2011	$3.02	$8.73	$15.6
2012	$2.93	$8.42	$14.7
2013	$2.89	$8.16	$14.4
2014	$2.85	$8.00	$14.0
2015	$2.81	$7.88	$13.2
2016	$2.80	$7.85	$12.5
2017	$2.79	$7.95	$12.5
2018	$2.78	$8.03	$12.7
2019	$2.77	$8.13	$12.9
2020	$2.76	$8.04	$13.0
2021	$2.76	$7.93	$13.2
2022	$2.76	$8.06	$13.3
2023	$2.77	$8.19	$13.6
2024	$2.77	$8.33	$13.8
2025	$2.77	$8.47	$14.1

MMBtu = millions of British thermal units.

The difference in cost of feedstock supply between biomass and coal is calculated using the costs outlined in Table J-1-4 and Table J-1-5. The difference in costs ($/MMBtu) is multiplied by the amount of coal energy (MMBtu) being replaced by biomass. The assumed incremental capital costs are based on the capital costs associated with establishing a biomass plant compared to a coal plant. Capital costs and operation and maintenance costs were taken from Table 38 of the U.S. Department of Energy (DOE) Energy Information Administration's (EIA) *Annual Energy Outlook 2008* (AEO 2008). While use of biomass may be pursued through other technology types (e.g., gasification) or end uses (e.g., heat or steam), this methodology was used to provide

[19] Based on eGRID data for Michigan: Coal, 58%; Nuclear, 26%; Oil, 0.8%; Natural Gas, 13%; Wind, 0%; and Biomass, 2% (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html).

[20] Fossil fuel costs ($/MMBtu) for 2009–2013 were taken from Detroit Edison's PSCR Filing (Case No. U-15701). These delivered forecast prices (in $/MMBtu) were discounted to 2006 $/MMBtu and were forecasted using *Annual Energy Outlook 2008* forecast information for the East North Central region.

an estimate of possible capital costs required to enable the utilization of biomass.[21] The results of the cost analysis are outlined in Table J-1-6.

Table J-1-6. Costs of generating electricity from biomass

Year	Approximate Electricity Output (MWh)	Approximate Cumulative Capacity (MW)	Annualized Capital Costs (2005$)	Estimated Additional Variable Operational and Maintenance Costs (2005$)	Estimated Additional Fixed Operational and Maintenance Costs (2005$)	Fuel Costs (Agriculture Residue, Forest Feedstocks and Energy Crops)	Cost/ Savings (million $2005)	Total GHG Emissions Avoided ($MMtCO_2e$)
2009	—	—	$0	$0	$0	$0	$0.0	0.000
2010	536,014	72	$6,366,106	$1,292,021	$2,647,366	$64,375	$10.4	0.516
2011	1,089,569	146	$12,940,534	$2,626,322	$5,381,364	–$3,422,269	$17.5	1.05
2012	1,667,633	224	$19,806,060	$4,019,702	$8,236,416	–$3,011,343	$29.1	1.60
2013	2,253,078	303	$26,759,245	$5,430,872	$11,127,922	–$2,169,292	$41	2.17
2014	2,865,109	385	$34,028,181	$6,906,126	$14,150,733	-$934,790	$54	2.76
2015	3,492,283	469	$41,476,976	$8,417,882	$17,248,339	$970,134	$68	3.30
2016	4,145,496	557	$49,235,023	$9,992,402	$20,474,549	$1,961,210	$82	3.92
2017	4,794,916	644	$56,948,020	$11,557,779	$23,682,025	$1,808,598	$94	4.46
2018	5,486,205	737	$65,158,294	$13,224,080	$27,096,295	$1,615,947	$107	5.04
2019	6,196,727	832	$73,596,984	$14,936,738	$30,605,552	$995,528	$120	5.71
2020	6,938,021	932	$82,401,143	$16,723,570	$34,266,791	$2,706,615	$136	6.37
2021	7,684,191	1,032	$91,263,215	$18,522,155	$37,952,114	$4,118,792	$152	7.08
2022	8,460,775	1,136	$100,486,511	$20,394,052	$41,787,652	$2,317,167	$165	7.76
2023	9,260,274	1,244	$109,981,960	$22,321,183	$45,736,366	–$45,330	$178	8.33
2024	10,094,512	1,356	$119,890,004	$24,332,051	$49,856,660	–$3,059,140	$191	9.0
2025	10,930,201	1,468	$129,815,272	$26,346,416	$53,984,116	–$6,480,936	$204	9.7
Cumulative							**$1,649**	**78.7**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MW = megawatt; MWh = megawatt-hour.

The capital infrastructure lifespan is assumed to be 30 years, and the interest rate is assumed to be 5%, giving a capital recovery factor of 0.065 (i.e., a $1 million plant is assumed to cost approximately $65,000 per year over the life of the project).

Key Assumptions:

- The proportion of each biomass feedstock used to meet the goal was based on the proportion of availability for each feedstock.

[21] The capital costs associated with using biomass as an alternative to fossil-based generation are dependent on many factors, including the end use (i.e., electricity, heat, or steam), the design and size of the systems, the technology employed, and the configuration specifications of the system. Each system implemented under this policy would require a detailed analysis (incorporating specific engineering design and costs aspects) to provide a more accurate cost estimate of the system.

- The GHG benefits from electricity were calculated by assuming that using biomass reduces emissions (in CO_2e) by the Michigan-specific emissions factor. To the extent that biomass offsets the use of coal or natural gas specifically, the estimated emission reductions could be too low or too high, respectively.
- The analysis assumes that the cogeneration component achieves additional GHG benefits, but does not result in additional costs.

Key Uncertainties

The capital costs associated with using biomass as an alternative to fossil-based generation are dependent on many factors, including the end use (i.e., electricity, heat, or steam), the design and size of the systems, the technology employed, and the configuration specifications of the system. Each system implemented under this policy would require a detailed analysis (incorporating specific engineering design and costs aspects) to provide a more accurate cost estimate of the system.

The potential availability of the unharvested above-ground biomass growth on timberland acres will be influenced by landowner willingness to harvest; available markets for the broad range of biomass species, size, or condition; and costs of harvesting, processing, and transportation. The extent to which this biomass source will be utilized will depend on identifying barriers and mechanisms to increase availability, including (but not limited to) the suggested implementation mechanisms, such as landowner education and outreach, new market development, and harvesting, processing, and transportation improvements.

Multiple initiatives propose increased biomass utilization (e.g., AFW-1 and AFW-2). The impacts of these initiatives on feedstock supply need to be considered hand-in-hand to ensure the sustainability of feedstock supply and other natural resources.

Lack of a robust feedstock portfolio, including an inventory of potential lands for energy plantations, makes it very difficult to clearly identify barriers to increased availability and supply and understanding the cumulative impact on the sustainability of feedstock, food/fiber, and other commodity supplies and natural resources.

Increasing domestic budgetary pressures on U.S. commodity subsidies, along with the June 2008 ruling by the World Trade Organization (WTO) that Brazil can seek $4 billion in retaliation against U.S. cotton subsidies, suggest that there is a high probability of major changes occurring in subsidy programs over the next 10 years.

MSW feedstock has not been included in the cost analysis because of the significant uncertainty regarding the price (e.g., uncertain separation, processing, and transportation costs) due to the lack of an established market in Michigan for utilizing MSW as an energy feedstock.

As mentioned under Key Assumptions above, the benefits are estimated by assuming that biomass combustion is offsetting average grid-based electricity. To the extent that either coal or natural gas is being offset, the use of this average value could under- or overestimate the benefits of this policy, respectively. For perspective on this, the Michigan I&F data show coal-based steam generation emission rates of about 0.97 tCO_2e/MWh, compared to natural gas turbine emission rates of about 0.65 tCO_2e/MWh. The average Michigan grid-based factors used in the I&F range from about 0.91 tCO_2e/MWh in 2010 to 0.84 tCO_2e/MWh in 2025.

Additional Benefits and Costs

None specified.

Feasibility Issues

Increased utilization of forest biomass will be dependent on the development of cost-effective supply-chain systems to harvest, process, and transport biomass material (especially smaller-sized material), as well as on the identification and successful removal of public and private barriers to incremental sustainable management.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-2. In-State Liquid Biofuels Production

Policy Description

Increase the sustainable in-state production and use of liquid biofuels from agriculture and/or forestry feedstock and/or municipal solid and other wastes to displace the use of fossil fuel. Promote the development of technologies and production systems that:

- Improve the embedded energy content of biomass fuels;
- Maintain the sustainability[22] of feedstock supply and other natural resources;
- Minimize net GHG emissions, and achieve net reductions in all harmful emissions using best available control technologies; and
- Utilize integrated feedstocks via integrated manufacturing (including co-location of manufacturing facilities) to capture higher-value products, as well as GHG emission and energy efficiencies.

Encourage advanced refining in ethanol plants to produce higher-value chemical products to further reduce the use of fossil fuels for the production of those materials.

Clarify life-cycle analysis expectations and definitions of carbon neutrality/balance to support decision making related to investments in biomass for liquid biofuels production.

Evaluate policy goals hand-in-hand with the impact of other GHG policy recommendations and their cumulative impact on the sustainability of feedstock, food and other commodity supplies, and other natural resources.

Note that this policy has linkages and potential overlap with TLU-1: Promote Low-Carbon Fuel Use in Transportation. This AFW recommendation focuses on the feedstocks needed for biofuels production and the associated benefits for the use of these fuels derived from next-generation feedstocks (e.g., cellulose, waste materials).

Policy Design

Goals: Achieve 10% use of renewable fuels with lower GHG emissions than petroleum-based fuels by 2012 and 25% by 2025.[23]

Timing: See Goals, above.

Parties Involved: Agricultural interests; forestry interests; food processing industries; primary and secondary forest products industries; auto industries; fuel industries; environmental/

[22] See the definition of sustainable forest management and sustainable agriculture in AFW-1.

[23] The goals of 10% by 2012 and 25% by 2025 are both included in the Michigan Renewable Fuels Commission final report. The goal of 25% by 2025 is included in the Midwestern Governors Association Energy Platform.

sustainability interests; relevant state regulatory authorities (MDEQ, MPSC), and the MDA, MDNR, MDLEG, and the MEDC.

Other: Growth in the use of biomass fuels needs to be linked to the health of Michigan's agricultural, food processing, and forest products industries, and to sustainable agricultural and forest management practices.

Implementation Mechanisms

- Develop, implement, and promote the use of woody biomass harvesting guidelines, best management practices for water quality, and applicable forestry and agriculture generally accepted management practices.
- Adopt appropriate land-use policies and practices that protect and enhance Michigan water quality, habitat, and other relevant ecological services must be incorporated in conjunction with any policies to expand the use of biofuels. Available biomass should be utilized for its highest-value purposes, which in addition to energy may include uses for food, fiber, and chemical feedstocks. Financial incentives, if any, should be carefully targeted to reward uses that achieve the maximum value from biomass consumed and achieve market transformation goals.[24]
- Undertake a comprehensive inventory of biomass resources. Preliminary indications show a potential for doubling the contribution of biomass resources to provide useful electricity and thermal energy.[25] There are also additional biomass demands associated with the biomass for energy recommendations in both AFW-1 and AFW-2, as well as the linked recommendations in the ES and TLU sectors (see Tables J-1 and J-2 under the Biomass Resource and Demand Assessment at the front of this appendix; there is also a discussion of this issue under policy recommendation ES-10). Accompanying any policies intended to promote the additional use of biomass for energy, adequate resources should be dedicated to completing and maintaining a comprehensive biomass inventory for Michigan, and appropriate sustainability indicators[26] should be used to track changes in the inventory over time. There should be a recognition that market forces will drive end-use decisions on biomass; however, systems need to be developed and implemented to monitor consumption levels of sustainable supply.
- Create feedstock portfolios that highlight feedstock type, location, current usage, and availability to facilitate facility sighting in an economically and ecologically sustainable manner. The feedstock portfolio should also include an analysis and inventory of potential

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[24] "Market transformation" incentives are designed to engender permanent changes in specific target markets, so that financial incentives can be removed in a reasonably short time and the market will maintain the new higher-efficiency behavior. See http://www.cee1.org/cee/mt-primer.php3.

[25] See *Michigan's 21st Century Electric Energy Plan,* Appendix II – Chapter 4 (January 2007). See: http://www.dleg.state.mi.us/mpsc/electric/capacity/energyplan.

[26] "Sustainability indicators" are measures of "stocks, inventories or qualities of economic, social, ecological or institutional assets over time." They are typically developed using "dynamic iterative processes and dialogue among non-expert citizen participants, government bureaucrats and technical experts [which] … allows participants to define locally-relevant aspects of sustainability from their unique perspectives, anchored by their own values" (László Pintér, Peter Hardi, Peter Bartelmus, International Institute for Sustainable Development, 2005, pp. 2, 5; http://www.iisd.org/measure/). See also: http://www.sustainabilityindicators.org/.

lands for energy plantations, including an assessment of the potential impact on current food and fiber production of utilizing identified lands for this purpose.

- Promote the development of cost-efficient systems for short-rotation crop establishment and biomass harvesting, processing, and transportation.
- Promote the development and implementation of fuel efficiency technologies.
- Conduct research and development and initiate outreach to promote enhanced feedstock yields and production in an ecologically and economically sustainable manner.
- Structure incentives to enable partnerships to develop biofuel facilities and current forest product manufacturers to increase capital investment pools and promote energy conversion efficiencies and integrated use of feedstocks to foster optimization of production of value-added products.
- Develop Centers of Excellence for the promotion of technology development and transfer to improve supply-chain efficiency, in order to promote bioenergy development while strengthening current forest and agricultural sector performance.
- Encourage the adoption of advanced technology in existing corn-based ethanol plants to improve their production of ethanol per bushel of corn, capture their CO_2 emissions, and install equipment to separate corn oil from their production process to be used for biodiesel blending.
- Encourage advanced refining in ethanol plants to produce higher-value products, such as fine chemicals and acids, to further reduce the use of fossil fuels for the production of those materials.
- Provide financial incentives to research the production of bio-oils from algae or other organisms grown in wastewater effluents (which would reduce carbon, nitrogen, and phosphorus).
- Measure/analyze the life-cycle carbon effects of implementation of this policy. Measure/analyze competition with food production.

Related Policies/Programs in Place

The Michigan Renewable Fuels Commission, established under Public Act 272 of 2006, is tasked with developing recommended policies and strategies to promote research, development, production, and distribution of alternative fuels in Michigan.

Michigan Renaissance Zones were established under Public Acts 270 and 273 of 2006 to allow for 10 additional zones to offer tax incentives to renewable energy production facilities, including agricultural processing facilities.

A number of ethanol and biodiesel production facilities have located, or are planning to locate, in Michigan. Maps of these facilities can be found at: http://www.michigan.gov/documents/mda/EthanolMap_186352_7.pdf and http://www.michigan.gov/documents/mda/BiodieselMap_183689_7.pdf.

Agricultural biomass producers should be encouraged to obtain MAEAP certification. Forestry biomass producers should be encouraged to participate in appropriate certification programs (e.g., sustainable forestry certifications, such as the Sustainable Forestry Initiative® or the Forest Stewardship Council). For details on MAEAP, see www.michigan.gov/mda/0,1607,7-125-1567_1599_25432-12819--,00.html.

Type(s) of GHG Reductions

The life-cycle emissions of advanced biofuels are lower than the life-cycle emissions of the petroleum-based fuels that they replace.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 (MMtCO_2e): *Emission reductions and costs associated with consumption of the biofuels produced in-state via this recommendation are captured within the TLU-1 analysis. Estimates of production volumes and their potential costs are provided under the Quantification Methods section below.*

Net Cost per tCO_2e: *See TLU-1: Promote Low-Carbon Fuel Use in Transportation.*

Data Sources: Argonne National Laboratories (ANL) GREET model; National Renewable Energy Laboratory, *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover*, NREL/TP-510-32438 (Golden, CO, June 2002); "The Economics of Biomass Collection, Transportation, and Supply to Indiana Cellulosic and Electric Utility Facilities," by Sarah C. Brechbill and Wallace E. Tyner, Working Paper #08-03, April 2008, Department of Agricultural Economics, Purdue University; EIA, *Biofuels in the U.S. Transportation Sector*, February 2007; AEO 2008.

Quantification Methods:

Biofuel GHG Reductions

The benefits for this policy are dependent on developing in-state production capacity that achieves GHG benefits beyond petroleum fuels. The full costs and GHG benefits of increased biofuel use in Michigan are quantified in TLU-1 (Promote Low-Carbon Fuel Use in Transportation). The purpose of AFW-2 is to examine the costs associated with expanded biofuels production. This policy quantifies the benefits and costs of producing sufficient renewable liquid biofuels to meet the policy goal after accounting for Michigan's current in-state biofuel production. Currently, 267 million gallons (gal) of starch-based ethanol are produced annually in Michigan.[27] Table J-2-1 lists the quantity of biofuels required in each year to meet the goals of AFW-2.

[27] Personal communication by Liesl Clark, Michigan Department of Agriculture and member of the AFW TWG, to the TWG, based on the Renewable Fuels Commission Report.

Table J-2-1. Quantity of biofuel required in AFW-2

Year	Implementation Path	Gasoline Demand (million gallons)	Diesel Demand (million gallons)	Displacement Goal (million gallons)
2009	0%	4,563	1,118	0
2010	5%	4,557	1,138	285
2011	8%	4,514	1,143	424
2012	10%	4,448	1,142	559
2013	11%	4,380	1,140	616
2014	12%	4,322	1,141	672
2015	13%	4,272	1,144	729
2016	15%	4,233	1,146	786
2017	16%	4,194	1,148	842
2018	17%	4,156	1,150	898
2019	18%	4,119	1,152	953
2020	19%	4,088	1,156	1,009
2021	20%	4,073	1,167	1,068
2022	22%	4,068	1,180	1,130
2023	23%	4,071	1,195	1,195
2024	24%	4,079	1,213	1,262
2025	25%	4,059	1,222	1,320

To determine the level of cellulosic ethanol that could be produced in Michigan, annual cellulose production is multiplied by the estimated ethanol yield per ton of biomass, based on the projection that ethanol yield will increase from 70 gal/ton biomass to 90 gal/ton biomass by 2012 and to 100 gal/ton biomass by 2020.[28] Table J-2-2 shows the number of 70 million gal/year (MM gal/yr) cellulosic plants that will need to go on line in Michigan to convert the available biomass feedstock to ethanol, and summarizes the quantity of other biofuels that can be produced with the Michigan feedstock supply, assuming that food crops will not be utilized for fuel. In Table 2-2, the biodiesel production is from waste grease (vegetable oil from restaurants).[29] Estimates of corn-based ethanol production were compared against figures provided by Jim Byrum regarding likely Michigan corn-based ethanol production for 2008–2028.[30] Byrum's figures have corn ethanol production increasing from 240 MM gal produced in 2008 to 460 MM gal of production in 2028, primarily due to anticipated technological improvements that increase the corn kernel starch content and ethanol production efficiencies. Table J-2-2 shows 267 MM gal of production

[28] J. Ashworth, U.S. Department of Energy, National Renewable Energy Laboratory, personal communication, S. Roe, CCS, April 2007.

[29] The waste grease estimated is based on per capita generation according to http://media.cleantech.com/node/376, accessed July 2008. The waste grease conversion factor of 7.6 pounds/gallon is from California Grain & Feed Association, "Evaluate the Cost and Usage of Various Fuels," accessed January 8, 2008, at http://www.cgfa.org/news.html. The Michigan 2025 population estimate is from http://www.michigan.gov/hal/0,1607,7-160-17451_28388_28392-116118--,00.html, accessed August 2008.

[30] Personal communication with Jim Byrum, Michigan Agri-Business Association. September 25, 2008.

in 2008, increasing to 458 MM gal in 2025. While these numbers do not match up perfectly, they are relatively similar throughout the policy period, and show that the AFW-2 goal for corn-based ethanol is realistic.

Table J-2-2. Projected biofuel production

Year	Cellulosic Ethanol Plants in Operation	Cellulosic Feedstock Used (million short tons annually)	Cellulosic Ethanol Production (million gallons annually)	Starch-Based Ethanol Production (million gallons annually)	Biodiesel Production (million gallons annually)
2009	0.0	0.0	0	267	0
2010	0.0	0.0	0	285	0
2011	1.4	1.4	98	325	1
2012	3.3	2.6	230	326	2
2013	4.0	3.1	280	333	3
2014	4.8	3.7	334	334	4
2015	5.5	4.2	379	345	6
2016	5.9	4.5	406	374	7
2017	6.6	5.0	454	380	8
2018	7.3	5.6	503	386	9
2019	8.0	6.1	552	391	10
2020	8.7	6.0	600	397	11
2021	9.4	6.5	649	407	12
2022	10.1	7.0	698	419	13
2023	10.8	7.5	747	434	14
2024	11.5	8.0	795	451	16
2025	12.2	8.4	844	458	18

Note: Cellulosic plants required are not whole numbers. The analysis assumes that these plants will be going on line mid-year.

Biofuel Costs

Cellulosic Ethanol Costs

The cellulosic ethanol costs of this policy are estimated based on the capital and operating costs of cellulosic ethanol production plants (Table J-2-3). A study by the National Renewable Energy Laboratory (NREL) was used to estimate the operation and maintenance costs of a 70 MM gal/yr cellulosic ethanol plant.[31] The capital costs of a cellulosic plant came from an average of the capital cost estimates for six biofuels plants across the country. Using this method, the average capital cost of a new cellulosic ethanol plant is $497 million. A new plant will need to be built

[31] National Renewable Energy Laboratory, *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover*, NREL/ TP-510-32438 (Golden, CO, June 2002), www.nrel.gov/docs/fy02osti/32438.pdf, accessed June 2008.

for every 70 MM gal of annual ethanol production needed. It was assumed that the capital costs will be paid according to a cost recovery factor over the 20-year lifetime of the plant. The cost of biomass feedstocks made up a significant portion (~60%) of variable costs. Therefore, we replaced the NREL estimate of feedstock costs ($30/metric ton[t]) with more current estimates of the cost of delivered biomass: $60/t for agricultural feedstocks and $65/t for woody feedstocks.[32] The plant proposed by the NREL study produces some excess electricity, although the costs and benefits of generating this electricity are not considered in this analysis. The revenue source for the ethanol plant is the wholesale value of the gasoline that is displaced by ethanol.

The break-even cost of cellulosic ethanol production is used in the TLU-1 analysis to estimate the likely costs of a gallon of cellulosic ethanol. This figure ranges from $1.87/gal in 2011 to $2.38/gal in 2025.

Table J-2-3. Cost summary for cellulosic ethanol plants

Year	Cellulosic Ethanol Produced (million gallons annually)	Annual Operating Costs ($MM)	Annualized Capital Costs ($MM)
2009	0	$0	$0
2010	0	$0	$0
2011	98	$127	$56
2012	230	$254	$133
2013	280	$308	$161
2014	334	$368	$192
2015	379	$418	$218
2016	406	$447	$234
2017	454	$501	$262
2018	503	$554	$290
2019	552	$608	$318
2020	600	$620	$346
2021	649	$671	$374
2022	698	$721	$402
2023	747	$771	$430
2024	795	$821	$458
2025	844	$872	$486

$MM = million dollars.

32 The basis for this is related to summaries on Michigan pulpwood costs in a document titled *Michigan Timber Market Analysis*: *Final Report*, prepared for the Michigan Department of Natural Resources by Prentiss and Carlisle, March 10, 2008.

Biodiesel Costs

The majority of biodiesel costs (approximately 88%) comes from the feedstock costs of vegetable oil.[33] If vegetable oil costs are $0.52/kilogram (kg), then biodiesel can be produced for $1.99/gal. Vegetable oil prices have increased to $0.73/kg, and thus the price of biodiesel must be adjusted.[34] The price of biodiesel increases by $0.08/gal for every $0.01/pound (lb) that the price of vegetable oil increases. Given this information, biodiesel costs are estimated at $2.73/gal. The costs of biodiesel production in Michigan are shown in Table J-2-4. The revenue source for the biodiesel production is the wholesale value of the diesel that is displaced.

Starch-Based Ethanol Production Costs

The gallons of starch-based ethanol that are required in this policy were determined based on the number of gallons of fuel required to meet the goal for AFW-2. After the gallons of biodiesel and cellulosic ethanol are determined, the gallons still needed to meet the goal are estimated to come from starch-based ethanol. Only the costs and GHG benefits beyond currently existing starch-based production (267 MM gal) are considered in this analysis. The price of starch-based ethanol was determined based on the cost of corn ethanol (the number of gallons in the policy times the price per gallon). The costs of starch-based ethanol production are shown in Table J-2-4.

Key Assumptions: Annual cellulosic plant costs are $40 MM/yr for a 69-MM-gal/yr plant, and include labor, general overhead, maintenance, taxes, insurance, and other operational costs, not including feedstock costs. Capital costs are $497 million per plant and assume an interest rate of 5% and a project life of 20 years. These capital costs are assumed to include all of the likely costs incurred from building an ethanol plant, including the necessary criteria air pollutant controls.

Key Uncertainties

This option's costs are highly dependent on the price of feedstock, which is still relatively unclear for many types of feedstock. If feedstock prices prove higher on a per-ton basis than currently estimated, this policy may have a net cost rather than a net revenue.

The potential availability of the unharvested above-ground biomass growth on timberland acres will be influenced by landowner willingness to harvest; the available markets for the broad range of biomass species, size, or condition; and the costs of harvesting, processing, and transportation. The extent to which this biomass source will be utilized will depend on identifying barriers and mechanisms to increase availability, including (but not limited to) the suggested implementation mechanisms, such as landowner education and outreach, new market development, and harvesting, processing, and transportation improvements.

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33 Haas, M., A. McAloon, W. Yee, and T. Foglia. "A Process Model to Analyze Biodiesel Production Costs." *Bioresource Technology*. 2006. Available at: http://www.ars.usda.gov/research/publications/publications.htm?seq_nso_115=156135.

34 Saulny, Susan. "As Oil Prices Soar, Restaurant Grease Thefts Rise." *New York Times*. May 30, 2008. http://www.nytimes.com/2008/05/30/us/30grease.html?pagewanted=all .

Table J-2-4. Total biofuel production costs

Year	Cellulosic Ethanol Production Costs ($MM)	Starch-Based Ethanol Production Costs ($MM)	Biodiesel Production Costs ($MM)	Total Production Costs ($MM)	Total Discounted Production Costs ($MM)
2009	$0	$0	$0	$0	$0
2010	$0	$40	$0	$40	$31
2011	$184	$134	$3	$321	$240
2012	$386	$139	$6	$531	$377
2013	$469	$132	$9	$611	$413
2014	$560	$134	$12	$706	$455
2015	$636	$141	$15	$792	$486
2016	$681	$227	$18	$925	$541
2017	$762	$247	$21	$1,030	$574
2018	$844	$264	$24	$1,132	$600
2019	$926	$278	$27	$1,231	$622
2020	$966	$297	$30	$1,293	$622
2021	$1,044	$323	$33	$1,400	$642
2022	$1,122	$347	$36	$1,505	$657
2023	$1,201	$386	$39	$1,626	$676
2024	$1,279	$427	$42	$1,748	$692
2025	$1,358	$442	$48	$1,848	$696
Total					**–$8,323**

$MM = millions of dollars.

Multiple initiatives propose increased biomass utilization (e.g., AFW-1 and AFW-2). The impacts of these initiatives on feedstock supply need to be considered hand-in-hand to ensure the sustainability of feedstock supply and other natural resources.

Lack of a robust feedstock portfolio, including an inventory of potential lands for energy plantations, makes it very difficult to clearly identify barriers to increased availability and supply, and understanding the cumulative impact on the sustainability of feedstock, food/fiber, and other commodity supplies and natural resources.

Conversion of cropland to fuel production may have impacts on food prices and supply. There is also a current scientific debate on the potential for biofuel production (often directed toward starch-based ethanol) and the change in land use in developing countries due to lower exports (and subsequent need within these countries to convert more forest to farmland). The concept could be expanded to include cellulosic fuel production to the extent that food crop lands are converted to energy crop lands. Hence, there is a potential for GHG increases outside of Michigan, if the recommended policy has a material effect on U.S. exports. The issue of sustainable biofuels production is discussed further under Additional Benefits and Costs, below.

It is unknown what impact the Energy Independence and Security Act of 2007 definition of "renewable biomass" will have on investments in cellulosic ethanol production.

Increasing domestic budgetary pressures on U.S. commodity subsidies, along with the June 2008 ruling by the WTO that Brazil can seek $4 billion in retaliation against U.S. cotton subsidies, suggest that there is a high probability of major changes occurring in subsidy programs over the next 10 years.

The recent collapse of the Doha Round of the WTO of world trade talks has led Brazil to threaten taking its case against the U.S. 54 cents/gallon tariff on imports of ethanol to the WTO. This potential action, increasing debates about food versus fuel and increasing food prices domestically and internationally, may lead to changes in ethanol subsidies, mandates, and tariffs over the next 10 years.

Additional Benefits and Costs

The NREL study on the costs and benefits of a cellulosic ethanol plant finds that the facility would generate additional electricity beyond the operational needs. This was not considered in the analysis due to the uncertainty of the amount of electricity produced, although this could provide an additional revenue stream for cellulosic producers.

As Michigan becomes a major producer of cellulosic ethanol, potential new revenue streams to Michigan landowners and farmers will be created as a value is placed on the biomass produced.

A recent article in *Science* magazine, "Sustainable Biofuels Redux,"[35] indicates that without proper management, intensive biofuel production can carry with it a significant environmental cost. The article pointed out that while practices, such as conservation tillage and advanced nutrient management, as well as additional research on low-impact biofuel production can help mitigate the environmental risks of expanded biofuel use, additional research and the development of effective performance standards will be required to achieve sustainability in biofuel production.

Incremental sustainable forest management has the potential to increase current forest growth rates. This potential biomass upside has not been included in this review.

The current review assumes that the commercial production of cellulosic ethanol is dependent on a clean wood fiber chip. As technology develops to generate cellulosic ethanol commercially from tops, limbs, above-ground stumps, agriculture residues, and other materials, additional forest-based, agriculture-based and other forms of biomass could be utilized.

Feasibility Issues

Increased utilization of forest biomass will be dependent on the development of cost-effective supply-chain systems to harvest, process, and transport biomass material, as well as on the

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[35] Robertson, Philip, et al. "Sustainable Biofuels Redux." *Science* 322, October 3, 2008. Available at: www.sciencemag.org.

identification and successful removal of public and private barriers to incremental sustainable management.

Development of the manufacturing facilities necessary to produce the identified volume of cellulosic ethanol is dependent on securing necessary capital investments.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-3. Methane Capture and Utilization From Manure and Other Biological Waste

Policy Description

Reduce the amount of methane emissions from organic waste materials (such as livestock manure, food processing residuals, and other agricultural organic residuals) through the adoption of anaerobic digestion, gasification, or similar systems. Methane generated from anaerobic digesters, gasifiers, or similar technologies can be used to offset fossil fuel-based energy production and the associated GHG emissions. (To date, most of these projects have been implemented at dairies and swine operations.) In addition, co-products are created by these technologies, such as stable fertilizer products and building materials. Implementation will result in reduced GHG emissions by replacing traditional fossil fuel-based materials.

Encourage and promote the use of anaerobic digestion, gasification, or other similar technologies for energy recapture of organic waste materials other than municipal solid waste at landfills (e.g., food processing waste, plant material, fish offal, ethanol syrup stillage, paunch manure, animal mortalities, and biodiesel glycerin). These projects will help reduce the emission of GHGs, while producing renewable energy. Co-mingling of these organic wastes with manure in anaerobic digesters and gasification systems can substantially increase biogas production while providing a sustainable method for treatment and disposal. These technologies make a twofold contribution to climate protection: the usual unchecked discharge of methane into the atmosphere is prevented, and the burning of fossil fuels is replaced with renewable energy (biogas).

Policy Design

Goals: Reduce GHG emissions from handing, treatment, and storage of livestock manure and organic waste by 15% by 2015 and 25% by 2025 through improved manure management practices and methane utilization.

Timing: See above.

Parties Involved: Agricultural interests; food processing industries; environmental/sustainability interests; biofuels industries; municipalities; public utilities; users of CHP; state agencies and regulatory authorities (MDA, MDEQ, U.S. Department of Agriculture [USDA] Natural Resources Conservation Service [NRCS], MPSC).

Other: Note that organic waste has other uses besides methane generation, such as hog feed.

Implementation Mechanisms

A detailed audit needs to be conducted to determine both the mass and the volume of organic wastes (non-manure) deemed acceptable for treatment by anaerobic digesters and the best uses of manure and other organic waste materials. Other measures include:

- Develop a comprehensive state map using geographic information system (GIS) technology to assist project developers and planners in identifying areas for technology deployment. The map should interface sources of biomass by type with utility options (electric and gas) and the access to transportation/distribution systems.

- Improve net metering systems in the state (increase the threshold up to 1 megawatt [MW] from 500 kW). The lack of an adequate net metering system limits the ability of on-site generation to either offset electricity consumption or sell electricity back to the grid.
- Streamline existing interconnection policy to ease the process and control the cost.
- Recognize a value for renewable energy and/or GHG emission reductions to encourage investors into the market.
- Develop regulatory policy that allows for co-mingling of animal manure and organic waste to improve the economic viability of anaerobic digesters, while allowing for sustainable treatment of organic waste.
- Promote policy and/or incentives that increase the generation of renewable energy from livestock manure and organic waste.
- Promote the capture and destruction of methane and other GHGs generated by livestock manure and organic waste.
- Increase the ceiling created by existing net metering policy.
- Promote policy that supports feed-in tariffs and distributed power systems.
- Promote or fund research to improve the efficiency of biogas production and utilization.
- Promote efficient use of biogas through CHP. Couple CHP users with biogas producers.

Related Policies/Programs in Place

The Michigan Biomass Energy Program created by MDLEG's Energy Office is focused on encouraging increased production and use of energy derived from Michigan's biomass. The program recently funded a study by MDA to develop analytical data on the quality of agricultural by-products treated by anaerobic digesters. The data will develop a better understanding of the benefits of co-feeding digester systems.

MDA has provided outreach to expand awareness and availability of renewable energy-generating treatment technologies. This effort has included tours for industry, conferences, and development of educational materials.

MDA, in conjunction with the Delta Institute, has launched a pilot project titled "Michigan Conservation and Climate Initiative" (MCCI). This program allows Michigan agricultural landowners to earn GHG emission reduction credits by installing methane digesters and earn revenue from the sale of their credits on the Chicago Climate Exchange (CCX). More information on the MCCI may be found at: http://www.michiganclimate.org/.

MDA provides training certification for operators of anaerobic digester systems. This is the first step in providing the system requirements necessary to claim available property tax exemptions.

Michigan State University (MSU) is developing a Center for Anaerobic Digestion Research and Education. The center will integrate laboratory and commercial research with education and outreach activities.

Type(s) of GHG Reductions

CO_2, N_2O, CH_4: Use of biogas displaces fossil energy consumption and the associated GHG emissions.

CH_4: Capture and utilization or preventing the creation of methane from manure or other organic wastes.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$): 0.09, 0.14, respectively.

Net Cost per tCO_2e: $3.

The benefits and costs estimated above only capture the livestock manure (dairy and swine) element of this policy. Information was lacking on other organic wastes that would also be targeted by this policy.

Data Sources: As indicated in the methodology below.

Quantification Methods:

Utilization GHG Benefits

Dairy and swine manures were assumed to be the primary livestock waste feedstocks to be targeted by this policy. The TWG felt that poultry litter had other uses as fertilizer, which made it an unlikely feedlot source. Information on other sources of organic waste, which are targeted by this policy, was not identified; hence, the emission reductions estimated here do not capture all of the potential reductions targeted by this policy.

Methane emissions data from the Michigan I&F (in $MMtCO_2e$) were used as the starting point to estimate the GHG benefits of utilizing the volumes of methane targeted by the policy and to add the additional benefit of electricity generation using this captured methane (through offsetting fossil-based generation). The first portion of GHG benefit is obtained through reduced methane emissions through the capture of methane emissions from manure management. An assumed collection efficiency of 75%[36] is applied to methane emissions from manure and poultry litter, which is then multiplied by the assumed policy target, ramping up to achieve 50% utilization by 2025.

The second portion of the GHG benefit is through the offsetting of fossil fuels. For the purposes of this analysis, it is assumed that the methane is used to create electricity, which will displace fossil-based electricity generation (methane could also be used for other energy purposes). The electricity-offset component was estimated by converting the methane captured in each year to

[36] The collection efficiency is an assumed value based on engineering judgment. No applicable studies were identified that provided information on methane collection efficiencies achieved using manure digesters (as it relates to collection of entire manure management system-level emissions).

its heat content, and then multiplying by a natural gas heat rate of 11,664 Btu/kWh to estimate the electricity produced.[37] The CO_2e associated with this amount of electricity in each year is estimated by converting the kWh to megawatt-hours (MWh), and then multiplying this value by the Michigan-specific emission factor for electricity production from the I&F (0.79 tCO_2e/MWh).[38] The total GHG benefit is estimated as the sum of both portions of the benefit described above and is summarized in Table J-3-1.

Table J-3-1. GHG reductions from methane utilization

Year	Policy Methane Utilization Objective (%)	Methane Captured and Utilized Under Policy ($MMtCO_2e$)	Methane (MMBtu)	Annual Electricity Produced (kWh)	CO_2e Offset as Electricity ($MMtCO_2e$)	Total Emission Reductions ($MMtCO_2e$)
2009	0	0.000	—	—	—	0.000
2010	3	0.013	32,184	2,759,234	0.002	0.015
2011	5	0.026	63,973	5,484,677	0.004	0.030
2012	8	0.038	95,383	8,177,572	0.006	0.044
2013	10	0.050	126,428	10,839,122	0.009	0.059
2014	13	0.063	157,120	13,470,488	0.011	0.073
2015	15	0.075	187,473	16,072,796	0.013	0.087
2016	16	0.079	198,857	17,048,807	0.013	0.093
2017	17	0.084	210,131	18,015,368	0.014	0.098
2018	18	0.088	221,299	18,972,852	0.015	0.10
2019	19	0.093	232,366	19,921,621	0.016	0.11
2020	20	0.097	243,335	20,862,026	0.017	0.11
2021	21	0.101	254,210	21,794,403	0.017	0.12
2022	22	0.106	264,995	22,719,079	0.018	0.12
2023	23	0.110	275,695	23,636,368	0.019	0.13
2024	24	0.114	286,311	24,546,575	0.019	0.13
2025	25	0.118	296,849	25,449,993	0.020	0.14
Cumulative						**1.5**

MMBtu = millions of British thermal units; $MMtCO_2e$ = millions of metric tons of carbon dioxide equivalent.

Utilization Costs

The costs for the dairy and swine manure utilization were estimated using the average of an NRCS analysis, *An Analysis of Energy Production Costs From Anaerobic Digestion Systems on U.S. Livestock Production Facilities.*[39] This is based on the assumption that facilities will most likely use a blend of manure. The production costs are assumed to be \$0.10/kWh, based on

[37] U.S. Department of Energy, Energy Information Administration (2007), Table A.6 Average Heat Rates by Prime Mover and Energy Source. Available at: http://www.eia.doe.gov/cneaf/electricity/epa/epata6.html.

[38] Total electricity emissions were divided by total electricity sales to determine the electricity emissions factor for Michigan.

[39] Beddoes, Bracmort, Burns, and Lazarus (2007), *An Analysis of Energy Production Costs From Anaerobic Digestion Systems on U.S. Livestock Production Facilities*, NRCS, Technical Note No. 1, October 2007.

$0.07/kWh for swine anaerobic digesters and $0.13/kWh for dairy anaerobic digesters.[40] These costs were converted to 2005 dollars (from 2006 dollars). The costs include annualized capital costs for the digester, generator, and operation and maintenance costs.[41] The value of electricity produced is taken from the projected "all sector average electricity price" for the East Central Area Reliability Coordination Agreement.[42] This price represents the value to the farmer for the electricity produced (to offset on-farm use) and is netted out from the production costs to estimate net costs. The costs are summarized in Table J-3-2.

Table J-3-2. Costs for dairy and swine manure utilization

Year	Annual Kilowatt-Hours Produced	Total Net Discounted Cost[43] of Deploying Dairy and Swine Methane Capture and Utilization Technology (2005$)	Total Emission Reductions ($MMtCO_2e$)	Cost-Effectiveness ($/$tCO_2e$)
2009	—	$0	0.000	
2010	2,759,234	$29,256	0.015	
2011	5,484,677	$66,361	0.030	
2012	8,177,572	$116,017	0.044	
2013	10,839,122	$168,646	0.059	
2014	13,470,488	$241,340	0.073	
2015	16,072,796	$312,422	0.087	
2016	17,048,807	$330,670	0.093	
2017	18,015,368	$344,492	0.098	
2018	18,972,852	$355,804	0.10	
2019	19,921,621	$355,829	0.11	
2020	20,862,026	$371,030	0.11	
2021	21,794,403	$385,768	0.12	
2022	22,719,079	$406,527	0.12	
2023	23,636,368	$404,936	0.13	
2024	24,546,575	$411,854	0.13	
2025	25,449,993	$428,424	0.14	
Cumulative		**$4,729,374**	**1.5**	**$3.22**

[40] It is assumed that the technologies employed are mixed digester systems for swine anaerobic digesters and plug-flow for dairy anaerobic digesters. Costs were obtained from Table 1 of the NRCS paper cited above. This is based on the sample size and the fact that simpler systems, such as covered lagoons, are less effective for dairy in Michigan than in southern and western states.

[41] The economic analysis conducted by Beddoes et al. does not include feedstock and digester effluent transportation costs. The technical note does not address the economics of centralized digesters, where biomass is collected from several farms and then processed in a single unit.

[42] DOE Energy Information Administration (EIA), *Annual Energy Outlook 2008*. Accessed on July 12, 2008, at: http://www.eia.doe.gov/oiaf/aeo/supplement/index.html.

[43] Net cost includes the cost of implementing methane capture and utilization technology (either natural gas or electricity displacement) and savings received through implementation (e.g., electricity savings).

$MMtCO_2e$ = millions of metric tons of carbon dioxide equivalent; $/t$CO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Key Assumptions:

- It is assumed that the technologies employed are mixed digester technology for swine manure and plug-flow digester technology for dairy manure.
- Costs were obtained from Table 1 of Beddoes, Bracmort, Burns, and Lazarus (2007), *An Analysis of Energy Production Costs From Anaerobic Digestion Systems on U.S. Livestock Production Facilities*, NRCS, Technical Note No. 1, October 2007.
- As noted above, due to a lack of data on the availability of other organic wastes, benefits and costs for their utilization are not included.

Key Uncertainties

None identified.

Additional Benefits and Costs

While this analysis has assumed that the methane captured from manure will be utilized through the generation of electricity, it should be noted that there are other potential uses, including displacement of natural gas and use as a feedstock in non-energy-related processes (e.g., fertilizer production).

Feasibility Issues

The feasibility of utilizing methane and displacing electricity is limited by the on-farm or community energy requirements. Due to the project locations and limited ability to interconnect, the feasibility of utilizing methane and displacing natural gas or electricity may be limited by on-farm or community energy requirements and/or the location of industries that could use that energy. Additionally, the lack of an adequate net metering system limits the ability of on-site generation to either offset electricity consumption or sell electricity back to the grid.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-4. Expanded Use of Bio-based Materials

Policy Description

Increase the amount of bio-based materials (e.g., wood, digester fiber, wheatboard, agricultural by-products, and biodegradable plastics) and green chemistry[44] applications that reduce GHG emissions over conventional petroleum-based products. GHG reduction is further enhanced by promoting the use of Michigan-produced materials, which results in lower transport-associated emissions. Increase the recycling or reuse of bio-based products to reduce waste. This policy does not refer to energy uses, such as ethanol or electricity production, which are covered in AFW-1 and AFW-2 (the use of bio-based products can increase carbon sequestration and produce fewer GHG emissions than processing high-energy or fossil-based input materials).

Promote the manufacturing and use of composite products made from low-grade wood timber, anaerobic digester fiber, and agricultural by-products. Michigan needs to develop the infrastructure to support sustainable bio-refineries that use biofuels to produce cellulose-based products, such as particle board, medium-density fiberboard, plant pots, and other composite products.

Policy Design

Goals: This policy has two elements:

A. Utilize 100,000 metric tons of bio-based products annually by 2025.

B. Reclaim 150,000 metric tons of solid wood residues from manufacturing processes, deconstruction sites, and urban/suburban trees annually by 2025—*a non-quantified recommendation.*

Timing: See above.

Parties Involved: Agricultural interests; manufacturing industries; environmental/sustainability interests; green building and green product industries and councils; state economic, environmental, and agriculture agencies (MDA, MDEQ), and USDA NRCS.

Implementation Mechanisms

- Support the development of markets for recycled materials.
- Consider a disposal ban for material that presents significant and avoidable harm if there are acceptable alternatives, such that the ban would not result in an unacceptable increase in illegal discharge.

[44] "Green chemistry" means chemistry and chemical engineering to design chemical products and processes that reduce or eliminate the use or generation of hazardous substances while producing high-quality products through safe and efficient manufacturing processes (www.michigan.gov/deqgreenchemistry). Green chemistry applies across the product life cycle, including the design, manufacture, and use of a chemical product.

- Consider deposit systems or the equivalent for high-risk or large-volume products only if they would create an efficient, effective, and equitable collection and utilization infrastructure.
- Expand the current container deposit system to include additional containers.
- Promote the use by municipalities of bio-based waste disposal bags.

Related Policies/Programs in Place

Promotion of implementation of this policy could occur through the Michigan AgriEnergy Conference.

Type(s) of GHG Reductions

CO_2: Carbon is sequestered in bio-products. If these products later biodegrade, the carbon is from renewable sources, so there is no net increase in atmospheric CO_2.

CO_2, N_2O, CH_4: Bio-products have the potential to consume less energy than petroleum-based alternatives and have lower net life-cycle GHG reductions.

CH_4: Reclamation of wood residues that would otherwise go to landfills reduces landfill methane emissions.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 (MMtCO_2e): Element A. 0.08, 0.21, respectively.
Element B. Not quantified.

Net Cost per tCO_2e: Element A. –$62; Element B. Not quantified.

The above costs and benefits only cover the bio-products element of this policy due to a lack of data for wood residues and their current management.

Data Sources: See text below.

Quantification Methods:

Element A. Bio-Products Use

The quantification of the bio-products element of this policy is based on supplanting fossil-based plastics with bio-plastics (note that the policy supports many other types of bio-products use). While numerous bio-based products have become commercially available over the past few years, the life-cycle GHG emissions of the bio-based product and the petroleum-based product being replaced have been analyzed for few of these products. Life-cycle analysis (LCA) for several corn-based polylactic acid (PLA) products and the alternative petroleum-based products was recently conducted for Athena Institute International (AII).[45] The LCA includes production of input materials, including extraction of raw materials through production of resin;

[45] *Life Cycle Inventory of Five Products Produced From Polylactide (PLA) and Petroleum-Based Resins, Summary Report*, prepared for Athena Institute International, by Franklin Associates, A Division of ERG, November 2006.

transportation of product resins to fabrication; fabrication of products from resins; and post-consumer disposal of products, including landfill and combustion of mixed MSW. Recycling and composting were not considered as part of the AII LCA. Of the products analyzed, only the 12-ounce polyethylene terephthalate (PET) bottle has a recycling rate of over 2%. Also, while PLA can be composted, this must be done in a commercial composting facility; PLA is not suitable for backyard composting.

Cradle-to-grave GHG emissions from three products made from PLA (16-ounce drink cup, 16-ounce deli container, 12-ounce water bottle) were compared to those of the PET-based products, as shown in Table J-4-1. The mass for 10,000 product units is also shown. The GHG benefit of replacing the PET with a PLA product was estimated by taking the difference between the PET and PLA product GHG emissions, and dividing by the PLA product mass. The GHG benefit of this policy was estimated using the average of the GHG emissions benefits for the three products. The resulting GHG benefits from producing 100,000 tons of PLA products are shown in Table J-4-2.

Table J-4-1. Life-cycle GHG emissions of PLA and PET products

Product	Mass (kg)	GHG Emissions ($MMtCO_2e$)	Avoided Emissions ($MMtCO_2e$/ton PLA product)
16-ounce drink cup (10,000 cups)			
PLA 2005	118	0.51	2.15
PET	125	0.79	
16-ounce deli container (10,000 containers)			
PLA 2005	160	0.669	2.84
PET	205	1.17	
12-ounce water bottle (10,000 bottles)			
PLA 2005	168	0.744	1.17
PET	162	0.961	
Average			**2.06**

GHG = greenhouse gas; kg = kilogram; PLA = polylactic acid; PET = polyethylene terephthalate; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table J-4-2. GHG benefits of bio-plastic production

Year	Increase in Bio-products (tons)	Avoided Emissions ($MMtCO_2e$)
2009	0	0.00
2010	6,250	0.01
2011	12,500	0.03
2012	18,750	0.04
2013	25,000	0.05
2014	31,250	0.06
2015	37,500	0.08
2016	43,750	0.09
2017	50,000	0.10
2018	56,250	0.12
2019	62,500	0.13
2020	68,750	0.14
2021	75,000	0.15
2022	81,250	0.17
2023	87,500	0.18
2024	93,750	0.19
2025	100,000	0.21
Total	**850,000**	**1.8**

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

Element A. Costs for Increased Bio-Products Production

With the rising cost of petroleum and advancements in production technology for PLA, PLA has become cost-competitive with PET. Recent prices for PLA are $0.90–$1.00/lb,[46] while recent prices for PET are $0.93/lb–$0.98/lb.[47] Using the midpoint of each price range and adjusting for the difference in density,[48] the cost difference for replacing PET with PLA was estimated, as shown in Table J-4-3.

Element B. GHG Benefits and Costs for Wood Residue Recovery

The benefits and costs of the wood residue recovery element of this policy were not estimated due to a lack of information on the availability of wood residues and their current management. A baseline study should be performed to gather this information.

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[46] J.A. Grande, "Close-Up on Technology: Materials, Biopolymers Strive to Meet Price/Performance Challenge," *Plastics Technology*. Available at: http://www.ptonline.com/articles/200703cu1.html.

[47] Polyethylene terephthalate (PET) Prices and Pricing Information, International Chemical Information Service, August 2008.

[48] CCS assumed that the same number of products (cups, clamshells) would be used, regardless of the type of plastic. Hence, where PLA plastic is lighter, less would be needed to produce the same number of products.

Table J-4-3. Cost analysis for bio-products

Year	Increase in Bioproducts (tons)	Cost ($)	Discounted Costs ($)
2009	0	0	0
2010	6,250	–$1,328,195	–$1,264,948
2011	12,500	–$2,656,390	–$2,409,424
2012	18,750	–$3,984,585	–$3,442,035
2013	25,000	–$5,312,780	–$4,370,837
2014	31,250	–$6,640,975	–$5,203,378
2015	37,500	–$7,969,170	–$5,946,718
2016	43,750	–$9,297,365	–$6,607,464
2017	50,000	–$10,625,561	–$7,191,798
2018	56,250	–$11,953,756	–$7,705,497
2019	62,500	–$13,281,951	–$8,153,966
2020	68,750	–$14,610,146	–$8,542,250
2021	75,000	–$15,938,341	–$8,875,065
2022	81,250	–$17,266,536	–$9,156,813
2023	87,500	–$18,594,731	–$9,391,603
2024	93,750	–$19,922,926	–$9,583,268
2025	100,000	–$21,251,121	–$9,735,383
Total	**850,000**	**–$180,634,529**	**–$107,580,445**

Note: Negative numbers indicate cost savings.

Key Assumptions:

The GHG benefits and costs for increased utilization of bio-products were based on current production technology and costs for PLA. With improvements in the production process, GHG emissions and costs from PLA production may be decreased. Another key assumption for the bio-plastics estimates is that PLA products will replace PET products. The AII analysis found that the GHG benefit of using PLA over other types of plastic for some of the products was smaller than the benefit of replacing PET with PLA. The future cost of petroleum and its effect on PET or other fossil-based plastics is a significant uncertainty. Any potential ramp-up of petroleum pricing during the policy period has not been factored into this analysis.

Key Uncertainties

The future costs of producing PLA and PET are uncertain. PLA and PET prices are likely to fluctuate due to changes in production technology and changes in the prices of petroleum and biomass feedstocks.

Increasing domestic budgetary pressures on U.S. commodity subsidies, along with the June 2008 ruling by the WTO that Brazil can seek $4 billion in retaliation against U.S. cotton subsidies, suggest a high probability of major changes occurring in subsidy programs over the next 10 years. These issues could have an effect on the pricing and availability of agricultural feedstocks that could be used for bio-products manufacturing.

Baseline information is needed on the availability of wood residues (e.g., urban wood waste, wood waste from construction and demolition debris) and how they are currently managed (e.g., landfilled) in order to assess the benefits and costs for Element B of this option.

Additional Benefits and Costs

There may be additional costs associated with disposing of PLA products. While PLA bio-based plastic is biodegradable, it does not readily break down in a landfill. The high heat in a commercial composting facility is needed to degrade PLA. In addition, PLA can contaminate recycled PET if mixed into the PET recycling stream and can harm existing recycling infrastructure. There are also the potential costs associated with increased cultivation of crops for bio-plastics feedstocks, such as increased soil degradation, and the costs associated with diverting food crops to make consumer products.

Feasibility Issues

None identified.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-5. Promote Continuous Vegetative Cover

Policy Description

Strengthen current programs and develop new programs to maintain existing, and promote new, continuous cover with higher carbon content than current cover on agricultural lands, forests, wetlands, prairies, buffer strips, roadsides, on-off ramp areas, and transportation medians. On agricultural lands, continuous vegetative cover would promote wind breaks, and winter cover crops, such as rye grass, could be planted on ground that otherwise would be left fallow. Windbreaks would promote new plantings of native grasses, shrubs, and trees that not only sequester carbon, but also help to prevent wind erosion. Windbreaks might need to be limited to short trees, shrubbery, and grasses if wind energy is to be produced nearby. Cover crops sequester carbon in the soil and in the plant itself and decrease winter soil erosion. Harvesting of a cover crop, filter strip, buffer strip, or grass waterway promotes new growth, takes excess nutrients off the field, allows for more carbon sequestration, and could offer a new source of biomass for energy production.

If there are more vigorous weather events, it is imperative that soil erosion be minimal; a continuous vegetative cover would assist with decreasing soil erosion from wind and water. Developing open spaces threatens to decrease Michigan's ability not only to absorb rainfall, grow food and fiber, and provide habitat for wildlife, but also to sequester carbon. Policy must allow all citizens to work together to plan the proper utilization of the land for the long term. The state must protect existing permanent cover, which sequesters carbon, and encourage new permanent cover, which captures and sequesters CO_2 from the atmosphere.

Note the linkage of this policy with AFW-6:Forestry and Agricultural Land Protection. The focus of this policy is on bringing additional areas under land cover with higher levels of sequestration potential. There is also a linkage with AFW-8: Forest Management for Carbon Sequestration and Biodiversity. That policy aims to protect carbon stores and enhance sequestration potential on existing forestlands and also to increase forested acreage via reforestation projects. This policy seeks to bring new areas into land cover with higher sequestration potential and is incremental to the AFW-8 goal for reforestation.

Policy Design

Goals: This policy has three separate elements:

A. Increase the acreage of lands with permanent cover by 10% by 2025 (existing land that is not under forest cover).

B. Reduce rates of carbon loss 90% by 2025 due to farmland and grassland coming out of Conservation Reserve Program (CRP) protection or other conservation programs (retain 90% of lands coming out of CRP by 2025 in some kind of conservation or permanent cover).[49]

[49] Loss of soil carbon through the return of CRP acres to active production is not included in the Michigan GHG I&F. Hence, the GHG benefits for it are not included in the estimated reductions from BAU emissions in the state

C. Reduce rates of carbon loss by restoring or enhancing the maximum feasible percentage of wetlands by 2025 (this element is being brought forward as a non-quantified goal).

Timing: See goal above.

Parties Involved: Landowners, Michigan Department of Transportation, and USDA NRCS.

Other: New, economically viable biomass opportunities are key to expanding permanent cover on Michigan land. Economic and technical support must drive these systems as demand for biomass develops. The definition of permanent cover can be broadened to include areas beside agricultural lands, such as medians, lands along highways, etc.

Implementation Mechanisms

An inventory of agricultural lands, forests, wetlands, prairies, buffer strips, and transportation median lands both in permanent cover and with the potential for permanent cover is needed and should be conducted jointly by the relevant agencies.

Request that MSU crop and soil science extension educators develop a survey directed at large farm operations to determine if bio-based production other than corn is in their future. The survey should include a gross per-acre return needed to compete with existing crops. Request that MSU soil scientists develop a paper stating the trade-offs of complete harvest of crops, as opposed to some of the crop returned as organic matter.

State and federal programs need to be strengthened and incentives need to be increased to prevent farmland, grasslands, and wetlands in the CRP and similar conservation programs from being plowed up and/or drained. Other mechanisms include:

- Promote the market potential for biomass crops locally through Conservation Districts.
- Provide technical information on production techniques and equipment for improving pasture land.
- Increase enrollment in the MCCI by promotion of financial incentives associated with the program.
- Expand successful programs like the federal Conservation Reserve Enhancement Program (CREP) to additional agricultural watersheds.
- Develop a certified and sustainable program comparable to MAEAP, which would use grass buffers, conservation tillage, and nutrient management to promote biofuel sources that are truly green.
- Increase the amount of land that is planted to riparian filter strips, grass waterways, and riparian buffer strips by 100%[50] by 2020.

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shown at the front of this appendix. This policy element is included as a measure of protection from higher levels of emissions than have been predicted in the agricultural soils forecast of the I&F.

[50] Currently there are approximately 35,000 acres planted. A 100% increase would mean 70,000 acres planted to these items.

- Increase the number of low windbreaks planted where wind erosion brings fields above the associated soil loss tolerance level.[51]
- Decrease the number of on-off ramp areas[52] that need to be mowed by 50% by 2015 by planting native grasses, shrubs, and trees.

Related Policies/Programs in Place

MCCI allows Michigan agricultural landowners to earn GHG emission reduction credits through grass planting and earn revenue from the sale of their credits on the CCX.

The Michigan Forest Carbon Offset and Trading Program allows Michigan forest landowners to earn and sell GHG emission reduction credits through increasing the amount of stored carbon on conservation lands.

The Federal Farm Bill offers a variety of cost-share programs for landowners implementing NRCS practices.

Type(s) of GHG Reductions

CO_2: Indirect sequestration via carbon accumulation in soil.

CO_2, CH_4, N_2O: Reduced through reductions in fossil fuel consumption and potentially reduced fertilizer application.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 (MMtCO_2e), Including Life-Cycle Benefits:
Element A. 0.08, 0.22, respectively.
Element B. 0.05, 0.11, respectively.

Net Cost per tCO_2e, Including Life-Cycle Benefits: Element A. $34; Element B. $23.

GHG Reduction Potential in 2015, 2025 (MMtCO_2e), Not Including Life-Cycle Benefits:
Element A. 0.08, 0.21, respectively.
Element B. 0.05, 0.11, respectively.

Net Cost per tCO_2e, Not Including Life-Cycle Benefits: Element A. $34; Element B. $23.

The above costs and benefits only cover option elements A and B. Element C on wetland expansion/restoration was not quantified due to a lack of information on the carbon dynamics of wetland ecosystems (e.g., soil carbon accumulation rates, methane emissions).

[51] Soil loss tolerance is the maximum amount of soil loss in tons/acre/year that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely (http://www.iwr.msu.edu/rusle/factors.htm).

[52] The "on-off ramp areas" referenced are not within 5 feet of the road itself, but rather the green area between the ramp and the road.

Element A. Increasing Acreage With Permanent Cover

For this element, information on the amount of land available for conversion to permanent cover was lacking (an inventory of such lands is noted above as an important implementation mechanism). For the purposes of quantification, lands with permanent cover are defined as "Other Rural Land" in Michigan. According to the Natural Resources Inventory (NRI), there were 1,841,500 acres of "Other Rural Land" in the state in 2003, so to increase this amount by 10% by 2025 would mean a little over 180,000 acres.[53] "Other Rural Land" is defined as "a *land cover/use* category that includes farmsteads and other farm structures, field windbreaks, barren land, and marshland."[54]

For the purposes of quantifying the benefits of this option element, it was assumed that the 10% increase in permanent cover would occur on agricultural lands that are currently annually tilled (note that the policy targets many other types of lands that are lacking in below- and above-ground carbon stocks). There are several GHG benefits of increasing the acreage of lands with permanent cover. The sequestration benefits of permanent cover were quantified by assuming a constant rate of carbon accumulation of 1 tCO_2e/acre/year.[55] This sequestration rate was applied to acres adopted into the program, as indicated in Table J-5-1.

The benefits from reduced diesel use and reduced fertilizer use were calculated using a methodology similar to that used in the AFW-7 analysis. It was assumed that nitrogen was not applied under the new land use, but was applied in the previous use at a rate of 25 kg/acre,[56] and the average CO_2 emissions factor was 5.82 tCO_2e per metric ton of nitrogen applied based on historical data and the life-cycle emissions factor for nitrogen fertilizer production (i.e., emissions associated with the production, transport, and energy consumption during application).[57] Additional GHG savings from reduced fossil fuel consumption were estimated by

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[53] Natural Resources Conservation Service. "National Resources Inventory. 2003 Annual NRI." February 2007. http://www.nrcs.usda.gov/technical/NRI/2003/Landuse-mrb.pdf.

[54] Natural Resources Conservation Service. "Glossary of Key Terms." Accessed 8/28/08 at: http://www.nrcs.usda.gov/technical/NRI/2001/glossary.html.

[55] Taken from CCX agricultural grass soil carbon sequestration offset project guidelines. Michigan is in zone A. See http://www.chicagoclimatex.com/docs/offsets/Grassland_Conversion_Protocol.pdf.

[56] Based on average fertilizer use (lb/acre) in Michigan (in 2004, 253,432 metric tons of nitrogen were applied in Michigan; total cropland is 10.1 million acres).

[57] The avoided life-cycle GHG emissions (i.e., emissions associated with the production, transport, and energy consumption during application) were taken from Sam Wood and Annette Cowie (2004), *A Review of Greenhouse Gas Emission Factors for Fertiliser Production* Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting. The estimate provided for the United States was 857.5 grams (g) CO_2e per kilogram of nitrogen (kgN), or 0.778 $MtCO_2e$ per metric ton of nitrogen (tN). (taken from T.O. West and G. Marland, "A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States," *Agriculture, Ecosystems & Environment* September 2002:91(1-3):217-232). Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T3Y-46MBDPX10&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=4bf71c930423acddffbcef6d46d763c3)

multiplying the fossil diesel emission factor (12.31 tCO_2e/1,000 gal)[58] by the diesel fuel reduction per acre (3.5 gal/acre).[59]

Table J-5-1. GHG benefits of agriculture land conversion to permanent cover

Year	Land in Program (acres)	Carbon Sequestered ($MMtCO_2e$)	Diesel Fuel Saved (1,000 gallons)	GHG Savings From Diesel Avoided ($MMtCO_2e$)	Amount of Nitrogen Fertilizer Avoided (short tons)	Life-Cycle GHG Emissions Savings ($MMtCO_2e$)	In-State GHG Emissions Savings ($MMtCO_2e$)
2009	0	0.000	0	0.000	0	0.000	0.000
2010	11,509	0.012	40	0.000	318	0.014	0.013
2011	23,019	0.023	81	0.001	637	0.027	0.027
2012	34,528	0.035	121	0.001	955	0.041	0.040
2013	46,038	0.046	161	0.002	1,273	0.055	0.053
2014	57,547	0.058	201	0.002	1,592	0.068	0.067
2015	69,056	0.069	242	0.003	1,910	0.082	0.080
2016	80,566	0.081	282	0.003	2,228	0.096	0.093
2017	92,075	0.092	322	0.004	2,547	0.11	0.107
2018	103,584	0.104	363	0.004	2,865	0.12	0.120
2019	115,094	0.115	403	0.005	3,183	0.14	0.133
2020	126,603	0.127	443	0.005	3,502	0.15	0.147
2021	138,113	0.138	483	0.006	3,820	0.16	0.160
2022	149,622	0.150	524	0.006	4,138	0.18	0.173
2023	161,131	0.161	564	0.007	4,457	0.19	0.187
2024	172,641	0.173	604	0.007	4,775	0.21	0.200
2025	184,150	0.184	645	0.008	5,093	0.22	0.213
Cumulative						**1.9**	**1.8**

In-state emission reductions consider only GHG benefits that will happen in the state of Michigan. Life-cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life-cycle emissions figure is used in the summary table on pages 1 and 2 of this appendix.

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

[58] 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/short/103/30/11206.

[59] Reduction associated with less intensive land use (e.g., fewer passes). The estimate is based on conservation tillage compared with conventional tillage, *What's Conservation Tillage?* Available at http://www.conservationinformation.org/Core4Brochures/CTBrochure.pdf, accessed May 2008.

Element A. Agriculture Land Conversion Costs

The cost of the program was assumed to be constant over the period at $118/acre/year in 2008 dollars.[60] The establishment costs were assumed to be $86/acre. The one-time establishment fee is based on the average establishment costs provided by an Iowa State University study.[61] It is further assumed that the federal government (through USDA) will pay up to 50% of these establishment costs (e.g., cover crop or tree establishment costs. This results in a net establishment cost of $43/acre. Cost savings were also assumed to occur through reduced nutrient application and reduced fuel consumption, using a methodology similar to that applied above.[62] These costs are discounted to 2005 dollars and are assumed to be constant in real terms across the policy period. Costs for each year are indicated in Table J-5-2. Using the cumulative discounted cost estimate of $63 million shown in Table J-5-2 and the cumulative GHG reductions of 1.9 MMtCO_2e shown in Table J-5-1 above yields a cost-effectiveness of $33/t$CO_2$e.

Element B. Retention of Conservation Management Acres

As of June 2008, there were about 260,000 acres of land in CRP protection in Michigan.[63] However, of these acres, approximately 85,000 acres are estimated to be leaving CRP protection and going into agricultural production during the policy period (i.e., through 2025).[64] Therefore, to have 90% of these acres go into a program similar to CRP would mean 76,500 acres under protection that otherwise could be converted to annual cultivation.

There are several GHG benefits of maintaining these lands in conservation programs for permanent cover rather than being annually cultivated. The sequestration benefits of protecting this land were quantified by assuming a constant rate of carbon accumulation of 1 tCO_2e/acre/year.[65] The sequestration rate was applied to acres in the program as indicated in Table J-5-3. There would also be a one-time loss of soil carbon as a result of returning this land into active cultivation. The benefit of this avoided carbon loss is calculated as 4.40 tCO_2e/acre, as indicated by USDA's COMET model.[66] See Table J-5-3 for more information.

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[60] Total continuous CRP land annual payments for Michigan were $117.69 per acre as of May 2008. This payment includes annual incentive and maintenance allowance payments, but not one-time signing and practice incentive payments or payment reductions, such as for lands enrolled less than a full year and lands hayed or grazed (see http://www.fsa.usda.gov/Internet/FSA_File/may2008.pdf).

[61] From "Estimated Costs of Pasture and Hay Production," Iowa State University Extension, November 2000. See http://www.econ.iastate.edu/faculty/duffy/Pages/pastureandhay.pdf.

[62] Assuming an application rate of 25 kg/acre, and multiplying the total fertilizer reduction in each year by the average cost of fertilizer from "2007 Fertilizer Use and Cost," at: www.ers.usda.gov/Data/FertilizerUse/Tables/Fert%20Use%20Table%207.xls. For diesel, the assumed price is $4.13/gal taken from the national average from the EIA gasoline and diesel update (http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp), accessed on August 25, 2008.

[63] NRCS. "CRP Enrollment by State as of June 2008." Accessed 8/25/08 at http://www.fsa.usda.gov/Internet/FSA_File/june2008.pdf

[64] Personal communication with Jim Byrum, August 21, 2008.

[65] Taken from CCX agricultural grass soil carbon sequestration offset project guidelines. Michigan is in zone A. See http://www.chicagoclimatex.com/docs/offsets/Grassland_Conversion_Protocol.pdf.

[66] The COMET model was used to calculate the soil carbon loss that would come from changing from CRP protection into intensive cultivation. Seven Michigan counties (Berrian, Iron, Jackson, Macomb, Saginow, Antrim,

Table J-5-2. Costs of agriculture land conversion

Year	Avoided Cost of Fertilizer (Million $)	Avoided Cost of Diesel (Million $)	Total Costs (Including Conservation Costs, and Establishment Costs) (Million $)	Net Costs (Million $)	Discounted Net Costs (Million $)
2009	$0.0	$0.0	$0.0	$0.0	$0.0
2010	–$0.1	–$0.2	$1.6	$1.3	$1.0
2011	–$0.2	–$0.3	$2.8	$2.2	$1.6
2012	–$0.4	–$0.5	$3.9	$3.1	$2.2
2013	–$0.5	–$0.7	$5.1	$4.0	$2.7
2014	–$0.6	–$0.8	$6.3	$4.8	$3.1
2015	–$0.7	–$1.0	$7.5	$5.7	$3.5
2016	–$0.9	–$1.2	$8.6	$6.6	$3.9
2017	–$1.0	–$1.3	$9.8	$7.5	$4.2
2018	–$1.1	–$1.5	$11.0	$8.4	$4.4
2019	–$1.2	–$1.7	$12.1	$9.2	$4.7
2020	–$1.3	–$1.8	$13.3	$10.1	$4.9
2021	–$1.5	–$2.0	$14.5	$11.0	$5.0
2022	–$1.6	–$2.2	$15.6	$11.9	$5.2
2023	–$1.7	–$2.3	$16.8	$12.8	$5.3
2024	–$1.8	–$2.5	$18.0	$13.6	$5.4
2025	–$2.0	–$2.7	$19.2	$14.5	$5.5
Cumulative				**$127**	**$63**

Table J-5-3. GHG benefits of CRP land protection

Year	Land in Program (Acres)	Carbon Sequestered ($MMtCO_2e$)	GHG Reductions from Diesel Avoided ($MMtCO_2e$)	GHG Emissions Avoided – Reduced N Application ($MMtCO_2e$)	GHG Emissions Avoided From One-Time Plowout ($MMtCO_2e$)	Life-Cycle GHG Emissions Reduced ($MMtCO_2e$)	In-State GHG Emissions Reduced ($MMtCO_2e$)
2009	0	0.000	0.000	0.000	0.00	0.000	0.000
2010	4,781	0.005	0.000	0.001	0.02	0.027	0.027
2011	9,562	0.010	0.000	0.001	0.02	0.032	0.032
2012	14,344	0.014	0.001	0.002	0.02	0.038	0.038
2013	19,125	0.019	0.001	0.003	0.02	0.044	0.043
2014	23,906	0.024	0.001	0.003	0.02	0.049	0.049
2015	28,688	0.029	0.001	0.004	0.02	0.055	0.054
2016	33,469	0.033	0.001	0.005	0.02	0.061	0.060

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and Wexford) were considered in the analysis, with sandy loam soil conditions and a change from CRP to continuous corn. These results ranged from 2.79 to 6.23 tCO_2 lost/acre, and were averaged to be a loss of 4.40 tCO_2/acre.

Year	Land in Program (Acres)	Carbon Sequestered ($MMtCO_2e$)	GHG Reductions from Diesel Avoided ($MMtCO_2e$)	GHG Emissions Avoided – Reduced N Application ($MMtCO_2e$)	GHG Emissions Avoided From One-Time Plowout ($MMtCO_2e$)	Life-Cycle GHG Emissions Reduced ($MMtCO_2e$)	In-State GHG Emissions Reduced ($MMtCO_2e$)
2017	38,250	0.038	0.002	0.006	0.02	0.067	0.065
2018	43,031	0.043	0.002	0.006	0.02	0.072	0.071
2019	47,813	0.048	0.002	0.007	0.02	0.078	0.076
2020	52,594	0.053	0.002	0.008	0.02	0.084	0.082
2021	57,375	0.057	0.002	0.008	0.02	0.089	0.088
2022	62,156	0.062	0.003	0.009	0.02	0.095	0.093
2023	66,938	0.067	0.003	0.010	0.02	0.101	0.099
2024	71,719	0.072	0.003	0.010	0.02	0.106	0.104
2025	76,500	0.077	0.003	0.011	0.02	0.112	0.110
Cumulative						**1.08**	**1.06**

In-state emission reductions consider only GHG benefits that will be realized in the state of Michigan. Life-cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life-cycle emissions figure is used in the summary table on pages 1 and 2 of this appendix.

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

The benefits from reduced diesel and fertilizer use were calculated using a methodology similar to that used in AFW-7. It was assumed that nitrogen was not applied if the lands were retained under conservation, but was applied in the absence of the policy element at a rate of 25 kg/acre,[67] and the average CO_2 emissions factor was 5.82 tCO_2e/ton of nitrogen applied based on historical data and the life-cycle emissions factor for nitrogen production (i.e., emissions associated with the production, transport, and energy consumption during application).[68] Additional GHG savings from reduced fossil fuel consumption were estimated by multiplying the fossil diesel emission factor (12.31 tCO_2e/1,000 gal)[69] by the diesel fuel reduction per acre (3.5 gal/acre).[70]

[67] Based on average fertilizer use (lb/acre) in Michigan (in 2004, was 253,432 metric tons of nitrogen were applied in Michigan; total cropland is 10.1 million acres).

[68] The avoided life-cycle GHG emissions (i.e., emissions associated with the production, transport, and energy consumption during application) were taken from Sam Wood and Annette Cowie (2004), *A Review of Greenhouse Gas Emission Factors for Fertiliser Production,* Research and Development Division, State Forests of New South Wales, Cooperative Research Centre for Greenhouse Accounting. The estimate provided for the United States was 857.5 grams (g) CO_2e per kilogram of nitrogen (kgN) or 0.778 tCO_2e per metric ton of nitrogen (tN) (taken from T.O. West and G. Marland, "A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States," *Agriculture, Ecosystems & Environment* September 2002:91(1-3):217-232). Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T3Y-46MBDPX10&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=4bf71c930423acddffbcef6d46d763c3).

[69] 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/short/103/30/11206.

Element B. Agriculture Land Conversion Costs

The cost of the program was assumed to be constant over the period at $118/acre/year in 2008 dollars.[71] Cost savings were also assumed to occur through reduced nutrient application and reduced fuel consumption, using a similar methodology to that applied to option element A, above.[72] These costs are discounted to 2005 dollars, and are assumed to be constant in real terms across the policy period. The costs for each year are indicated in Table J-5-4. Combining the cumulative GHG reductions from Table J-5-3 and the cumulative discounted costs from Table J-5-4 yields a cost-effectiveness estimate of $267/t$CO_2$e.

Table J-5-4. Costs of CRP land protection

Year	Avoided Cost of Fertilizer (Million $)	Avoided Cost of Diesel (Million $)	Total Conservation Costs (Million $)	Net Costs (Million $)	Discounted Costs (Million $)
2009	$0.0	$0.0	$0.0	$0.0	$0.0
2010	–$0.1	–$0.1	$0.5	$0.4	$0.3
2011	–$0.1	–$0.1	$1.0	$0.7	$0.5
2012	–$0.2	–$0.2	$1.5	$1.1	$0.8
2013	–$0.2	–$0.3	$1.9	$1.5	$1.0
2014	–$0.3	–$0.3	$2.4	$1.8	$1.2
2015	–$0.3	–$0.4	$2.9	$2.2	$1.3
2016	–$0.4	–$0.5	$3.4	$2.6	$1.5
2017	–$0.4	–$0.6	$3.9	$2.9	$1.6
2018	–$0.5	–$0.6	$4.4	$3.3	$1.7
2019	–$0.5	–$0.7	$4.9	$3.7	$1.8
2020	–$0.6	–$0.8	$5.3	$4.0	$1.9
2021	–$0.6	–$0.8	$5.8	$4.4	$2.0
2022	–$0.7	–$0.9	$6.3	$4.8	$2.1
2023	–$0.7	–$1.0	$6.8	$5.1	$2.1
2024	–$0.8	–$1.0	$7.3	$5.5	$2.2
2025	–$0.8	–$1.1	$7.8	$5.9	$2.2
Cumulative				**$50**	**$24**

[70] Reduction associated with less intensive land use (e.g., fewer passes). The estimate is based on conservation tillage compared to conventional tillage, *What's Conservation Tillage?* Available at http://www.conservation information.org/Core4Brochures/CTBrochure.pdf, accessed May 2008.

[71] Total continuous CRP land annual payments for Michigan were $117.69/acre as of May 2008. This payment includes annual incentive and maintenance allowance payments, but not one-time signing and practice incentive payments or payment reductions, such as for lands enrolled less than a full year and lands hayed or grazed (see http://www.fsa.usda.gov/Internet/FSA_File/may2008.pdf).

[72] Assuming an application rate of 25 kg/acre, and multiplying the total fertilizer reduction in each year by the average cost of fertilizer from "2007 Fertilizer Use and Cost," at: www.ers.usda.gov/Data/FertilizerUse/Tables/ Fert%20Use%20Table%207.xls. For diesel, the assumed price is $4.13/gal taken from the national average from the EIA gasoline and diesel update. Accessed on August 25, 2008, at: http://tonto.eia.doe.gov/oog/info/gdu/ gasdiesel.asp.

It should be noted that the financial costs and GHG benefits of increasing the land with permanent cover and decreasing the conversion of land coming out of CRP into annual cultivation are quite similar. The important difference between these two policies is that the protection of CRP lands is preventing a loss in soil carbon, whereas the increase in permanent cover is the addition of a carbon sink. Thus, while the quantification of the benefits may be similar, the implementation of the policies is distinctly different.

Key Assumptions:

It is assumed that land that remains in programs similar to CRP protection will continue to sequester carbon at a constant rate of 1 tCO_2e/acre/year. In addition, the assumption is made that if these lands are not under some sort of protection program, they will be placed under conventional agriculture, with typical rates of diesel fuel consumption and fertilizer use.

Key Uncertainties

None identified.

Additional Benefits and Costs

Additional revenues could be generated for the landowner by selling carbon credits for the emissions savings from agricultural land conversion. Markets such as the CCX could serve this purpose.

Feasibility Issues

None identified.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-6. Forestry and Agricultural Land Protection

Policy Description

Reduce the rate at which agricultural and forestlands and wetlands are converted to developed uses, while protecting private property rights and responsibilities. This retains the above- and below-ground carbon on these lands, as well as the carbon sequestration potential of these lands. Promote the implementation of goals and mechanisms that:

- Reduce agricultural and forestland conversion to non-agriculture or forest through conservation land grants and conservation easements between landowners and governmental and nonprofit land conservation agencies.
- Encourage expanded use of existing available infrastructure and public utilities, and encourage brownfield redevelopment to redirect development away from greenfield forests and farmlands.
- Promote state and federal tax benefits that create incentives for retaining forest and agricultural land uses.
- Promote local, regional, and state markets so landowners have outlets for a variety of products (traditional and/or ecosystem service-based) to provide income streams and incentives to keep working farmlands and forestlands, promote carbon sequestration, and reduce GHG emissions.
- Quantify and retain wetland carbon sequestration capacity.

Note the linkage to AFW-5; also note that this policy has linkage and overlap with TLU-6 (Land Use Planning and Incentives), which includes a provision for "greenfield open land" protection.

Policy Design

Goals: There are three policy elements associated with this option:

A. Reduce the rate of conversion from agriculture to developed use by 50% by 2025.[73]

B. Maintain or increase forestland acreage by 2025, without converting agricultural land to forest, unless it has higher carbon sequestration potential.

C. Protect and restore northern peatlands and other wetlands to prevent releases of GHGs, which will allow existing peatlands to continue to sequester carbon (nonquantified).

Timing: Assumes implementation begins in 2009, and that policy goals are fully achieved by 2025 using a linear ramp-up for each element.

[73] Per direction from the MCAC, the TWG also quantified achieving no net loss of land from agriculture and forestry to developed use by 2025.

Parties Involved: Private landowners; Michigan Forestry Association; MDA, MDNR, and MDEQ; Conservation Districts; Farm Bureau; environmental/sustainability interests; forest industries; People and Land (a Kellogg Foundation-funded organization that tracks progress on the 2003 Michigan Land Use Leadership Conference Report recommendations); American Farmland Trust; Michigan United Conservation Club; The Nature Conservancy, Heart of the Lakes; USFS State and Private Forests and USFS Forest Legacy; Land Policy Institute (MSU supported); MSU Extension.

Other: Smart urban development will have a secondary benefit of reducing GHG emissions.

Implementation Mechanisms

Agricultural and forestland conversion (including unique areas of fruit and vegetable production) may be prevented through conservation land grants and conservation easements facilitated through nonprofit land preservation organizations, policies to discourage green space development, expanded availability of public utilities, and encouragement of urban redevelopment.

- The Farmland and Open Space Preservation Program, commonly known as PA 116, is an effective voluntary method of protecting farmland, while giving farmers needed property tax relief. This program is already effective at improving Michigan's carbon footprint by keeping land in open space. However, additional use of PA 116 is needed by creating additional incentives to maintain and increase participation.
- The Agricultural Preservation Fund (PA 262 of 2000) provides grants to eligible local units of government for the purchase of agricultural conservation easements through Purchase of Development Rights programs to preserve farmland. This program already has a proven track record of reducing carbon emissions by permanently preserving land as open space. However, the Agricultural Preservation Fund is currently not receiving adequate funding. Annual funding sources should not be less than $35,000,000. For long-term funding, a statewide agricultural land conversion fee should be implemented. The fee, based on 5%–7% of market value, should be paid at the time of conversion by the developer who converts the land. Sales where land remains in agriculture would be exempt from the conversion fee as an incentive to keeping land as open space to reduce Michigan's carbon footprint.
- Legislation is needed to establish voluntary Agricultural Security Areas (ASAs) to place a temporary, long-term agricultural conservation easement on farmland. ASAs must be designed to preserve large blocks of farmland by a voluntary, incentive-based contract between the landowner, local unit of government, and state government.

Funding is often the limiting factor in protecting farmland from development. The creative development of farmland protection funding mechanisms at the local and state levels is needed in addition to substantiated concepts (e.g., conversion fees, millage proposals, tax credits, recapture penalties). Other implementation mechanisms include the following:

- Enhance investments in mechanisms with clear points of entry for non-industrial private forest landowners to obtain assistance to facilitate increased participation in forest management.

- Promote local, regional, and state markets so private and public landowners have outlets for a variety of products (traditional and/or ecosystem service-based) to provide income streams and incentives to manage forestlands, promote carbon sequestration, and reduce GHG emissions (e.g., promote enrollment in agriculture and forest carbon trading markets).
- Provide information on current and projected land use for local and regional land use planners.
- Review tax policies and incentives to ensure the support of this policy option's goals.
- Develop policies to encourage expanded use of existing available infrastructure and public utilities and to support brownfield redevelopment.
- Review and promote existing and proposed state and federal tax benefits that create incentives for retaining forest and agricultural land.
- Promote efficient forestry and agriculture production techniques, conservation tillage, and other land conservation practices (e.g., buffer strips and water quality best management practices).
- Promote development of technology and information to enhance the profitability of forestry and agriculture to reduce the likelihood of development.
- Increase the acreage of agriculture, forestry, and wetland conservation land grants and conservation easements to 1.5 million acres by 2025, with priority for areas under significant development pressure.

Related Policies/Programs in Place

Michigan maintains temporary conservation easement on 41,000 farm parcels protecting more than 3.3 million acres of farmland. New applications for the program in 2007 consisted of 360 newly enrolling parcels totaling 28,800 acres. Michigan provides grants to local qualified permanent conservation easement programs to protect farmland. To qualify, local programs must adopt an ordinance and update their long-range plan showing farmland protection areas. Grants have been awarded to 11 local programs for $2.8 million to protect approximately 1,875 acres. Michigan also holds 87 permanent conservation easements protecting 19,000 acres. Other related policies and programs include:

- The Governor sponsored a Blue Ribbon Commission on land use changes in Michigan.
- Michigan has an underfunded purchase of development rights program, where farmers can sell the development rights to their land and thus put it into agricultural production for perpetuity.
- MDNR holds conservation easements on 138,500 acres of forestland for an array of rights, including public recreation, hunting and fishing, and maintenance of forest cover. Additional forest tracts totaling more than 200,000 acres have been identified for their forest and biodiversity values.
- MDNR, in conjunction with the Delta Institute, has launched a pilot project titled "Michigan Forest Carbon Offset and Trading Program." This program allows Michigan forest landowners to document their creation of GHG emission reduction credits from increasing

stored carbon on non-industrial working forests, and earn revenue from their sale on the CCX.

- MDNR administers the Commercial Forest Program and supports local tax offices in the implementation of the Qualified Forest Program. Both of these programs offer tax incentives to landowners to maintain managed forests. MDNR also administers a Forest Stewardship program that distributes federal grants to support private forest landowners to develop stewardship plans that promote sustainable forest management.
- Heart of the Lakes Center for Land Conservation member organizations own or hold easements on 411,517 acres of forests, wetlands, and open lands.
- MDA works in collaboration with the Conservation Districts to provide private forest landowners support related to the implementation of sustainable forest management (presently not funded in the state budget).

Type(s) of GHG Reductions

CO_2: Directly, prevents release of carbon from conversion of forests, wetlands, and agricultural lands to development and maintains annual carbon sequestration from forest growth, thriving wetlands, and productive agricultural lands. Indirectly, reduces urban sprawl, thus avoiding additional emissions from vehicle miles traveled.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$): Element A: 0.46, 1.1, respectively.

Net Cost per tCO_2e: Element A: $86.

The above costs and benefits only cover option element A. Element B on forest protection was not quantified, since the Forestry I&F indicates that Michigan has been gaining forested acreage in recent years. Element C on peatland/wetland protection/restoration was not quantified due to a lack of information on the carbon dynamics of wetland ecosystems (e.g., soil carbon accumulation rates, methane emissions).

Quantification Methods:

Element A. Agricultural Land Protection

Studies are lacking on the changes in below- and above-ground carbon stocks when agricultural land is converted to developed uses. For some land-use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top 8 inches of soil for these graded and covered surfaces would be lost and not replaced. CCS also assumed no change in the levels of above-ground carbon stocks.

The benefit in each year was calculated by:

- Determining the amount of land protected in each year by estimating the annual rate of agricultural land lost (96,187 acres per year, determined from NRI Michigan data)[74] and assuming that agricultural land is protected at an increasing rate up to 2025, where it is assumed that net loss of agricultural land is reduced by 50%.
- Multiplying the soil carbon (C) content (assumed to be 0.017 MMtC per 1,000 acres)[75] on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost).
- Converting the soil carbon lost to CO_2 by multiplying by 44/12.

The GHG benefits are indicated in Table J-6-1. Note that the GHG benefits only include changes to below-ground soil carbon, and the quantification does not include emissions caused by activities associated with the various land uses (e.g., emissions from tractor activities on agricultural land or urban vehicle activity on developed land). Table J-6-2 provides an assessment of the GHG reductions and costs for a no net loss of agricultural lands goal.

Element A. Agriculture Lands Cost

To estimate program costs in each year, the estimated agricultural acres protected from development was multiplied by the conservation cost. The conservation costs were assumed based on the average easement acquisition cost per acre from the USDA ($6,907/acre).[76] This cost of conservation is assumed to remain constant across the policy period. It is further assumed that subsidies are available through the NRCS Farm and Ranch Lands Protection Program[77] for a 50% cost share. The resulting cost-effectiveness is $85/t$CO_2$e. This estimate only accounts for the direct reductions associated with soil carbon losses estimated above, and does not include potentially much larger indirect benefits associated with avoided emissions during land development and additional reductions in vehicle miles traveled that might result from smarter development. The GHG benefits and program costs are summarized in Tables J-6-1 (50% reduction in conversion) and J-6-2 (no net loss of agricultural lands).

The MCAC requested that the quantification of this policy also show the costs and benefits of adopting a no net loss policy for the state of Michigan. This would mean that the implementation path would increase toward 100% in 2025, and the acres and costs of the policy would double. The costs and benefits of this policy are shown in Table J-6-2. These costs and benefits are not reflected in the table at the front of this policy options document; the results from Table J-6-1 are shown instead.

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[74] The most recent NRI data available at the detailed state level is for 1982–1997. It is expected that data up to 2003 will be available later in 2008.

[75] Franzluebbers, A.J., B. Grose, L.L. Hendrix, P.K. Wilkerson, B.G. Brock, "Surface-Soil Properties in Response to Silage Intensity Under No-Tillage Management in the Piedmont of North Carolina," presented at the 25th Southern Conservation Tillage Conference for Sustainable Agriculture, Auburn, AL, June 24–26, 2002.

[76] FY 2007 FRPP [Farm and Ranch Lands Protection Program] Financial Assistance Dollars Obligated and Number of Acres in Program, from http://www.nrcs.usda.gov/programs/frpp/2007_Easements/07FRPPFAOblig.pdf, accessed on 7 August, 2008.

[77] The FRPP provides matching funds (up to 50%) to keep productive farmland and ranchland in agricultural uses. Working through existing programs, USDA partners with state, tribal, or local governments and nongovernmental organizations to acquire conservation easements or other interests in land from landowners.

Table J-6-1. Acreage protected annually and associated avoided emissions and costs under policy implementation

Year	Assumed Level of Goal Achievement (%)	Agricultural Land Protected (acres)	GHG Reduced ($MMtCO_2e$)	Costs (Million $)	Discounted Costs (Million $)
2008	0	—	0.00	$0	$0
2009	3	2,829	0.07	$10	$9
2010	6	5,658	0.13	$20	$18
2011	9	8,487	0.20	$29	$25
2012	12	11,316	0.26	$39	$32
2013	15	14,145	0.33	$49	$38
2014	18	16,974	0.40	$59	$44
2015	21	19,803	0.46	$68	$49
2016	24	22,632	0.53	$78	$53
2017	26	25,461	0.60	$88	$57
2018	29	28,290	0.66	$98	$60
2019	32	31,119	0.73	$107	$63
2020	35	33,948	0.79	$117	$65
2021	38	36,777	0.86	$127	$67
2022	41	39,606	0.93	$137	$69
2023	44	42,435	0.99	$147	$70
2024	47	45,264	1.1	$156	$72
2025	50	48,093	1.1	$166	$72
Totals			**10**	**$1,495**	**$864**

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

Table J-6-2. Acreage protected annually and associated avoided emissions and costs under implementation of a no net loss policy for Michigan agriculture

Year	Assumed Level of Goal Achievement (%)	Agriculture Acres Protected	$MMtCO_2e$ Saved	Costs (Million $)	Discounted Costs (Million $)
2008	0	—	0.00	$0	$0
2009	6	5,658	0.13	$20	$19
2010	12	11,316	0.26	$39	$35
2011	18	16,974	0.40	$59	$51
2012	24	22,632	0.53	$78	$64
2013	29	28,290	0.66	$98	$77
2014	35	33,948	0.79	$117	$87
2015	41	39,606	0.93	$137	$97
2016	47	45,264	1.1	$156	$106
2017	53	50,922	1.2	$176	$113
2018	59	56,580	1.3	$195	$120

Year	Assumed Level of Goal Achievement (%)	Agriculture Acres Protected	$MMtCO_2e$ Saved	Costs (Million $)	Discounted Costs (Million $)
2019	65	62,238	1.5	$215	$126
2020	71	67,896	1.6	$234	$131
2021	76	73,555	1.7	$254	$135
2022	82	79,213	1.9	$274	$138
2023	88	84,871	2.0	$293	$141
2024	94	90,529	2.1	$313	$143
2025	100	96,187	**2.3**	$332	$145
Totals			**20**	**$2,990**	**$1,728**

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

Element B. Forestland Protection

Forestland is currently increasing in extent in Michigan. As a result, it is not possible to quantify the effect of reducing the rate of forest loss. However, the TWG emphasizes the importance of maintaining forest cover in order to avoid substantial loss from forest conversion. AFW-8 quantifies the net effect of increasing the area of land in forest cover (afforestation) and of establishing short-rotation woody crops. This policy (AFW-6b) is not quantified.

Element C. Peatland/Wetland Protection

As mentioned above, this element was not quantified due to a lack of a full understanding of the carbon dynamics of these ecosystems (e.g., carbon sequestration rates, potential for methane emissions).

Key Assumptions:

This policy assumes that below-ground carbon will decrease as a result of land-use change from agricultural to developed use. Above-ground carbon stores are not assumed to change, because the above-ground carbon of both cropland and developed land use are highly uncertain.

Key Uncertainties

None specified.

Additional Benefits and Costs

None identified.

Feasibility Issues

None identified.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-7. Promotion of Farming Practices That Achieve GHG Benefits

Policy Description

Promote farming and food system practices that achieve GHG benefits by promoting technologies and farming practices with the highest proven record of net GHG benefits covering carbon sequestration, energy use, and nutrient consumption. For carbon sequestration, these technologies/practices could include (but are not limited to) conservation tillage, various forms of cover crop management, and crop rotation. Adoption of energy-efficient technologies and practices will also increase the economic sustainability of farms in Michigan. For nutrient management, programs are needed to significantly reduce GHG emissions from conventional agriculture, especially in terms of increasing the efficiency of plant nutrient use.

The carbon footprint of Michigan's various food systems can also be reduced by promoting a range of local, regional, and state programs that encourage "buying local," re-establishing local food infrastructures, reducing food-miles, recycling and/or composting more food wastes, and generally encouraging healthier communities that are more self-reliant, are more sustainable, and have energy-efficient local and regional food economies.

Policy Design

Goals: Increase practices that achieve net GHG benefits with the following four option elements:

A. Increase conservation tillage farming to 4 million acres by 2025.

B. Adopt soil management and nutrient management practices on 5 million acres by 2025.

C. Reduce the net on-farm fossil fuel energy consumption by 50% by 2025.

D. Increase the local/regional purchasing of locally grown agricultural produce and products by 50% by 2025.

Timing: See Goals, above.

Parties Involved:

Conservation Tillage, Soil Management, and Fossil Fuel Energy Efficiency Goals

Agricultural interests; environmental/sustainability interests; relevant state regulatory authorities, and MDA, MDNR, MDLEG, and MEDC; Michigan Food Policy Council; MSU Research and Extension; and USDA NRCS.

Local/Regional Food System

The above parties, plus: Michigan Departments of Transportation and Community Health; Michigan food policy organizations; retailers; farmers' markets; institutional food service providers; hunger organizations; public health agencies; local and regional recycling and composting agencies and interests; local, regional, and state planning and economic development bodies; the County Extension, County Conservation Commissions, and local land and watershed conservation groups.

Other: There are currently 2 million conservation tillage acres in Michigan. As mentioned under the Implementation Mechanisms section below, a strong research and development component will be needed to identify applicable technologies and practices for Michigan's cropping systems in order to achieve the above goals.

Growth in the use of biomass fuels (see AFW-1 and AFW-2) needs to be linked to the health of Michigan's agricultural, food processing, and forest products industries, and to sustainable agricultural and forest management practices. Tax revenue and community wealth will increase due to the retention/capturing of economic activity dollars in regional communities. Regionally directed activity creates tax revenues that can be used to fund GHG reduction incentives.

Implementation Mechanisms

Element A. Soil Carbon Management

- Promote conservation tillage for GHG benefits. High fuel costs are making large-scale operations take another look at reduced tillage.
- Based on existing research, develop and conduct targeted research programs to identify important Michigan crop systems that could achieve soil carbon gains through changes in practices/technology, while still achieving net GHG benefits per unit of output (i.e., taking into consideration soil carbon gains, energy consumption, nutrient/pesticide/herbicide use, etc.). Develop and promote best management practices for Michigan producers that are adapted to regional differences and farming practices.
- Promote applicable farming practices that achieve net GHG benefits by providing technical assistance and financial support for small and medium-size farm operations.
- Promote greater use of MCCI as an additional incentive for adoption of practices that serve to meet the desired goals of this option. The value of carbon credits on the CCX has increased dramatically over the past year.
- Develop assessment models so that growers can make decisions on how they can reduce their carbon footprint. This can be enhanced with support of emerging approaches to increase long-term soil carbon content, such as conservation tillage roller crimpers, which combine winter cover crops with conservation tillage, while reducing or eliminating the need for chemical fertilizers. Also, explore new approaches, like the application of biochar, which may enhance soil carbon stability.
- Work locally through Conservation Districts to get back to basics on equipment and techniques to make conservation tillage successful.

Element B. Soil and Nutrient Management

- Promote better management of the application of crop nutrients by using grid soil testing and variable-rate fertilizer application, and making more use of cover crops and new, slow-release fertilizer products. Using auto steer for application and other field work also maximizes the efficacy of crop nutrients.
- Promote greater use of manure as a crop nutrient. Develop nutrient management plans that avoid runoff and overapplication, provide better crop nutrient analysis for manure use, and encourage professional handling and application.

- Promote MAEAP for livestock and cash crop producers. Soil testing and manure analysis are critical components to emphasize.
- Encourage use of the technical assistance that is available through Certified Crop Advisors and local county Conservation Districts.

Element C. On-Farm Energy Efficiency

- Develop outreach programs to improve on-farm energy efficiency that includes the identification of areas where the greatest savings can be achieved. Examples include the use of more fuel-efficient equipment, more energy-efficient lighting systems, and less energy-intensive irrigation practices.
- Encourage the development and adoption of life-cycle cost-benefit and carbon impact analyses that would be applied to new and current regulations that involve food production and processing.
- Develop an agricultural energy conservation board consisting of farmers with 1,000 acres or more of production, who would to recommend energy-saving plans targeted at large farm operations. Increase the energy efficiency and sustainability of small and mid-size farms by promoting more on-farm and local energy sources (wind and solar), displacement of fossil fuels, and more efficient whole-farm and watershed planning, something facilitated by programs like MAEAP.
- Facilitate technology transfer from universities to the farm to augment carbon footprint reductions. Develop the network locally to put the transfer in place.

Element D. Locally Grown Agricultural Products

- Conduct research to identify areas of the state where local producers are lacking; develop programs to incentivize local production; develop and promote programs to match local consumers (e.g., farmers' markets, institutional buyers) with local producers.
- Develop programs, policies, and legislation to encourage and facilitate the purchase of local agricultural produce and products by local, regional, and state institutions and wholesale and retail firms.
- Develop and support economic development programs to help rebuild their local and regional food infrastructures.
- Develop programs, policies, and legislation to encourage and facilitate the reduction of food-miles and the recycling and/or composting of food wastes, and to generally encourage more sustainable and energy-efficient local and regional food economies.
- Encourage healthier communities that are more self-reliant and more sustainable, and have energy-efficient local and regional food economics.
- Strengthen current efforts by the Michigan Department of Community Health to encourage greater consumption of fruits and vegetables grown in Michigan.

Related Policies/Programs in Place

MAEAP teaches farmers how to identify and prevent environmental risks and comply with state and federal environmental regulations. Farmers who successfully complete the three phases of a MAEAP system are rewarded by becoming verified in that system. It involves a systems approach to environmental stewardship for numerous crops in Michigan, including nutrient and pest management, water use, and soil conservation.

The 2007 Federal Farm Bill offers a variety of cost-share programs for landowners implementing NRCS practices.

MCCI allows Michigan agricultural landowners to earn GHG emission reduction credits through conservation practices, including no-till and strip-till farming, and to earn revenue from the sale of their credits on the CCX.

USDA NRCS offers a variety of cost-share programs for producers who improve their system management by implementing NRCS-approved practice standards.

The Student Organic Farm at MSU exposes students and faculty to organic farming concepts and techniques.

The Farm Energy Audit Program at MSU currently targets Michigan dairy farms by measuring farm energy efficiency.

Michigan's new "Garden for Growth" program is run by the Michigan Land Bank Fast Track Authority, an agency within MDLEG. The program offers individuals and nonprofit organizations leases on vacant parcels of land for $50 per year to create agricultural spaces in their community.

The Michigan Food Policy Council issued a report with recommendations that include preserving farmland, enhancing the viability of small- to mid-scale family farms, increasing markets for organic and sustainably produced food, and increasing access to fresh and healthy Michigan-grown food.[78] Greater use of Michigan-grown food reduces food miles (and their GHG emissions), recycles dollars, and builds healthier and more self-reliant communities.

Michigan Food & Farming Systems (MIFFS), Michigan Organic Food and Farming Alliance, and various regional and local organizations encourage sustainable agriculture as part of local and regional food systems. MIFFS coordinates efforts between the Michigan Farmers' Market Association and MSU to build and publicize farmers' markets around the state.

The Select Michigan Program of MDA seeks to increase awareness and purchases of Michigan locally grown food products, and to increase marketing opportunities for those products.

[78] Michigan Food Policy Council. Report of Recommendations. October 12, 2006. Available at: http://www.michigan.gov/mfpcht.

MDEQ and MSU recently developed an on-farm energy audit program. The state should develop the ranks of this program and build in carbon impact analysis. The state will also need to get the tools in the hands of practitioners who can help with on-farm adjustments.

2007 Farm Bill

Rural Business Enterprise Grants (RBEG) Program

As part of the 2007 Farm Bill, 5% of loans and loan guarantees for rural development in the RBEG program are reserved for entities involved in locally and regionally produced food products. Individuals, cooperatives, and businesses are eligible for the funds and guarantees to "establish and facilitate enterprises that process, distribute, aggregate, store, and market locally or regionally produced" food. Managed through each State Rural Development Department, this broad-based program reaches to the core of rural development in a number of ways. Any project funded under the RBEG program should benefit small and emerging private businesses in rural areas (i.e., businesses that employ 50 or fewer new employees and have less than $1 million in projected gross revenues [http://www.rurdev.usda.gov/rbs/busp/rbeg.htm]).

Rural Cooperative Development Grant (RCDG) Program

RCDGs are awarded for establishing and operating centers for cooperative development for the primary purpose of improving the economic condition of rural areas through the development of new cooperatives and the improvement of operations of existing cooperatives. USDA works to encourage and stimulate the development of effective cooperative organizations in rural America as a part of its total package of rural development efforts (http://www.rurdev.usda.gov/rbs/coops/rcdg/rcdg.htm).

Rural Business Opportunity Grant (RBOG) Program

The RBOG program promotes sustainable economic development in rural communities with exceptional needs by providing training and technical assistance for business development, entrepreneurs, and economic development officials and assisting with economic development planning (http://www.rurdev.usda.gov/rbs/busp/rbog.htm).

Community Food Projects Competitive Grants Program

This program, which has existed since 1996 (http://www.csrees.usda.gov/nea/food/in_focus/hunger_if_competitive.html), offers 1–3-year grants to coalitions of nonprofits to:

- Meet the needs of low-income people by increasing their access to fresher, more nutritious food supplies.
- Increase the self-reliance of communities in providing for their own food needs.
- Promote comprehensive responses to local food, farm, and nutrition issues.
- Meet specific state, local, or neighborhood food and agricultural needs for infrastructure improvement and development.
- Plan for long-term solutions.
- Create innovative marketing activities that mutually benefit agricultural producers and low-income consumers.

Type(s) of GHG Reductions

CO_2, CH_4 and N_2O: Reductions occur through a variety of methods including carbon sequestration in agricultural soils and potentially nitrogen mineralization; reduced life-cycle GHG emissions through lower fuel consumption and nutrient inputs; and reduced nitrous oxide emissions from nitrogen run-off or leaching.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 (MMtCO_2e): Element A. 0.7, 1.7, respectively.
Element B. 0.06, 0.14, respectively.
Element C. 0.16, 0.38, respectively.

Net Cost per tCO_2e: Element A. –\$13; Element B. –\$22; Element C. –\$30.

GHG Reduction Potential in 2015, 2025 (MMtCO_2e), Not Including Life-Cycle Benefits:
Element A. 0.7, 1.7, respectively.
Element B. 0.05, 0.12, respectively.
Element C. 0.13, 0.32, respectively.

Net Cost per tCO_2e, Not Including Life-Cycle Benefits: Element A. –\$13.
Element B. –\$26.
Element C. –\$35.

To maintain consistency with other MCAC recommendations, the above in-state benefits and costs for Elements A through C were used to develop a sector total in the summary table at the front of this appendix.

Element D on development of local food systems was not quantified due to a lack of information on all of the infrastructure needed to establish a local/regional food system in Michigan (e.g., storage, processing, packaging, and distribution). This element requires additional study that was beyond the time and resources available to the TWG. It is being brought forward as a non-quantified policy recommendation.

Data Sources: Data sources used in this assessment are cited in the Quantification Methods section, below.

Quantification Methods:

Element A. Soil Carbon Management

Total cropland in Michigan was estimated at about 8.0 million acres[79] in 2007. For the purposes of this analysis, it is assumed that conservation practices include conservation till (no-till and strip-till), and other conservation farming practices that provide enhanced ground cover, or other crop management practices that achieve similar soil carbon benefits. Common definitions of conservation tillage are systems that leave 50% or more of the soil covered with residue. In this

[79] USDA. State Fact Sheet—Michigan. Accessed August 28, 2008, at: http://www.ers.usda.gov/statefacts/mi.htm.

policy, CCS is using the definition of the Conservation Technology Information Center (CTIC).[80]

Based on the policy design parameters, the schedule for acres to be put into conservation tillage cultivation is displayed in Table J-7-1. This table represents the percentage of cropland covered by the policy design. The Michigan data came from the CTIC's National Crop Residue Management Surveys.[81]

It is assumed that the sequestration rate provided by the CCX for the carbon credit program is reliable for the state of Michigan. It is also assumed that 50% of Michigan is in Zone A (0.6 tCO_2/acre/year), and 50% is in Zone B (0.4 tCO_2/acre/year); therefore, an average of the two (0.5 tCO_2/acre/year) is used for the state as a whole.[82] Finally, it is assumed that this rate of accumulation occurs for 20 years, which extends beyond the policy period. Currently, 1.83 million acres of Michigan cropland are using conservation tillage practices.[83] Therefore, to reach the goal of 5 million total acres, 3.17 million acres of additional conservation tillage are needed. See Table J-7-1 for more information.

Additional GHG savings from reduced fossil fuel consumption are estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate. The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gal/acre.[84] The life-cycle fossil diesel GHG emission factor of 12.31 tCO_2e/1,000 gal was used.[85] Results are shown in Table J-7-1, along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

The costs of adopting soil management practices (e.g., conservation tillage/no-till practices) are based on cost estimates from the Minnesota Agriculture Best Management Practices (AgBMP)

[80] The definitions of tillage practices from the CTIC are used under this policy. However, only no-till/strip-till and ridge-till are considered "conservation tillage" practices. No-till means leaving the residue from last year's crop undisturbed until planting. Strip-till means no more than one-third of the row width is disturbed with a coulter, residue manager, or specialized shank that creates a strip. If shanks are used, nutrients may be injected at the same time. Ridge-till means that 4–6-inch-high ridges are formed at cultivation. Planters using specialized attachments scrape off the top 2 inches of the ridge before placing the seed in the ground.

[81] Iowa State University, Agronomy Department. "Residue Remaining After Planting, All Tillage Practices: Totals for United States—Annual Crops." Sourced from the Conservation Technology Information Center, National Crop Residue Management Surveys. Available at: http://extension.agron.iastate.edu/soils/pdfs/CTIC/cticus1.pdf.

[82] Chicago Climate Exchange. Agricultural Soil Carbon Offsets. Available at: http://www.chicagoclimatex.com/content.jsf?id=781.

[83] 1998 data from Conservation Technology Information Center (includes No-Till and Ridge-Till tillage practices). Available at: http://www.conservationinformation.org/index.asp?site=1&action=crm_results

[84] Reduction associated with conservation tillage compared with conventional tillage. See: Conservation Technology Information Center. "Reductions Associated With Conservation Tillage Compared With Conventional Tillage." Available at: http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html.

[85] Life-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* July 25, 2006;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.

Program.[86] This program provides farmers a low-interest loan as an incentive to initiate or improve their current tillage practices. The equipment funded is generally specialized tillage or planting implements that leave crop residues covering at least 15%–30% of the ground after planting. The average total cost for this equipment is $23,000, though the average loan for tillage equipment is $16,000. The average-size farm using an AgBMP loan to purchase conservation tillage equipment is 984 acres. The average loan size was determined based on the average size of a farm in Michigan (191 acres),[87] and the amount of a loan per acre as estimated in the Minnesota AgBMP Program ($16.26/acre).[88] This put the average loan size at $3,106 to finance no-till/conservation tillage practices. This loan payment was applied to each new acre entering the program to determine an approximate cost of encouraging the use of soil management practices. The cost savings for this program comes from reduced diesel fuel costs. The cost-effectiveness for this option element of –$167/t$CO_2$e was derived by dividing the cumulative discounted costs shown in Table J-7-2 by the cumulative GHG reductions shown in Table J-7-1.

Table J-7-1. GHG reductions from conservation tillage practices

Year	Acres Under Conservation Tillage (%)	New Land Under Conservation Tillage (acres)	Carbon Sequestered (tCO_2e)	Diesel Saved (1,000 gal)	GHGs Reduced From Diesel Avoided (tCO_2e)	Life Cycle GHGs Reduced Annually (MMtCO_2e)	In-State GHGs Reduced Annually (MMtCO_2e)
2008	0	0					
2009	4	119,284	0.060	417	0.005	0.065	0.06
2010	12	383,784	0.19	1,343	0.017	0.21	0.21
2011	18	570,490	0.29	1,997	0.025	0.31	0.31
2012	24	757,196	0.38	2,650	0.033	0.41	0.41
2013	30	943,902	0.47	3,304	0.041	0.51	0.51
2014	36	1,130,608	0.57	3,957	0.049	0.61	0.61
2015	42	1,317,314	0.66	4,611	0.057	0.72	0.71
2016	47	1,504,020	0.75	5,264	0.065	0.82	0.81
2017	53	1,690,725	0.85	5,918	0.073	0.92	0.91
2018	59	1,877,431	0.94	6,571	0.081	1.02	1.01
2019	65	2,064,137	1.0	7,224	0.089	1.12	1.11
2020	71	2,250,843	1.1	7,878	0.097	1.22	1.21
2021	77	2,437,549	1.2	8,531	0.10	1.32	1.31
2022	83	2,624,255	1.3	9,185	0.11	1.43	1.41
2023	89	2,810,961	1.4	9,838	0.12	1.53	1.51
2024	94	2,997,667	1.5	10,492	0.13	1.63	1.61

[86] Minnesota Department of Agriculture, *Agricultural Best Management Practices Loan Program State Revolving Fund Status Report*, February 28, 2006.

[87] USDA, National Agricultural Statistical Service. "Michigan State Agriculture Overview—2007." 2008. Accessed July 21, 2008, at: http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/MichiganFactSheets/STHILGTS.pdf.

[88] Minnesota Department of Agriculture, *Agricultural Best Management Practices Loan Program State Revolving Fund Status Report*, February 28, 2006.

2025	100	3,174,000	1.587	11,109	0.14	1.72	1.70
Total						**15.6**	**15.4**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; tCO_2e = metric tons of carbon dioxide equivalent; gal = gallon. In-state emission reductions consider only GHG benefits that will happen in the state of Michigan. Life-cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life-cycle emissions figure is used in the summary table on pages 1 and 2 of this policy options document.

Table J-7-2. Costs of the conservation tillage program

Year	Cost of Loan	Cost Savings of Program	Total Costs of Program	Discounted Costs of Program
2008	$0	$0	$0	$0
2009	$1,939,563	–$1,695,030	$244,533	$201,178
2010	$4,300,770	–$5,453,575	–$1,152,805	–$903,253
2011	$3,035,838	–$8,106,666	–$5,070,828	–$3,783,930
2012	$3,035,838	–$10,759,756	–$7,723,919	–$5,489,245
2013	$3,035,838	–$13,412,847	–$10,377,009	–$7,023,568
2014	$3,035,838	–$16,065,937	–$13,030,100	–$8,399,319
2015	$3,035,838	–$18,719,028	–$15,683,190	–$9,628,118
2016	$3,035,838	–$21,372,119	–$18,336,281	–$10,720,844
2017	$3,035,838	–$24,025,209	–$20,989,372	–$11,687,667
2018	$3,035,838	–$26,678,300	–$23,642,462	–$12,538,102
2019	$3,035,838	–$29,331,390	–$26,295,553	–$13,281,041
2020	$3,035,838	–$31,984,481	–$28,948,643	–$13,924,792
2021	$3,035,838	–$34,637,572	–$31,601,734	–$14,477,118
2022	$3,035,838	–$37,290,662	–$34,254,825	–$14,945,266
2023	$3,035,838	–$39,943,753	–$36,907,915	–$15,336,001
2024	$3,035,838	–$42,596,843	–$39,561,006	–$15,655,633
2025	$2,867,180	–$45,102,540	–$42,235,360	–$15,918,063
Total				**–$173,510,784**

Element B. Nutrient Efficiency GHG Benefits

The GHG benefits of this policy are quantified by calculating the CO_2e emissions/kgN applied in Michigan. This uses a figure of the nitrogen emissions from fertilizer (4.96 $kgCO_2e$/kgN applied), calculated from the Michigan I&F. This is then combined with a figure for the life-cycle emissions of nitrogen fertilizer (0.857 $kgCO_2e$/kgN).[89] These life-cycle emissions include emissions that come from the production and transport of fertilizer. Thus, the total CO_2e emissions in Michigan are 5.82 $kgCO_2e$/kgN applied. The BAU estimate of nitrogen fertilizer

[89] T.O. West and G. Marland. "A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States." *Agriculture, Ecosystems & Environment* September 2002:91(1-3):217-232. Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T3Y-46MBDPX10&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=4bf71c930423acddffbcef6d46d763c3.

use in the I&F assumes constant rates of nitrogen application from 2005. The goal is to improve nutrient efficiency on 5 million acres by 2025 (i.e., lower nutrient use per unit of crop production). Improved management practices are assumed to increase nutrient efficiency by 15% compared to the BAU estimate. This reduction of nitrogen application is then multiplied by the nitrogen emissions factor to determine the GHG benefits of this policy. Table J-7-3 presents the nitrogen reductions and the GHG benefits of the proposed nutrient efficiency policy.

Table J-7-3. GHG emissions from the proposed nutrient efficiency policy

Year	MI Baseline Fertilizer Use (metric tons N)	Acres Within Program	N Fertilizer Reduction (metric tons N)	Life-Cycle Emission Reductions ($MMtCO_2e$)	In-State Emission Reductions ($MMtCO_2e$)
2008	253,432	0	0	0.00	0
2009	253,432	294,118	1,401	0.01	0.01
2010	253,432	588,235	2,802	0.02	0.01
2011	253,432	882,353	4,203	0.02	0.02
2012	253,432	1,176,471	5,604	0.03	0.03
2013	253,432	1,470,588	7,006	0.04	0.03
2014	253,432	1,764,706	8,407	0.05	0.04
2015	253,432	2,058,824	9,808	0.06	0.05
2016	253,432	2,352,941	11,209	0.07	0.06
2017	253,432	2,647,059	12,610	0.07	0.06
2018	253,432	2,941,176	14,011	0.08	0.07
2019	253,432	3,235,294	15,412	0.09	0.08
2020	253,432	3,529,412	16,813	0.10	0.08
2021	253,432	3,823,529	18,214	0.11	0.09
2022	253,432	4,117,647	19,615	0.11	0.10
2023	253,432	4,411,765	21,017	0.12	0.10
2024	253,432	4,705,882	22,418	0.13	0.11
2025	253,432	5,000,000	23,819	0.14	0.12
Total				**1.3**	**1.1**

MI = Michigan; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; N = nitrogen. In-state emissions reductions consider only GHG benefits that will happen in the state of Michigan. Life-cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life-cycle emissions figure is used in the summary table on pages 1 and 2 of this appendix.

Element B. Nutrient Efficiency Costs

The costs of the nutrient efficiency policy were estimated based on the implementation of a soil-testing policy to optimize fertilizer application. This policy assumes a $20 cost to test a 75-acre field, with the field tested every 5 years, across all of Michigan. There are also staffing costs for the testing and information program ($500,000/year) and costs of preparing a guidance document ($150,000). Subtracted from these costs are the savings from reduced fertilizer use, which results in a net savings over the policy period. The cost of fertilizer used ($385/ton) in the analysis comes from the USDA April 2007 estimate.[90] See Table J-7-4 for more details. The cost-effectiveness estimate of –\$21/tCO_2e was derived by dividing the cumulative discounted costs by the cumulative reductions shown in Table J-7-3.

Table J-7-4. Costs of nutrient efficiency program

Year	Target Fertilizer Reduction (kg N)	Annual Cost of Fertilizer Programs ($MM)	Avoided Cost of Fertilizer ($MM)	Net Cost ($MM)	Discounted Cost ($MM)
2008	0	$0.00	$0.00	$0.00	$0.00
2009	1,401	$1.70	–$0.54	$1.16	$0.96
2010	2,802	$1.55	–$1.08	$0.48	$0.37
2011	4,203	$1.55	–$1.62	–$0.06	–$0.05
2012	5,604	$1.55	–$2.16	–$0.60	–$0.43
2013	7,006	$1.55	–$2.69	–$1.14	–$0.77
2014	8,407	$1.55	–$3.23	–$1.68	–$1.08
2015	9,808	$1.55	–$3.77	–$2.22	–$1.36
2016	11,209	$1.55	–$4.31	–$2.76	–$1.61
2017	12,610	$1.55	–$4.85	–$3.30	–$1.84
2018	14,011	$1.55	–$5.39	–$3.84	–$2.03
2019	15,412	$1.55	–$5.93	–$4.37	–$2.21
2020	16,813	$1.55	–$6.47	–$4.91	–$2.36
2021	18,214	$1.55	–$7.01	–$5.45	–$2.50
2022	19,615	$1.55	–$7.54	–$5.99	–$2.61
2023	21,017	$1.55	–$8.08	–$6.53	–$2.71
2024	22,418	$1.55	–$8.62	–-$7.07	–$2.80
2025	23,819	$1.55	–$9.16	–$7.61	–$2.87
Total					**–$27.2**

kg = kilogram; N = nitrogen; $MM = millions of dollars.

Element C. Energy Efficiency GHG Benefits

This analysis considers the costs and benefits of improving the efficiency of diesel water pumps as one technology possibility available to reduce on-farm fossil fuel consumption. Other options, such as efficient grain dryers and more efficient electric motors are most likely available to provide GHG benefits, and would be utilized after farms have undertaken an energy audit. The GHG benefits were calculated based on the avoided emissions from these new technologies. The total GHG benefit was calculated based on the emissions factor for diesel fuel (CO_2e/Btu or CO_2e/gal. The BAU fuel use was derived by dividing the average of farm fuel costs sold in agricultural use in Michigan and Ohio (from USDA)[91] by the cost of a gallon of diesel fuel in the

[90] USDA, Economic Research Service. U.S. Fertilizer Use and Price. Accessed on July 17, 2008, at: http://www.ers.usda.gov/Data/FertilizerUse/Tables/.

[91] USDA. Accessed August 8, 2008, at: http://usda.mannlib.cornell.edu/usda/current/FarmProdEx/FarmProdEx-08-02-2007.pdf.

Midwest in 2006 (from EIA).[92] This was then multiplied by the number of farms in Michigan[93] to determine the total number of diesel gallons used on farms in Michigan. No growth in diesel fuel consumption was assumed because of conflicting growth estimates.

The savings for the energy efficiency technologies considered did not meet the goal of the policy, so an energy audit program was also included. This program will provide state funding for energy audits to improve the energy efficiency of farms across Michigan. It is assumed that these audit programs will find energy efficiency gains at a similar cost/benefit to that of the efficiency technologies considered in this analysis, and will allow the goal of a 50% reduction in fossil fuel use to be met. Note that Element A of this policy covering conservation tillage or other soil carbon management practices will also result in fuel savings. The analysis performed here assumes that reductions in fuel consumption occurring in Element A should also be considered toward the goal of reducing on-farm fuel consumption by 50%. Therefore, the diesel reductions necessary for Element C are reduced by the amount of fuel reductions achieved by Element A (to avoid double counting).

This analysis was conducted by examining the cost of one energy efficiency improvement (more efficient diesel pumps). To maximize pump efficiency, the pumps must be tested and replaced periodically, which requires a capital investment. The cost of diesel fuel is assumed to be $4.06.[94] Table J-7-5 shows the costs and GHG benefits of improving the efficiency of diesel irrigation pumps. The Policy Path column shown in J-Table 7-5 represents the percentage of all diesel fuel pumps in the state that have been converted to higher-efficiency pumps. Because it is not realistic to assume that all pumps in Michigan will be replaced with more efficient models, this number approaches 90% by 2025.

Improved efficiency of diesel pumps is representative of the type of efficiency improvement that could be recommended from the energy audit. While other energy efficiency investments are likely to be different from this particular technology, it is assumed that other efficiency improvements can be made at a similar cost and GHG benefit.

The additional cost of the energy audit program is included to encourage the adoption of these types of energy efficiency improvements. The cost of the program is assumed to be $500,000 annually for staffing/travel costs, and $1,000 for every energy audit performed.[95] The number of energy audits performed depends on the amount of energy savings required to meet the energy efficiency goal for the year. Since the diesel pump efficiency program has net cost savings, the money spent on the energy audit program is recouped throughout the period. Table J-7-6 shows the costs and savings from the energy audit. The costs and savings from the energy efficiency programs are discounted back to 2005 dollars. While the costs of one energy efficiency program

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[92] U.S. DOE EIA. "Real Prices for Diesel." Accessed August 8, 2008, at: http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_a_epd2d_pte_cpgal_a.htm.

[93] USDA National Agricultural Statistics Service (NASS), Michigan 2006–2007 Highlights. Accessed August 8, 2008, at: http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/MichiganFactSheets/STHILGTS.pdf.

[94] From U.S. DOE EIA. Accessed July 10, 2008, at: http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp.

[95] This estimate comes from personal communication with Heath Elson, Iowa Soybean Association (ISA). ISA conducted an energy audit program in Iowa where consultants were paid $500 to work with local farmers on reducing field energy use. This estimate was doubled to account for auditing potential building/storage energy use.

(diesel pumps) was shown in Table J-7-5, Table J-7-6 shows the costs of the entire energy efficiency program, including the energy audit and all of the costs/savings that come from a variety of other energy efficiency improvements.

Table J-7-5. Example of one energy efficiency program: improving the efficiency of diesel pumps

Year	Policy Path (%)	Diesel Fuel Reduced (gallons)	Program Costs	Cost Savings	Net Cost	Metric Tons CO_2e Reduced From Fuel Savings
2008	0	—	$0	$0	$0	0
2009	10	29,961	$115,815	$121,641	–$5,825	301
2010	15	44,941	$135,073	$182,461	–$47,388	451
2011	20	59,922	$154,331	$243,282	–$88,951	602
2012	25	74,902	$173,589	$304,102	–$130,513	752
2013	30	89,882	$192,846	$364,922	–$172,076	903
2014	35	104,863	$212,104	$425,743	–$213,639	1,053
2015	40	119,843	$231,362	$486,563	–$255,201	1,204
2016	45	134,824	$250,620	$547,384	–$296,764	1,354
2017	50	149,804	$269,877	$608,204	–$338,327	1,505
2018	55	164,784	$289,135	$669,025	–$379,889	1,655
2019	60	179,765	$308,393	$729,845	–$421,452	1,806
2020	65	194,745	$327,651	$790,665	–$463,015	1,956
2021	70	209,726	$346,908	$851,486	–$504,577	2,107
2022	75	224,706	$366,166	$912,306	–$546,140	2,257
2023	80	239,686	$385,424	$973,127	–$587,703	2,408
2024	85	254,667	$404,682	$1,033,947	–$629,265	2,558
2025	90	269,647	$423,939	$1,094,767	–$670,828	2,709

Note: Net costs are program costs, less cost savings.

CO_2e = carbon dioxide equivalent.

Using estimates of the total number of pumps potentially available in Michigan, the total costs of the energy efficiency program were estimated. This total cost figure was balanced against the fuel savings that occur with such an efficiency investment. The diesel pump program includes the costs of testing ($200/test, one test assumed every 5 years) and the cost of retrofitting older pumps to be more efficient ($24,913).[96] Since this results in an average efficiency improvement of 19%, it will on average save over 23,000 gallons of fuel during the lifetime of the pump.

[96] U.S. Environmental Protection Agency. October 2006. "Diesel Pumping Efficiency Program." Available at: http://www.pumpefficiency.org/About/literature/Final%20Diesel%20Pumping%20Efficiency%20Report,%20USEPA.doc.

Table J-7-6. GHG benefits and costs from an energy efficiency program

Year	Diesel Reduced (gallons)	Life-Cycle GHG Reduced ($MMtCO_2e$)	In-State GHG Reduced ($MMtCO_2e$)	Cost Savings From Energy Efficiency	Energy Audit Program Costs	Discounted Net Costs (million $)
2008	0	0	0	$0	$0	$0.0
2009	2,042,830	0.03	0.02	–$4,597,810	$11,300,000	$5.5
2010	3,577,405	0.04	0.04	–$8,069,137	$11,100,000	$2.3
2011	5,384,259	0.07	0.06	–$12,162,543	$11,100,000	–$0.9
2012	7,191,114	0.09	0.08	–$16,255,950	$11,100,000	–$3.8
2013	8,997,968	0.11	0.09	–$20,349,356	$11,100,000	–$6.4
2014	10,804,822	0.13	0.11	–$24,442,762	$11,100,000	–$8.7
2015	12,611,677	0.16	0.13	–$28,536,169	$11,100,000	–$10.9
2016	14,418,531	0.18	0.15	–$32,629,575	$11,100,000	–$12.8
2017	16,225,386	0.20	0.17	–$36,722,981	$11,100,000	–$14.5
2018	18,032,240	0.22	0.19	–$40,816,388	$11,100,000	–$16.0
2019	19,839,094	0.24	0.21	–$44,909,794	$11,100,000	–$17.3
2020	21,645,949	0.27	0.23	–$49,003,200	$11,100,000	–$18.5
2021	23,452,803	0.29	0.25	–$53,096,607	$11,100,000	–$19.5
2022	25,259,657	0.31	0.26	–$57,190,013	$11,100,000	–$20.4
2023	27,066,512	0.33	0.28	–$61,283,419	$11,100,000	–$21.1
2024	28,873,366	0.36	0.30	–$65,376,826	$11,100,000	–$21.7
2025	30,716,524	0.38	0.32	–$69,553,176	$11,100,000	–$22.3
Total		**3.4**	**2.9**			**–$102**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent. In-state emission reductions consider only GHG benefits that will happen in the state of Michigan. Life-cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life-cycle emissions figure is used in the summary table on pages 1 and 2 of this appendix.

References for Locally Grown Agricultural Products

The following useful reference sources related to locally grown agricultural products were identified:

- Martin Heller and Gregory Keolian,. "Life Cycle-Based Sustainability Indicators for Assessment of the U.S. Food System." University of Michigan Center for Sustainable Systems. December 2000.
- Michigan Land Use Institute and The Mott Group. "Eat Fresh and Grow Jobs, Michigan." September 2006.
- Christopher L. Weber and H. Scott Matthews. "Food-Miles and the Relative Climate Impacts of Food Choices in the United States." *Environmental Science & Technology* 2008:42(10).

A full assessment of the infrastructure needs to create a locally or regionally sourced food system in Michigan was beyond the time and resources available to the MCAC process. Beyond measures needed to increase local crop production and local consumption of these crops, additional infrastructure needed will most likely include some or all of the following: storage and distribution facilities, food processing and packaging facilities, and meat and poultry processing facilities. A full assessment for Michigan is needed to identify the types of agricultural commodities that could be produced, processed, packaged, and distributed in the state or region; incentives needed to establish the local producers and build the needed infrastructure; and programs needed to increase demand of locally or regionally produced items (possibly in coordination with nearby states/provinces).

Key Assumptions:

Under Element A, the conservation tillage policy assumes that the switch to conservation tillage farming practices can occur without a loss to yield. In addition, it assumes that equipment loan subsidies like those in Minnesota will be made available in Michigan.

Under Element B, the nutrient efficiency policy assumes that fertilizer use can be reduced without a decrease in yield. Alternatively, if the same amount of nitrogen is used to produce more of a given crop, then less of that crop will need to be grown elsewhere (potentially even outside of the state). Hence, using this logic, emissions could be offset either inside or outside of the state. BAU fertilizer application rates are assumed under historic fertilizer costs. The current ramp-up in energy and fertilizer costs may substantially alter BAU application rates.

In addition, the analysis of Element B assumes that nitrogen application can be reduced through improved management practices without having a negative impact on yield. If this is not the case, the costs of this policy are likely to increase significantly.

Key Uncertainties

Impacts on trade are uncertain. Increasing domestic budgetary pressures on U.S. commodity subsidies, along with the June 2008 WTO ruling that Brazil can seek $4 billion in retaliation against U.S. cotton subsidies, suggest a high probability of major changes occurring in subsidy programs over the next 10 years. In addition, current international turmoil in finance, trade, and aid, as well as energy and commodity prices, makes it unclear how the agricultural sector will fare in the next decade and how it will being restructured.

Element D. Locally Grown Agricultural Products

- Established agriculture businesses might not see the value of emerging regional food markets and potential GHG reduction strategies.
- The price of regional food system products, without early government incentives, will inhibit the growth and acceptance of these foods.
- Seasonality and volume constraints will inhibit significant GHG reductions.
- Additional tax revenue generated from local economic food system activity will not be utilized to incentivize the growth and success of an integrated regional food system, and/or government will not direct appropriate spending at critical growth stages to allow emerging markets to reach critical mass.

Additional Benefits and Costs

Element D. Locally Grown Agricultural Products

- In addition to emission reductions due to reduced transportation, other environmental and economic benefits associated with localizing packaging, refrigeration, storage, and processing may be realized through the implementation of this option.
- A plethora of additional direct and indirect social, health, and economic benefits are accrued from marketing local goods, including a potential for reduction in packaging and the GHGs associated with its production and management as a waste.
- Shortening the supply chain and distance between producer and consumer puts more money directly in the pockets of producers within the community. The community benefits from this localized exchange by keeping dollars circulating within the community, instead of being a net exporter of capital.
- Research suggests that fresh produce can contain higher nutritional content than older produce, contributing to more robust health. Consumers concerned about food-growing practices and handling can inquire directly from producers.
- Tax revenue and community wealth will increase due to the retention/capturing of economic activity dollars in regional communities. Regionally directed activity creates tax revenue that can be used to fund GHG reduction incentives.
- A regional food system can assist food security and risk mitigation strategies by decentralizing food production, thereby reducing the impact of any crop failure, disease, or terrorist attack on the national food supply.

Feasibility Issues

Elements A Through C and the Use of Organic Farming Methods

Organic farming methods were considered for achieving the soil carbon management, nutrient management, and energy efficiency goals of this policy. However, sufficient information on the net GHG benefits of organic farming was not identified to create either a specific organic farming goal or implementation mechanisms featuring organic farming that would support the overall goals of Elements A through C. Studies have shown that organic farming methods can build soil carbon and reduce the use of conventional fertilizers.[97] On the other hand, there is also a potential for higher fuel consumption (potentially associated with higher mechanical cultivation requirements in place of chemical application), and a potential for lower yields in some cases, as compared to conventional production. There is also limited information on large-scale organic farming systems and their net GHG impacts. A recent study conducted in the United Kingdom that addressed life-cycle GHG emissions concluded that the net benefits of

[97] A comparative study of long-term trials conducted in six different regions concluded: "Use of organic farming practices increased the soil organic carbon (SOC) concentrations of surface soils by 14% compared with conventional counterparts." E. Marriott and M.M. Wander, "Total and Labile Soil Organic Matter in Organic and Conventional Farming Systems," *Soil Science Society of America Journal* 70:950-959. Trials conducted at Michigan's Kellogg Biological Station were included. See A.S. Grandy and G.P Robertson, "Land-Use Intensity Effects on Soil Organic Carbon Accumulation Rates and Mechanisms." *Ecosystems* 10(2007):58-73.

organic systems are not clear due to the issues noted above.[98] However, a 2007 International Trade Center report described "the considerable potential of organic agriculture for reducing emissions of greenhouse gases and its contribution to sequestration of CO_2 in the soil."[99] A systematic study of Michigan's major agricultural crop systems and the application of organic farming methods to these systems is needed to address the potential for the net GHG benefits of organic farming in Michigan.

Element D. Locally Grown Agricultural Products

The ability to produce some goods locally may be limited, given the local conditions, such as local land quality (e.g., soil fertility), local climate (e.g., precipitation), available infrastructure (e.g., transportation network), and/or the willingness of consumers to buy local produce.

Given the regional diversity of Michigan's waters, soils, local climates, farms, forests, and fisheries and the contextual nature of sustainable practices, it may be necessary to establish ongoing sustainability work groups at the state and/or regional level. These will serve to establish and monitor the benchmarks required to sustain the ecological, social, and economic health of each of Michigan's regions.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

[98] "Environmental Impacts of Food Production and Consumption," Manchester Business School, prepared for the Department for Environment, Food and Rural Affairs, December 2006. Available at: http://www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf.

[99] International Trade Center. *Organic Farming and Climate Change*. Technical Report, 2007. Available at: http://www.intracen.org/Organics/documents/Organic_Farming_and_Climate_Change.pdf.

AFW-8. Forest Management for Carbon Sequestration and Biodiversity

Policy Description

Michigan's forests—whether they are public or private, urban, managed or wild—provide many carbon sequestration and other natural resource benefits, such as biodiversity, water quality, wildlife habitat, and recreational opportunity. Policies should be implemented that:

- Promote forest management activities that maintain and enhance forest health, productivity, and carbon sequestration in forest biomass and soils and in harvested wood products, while sustaining biodiversity and other natural resource benefits.
- Promote local, regional, and state markets, so landowners have outlets for a variety of products (traditional and/or ecosystem service-based) to provide income streams and incentives to manage forestlands, promote carbon sequestration, and reduce GHG emissions.
- Protect and enhance the carbon stored in tree biomass by maintaining and improving forest health and canopy cover in urban and residential areas. Emission reductions from reduced heating and cooling resulting from increased canopy cover will be a co-benefit.
- Maintain the carbon sequestration potential of forests through reduction of the potential and severity of wildfires and associated GHG emissions.

Policy Design

Goals: This policy includes the following three elements:

A. Enhance forestland management (including improved stocking of understocked stands) across the state on 1 million acres through afforestation and reforestation by 2025.

B. Achieve 40% canopy cover in urban communities by 2025.

C. Implement wildfire reduction community-wide protection plans for 10–12 identified communities at risk by 2025.

Timing: Implementation beginning in 2010, with full level of implementation achieved by 2025.

Parties Involved: Private landowners; Michigan Forestry Association; MDA; Conservation Districts; environmental/sustainability interests; forest industries; People and Land (a Kellogg Foundation-funded organization that tracks progress on the 2003 Michigan Land Use Leadership Conference Report recommendations); The Global Observatory for Ecosystem Services; Michigan United Conservation Club; The Nature Conservancy; USFS State and Private Forests; MSU Extension; Farm Bureau; carbon traders.

Other: Note that plantations of native trees should be encouraged—not fast-growing trees from Southeast Asia.

Implementation Mechanisms

- Develop the scientific foundation related to carbon sequestration practices in forestlands, associated life-cycle analyses that consider the end use of various forest products, and the long-term impacts of climate change on Michigan's forests.
- Enhance investments in mechanisms with clear points of entry for non-industrial private forest landowners to obtain assistance to facilitate increased participation in forest management.
- Develop information related to improving carbon sequestration in a manner that improves forest health and productivity, while sustaining biodiversity and other natural resource benefits.
- Look for opportunities and provide necessary resources to improve forest health and productivity on state-owned forests, as described in the State Forest Management Plan, and supporting projects identified by the Michigan Forest Finance Authority.
- Document the long-term impacts of climate change on Michigan forests.
- Promote local, regional, and state markets so private and public landowners have outlets for a variety of products (traditional and/or ecosystem service-based) to provide income streams and incentives to manage forestlands, promote carbon sequestration, and reduce GHG emissions. (For example, promote enrollment in agriculture and forest carbon trading markets.)
- In terms of forestry, change current programs to offer new initiatives that provide landowners incentives to improve forest resources, encourage proper management, promote sustainability of forestlands, and benefit the forest products industry. Practices may include increased stocking of poorly stocked lands, thinning and density management, fertilization and waste recycling, expanded short-rotation woody crops (for fiber and energy), expanded use of genetically preferred species, modified biomass removal practices, fire management and risk reduction, pest and disease management, and promoting biodiversity of forests to improve ecosystem services and sustainability.

Related Policies/Programs in Place

The Michigan Forest Carbon Offset and Trading Program allows Michigan forest landowners to earn and sell GHG emission reduction credits through reforesting degraded forestland. MDNR also administers a Forest Stewardship program that distributes federal grants to support private forest landowners to develop stewardship plans that promote sustainable forest management.

MDA works in collaboration with the Conservation Districts to provide private forest landowners support related to the implementation of sustainable forest management (presently not funded in the state budget).

Type(s) of GHG Reductions

CO_2: Carbon sequestration on afforested land.

CO_2, CH_4, and N_2O: Fossil fuel reductions due to reduced energy demand in urban communities.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$):

Element A.
1. Afforestation: 0.35, 0.94, respectively.
2. Enhanced stocking: 0.07, 0.18, respectively.
3. Short-rotation woody crop (SRWC) establishment: 0.11, 0.30, respectively.

Element B. Urban forestry: 1.2, 2.9, respectively.

Net Cost per tCO_2e:

Element A.
1. Afforestation: $45.44.
2. Enhanced stocking: $237.42.
3. SRWC establishment: $29.38.

Element B. Urban forestry: –$13.

The above costs and benefits only cover option elements A and B. Element C was not quantified due to a lack of information on the potential for measures to reduce the occurrence and severity of wildfires and the subsequent forest carbon dynamics. This element requires additional study, which was beyond the time and resources available to the TWG. It is being brought forward as a non-quantified policy recommendation.

Data Sources:

Element A. Increased Forest Cover

J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. *Methods for Calculating Forest Ecosystem and Harvested Carbon With Standards Estimates for Forest Types of the United States*. General Technical Report NE-343. USDA/USFS, Northern Research Station, 2006. Available at: http://www.treesearch.fs.fed.us/pubs/22954.

U.S. Department of Agriculture, Farm Service Agency. *Conservation Reserve Program Summary and Enrollment Statistics: FY 2007.* Prepared by Alex Barbarika. April 2008. Available at: http://www.fsa.usda.gov/Internet/FSA_File/annual_consv_2007.pdf.

Center for Sustainable Systems, University of Michigan. *Michigan at a Climate Crossroads: Strategies for Guiding the State in a Carbon-Constrained World: Report No: CSS07-02*. Prepared by Michael H. Edison, Kate Elliott, Bernie Fischlowitz-Roberts, Rachel A. Permut, Sarah A. Popp, Andrew G. Winkelman, and Gregory A. Keoleian. April 2007. Available at: http://css.snre.umich.edu/css_doc/CSS07-02.pdf.

S. Walker, S. Grimland, J. Winsten, and S. Brown. "Opportunities for Improving Carbon Storage Through Afforestation of Agricultural Lands." Part 3A in *Terrestrial Carbon Sequestration in the Northeast: Quantities and Costs*, The Nature Conservancy, Winrock International, and The Sampson Group. October 2007. Available at: http://www.sampsongroup.com/Papers/carbon.htm.

Element B. Urban Forest

D.J. Nowak and D.E. Crane. "Carbon Storage and Sequestration by Urban Trees in the USA." *Environmental Pollution* March 2002;116(3):381-389. Available at: http://www.treesearch.fs.fed.us/pubs/15521.

U.S. Environmental Protection Agency (EPA). *Inventory of U.S. Greenhouse Gas Sources and Sinks: 1990–2006*. USEPA #430-R-08-005. April 2008. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

McPherson, E.G., and J.R. Simpson. 1999. "Carbon Dioxide Reduction Through Urban Forestry: Guidelines for Professional and Volunteer Tree Planters." General Technical Report USFS PSW-GTR-171. Washington, DC: U.S. Department of Agriculture, U.S. Forest Service. Available at: http://www.treesearch.fs.fed.us/pubs/6779.

McPherson, E.G., J.R. Simpson, P.J. Peper, S.L. Gardner, K.E. Vargas, S.E. Maco, Q. Xiao. 2006. *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planting*. General Technical Report PSW-GTR-199. USDA Forest Service Pacific Southwest Research Station. Available at: http://www.treesearch.fs.fed.us/pubs/25927.

Quantification Methods:

Element A. Increased Forest Cover

This policy recommendation seeks to enhance forestland management on 1 million acres of forest by 2025. To achieve this goal, it was assumed that the acreage undergoing enhanced management would be divided equally among three types of forest management. One-third of the acreage (333,333 acres) would be afforested by 2025, assuming a linear ramp up (between 2010 and 2025) of 20,833 acres per year. On another third of the acreage (333,333 acres), enhanced stocking on existing forestlands would take place. And the remaining third (333,333 acres) would be managed for SRWCs.

A.1. Increase permanent forestland cover on 333,333 acres through afforestation

GHG Benefit

Forests grown or planted on land not currently in forest cover will most likely accumulate carbon at a rate consistent with the accumulation rates of average forests in the region. Therefore, carbon sequestered by afforestation activities can be assumed to occur at the same rate as carbon sequestration in average Michigan forests. This analysis used the forest type distribution used for the Michigan I&F: forest area in Michigan is roughly 38% maple-beech-birch, 17% aspen-birch, 15% spruce-fir, 11% white-red-jack pine, 10% oak-hickory, and 9% elm-ash-cottonwood.

Average carbon storage was determined using methods described by the USDA Forest Service in Smith et al., assuming that afforestation activity would occur on forests that were consistent with the existing forest type distribution in Michigan.[100] Annual carbon sequestration rates in each

[100] J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. *Methods for Calculating Forest Ecosystem and Harvested Carbon With Standards Estimates for Forest Types of the United States*. General Technical Report NE-343, Tables A47, A48, B47, B49, B50, and B51. U.S. Department of Agriculture, Forest Service, Northern Research Station, December 21, 2005. Available at: http://www.treesearch.fs.fed.us/pubs/22954.

forest type group were calculated by subtracting carbon stocks in new stands (0 years) from carbon stocks in 35-year-old stands and dividing by 35 years. A weighted statewide average carbon sequestration rate for afforestation activity was calculated, taking into account the variation in carbon sequestration across forest types (Table J-8-1). The 35-year period was chosen to reflect the average length of an afforestation project period. In this afforestation calculation, soil carbon was assumed to accumulate at a rate consistent with soil carbon accumulation in afforested stands in Smith et al. The average rate of carbon accumulation on afforested land in Michigan is roughly 2.8 tCO_2e/ac/yr (Table J-8-1).

Table J-8-1. Carbon sequestration rates in afforested stands in Michigan

Forest Type	tCO_2e/acre (0 year)	tCO_2e/acre (35 year)	tCO_2e/acre/year (35-year average)	Proportion of Michigan Forest (%)
Maple-beech-birch (Table B9)	152.9	218.2	1.9	38
Aspen-birch (Table B7)	165.4	268.8	3.0	17
Spruce-fir (Table B11)	294.8	438.9	4.1	15
White-red-jack pine (Table B12)	137.5	267.3	3.7	11
Oak-hickory (Table B10)	111.1	218.2	3.1	10
Elm-ash-cottonwood (Table B8)	203.1	309.5	3.0	9
Weighted Average (tCO_2e/year)			**2.8**	10

tCO_2e/acre/year = metric tons of carbon dioxide equivalent per acre per year.
Source: Smith et al., NE-GTR-343.

Forests planted in one year will continue to store carbon in subsequent years. Therefore, the GHG benefit of afforestation in one year is the cumulative impact of forests planted in prior years. The overall GHG benefit of afforestation activity in Michigan is described in Table J-8-2. The cumulative effect of afforesting 333,333 acres of marginal agricultural lands by 2025 is the sequestration of 7.98 $MMtCO_2e$.

Economic Costs

Analyses of vegetation planting costs typically employ four categories: opportunity cost (of planting forest, rather than another, potentially more lucrative land use), conversion cost, maintenance cost, and measuring/monitoring costs.[101] The opportunity cost for afforestation activity was assumed to be $117.50/acre/year, which was the annual average rental payment to farmers in Michigan with land enrolled in the CRP as of 2007.[102] Planting and maintenance costs

[101] S. Walker, S. Grimland, J. Winsten, and S. Brown. "Opportunities for Improving Carbon Storage Through Afforestation of Agricultural Lands." Part 3A in *Terrestrial Carbon Sequestration in the Northeast: Quantities and Costs*, The Nature Conservancy, Winrock International, and The Sampson Group. October 2007. Available at: http://www.sampsongroup.com/Papers/carbon.htm.

[102] U.S. Department of Agriculture, Farm Service Agency. *Conservation Reserve Program Summary and Enrollment Statistics: FY 2007.* Prepared by Alex Barbarika. April 2008. Available at: http://www.fsa.usda.gov/Internet/FSA_File/annual_consv_2007.pdf.

for marginal agriculture land (as defined by the Midwest Regional Carbon Sequestration Project) were used. Initial costs of vegetation establishment include site preparation and vegetation planting, with a replanting to account for seedling mortality. It was assumed that only forestlands in lower Michigan require herbicide site preparation and herbicide release. As 55% of Michigan forestlands are in lower Michigan,[103] the cost of herbicide application was applied to 55% of afforested lands (Table J-8-3).

Table J-8-2. Cumulative GHG effect of afforestation activity in Michigan

Year	Acres Planted This Year (acre/year)	Acres Planted in Prior Years	Carbon Sequestered in Cumulative Planted Acreage (tCO_2e/year)	Carbon Sequestered in Cumulative Planted Acreage ($MMtCO_2e$/year)
2010	20,833	0	58,660	0.06
2011	20,833	20,833	117,320	0.12
2012	20,833	41,667	175,980	0.18
2013	20,833	62,500	234,640	0.23
2014	20,833	83,333	293,300	0.29
2015	20,833	104,167	351,960	0.35
2016	20,833	125,000	410,620	0.41
2017	20,833	145,833	469,280	0.47
2018	20,833	166,667	527,941	0.53
2019	20,833	187,500	586,601	0.59
2020	20,833	208,333	645,261	0.65
2021	20,833	229,166	703,921	0.70
2022	20,833	250,000	762,581	0.76
2023	20,833	270,833	821,241	0.82
2024	20,833	291,666	879,901	0.88
2025	20,833	312,500	938,561	0.94
Total	**333,333**			**7.98**

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

Table J-8-3. Planting costs for afforestation on marginal agricultural lands in Michigan

Planting and Site Preparation	Costs ($/acre)
Site preparation on lower Michigan forest lands (applied to 55% of forested lands)	$90
Conifer planting (1,200 seedlings and planting costs)	$240
Replanting assuming 30% seedling mortality	$64
Hardwood planting (1,200 seedlings and planting costs)	$690
Replanting assuming 30% seedling mortality	$209
Average combined planting and replanting costs	**$601.5**

Source: Personal communication with C. Boucher and D. Neumann ,Michigan Department of Natural Resources.

[103] K. Potter-Witter. *Timber Producer Certification in Michigan: A Report to the Mackinac Center for Public Policy*. February 1995. Available at: http://www.mackinac.org/article.aspx?ID=5256.

Discounted costs to 2025 were calculated using a 5% discount rate. Results, including annual costs, are summarized in Table J-8-4. The net present value (NPV) of this policy, expressed in 2010 dollars, is roughly $363 million, and the overall cost of implementing this policy was calculated to be $45/t$CO_2$e stored.

Table J-8-4. Summary of net economic cost of afforestation activity in Michigan

Year	Acres Planted This Year (acre/ year)	Acres Planted in Prior Years	Opportunity Cost	Establishment Cost	Site Preparation Costs	Total Cost	Discounted Cost
2010	20,833	0	$2,447,914	$12,531,237	$1,027,499	$16,006,651	$16,006,651
2011	20,833	20,833	$4,895,828	$12,531,237	$1,027,499	$18,454,565	$17,575,776
2012	20,833	41,667	$7,343,743	$12,531,237	$1,027,499	$20,902,479	$18,959,165
2013	20,833	62,500	$9,791,657	$12,531,237	$1,027,499	$23,350,393	$20,170,948
2014	20,833	83,333	$12,239,571	$12,531,237	$1,027,499	$25,798,308	$21,224,331
2015	20,833	104,167	$14,687,485	$12,531,237	$1,027,499	$28,246,222	$22,131,654
2016	20,833	125,000	$17,135,400	$12,531,237	$1,027,499	$30,694,136	$22,904,437
2017	20,833	145,833	$19,583,314	$12,531,237	$1,027,499	$33,142,050	$23,553,436
2018	20,833	166,667	$22,031,228	$12,531,237	$1,027,499	$35,589,964	$24,088,689
2019	20,833	187,500	$24,479,142	$12,531,237	$1,027,499	$38,037,879	$24,519,556
2020	20,833	208,333	$26,927,056	$12,531,237	$1,027,499	$40,485,793	$24,854,765
2021	20,833	229,166	$29,374,971	$12,531,237	$1,027,499	$42,933,707	$25,102,449
2022	20,833	250,000	$31,822,885	$12,531,237	$1,027,499	$45,381,621	$25,270,185
2023	20,833	270,833	$34,270,799	$12,531,237	$1,027,499	$47,829,536	$25,365,024
2024	20,833	291,666	$36,718,713	$12,531,237	$1,027,499	$50,277,450	$25,393,529
2025	20,833	312,500	$39,166,628	$12,531,237	$1,027,499	$52,725,364	$25,361,802
Total	**333,333**						**$362,482,395**

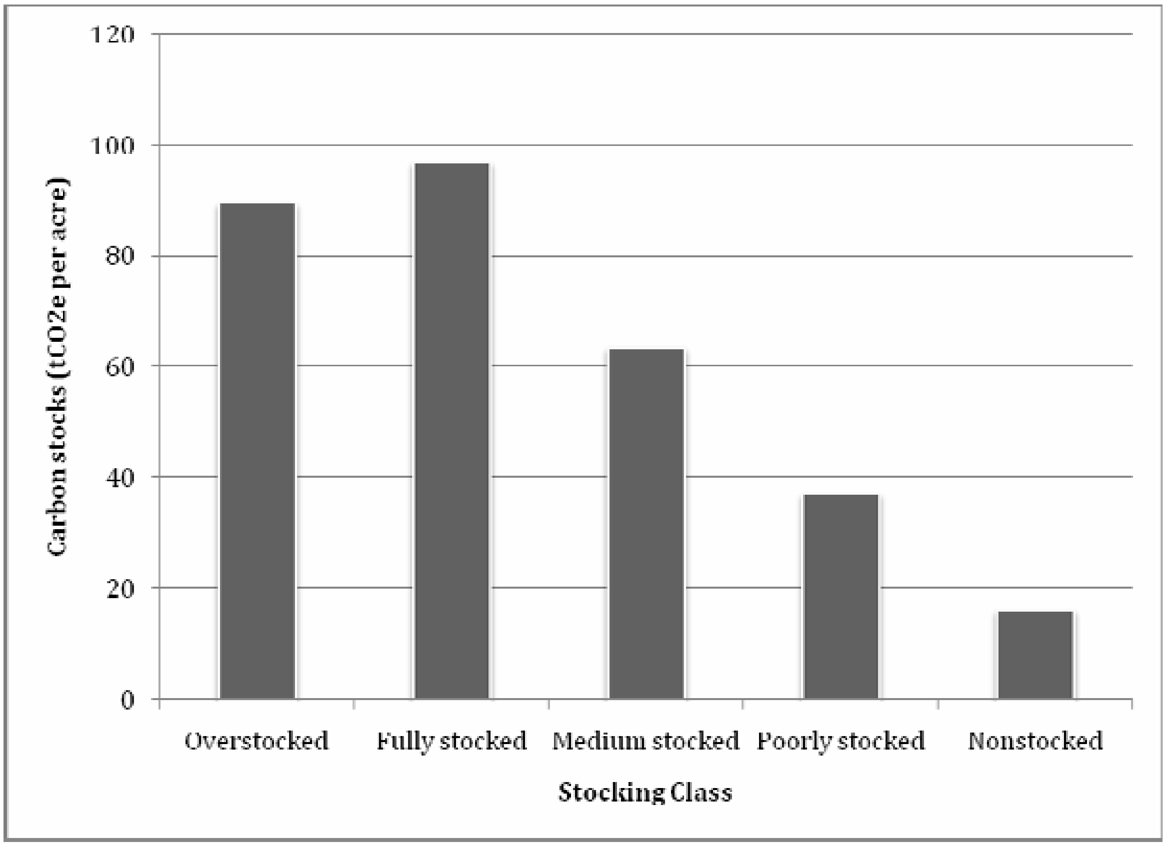
A.2. Enhance stocking on 333,333 acres of existing forestland

GHG Benefit

Carbon sequestration can be enhanced on existing understocked forestland in Michigan by improving stocking in these stands. This policy quantifies the impact of a stepwise transition from a less-stocked to a more-stocked category for forest that is currently categorized as nonstocked, poorly stocked, or medium stocked. Over the 16-year period between 2010 and 2025, it was assumed that an understocked forest stand will be improved by one categorical step (i.e., a poorly stocked stand will be improved to medium-stocked stand, and a medium-stocked stand will be improved to fully stocked). In other words, it was assumed that a poorly stocked stand would not become fully stocked by 2025.

A relationship between forest stocking and existing carbon stocks in Michigan forests was developed, using current data on forest area and carbon stocks by stocking class[104] (Figure J-8-1). As full policy implementation would result in enhanced stocking on 333,333 acres in Michigan forests, it was assumed that 33% (111,111 acres) would originally be in the nonstocked category, 111,111 acres (33%) would originally be in the poorly stocked category, and the remaining 111,111 acres (33%) would originally be in the medium-stocked category (Table J-8-5). Of the forested acres in Michigan, roughly 318,300 acres are currently in the nonstocked category, while 2.5 million acres and 6.4 million acres are categorized as poorly stocked and medium stocked, respectively.[105]

Figure J-8-1. Total carbon stocks in Michigan forests by stocking class (units tCO_2e/acre)



tCO_2e = metric tons of carbon dioxide equivalent.

To calculate the incremental carbon storage resulting from enhanced stocking, the difference in tCO_2e stocks between a forest in the current stocking condition and a forest in the incrementally stocked condition was calculated. This value was divided by 50 to estimate the annual incremental carbon storage due to increased stocking over a 50-year period (Table J-8-5). A weighted average was calculated to represent the average carbon storage resulting from

[104] USDA Forest Service. Forest Inventory and Analysis Mapmaker (3.0), found at: http://www.ncrs2.fs.fed.us/4801/fiadb/fim30/wcfim30.asp.

[105] Ibid.

implementation of this policy option, assuming equal representation of nonstocked, poorly stocked, and medium-stocked forest in each year.

To reach the goal of 333,333 acres by 2025, a linear ramp-up to the goal level was assumed, such that 20,833 acres were added to the program each year. The cumulative impact of the policy (2010–2025) is 1.53 $MMtCO_2e$ (Table J-8-6). It should be noted that the carbon sequestration numbers in Table J-8-6 only include additional carbon sequestered by improved stocking, and do not include carbon already stored in the existing understocked forest.

Table J-8-5. Incremental carbon storage (per acre) resulting from enhanced stocking of existing forested land in Michigan

Enhanced Stocking Acreage	Original Stocking Class	Enhanced Stocking Class	Incremental C Storage (tCO_2e/acre)	Incremental C Storage (tCO_2e/ acre/yr)
111,111	Nonstocked	Poorly Stocked	20.99	0.42
111,111	Poorly Stocked	Medium Stocked	26.38	0.53
111,111	Medium Stocked	Fully Stocked	33.45	0.67
Weighted Average of Incremental Carbon Storage (tCO_2e/acre/year)				**0.54**

C = carbon; tCO_2e/acre/yr = metric tons of carbon dioxide equivalent per acre per year.

Table J-8-6. Cumulative impact of improved stocking on 333,333 acres of existing forest land in Michigan

Year	Acres Improved Stocking This Year (acres/year)	Acres Improved Stocking in Prior Years	Carbon Sequestered in Cumulative Improved Stocking Acreage (tCO_2e/yr)	Carbon Sequestered in Cumulative Improved Stocking Acreage ($MMtCO_2e$/yr)
2010	20,833	0	11,226	0.011
2011	20,833	20,833	22,452	0.022
2012	20,833	41,667	33,678	0.034
2013	20,833	62,500	44,904	0.045
2014	20,833	83,333	56,130	0.056
2015	20,833	104,167	67,356	0.067
2016	20,833	125,000	78,582	0.079
2017	20,833	145,833	89,808	0.090
2018	20,833	166,667	101,034	0.101
2019	20,833	187,500	112,260	0.112
2020	20,833	208,333	123,486	0.123
2021	20,833	229,166	134,712	0.135
2022	20,833	250,000	145,938	0.146
2023	20,833	270,833	157,164	0.157
2024	20,833	291,666	168,389	0.168
2025	20,833	312,500	179,615	0.180
Total	**333,333**			**1.527**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent per year; tCO_2e = metric tons of carbon dioxide equivalent per year.

Economic Costs

The economic costs of afforestation were assumed to be equivalent to the economic costs of enhanced stocking (see Table J-8-3). Results, including annual costs, are summarized in Table J-8-7. The NPV of this policy, expressed in 2010 dollars, is roughly $362 million, and the overall cost of implementing this policy was calculated to be $237/t$CO_2$e stored.

Table J-8-7. Economic cost of enhanced stocking in Michigan

Year	Acres Improved Stocking This Year (acres/year)	Acres Improved Stocking in Prior Years	Opportunity Cost	Establishment Cost	Maintenance Costs	Total Cost	Discounted Cost
2010	20,833	0	$2,447,914	$12,531,237	$1,027,499	$16,006,651	$16,006,651
2011	20,833	20,833	$4,895,828	$12,531,237	$1,027,499	$18,454,565	$17,575,776
2012	20,833	41,667	$7,343,743	$12,531,237	$1,027,499	$20,902,479	$18,959,165
2013	20,833	62,500	$9,791,657	$12,531,237	$1,027,499	$23,350,393	$20,170,948
2014	20,833	83,333	$12,239,571	$12,531,237	$1,027,499	$25,798,308	$21,224,331
2015	20,833	104,167	$14,687,485	$12,531,237	$1,027,499	$28,246,222	$22,131,654
2016	20,833	125,000	$17,135,400	$12,531,237	$1,027,499	$30,694,136	$22,904,437
2017	20,833	145,833	$19,583,314	$12,531,237	$1,027,499	$33,142,050	$23,553,436
2018	20,833	166,667	$22,031,228	$12,531,237	$1,027,499	$35,589,964	$24,088,689
2019	20,833	187,500	$24,479,142	$12,531,237	$1,027,499	$38,037,879	$24,519,556
2020	20,833	208,333	$26,927,056	$12,531,237	$1,027,499	$40,485,793	$24,854,765
2021	20,833	229,166	$29,374,971	$12,531,237	$1,027,499	$42,933,707	$25,102,449
2022	20,833	250,000	$31,822,885	$12,531,237	$1,027,499	$45,381,621	$25,270,185
2023	20,833	270,833	$34,270,799	$12,531,237	$1,027,499	$47,829,536	$25,365,024
2024	20,833	291,666	$36,718,713	$12,531,237	$1,027,499	$50,277,450	$25,393,529
2025	20,833	312,500	$39,166,628	$12,531,237	$1,027,499	$52,725,364	$25,361,802
Total	**333,333**						**$362,482,395**

A.3. Establishment of short-rotation woody crops

GHG Benefit

This goal has significant overlap with AFW-1, where the fuel-switching GHG benefits of SRWCs are quantified. It is assumed that all carbon sequestration benefits from fuel switching are included in the quantification of AFW-1; only the long-term, below-ground carbon sequestration in soils is included in this AFW-8 quantification. SRWCs can sequester an additional 0.9 tCO_2e/acre/year in below-ground roots and stumps.[106] A linear ramp-up was used, assuming 20,833 acres/year of SRWCs were planted (Table J-8-8). The overall GHG benefit of planting SRWCs was roughly 2.55 MMtCO_2e over the 16-year policy period.

[106] S. Walker, S. Grimland, J. Winsten, and S. Brown. "Opportunities for Sequestering Carbon and Offsetting Emissions Through Production of Biomass Energy." Part 3C in *Terrestrial Carbon Sequestration in the Northeast: Quantities and Costs*, The Nature Conservancy, Winrock International, and The Sampson Group. March 2007. Available at: http://www.sampsongroup.com/Papers/carbon.htm.

Table J-8-8. Carbon sequestration in SRWCs in Michigan

Year	Acres Planted This Year (acres/year)	Acres Planted in Prior Years	Carbon Sequestered in Cumulative Planted Acreage (tCO_2e/yr)	Carbon Sequestered in Cumulative Planted Acreage ($MMtCO_2e/yr$)
2010	20,833	0	18,750	0.019
2011	20,833	20,833	37,500	0.037
2012	20,833	41,667	56,250	0.056
2013	20,833	62,500	75,000	0.075
2014	20,833	83,333	93,750	0.094
2015	20,833	104,167	112,500	0.112
2016	20,833	125,000	131,250	0.131
2017	20,833	145,833	150,000	0.150
2018	20,833	166,667	168,750	0.169
2019	20,833	187,500	187,500	0.187
2020	20,833	208,333	206,250	0.206
2021	20,833	229,166	225,000	0.225
2022	20,833	250,000	243,750	0.244
2023	20,833	270,833	262,500	0.262
2024	20,833	291,666	281,250	0.281
2025	20,833	312,500	300,000	0.300
Total	**333,333**			**2.550**

$MMtCO_2e/yr$ = million metric tons of carbon dioxide equivalent per year; SWRC = short-rotation woody crops; tCO_2e/yr = metric tons of carbon dioxide equivalent per year.

Economic Costs

The cost of SRWC establishment and maintenance was $316/acre.[107] This cost assumes a purchase cost of $0.30 per seedling and machine planting with one herbicide treatment; it does not include the cost of harvest. The NPV of this policy (in 2010 dollars) was calculated at roughly $75 million, with a cost-effectiveness of $29/$tCO_2e$ stored (Table J-8-9). Harvest costs are quite variable, ranging from $20 to $80 per green ton harvest, with near-prohibitive costs in very short-rotation systems (<15 years) using traditional harvest equipment.[108] Because of their extreme variability and their apparent reliance on rotation age and equipment, harvest costs were not included in this analysis.

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[107] Miller, C.A., and R.E. Froese, 2008. "The Economic Feasibility of Afforestation of Abandoned Agriculture Land With Quaking Aspen (*Populus tremuloides Michx*.) for Production of Coal Co-Fire Feedstock in Presque Isle County, Michigan." Michigan Technological University, Houghton, Michigan. Unpublished manuscript, available from the authors.

[108] Ibid.

Table J-8-9. Economic cost of SRWC establishment in Michigan

Year	Acres Planted This Year (acres/year)	Establishment Cost	Discounted Cost
2010	20,833	$6,583,327	$6,583,327
2011	20,833	$6,583,327	$6,269,835
2012	20,833	$6,583,327	$5,971,271
2013	20,833	$6,583,327	$5,686,925
2014	20,833	$6,583,327	$5,416,119
2015	20,833	$6,583,327	$5,158,209
2016	20,833	$6,583,327	$4,912,580
2017	20,833	$6,583,327	$4,678,647
2018	20,833	$6,583,327	$4,455,855
2019	20,833	$6,583,327	$4,243,671
2020	20,833	$6,583,327	$4,041,592
2021	20,833	$6,583,327	$3,849,135
2022	20,833	$6,583,327	$3,665,843
2023	20,833	$6,583,327	$3,491,279
2024	20,833	$6,583,327	$3,325,027
2025	20,833	$6,583,327	$3,166,693
Total	**333,333**		**$74,916,007**

Element B. Urban Forestry

The following quantifies the cumulative impact on carbon sequestration and avoided fossil fuel emissions of incrementally increasing the existing tree canopy cover in Michigan. Specifically, AFW-8 seeks to achieve a goal of 40% urban canopy cover by 2025. Currently, Michigan's urban areas are 29.7% forested.[109] This goal recommends roughly a 35% increase over the existing canopy cover by 2025.

GHG Reductions

Currently, Michigan contains 110,858,000 million urban trees. This policy quantifies the effect of adding approximately 37 million new trees by 2025. The number of trees planted each year is constant, at roughly 2.17 million/year, with the target number of trees planted by 2025.

GHG benefits are twofold: direct carbon sequestration by planted trees, and avoided GHG emissions from strategic tree planting to reduce energy demand due to heating and cooling.

1. Direct carbon sequestration by urban trees

The average annual per-tree gross carbon sequestration value for urban trees was found by dividing the total estimated annual carbon sequestration in Michigan urban trees (668,000 tons of carbon/year, equating to 2.45 million tCO_2e/year) by the total number of urban trees. Annual gross carbon sequestration per urban tree was thus calculated as 0.006 metric tons of carbon

[109] USDA USFS data (D. Nowak). Available at http://www.fs.fed.us/ne/syracuse/Data/State/data_MI.htm.

(0.022 tCO_2e) per tree per year. Gross sequestration as calculated above does not account for the emissions resulting from tree mortality, disposal, and decomposition. To account for these emissions, the estimated gross carbon sequestration per tree was multiplied by 0.72, which is the ratio of gross to net sequestration for urban trees reported by Nowak and Crane (2002)[110] and used in EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.[111] Annual net carbon sequestration per urban tree in Michigan is 0.004 metric tons of carbon (0.015 tCO_2e) per tree per year.

Since trees planted in one year continue to accumulate carbon in subsequent years, annual carbon sequestration in any given year was calculated as the sum of carbon stored in trees planted in that year, plus sequestration by trees that were planted in prior years. It was assumed that new trees planted in urban areas in Michigan would sequester carbon at a rate consistent with sequestration by the average urban tree statewide.

2. Avoided GHG emissions

The total avoided GHG benefits are a function of three different types of impacts: reduced cooling demand, reduced demand for heating due to wind reduction, and increased demand for heating due to wintertime shading. An average potential GHG reduction factor of 0.0598 tCO_2e/tree/year for trees in the North Central region was calculated from data in McPherson and Simpson in GTR-PSW-171 (Table J-8-10; Appendix A, Table V.3).[112] The estimate assumed that the trees planted are split among residential settings with pre-1950, 1950–1980, and post-1980 homes using the default distribution for the North Central region provided by McPherson and Simpson of 42%, 48%, and 10%, respectively. This estimate further assumes a default distribution of trees planted around buildings, based on measured data from existing urban canopy in the region.

To calculate potential avoided GHG emissions due to increased shading, it was assumed that all of the new trees are planted where they can have shading effects. It was assumed that medium-sized evergreen trees would be planted, with average tree distribution around buildings. Note that these fossil fuel reduction factors are average for existing buildings, and do not necessarily assume that trees are optimally placed around buildings to maximize energy efficiency. These factors are also dependent on the electricity fuel mix (coal, hydroelectric, nuclear, etc.) in the regions of interest, and may thus change if the mix changes.

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[110] D.J. Nowak and D.E. Crane. "Carbon Storage and Sequestration by Urban Trees in the USA." *Environmental Pollution* March 2002;116(3):381-389. Available at: http://www.treesearch.fs.fed.us/pubs/15521.

[111] U.S. Environmental Protection Agency. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*. USEPA #430-R-08-005. April 2008. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[112] E.G. McPherson and J.R. Simpson. *Carbon Dioxide Reduction Through Urban Forestry*: *Guidelines for Professional and Volunteer Tree Planters*. Appendix A, Table V.5. Gen. Tech. Rep. PSW-GTR-171. Washington, DC: U.S. Department of Agriculture, U.S. Forest Service, 1999. Available at: http://www.treesearch.fs.fed.us/pubs/6779.

Table J-8-10. Factors used to calculate CO_2e savings from reduced need for fossil fuel for heating and cooling and from windbreak effect of urban trees

Housing Age	Proportion of Urban Trees in This Housing Age Category (%)	Cooling (tCO_2 Saved per Tree)	Heating (tCO_2 Emitted per Tree)	Wind (tCO_2 Saved per Tree)	Net Effect (tCO_2e/tree)
Pre-1950	42	0.0087	–0.0181	0.0869	0.0775
1950-1980	48	0.0063	–0.0162	0.0791	0.0692
Post-1980	10	0.0094	–0.0191	0.0521	0.0424
Weighted Average (tCO_2e/tree/yr)					**0.0598**

tCO_2e = metric tons of carbon dioxide equivalent.

Source: McPherson et al., 1999.

3. Overall GHG benefit of urban tree planting

Total GHG benefits are calculated as the sum of direct carbon sequestration plus fossil fuel offset from reduced cooling demand and wind reduction (Table J-8-11).

Table J-8-11. Overall GHG benefit of urban tree planting in Michigan

Year	Trees Planted This Year (acres/year)	Trees Planted in Previous Years	GHGs Sequestered ($MMtCO_2$e/year)	GHGs Avoided ($MMtCO_2$e/ year)	Overall GHG Savings ($MMtCO_2$e/year)
2009	2,261,512	0	0.036	0.1	0.17
2010	2,261,512	2,261,512	0.072	0.27	0.34
2011	2,261,512	4,523,024	0.11	0.4	0.51
2012	2,261,512	6,784,536	0.14	0.54	0.69
2013	2,261,512	9,046,048	0.18	0.68	0.86
2014	2,261,512	11,307,560	0.22	0.81	1.0
2015	2,261,512	13,569,072	0.25	0.95	1.2
2016	2,261,512	15,830,584	0.29	1.1	1.4
2017	2,261,512	18,092,096	0.32	1.2	1.5
2018	2,261,512	20,353,608	0.36	1.4	1.7
2019	2,261,512	22,615,120	0.40	1.5	1.9
2020	2,261,512	24,876,632	0.43	1.6	2.1
2021	2,261,512	27,138,144	0.47	1.8	2.2
2022	2,261,512	29,399,656	0.50	1.9	2.4
2023	2,261,512	31,661,168	0.54	2.0	2.6
2024	2,261,512	33,922,680	0.58	2.2	2.7
2025	2,261,512	36,184,192	0.61	2.3	2.9
Total		**38,445,704**	**5.5**	**20.7**	**26.2**

GHG = greenhouse gas; $MMtCO_2$e/year = million metric tons of carbon dioxide equivalent per year.

Cost Analysis

Data are available on the costs and cost savings of urban tree planting in the Midwest (McPherson et al. 2006). Economic costs of tree planting take into account the cost of tree planting and annual maintenance costs, including the costs of program administration and waste disposal. Economic benefits of tree planting include the cost avoided from reduced energy use. Data are also available on the estimated economic benefits of services, such as provision of clean air; hydrologic benefits, such as stormwater control; and aesthetic enhancement. However, these co-benefits are not explicitly included in the analysis.

Costs and cost savings were estimated from published average annual costs and cost savings over 40 years, provided by public and private parties, for a range of tree sizes. The cost estimate used in this analysis, $26 per tree, was calculated as the average of small, medium, and large trees under public and private management. A cost savings of –$28 per tree per year was also calculated as the average of small, medium, and large trees under public and private management. The average cost and cost savings values yield a net cost savings of –$1.65 per tree (costs minus cost savings). Table J-8-12 shows estimated economic costs and cost savings for all categories.

Table J-8-12. Cost data for public and private entities in the Midwest planting small, medium, and large trees (40-year annual averages)

Tree Size	Private ($/tree)	Public ($/tree)	Average of Public and Private ($/tree)
Small (crabapple)			
Cost savings (energy saved)	$15.60	$18.64	$17.12
Costs*	$17.02	$26.87	$21.95
Medium (red oak)			
Cost savings (energy saved)	$20.31	$25.62	$22.97
Costs*	$20.66	$33.61	$27.14
Large (hackberry)			
Cost savings (energy saved)	$44.05	$43.93	$43.99
Costs*	$23.10	$36.99	$30.05
Average across small, medium, large trees ($/tree)			
Cost savings (energy saved)			$28.03
Costs*			$26.38
Net Costs			**–$1.65**

*Includes tree and planting, pruning, removal and disposal, pest and disease, infrastructure repair, irrigation, cleanup, liability and legal, administration, and other costs.

The cost savings is estimated using 40-year averages. Thus, it represents lifetime costs applicable in the year planted and every year thereafter during the time frame of this analysis (e.g., planting costs $80 per tree in the year the tree is planted; however the 40-year average cost is $10 per tree). To estimate total cost savings, –$1.65 per tree was multiplied by the cumulative number of trees planted each year (Table J-8-13). This corresponds to a cumulative cost savings (or NPV) of –$346 million from 2009 to 2025, and an estimated cost-effectiveness of –$13 per tCO_2e.

Table J-8-13. Net economic benefits of enhanced urban canopy in Michigan

Year	Trees Planted This Year	Trees Planted in Previous Years	Net Economic Benefit	Discounted Net Benefits
2009	2,261,512	0	–$3,731,495	–$3,731,495
2010	2,261,512	2,261,512	–$7,462,990	–$7,107,609
2011	2,261,512	4,523,024	–$11,194,484	–$10,153,727
2012	2,261,512	6,784,536	–$14,925,979	–$12,893,622
2013	2,261,512	9,046,048	–$18,657,474	–$15,349,550
2014	2,261,512	11,307,560	–$22,388,969	–$17,542,343
2015	2,261,512	13,569,072	–$26,120,463	–$19,491,492
2016	2,261,512	15,830,584	–$29,851,958	–$21,215,229
2017	2,261,512	18,092,096	–$33,583,453	–$22,730,603
2018	2,261,512	20,353,608	–$37,314,948	–$24,053,548
2019	2,261,512	22,615,120	–$41,046,442	–$25,198,955
2020	2,261,512	24,876,632	–$44,777,937	–$26,180,733
2021	2,261,512	27,138,144	–$48,509,432	–$27,011,867
2022	2,261,512	29,399,656	–$52,240,927	–$27,704,479
2023	2,261,512	31,661,168	–$55,972,422	–$28,269,876
2024	2,261,512	33,922,680	–$59,703,916	–$28,718,605
2025	2,261,512	36,184,192	–$63,435,411	–$29,060,493
Cumulative Totals		**38,445,704**	**–$570,918,700**	**–$346,414,225**

Element D. Wildfire Risk Reduction

The MCAC recommends that this policy should go forward as non-quantified due to the difficulty estimating net GHG reductions from community wildfire reduction programs.

Key Assumptions: None specified.

Key Uncertainties

Element B. Urban Forestry

Cities and communities would need to conduct canopy surveys to establish a baseline of current canopy cover. The costs of such a survey and continued monitoring are variable and may exceed available resources. The longevity of urban trees may be affected by climate perturbations.

Additional Benefits and Costs

Element B. Urban Forestry

In addition to the numerous benefits articulated in the policy description, urban trees contribute to improved property values, add aesthetic value for residents and visitors, provide humidity balancing, and reduce the intensity of stormwater runoff. Sociological studies suggest that more attractive and comfortable neighborhoods have lower crime rates.

Feasibility Issues

None identified.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-9. Source Reduction, Advanced Recycling, and Organics Management

Policy Description

Increase recycling and reduce waste generation in order to limit GHG emissions associated with landfill methane generation and with the production of raw materials relative to recycled materials. Increase the breadth and depth of recycling programs, provide incentives for the recycling of construction materials, develop markets for recycled materials, and increase average participation/recovery rates for all existing recycling programs. Increase reuse and composting. Reduce the volume of waste from residential, commercial, and government sectors through programs that reduce the generation of wastes. Reduction of generation at the source reduces both landfill emissions as well as upstream production emissions.

Note the linkage to AFW-10 covering landfill gas (LFG) methane collection and control. To the extent that this policy achieves lower levels of biodegradable waste emplacement in the future, lower levels of landfill methane will be generated. The analysis of AFW-10 assumes implementation of this policy.

The quantitative analysis of benefits and costs of this policy recommendation includes estimates for life-cycle and non-life-cycle GHG benefits. This distinction is made in an effort to report only the GHG benefits accrued within the borders of Michigan. In the case of AFW-9, an increase in the recycling rate would produce indirect GHG benefits due to the reduction in goods and packaging produced from raw materials. It is likely that most of these indirect benefits of recycling would occur outside of Michigan's borders. Emission reductions due to organics composting are likely to take place within Michigan's borders and represent the GHG benefit due to the difference in emissions that result from the decomposition of waste in a compost facility, relative to a landfill. All other emission reductions are based on the reduced amount of waste placed in landfills and waste-to-energy facilities; therefore, they are assumed to take place within Michigan's borders.

Policy Design

Goals:

- Achieve a 75% MSW recycling rate by 2025.
- Achieve a 50% industrial/commercial recycling rate by 2025.
- Achieve a 75% enhanced organics management rate by 2025.
- Achieve a 50% recycle rate for new construction waste by 2025.

Timing:

Interim goal

- Comply with the state solid waste plan goal of achieving a 50% MSW recycling rate by 2015.

- Ensure that all Michigan citizens have convenient access to residential recycling programs by 2012.

Parties Involved: MDEQ, private waste management industry, counties and other local units of government, and environmental groups.

Implementation Mechanisms

- Support the development of markets for recycled materials. Identify and implement a sustainable and equitable funding mechanism to provide for a minimum level of solid waste management activities identified by the state.
- Consider a disposal ban for material that presents significant and avoidable harm if there are acceptable alternatives, such that the ban would not result in an unacceptable increase in illegal discharge.
- Consider deposit systems or their equivalent for high-risk or large-volume products only if they would create an efficient, effective, and equitable collection and utilization infrastructure.
- Prohibit within an implementable time frame the on-site burning or burying of household refuse
- Develop and implement an effective and efficient data collection system for measuring solid waste generation, reduction, utilization, and disposal. The system should measure and track trends on the magnitude and percentage of solid waste generated, reduced, utilized, and disposed.
- Expand the current container deposit system to include additional containers.
- Promote the use by municipalities of bio-based waste disposal bags.
- Hire a "waste finder" to reduce waste and increase recycling within governmental offices.

Related Policies/Programs in Place

MDEQ promotes recycling, including mandated recycling of office paper by the Michigan state government. Details on the various recycling efforts in Michigan are available at: http://www.michigan.gov/deq/0,1607,7-135-3585_4130---,00.html.

Type(s) of GHG Reductions

CO_2, CH_4, N_2O: *Reductions in Upstream Energy Use*—The energy and GHG intensity of manufacturing a product are generally less when using recycled, rather than virgin, feedstocks.

CH_4: Diverting biodegradable wastes from landfills decreases methane gas releases from landfills.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$)—Including Life-Cycle Benefits: 14, 35, respectively.

Net Cost per tCO_2e—Including Life-Cycle Benefits: –$10.

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$). Not Including Life-Cycle Benefits: 1.4, 3.0, respectively.

Net Cost per tCO_2e, Not Including Life-Cycle Benefits: –$112.

Data Sources:

Center for Climate Strategies. *Michigan Draft Inventory and Forecast*. Source Data for Appendix G: Waste Management. Document available online at: http://www.miclimatechange.us/ewebeditpro/items/O46F14881.pdf.

Michigan Department of Environmental Quality. *Report of Solid Waste in Michigan, FY2007*. January 31, 2008. Retrieved on August 4, 2008, from: http://www.michigan.gov/documents/deq/deq-whmd-swp-FY2007-SW-Landfilled-Rpt_247498_7.pdf.

U.S. EPA. *2006 MSW Characterization Data Tables (PDF)*. Accessed on July 7, 2008, from: http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf.

U.S. EPA. "WAste Reduction Model (WARM)." Version 8, May 2006. Available at: http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html.

Additional data sources are detailed in the quantification documentation below.

Quantification Methods:

GHG Benefits

The GHG benefits resulting from increased waste diversion in Michigan are quantified by:

- Establishing BAU projections for landfill disposal, incineration, recycling, and composting;
- Using the goals set forth by the TWG to project the policy scenario for waste management;
- Using the baseline recycling rate from the MDEQ *Recommendations for Improving and Expanding Recycling in Michigan* report[113] and national-level generation and disposal data from U.S. EPA *2006 Municipal Solid Waste Characterization Data Tables*,[114] CCS disaggregated the Michigan recycling, composting, and disposal data; and
- Inserting the resulting waste characterization for the baseline and policy scenarios into WARM to determine the incremental GHG benefit resulting from the goals set forth in this policy.[115] WARM provides a life-cycle estimate of the GHG benefits from additional recycling and composting. These benefits include the energy required to produce materials

[113] Michigan Department of Environmental Quality. *Recommendations for Improving and Expanding Recycling in Michigan.* February 22, 2005. Retrieved on August 25, 2008, from: http://www.deq.state.mi.us/documents/deq-whm-stsw-recyclingreport2-22-05.pdf.

[114] U.S. Environmental Protection Agency. *2006 MSW Characterization Data Tables (PDF)*. Accessed on July 7, 2008, from: http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf.

[115] U.S. Environmental Protection Agency. "WAste Reduction Model (WARM)." Version 8, May 2006. Available at: http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html.

from virgin inputs, the energy required to recycle materials, and the change in landfill gas emissions.

The BAU waste management scenario was developed using waste emplacement data from the Michigan I&F, which were provided by MDEQ. These data include the quantities of waste landfilled and combusted in Michigan for the years 1950 through 2006. For the purposes of developing the BAU waste management forecast for this quantification, CCS focused on 2002–2006. As Michigan is a net importer of waste (from surrounding states and provinces), CCS used information from MDEQ to estimate the total waste generated, as well as the in-state waste placed in landfills and incinerators. The amounts of waste landfilled and combusted were projected to increase at the same rates used by the Michigan I&F (2.9% and 1.0%, respectively). MDEQ estimated the baseline recycling rate in 2005 to be 20%.[116] It was assumed that this rate represented total diversion, which would include both recycling and composting. The recycling and composting rates were calculated by applying the national share of recycling and composting diversion to the Michigan estimated waste diversion.[117] Table J-9-1 displays the historical Michigan waste management data and calculations, while Table J-9-2 shows the projected BAU waste management scenario.

Table J-9-1. Michigan historical waste management

Item	2002	2003	2004	2005	2006
Landfill Disposal (tons)[a]	16,024,510	16,396,875	17,043,576	17,261,276	17,114,129
Landfill Disposal of in-state waste (%)[a]	79.80	75.00	71.50	71.10	69.20
Landfill Disposal of in-state waste (tons)[b]	12,787,559	12,297,656	12,186,157	12,272,767	11,842,978
Waste Combusted (tons)[a]	990,681	993,261	995,841	998,420	1,001,000
Combustion of in-state waste(tons)[a]	790,563	744,946	712,026	709,877	692,692
Diversion %[a]	20.0	20.0	20.0	20.0	20.0
Total Generation (tons)[b]	*16,972,653*	*16,303,252*	*16,122,728*	*16,228,305*	*15,669,587*
MI Population[a]	*10,042,495*	*10,082,364*	*10,112,620*	*10,207,421*	*10,254,919*
Generation per Capita (tons/cap/year)[b]	*1.690*	*1.617*	*1.594*	*1.590*	*1.528*
Total Diversion (tons)[b]	3,394,531	3,260,650	3,224,546	3,245,661	3,133,917
Recycling (tons)[b]	2,532,098	2,432,232	2,405,301	2,421,051	2,337,698
Recycling %[b]	14.9	14.9	14.9	14.9	14.9
Composting (tons)[b]	862,432	828,418	819,245	824,610	796,220
Composting %[b]	5.1	5.1	5.1	5.1	5.1

[a] Data from Michigan Department of Environmental Quality and Michigan Inventory & Forecast.

[116] Michigan Department of Environmental Quality. *Recommendations for Improving and Expanding Recycling in Michigan.* February 22, 2005. Retrieved on August 25, 2008, from: http://www.deq.state.mi.us/documents/deq-whm-stsw-recyclingreport2-22-05.pdf.

[117] U.S. Environmental Protection Agency. *2006 MSW Characterization Data Tables (PDF)*. Accessed on July 7, 2008, from: http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf.

[b] Calculated.

Table J-9-2. BAU waste management projections for Michigan

Item	2006	2010	2012	2015	2020	2025
MSW Generation (tons)	15,669,587	17,476,188	18,458,091	20,037,842	22,984,099	26,373,161
MI Population (from I&F)	10,254,919	10,428,683	10,504,167	10,599,122	10,695,993	10,713,730
MSW Generation Per Capita (tons/person)	1.53	1.68	1.76	1.89	2.15	2.46
Compostable Organics Generation (tons)	3,968,207	4,425,716	4,674,375	5,074,436	5,820,553	6,678,808
MSW Recycled (tons)	2,337,698	2,607,219	2,753,706	2,989,384	3,428,927	3,934,531
Organic Composting (tons)	796,220	888,019	937,912	1,018,184	1,167,892	1,340,101
Landfill Disposal of In-State Waste (tons)	11,842,978	13,261,497	14,033,253	15,275,910	17,596,312	20,269,181
Combustion of In-State Waste (tons)	692,692	719,453	733,219	754,363	790,967	829,348

The policy goals set forth by the TWG are applied to the baseline recycling and composting tonnages to project future waste management under the policy scenario. The remainder of the waste generated is assumed to be disposed in landfills. Table J-9-3 shows the projected management of waste generated in Michigan under the policy scenario. Table J-9-4 shows the incremental waste diversion, or the difference between the policy and BAU scenarios.

Table J-9-3. Waste management projection for Michigan, including policy goals

Item	2006	2010	2012	2015	2020	2025
MSW Generation (tons)	15,669,587	17,476,188	18,458,091	20,037,842	22,984,099	26,373,161
Recycling Target (%)	20.0	25.0	35.0	50.0	62.5	75.0
MSW Recycled (tons)	2,337,698	3,260,222	4,822,782	7,481,703	10,727,216	14,770,764
Composting Target (%)	20.0	25.0	35.0	50.0	62.5	75.0
Organic Composting (tons)	796,220	1,108,825	1,637,550	2,537,218	3,637,846	5,009,106
Landfill Disposal of In-State Waste (tons)	11,842,978	12,432,653	11,402,018	9,547,444	8,248,271	6,334,119
Combustion of In-State Waste(tons)	692,692	674,487	595,741	471,477	370,766	259,171

Table J-9-4. Incremental diversion under policy goals

Item	2006	2010	2012	2015	2020	2025
Recycling (tons)	—	653,003	2,069,076	4,492,319	7,298,289	10,836,233
Organic Composting (tons)	—	220,807	699,638	1,519,034	2,469,954	3,669,005
Landfill Disposal (tons)	—	–828,844	–2,631,235	–5,728,466	–9,348,041	–13,935,062
Waste Combustion (tons)	—	–44,966	–137,479	–282,886	–420,201	–570,176

The national baseline composition of waste generated is used to develop the breakdown of waste generation for Michigan by waste type.[118] The waste types used for this analysis correspond to the material inputs available for WARM. Table J-9-5 shows the waste generation characteristics of broad waste categories and the mix of generation by specific waste type within some of these categories. This table presents an estimated waste characterization for Michigan, based on national generation and diversion rates that are assumed to adequately represent the Michigan waste stream.

To establish the baseline waste characterization for each waste type, the generation percentage is multiplied by the total amount of waste generated in a given year. The recycling or composting percentage is multiplied by the amount of waste recycled or composted. Once the tonnages of waste generated, recycled, and composted are established, the recycled and composted wastes are subtracted from the amount generated, leaving the amount of waste that has not been diverted. This amount is the assumed quantity of waste landfilled or combusted by waste type, using the ratio of waste landfilled to waste combusted in the BAU scenario in Table J-9-2. For some waste types, the calculated amount of waste recycled exceeds the amount of waste generated once the MCAC goal has been applied. This is remedied by assuming that no more than 95% of each waste type may be diverted. The results of this process are entered into WARM. Tables J-9-6 and J-9-7 display WARM inputs for 2025.

[118] U.S. Environmental Protection Agency. *2006 MSW Characterization Data Tables (PDF)*. Accessed on July 7, 2008 from: http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf

Table J-9-5. Characteristics of baseline generated MSW and baseline recycled and composted wastes

Waste Category	2006 Baseline MSW Generation (% of total)	2006 Baseline Recycling/Composting (% of total)
		Recycling
Paper	**33.9**	**72.2**
Corrugated Cardboard	12.5	37.1
Magazines/Third-Class Mail	3.4	5.4
Newspaper	4.9	17.8
Office Paper	2.5	6.8
Phonebooks	0.3	0.2
Textbooks	0.4	0.5
Mixed—Residential	7.3	2.0
Mixed—Office	2.6	2.3
Glass	**5.3**	**4.7**
Metals	**7.6**	**11.4**
Aluminum Cans	0.6	2.6
Steel Cans	1.0	1.1
Mixed Metals	6.0	7.7
Plastics	**11.7**	**3.3**
HDPE	2.4	1.0
LDPE	2.6	0.5
PET	1.2	1.0
Mixed Plastics	5.5	0.9
Other	**16.1**	**8.4**
		Composting
Organics	**25.3**	**100.0**
Food Scraps	12.4	3.3
Yard Trimmings	12.9	96.7

HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate.

Table J-9-6. 2025 baseline WARM inputs

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum cans	159,494	101,894	55,336	2,264	N/A
Steel cans	263,375	41,918	212,751	8,705	N/A
Copper wire					N/A
Glass	1,385,079	185,731	1,152,203	47,144	N/A
HDPE	633,779	37,404	572,932	23,442	N/A
LDPE	688,342	18,057	643,937	26,348	N/A
PET	321,086	39,984	270,053	11,050	N/A
Corrugated cardboard	3,297,957	1,459,407	1,766,279	72,270	N/A
Magazines/third-class mail	887,710	214,107	647,125	26,478	N/A
Newspaper	1,296,937	701,006	572,507	23,425	N/A
Office paper	663,159	267,633	379,978	15,547	N/A
Phonebooks	71,353	8,384	60,494	2,475	N/A
Textbooks	118,571	18,702	95,943	3,926	N/A
Dimensional lumber					N/A
Medium-density fiberboard					N/A
Food scraps	3,279,069	N/A	3,108,045	127,171	43,853
Yard trimmings	3,399,739	N/A	2,020,807	82,685	1,296,248
Grass		N/A			
Leaves		N/A			
Branches		N/A			
Mixed paper (general)					N/A
Mixed paper (primarily residential)	1,917,075	79,323	1,765,513	72,239	N/A
Mixed paper (primarily from offices)	695,687	90,286	581,604	23,797	N/A
Mixed metals	1,584,446	304,393	1,229,737	50,317	N/A
Mixed plastics	1,451,185	36,114	1,359,446	55,624	N/A
Mixed recyclables	4,259,117	330,188	3,774,489	154,440	N/A
Mixed organics		N/A			
Mixed MSW		N/A			N/A
Carpet					N/A
Personal computers					N/A
Clay bricks		N/A		N/A	N/A
Concrete				N/A	N/A
Fly ash				N/A	N/A
Tires					N/A

WARM = [EPA's] WAste Reduction Model; N/A = not applicable; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate; MSW = municipal solid waste.

Table J-9-7. 2025 policy WARM inputs

Material	Baseline Generation	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum cans	159,494	151,519	7,661	313	
Steel cans	263,375	236,051	26,249	1,074	
Copper wire					
Glass	1,385,079	1,045,889	325,857	13,333	
HDPE	633,779	210,630	406,515	16,633	
LDPE	688,342	101,684	563,598	23,061	
PET	321,086	225,157	92,159	3,771	
Corrugated cardboard	3,297,957	3,133,059	158,416	6,482	
Magazines/third-class mail	887,710	843,324	42,641	1,745	
Newspaper	1,296,937	1,232,091	62,298	2,549	
Office paper	663,159	630,001	31,855	1,303	
Phonebooks	71,353	47,210	23,193	949	
Textbooks	118,571	105,315	12,735	521	
Dimensional lumber					
Medium-density fiberboard					
Food scraps	3,279,069		1,440,764	58,951	1,779,354
Yard trimmings	3,399,739		163,305	6,682	3,229,752
Grass					
Leaves					
Branches					
Mixed paper, broad					
Mixed paper, residential	1,917,075	446,682	1,412,595	57,799	
Mixed paper, office	695,687	508,418	179,908	7,361	
Mixed metals	1,584,446	1,505,224	76,108	3,114	
Mixed plastics	1,451,185	203,367	1,198,768	49,050	
Mixed recyclables	4,259,117	4,145,142	109,495	4,480	
Mixed organics					
Mixed MSW					
Carpet					
Personal computers					
Clay bricks					
Concrete					
Fly ash					
Tires					

WARM = [EPA's] WAste Reduction Model; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate; MSW = municipal solid waste.

The WARM analysis predicts a GHG benefit of 14.5 $MMtCO_2e$ in 2015 and 35.4 $MMtCO_2e$ in 2025. Assuming the program implementation begins in 2010 and a linear increase in emission reductions between target years, the cumulative GHG benefit is estimated to be 314 $MMtCO_2e$ through 2025 (Table J-9-8).

Table J-9-8. Overall policy results—GHG benefits

Year	Avoided Life-Cycle Emissions ($MMtCO_2e$)	Avoided Michigan Emissions ($MMtCO_2e$)	Incremental Waste Diversion (tons)	Incremental Recycling (tons)	Incremental Composting (tons)	Avoided Landfill Emplacement (tons)	Avoided Waste Combustion (tons)
2009	—	—	—	—	—	—	—
2010	2.4	0.2	873,809	653,003	220,807	–828,844	–44,966
2011	4.8	0.5	1,796,028	1,342,182	453,846	–1,705,240	–90,788
2012	7.3	0.7	2,768,714	2,069,076	699,638	–2,631,235	–137,479
2013	9.7	0.9	3,794,004	2,835,281	958,723	–3,608,953	–185,050
2014	12.1	1.1	4,874,116	3,642,455	1,231,661	–4,640,601	–233,515
2015	14.5	1.4	6,011,353	4,492,319	1,519,034	–5,728,466	–282,886
2016	16.7	1.5	6,693,238	5,001,614	1,691,625	–6,383,860	–309,378
2017	18.8	1.7	7,408,491	5,535,828	1,872,663	–7,072,142	–336,349
2018	21.0	1.9	8,158,464	6,095,973	2,062,491	–7,794,659	–363,805
2019	23.1	2.1	8,944,562	6,683,097	2,261,465	–8,552,808	–391,754
2020	25.3	2.3	9,768,242	7,298,289	2,469,954	–9,348,041	–420,201
2021	27.5	2.4	10,631,015	7,942,676	2,688,339	–10,181,859	–449,155
2022	29.6	2.6	11,534,446	8,617,428	2,917,018	–11,055,823	–478,623
2023	31.8	2.8	12,480,161	9,323,759	3,156,402	–11,971,550	–508,611
2024	34.0	3.0	13,469,843	10,062,926	3,406,917	–12,930,717	–539,126
2025	35.4	3.0	14,505,238	10,836,233	3,669,005	–13,935,062	–570,176
Total	**314**	**28.0**	**123,711,723**	**92,432,137**	**31,279,586**	**–118,369,861**	**–5,341,862**

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

Analysis of Costs

Recycling—The net cost of increased recycling rates in Michigan was estimated by adding the increased costs of collection for two-stream recycling, revenue obtained for the value of recycled materials, and avoided landfill tipping fees. The additional cost for separate curbside collection of recyclables is $2.50/household/month, or $30/household/year.[119] Dividing this number by the incremental recycling per capita in 2025,[120] and multiplying that number by the average

[119] Data gathered in Minnesota during a similar state-level analysis. Citation: T. Brownell, Eureka Recycling, personal communication with S. Roe, CCS, December 17, 2007. This value compares favorably with data provided to the Minnesota AFW TWG (T. Troolin, St. Louis County) on recycling costs incurred by Minnesota counties.

[120] Population projection for 2025 from the Michigan I&F.

household size of 2.56,[121] yields the maximum annual collection cost of $7.67/ton. The capital cost of additional recycling facilities in Michigan is estimated to be $487 million.[122] Annualized over the 15-year policy period at 8% interest, the annualized capital cost is $28 million/year. The avoided cost for landfill tipping is $38/ton.[123] CCS also factored in the commodity value of recycled materials with a value of $38/ton.[124] Table J-9-9 provides the results of the cost analysis. The analysis assumes that costs begin to be incurred in 2010. The estimated cost savings result in an NPV of –$4,058 million. Cumulative life-cycle reductions are 150 $MMtCO_2e$, and the estimated cost-effectiveness is –$27/$tCO_2e$. Cumulative Michigan reductions are 5.4 $MMtCO_2e$, and the estimated cost-effectiveness is –$745/$tCO_2$.

Composting—Since WARM considers the sole form of diversion for yard trimmings and food waste to be composting, the tons of these items that are termed "recycled" by some reports are assumed to be composted. The net costs for increased composting in Michigan were estimated by adding the additional costs for collection (same calculation as recycling) and the net cost for composting operations. The net cost for composting operations is the sum of the annualized capital and operating costs of composting, increased collection fees, revenue generated through the sale of compost, and the avoided tipping fees for landfilling. Information on the capital and operating costs of composting facilities was received from Cassella Waste Management during the analysis of a similar policy in Vermont.[125] These data are summarized in Table J-9-10.

[121] U.S. Census Bureau. "State & County QuickFacts—Michigan." Accessed on August 25, 2008, at: http://quickfacts.census.gov/qfd/states/26000.html.

[122] Based upon the ratio of capital cost per household used in the Vermont analysis. The Vermont capital cost is a result of personal communication between P. Calabrese (Cassella Waste Management) and S. Roe (CCS) on June 5, 2007.

[123] P. Simmons, N. Goldstein, S.M. Kaufman, N.J. Themelis, and J. Thompson, Jr. "The State of Garbage in America." *BioCycle*. April 2006. Accessed on August 24, 2008, at: http://www.seas.columbia.edu/earth/wtert/sofos/Simmons_SOG06.pdf.

[124] RecycleNet Composite Index. "U.S. Municipal Recycling Index—Spot Market Prices: February 1, 2008." Accessed on February 1, 2008, at: http://www.scrapindex.com/municipal.html. Adjusted to 2005$ using the Consumer Price Index calculator found at Federal Reserve Bank of Minneapolis, "What Is a Dollar Worth?" Available at: http://minneapolisfed.org/Research/data/us/calc/

[125] P. Calabrese (Cassella Waste Management), personal communication with S. Roe (CCS) on June 5, 2007. Because the cost was not originally specified in terms of 2007$, the TWG assumed the cost to be valid for 2005.

Table J-9-9. Cost analysis results for recycling

Year	Tons Recycled	Annual Collection Cost (MM$)	Annual Capital Cost (MM$)	Annual Recycled Material Revenue (MM$)	Landfill Tip Fees Avoided (MM$)	Net Policy Cost (Recycling) (MM$)	Discounted Costs (MM$)	Life-Cycle GHG Reductions ($MMtCO_2e$)	Michigan GHG Reductions ($MMtCO_2e$)	Michigan Cost-Effective-ness ($/Mt)
2009	—	$0.0	$0	$0	$0	$0	$0	—	—	
2010	653,003	$5.0	$28	$25	$32	–$23	–$22	2.3	0.0	
2011	1,342,182	$10.3	$28	$51	$65	–$78	–$70	4.6	0.0	
2012	2,069,076	$15.9	$28	$79	$100	–$135	–$117	7.0	0.1	
2013	2,835,281	$21.7	$28	$109	$137	–$196	–$161	9.3	0.1	
2014	3,642,455	$27.9	$28	$140	$176	–$259	–$203	12	0.1	
2015	4,492,319	$34.5	$28	$172	$217	–$326	–$244	14	0.8	
2016	5,001,614	$38.4	$28	$192	$242	–$367	–$261	16	0.8	
2017	5,535,828	$42.5	$28	$212	$267	–$409	–$277	18	0.8	
2018	6,095,973	$46.8	$28	$234	$294	–$453	–$292	20	0.9	
2019	6,683,097	$51.3	$28	$256	$323	–$499	–$307	22	0.9	
2020	7,298,289	$56.0	$28	$280	$352	–$548	–$320	24	0.9	
2021	7,942,676	$60.9	$28	$305	$384	–$599	–$334	26	0.9	
2022	8,617,428	$66.1	$28	$331	$416	–$652	–$346	29	1.0	
2023	9,323,759	$71.5	$28	$358	$450	–$708	–$358	31	1.0	
2024	10,062,926	$77.2	$28	$386	$486	–$766	–$369	33	1.0	
2025	10,836,233	$83.1	$28	$416	$523	–$828	–$379	34	1.7	
Totals						**–$6,846**	**–$4,058**	**150**	**5.4**	**–$745**

MM = million; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent. In-state emission reductions consider only GHG benefits that will happen in the state of Michigan. Life cycle emission reductions consider the energy inputs and outputs that come with production and distribution of the various fuels. The life cycle emissions figure is used in the summary table on pages 1 and 2 of this policy options document.

Note that negative numbers indicate cost savings.

Table J-9-10. Capital and operating costs of composting facilities

Annual Volume (tons)	Capital Cost ($1,000)	Operating Cost ($/ton)
< 1,500	$75	$25
1,500–10,000	$200	$50
10,000–30,000	$2,000	$40
30,000–60,000+	$8,000	$30

CCS assumed that the composting facilities to be built within the policy period would tend to be from the largest category (achieving the most efficient operating costs) shown in Table J-9-10. The composting volumes in 2015 and 2025 shown in Table J-9-10 suggest the need for 90 additional large composting operations (45,000 tons annual volume) to meet the incremental increase in composting through 2025. To annualize the capital costs of these facilities, CCS assumed a 15-year operating life and an 8% interest rate. Other cost assumptions include an assumed landfill tipping fee of $38/ton,[126] an additional source-separated organics collection fee of $2.50/household (or $7.67/ton, as used above in the recycling element), a compost facility tipping fee of $38/ton,[127] and a compost value of $11/ton.[128]

Table J-9-11 presents the results of the cost analysis for composting. GHG reductions were assumed not to begin until 2010, and the cumulative reductions estimated were 6.0 $MMtCO_2e$. An NPV of $922 million was estimated, along with a cost-effectiveness of $153/$tCO_2e$.

Table J-9-11. Cost analysis results for composting

Year	Annual Cost O&M ($MM)	Capital Cost ($MM)	Annualized Capital Cost ($MM)	Annual Collection Cost ($MM)	Incre-mental Landfill Tipping Fee Cost ($MM)	Value of Composted Material ($MM)	Tons of Waste Composted	Total Annual Compost-ing Cost ($MM)	Discounted Costs ($MM)	GHG Reductions ($MMtCO_2e$)	Cost-Effective-ness ($/t)
2009	$0	$0	$0.0	$0	$0	$0	—	$0	$0	—	
2010	$7	$40	$4.7	$2	$0	$2	220,807	$10	$10	0.09	
2011	$14	$48	$10.3	$3	$0	$5	453,846	$22	$20	0.19	
2012	$21	$48	$15.9	$5	$0	$8	699,638	$34	$30	0.28	
2013	$29	$48	$21.5	$7	$0	$11	958,723	$47	$38	0.38	
2014	$37	$56	$28.0	$9	$0	$14	1,231,661	$61	$47	0.47	
2015	$46	$56	$34.6	$12	$0	$17	1,519,034	$75	$56	0.57	
2016	$51	$32	$38.3	$13	$0	$19	1,691,625	$83	$59	0.65	
2017	$56	$40	$43.0	$14	$1	$21	1,872,663	$92	$63	0.73	
2018	$62	$40	$47.7	$16	$1	$23	2,062,491	$102	$66	0.80	
2019	$68	$40	$52.3	$17	$1	$25	2,261,465	$112	$69	0.88	
2020	$74	$40	$57.0	$19	$1	$27	2,469,954	$122	$71	0.96	
2021	$81	$40	$61.7	$21	$1	$30	2,688,339	$133	$74	1.04	
2022	$88	$48	$67.3	$22	$1	$32	2,917,018	$144	$76	1.12	
2023	$95	$48	$72.9	$24	$1	$35	3,156,402	$156	$79	1.19	
2024	$102	$48	$78.5	$26	$1	$37	3,406,917	$168	$81	1.27	
2025	$110	$48	$84.1	$28	$1	$40	3,669,005	$181	$83	1.30	
Total									**$922**	**6.0**	**$153**

O&M = operation and maintenance; $MM = millions of dollars; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/t = dollars per metric ton.

[126] P. Simmons, N. Goldstein, S.M. Kaufman, N.J. Themelis, and J. Thompson, Jr. "The State of Garbage in America." *BioCycle*. April 2006. Accessed on August 24, 2008, at http://www.seas.columbia.edu/earth/wtert/sofos/Simmons_SOG06.pdf.

[127] Emerson, Dan. *Latest Trends in Yard Trimmings* Composting. 2005. Accessed on May 23, 2008, from: http://hs.environmental-expert.com/resultEachArticle.aspx?cid=6042&codi=5723&idproducttype=6.

[128] The 2004 price of $10/yard was obtained from a case study of the City of Davenport, IA, available at: *http://www.cityofdavenportiowa.com/department/division.asp?fDD=28-375*. Assuming a dry solids content of 55% and a bulk density of 0.5 tons/yard, the value of composted material was calculated to be $11/ton of initial feedstock.

The overall cost analysis, as seen in Table J-9-12, yields an NPV of –$3,136 and a life-cycle cost-effectiveness of –$10/t$CO_2$e, based on the cumulative emission reductions of 314 MMtCO_2e (sum of the cumulative reductions shown in Tables J-9-9 and J-9-11). The cost-effectiveness based on GHG benefits from within Michigan's boarders is –$112/t$CO_2$e, based on cumulative emission reductions of 30 MMtCO_2e.

Table J-9-12. Overall policy results—cost-effectiveness

Year	Net Program Cost: Recycling ($MM)	Net Program Cost: Composting ($MM)	Total Net Program Cost ($MM)	Discounted Cost ($MM)	Life-Cycle Cost-Effectiveness ($/t$CO_2$e)	Michigan Cost-Effectiveness ($/t$CO_2$e)
2009	$0	$0	$0	$0		
2010	–$23	$10	–$13	–$12		
2011	–$78	$22	–$55	–$50		
2012	–$135	$34	–$101	–$87		
2013	–$196	$47	–$149	–$122		
2014	–$259	$61	–$199	–$156		
2015	–$326	$75	–$252	–$188		
2016	–$367	$83	–$284	–$202		
2017	–$409	$92	–$316	–$214		
2018	–$453	$102	–$351	–$226		
2019	–$499	$112	–$387	–$238		
2020	–$548	$122	–$426	–$249		
2021	–$599	$133	–$466	–$260		
2022	–$652	$144	–$508	–$269		
2023	–$708	$156	-–$552	-–$279		
2024	–$766	$168	-–$598	–$288		
2025	-$828	$181	–$647	–$296		
Total				**–$3,136**	**–$10**	**–$112**

$MM = millions of dollars; $/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent.

Sum of columns may not equal totals due to independent rounding. Negative numbers represent costs savings.

Industrial and New Construction Waste

Based on the best information available to CCS, the following estimate of industrial and construction waste quantities generated in Michigan were estimated. However, the volume of these wastes that is landfilled in the state is unknown, as a great deal of construction and demolition (C&D) and industrial waste may end up at Type II landfills, where it mixes in with traditional MSW. Additionally, a GHG benefit estimation technique has not been identified by CCS or the TWG. As most of these wastes are comprised of cement, ash, and other composites, there will likely be little change in landfill gas generated as a result of reduced landfill disposal of these wastes. The largest GHG benefit would most likely result from the reduced production of the raw materials for wastes that could be recycled.

Industrial and C&D wastes both fall under Michigan's definition of Type III wastes. The volume of Type III waste generated in the state was not available; therefore, it was estimated using estimated waste generation rates. The amount of industrial waste generated was estimated using a waste generation rate of 8.93 lb/employee/day[129] and industrial employment data from the Michigan Department of Labor. The volume of C&D waste was estimated using the EPA per-capita waste generation rate of 2.80 lb/person/day.[130] The estimated volume of in-state Type III waste generated in Michigan is shown in Table J-9-13.

Table J-9-13. Estimated amount of Type III waste generated in 2007

Type III Waste	Volume of Waste
Industrial Waste Generated (tons)	1,357,976
C&D Waste Generated (tons)	5,255,986
Total Type III Waste (tons)	6,613,962

As a result of this analysis, no additional GHG reductions and costs were estimated for the policy elements associated with industrial and C&D wastes. The MCAC recommends that additional research be conducted to better characterize in-state industrial and C&D waste generation and current forms of management.

Key Assumptions: For the MSW management input data to WARM, the key assumption is that none of the goals would be achieved via existing programs in place. To the extent that those programs will fully or partly achieve the goals of this policy, the GHG reductions estimated would be lower (no additional penetration from the current Michigan recycling and composting campaigns has been incorporated into the BAU assumptions for this analysis). Therefore, the most important assumption relates to the assumed BAU projection for solid waste management. This BAU forecast is based on current practices, and does not factor in the effects of further gains in recycling or composting rates during the policy period. The BAU assumptions are needed to tie into the assumptions used to develop the GHG forecast for the waste management sector, which does not factor in these changes in waste management practices during the policy period (2010–2025). To the extent that these gains in recycling and composting would occur without this policy, the benefits and costs are overstated.

The other key assumptions relate to the use of WARM in estimating life-cycle GHG benefits and the use of the stated assumptions regarding costs for increased source reduction, recycling, and organics recovery (composting in this example) programs.

Another important assumption is that under BAU, the waste directed to landfills would include methane recovery (75% collection efficiency) and utilization. The need for this assumption is partly based on limitations of WARM (which doesn't allow for management of landfilled waste into both controlled and uncontrolled landfills), but is also based on the overall direction of the policy recommendations of AFW-9.

[129] California Integrated Waste Management Board, Estimated Solid Waste Generation Wastes for Industrial Establishments. Available at: http://www.ciwmb.ca.gov/WASTECHAR/WasteGenRates/Industrial.htm.

[130] U.S. Environmental Protection Agency. *Characterization of Building-Related Construction and Demolition Debris in the United States*. Prepared for the by Franklin Associates. June 1998. Available at: http://www.epa.gov/epaoswer/hazwaste/sqg/c&d-rpt.pdf.

Additionally, transportation emissions for WARM are taken as default. This analysis has not considered the impacts of reduced exports as a result of the goals in this recommendation's Policy Design section.

This analysis assumes that no additional uncontrolled landfill sites trigger EPA control requirements during the policy period.

Key Uncertainties

It is likely that the impacts of this policy will cross state lines. Recycled materials in Michigan may be reprocessed into finished products in other states. Also, the recycled materials may be replacing virgin inputs that are mined, processed, and manufactured into finished goods outside of Michigan's boarders. Thus, the practice of increased recycling in Michigan will create GHG reductions outside of the state's boundary. The life-cycle analysis approach used here is consistent with the approaches used in other AFW policy options and options in other sectors (e.g., fuel use, nutrient consumption).

Due to insufficient data on the characterization of waste landfilled in Michigan, CCS was required to project the BAU and policy scenarios using a default national waste characterization from EPA. The adjustments and aggregation of material types required to fit the data to WARM reduce the certainty of the GHG benefit estimates.

There are major differences in emissions modeled for different purposes. Landfill industry representatives believe Michigan's collection system efficiency is much higher than that being modeled. They report continuous monitoring tests that show essentially no release of methane from landfills that are producing gas for energy use. They say the methane gets converted to CO_2 by bacteria in the soil cover at landfills. If methane release from landfills is overestimated, then the savings that could be attributed to the proposed policy mechanisms could be overstated. Additionally, several landfill gas projects are already being developed, so the landfill methane-related savings anticipated from this policy may be significantly less than modeled.

Growth rates for MSW generation are uncertain and should be further investigated and monitored. The current estimates for waste generation growth are likely skewed by inadequate information on current levels of recycling and composting, as well as imported Canadian waste.

The MCAC suggested that the quantification of this policy using WARM be reviewed by EPA to corroborate the GHG levels of reduction being achieved. CCS acknowledges that this would be a useful exercise; however, external review of quantification results is beyond the scope of technical support available in the MCAC process.

Additional Benefits and Costs

Successful implementation of this policy will also reduce landfill methane emissions and potentially emissions associated with waste combustion. AFW-10 covers additional mitigation for landfill methane.

Feasibility Issues

None specified.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-10. Landfill Methane Energy Programs

Policy Description

Use the renewable energy (methane) created at landfills during anaerobic degradation of wastes unable to be utilized in recycling and compost programs to displace fossil fuel use through the creation of useful energy.

Note the linkage to AFW-9 covering source reduction, recycling, and composting. There is also potential linkage to the biomass utilization options under AFW-1 and AFW-2, such that some biomass fiber in the MSW stream could be diverted to energy use under those options. To the extent that that those options achieve lower levels of biodegradable waste emplacement in the future, lower levels of landfill methane will be generated for collection and control. The analysis of the costs and benefits for this policy captures the effects of AFW-9. The potential effects of MSW biomass for energy utilization are also addressed.

Policy Design

Goals: Implement controls or waste management options at MSW landfills, such that 50% of the methane emissions that would be generated under BAU conditions are avoided by 2025.

Timing: By 2012, develop improved collection efficiency regulations for existing landfills that have active gas collection systems. By 2025, achieve full implementation of improved collection efficiency at all solid waste landfills to reduce methane emissions by at least 50%.

Parties Involved: MDEQ, private waste management industry, counties and other local units of government, and environmental groups.

Implementation Mechanisms

The policy goals could be achieved via a combination of improving the collection efficiency of existing LFG collection systems, developing additional landfill-gas-to-energy (LFGTE) projects, reducing the amount of biodegradable waste being landfilled (see AFW-9), or possibly other methods. Policies should be designed to incorporate the following:

- Ensure comprehensive environmental protection, including the greatest: total efficiency of energy use (i.e., useful energy divided by wasted energy), maximum displacement of fossil fuels, net GHG reductions, and reductions of all harmful emissions.
- Develop all financial incentives as market transformation policies.
- To the extent practical, capture and utilize LFG at all existing landfills. The policy may need to be different for large versus small landfills. If the economics of interconnecting with the electric grid and/or shipment off site of pipeline gas are not favorable, then the addition of some on-site facilities to use the energy might be needed.

- Conduct studies to determine the most appropriate policies for future waste collection and conversion to biomass fuels.
- Optimize energy production at existing landfill methane projects through operational efficiency.
- Perform a survey or audit of existing LFGTEs, and develop a database of existing emissions and collection efficiencies (e.g., possibly in coordination with EPA's Landfill Methane Outreach Program [LMOP]).
- Develop administrative rules that include design standards, monitoring standards, reporting requirements, and action limits.
- Join EPA LMOP as a State Partner.

Related Policies/Programs in Place

Federal New Source Performance Standards and emission guidelines for municipal solid waste landfills (require landfill collection and control for landfills of specific sizes and pollutant emission levels).

MPSC has commenced a formal rulemaking proceeding in Case No. U-15239 to revise the state's Electric Interconnection Standards Rules. The intention is to make the interconnection procedures more predictable and smoother. A revised set of rules is being filed as a starting point for the formal rulemaking process.[131] Also, utility rates, terms, and conditions of service for interconnected generators are being reviewed by MPSC staff. Concerns, issues, or barriers that might affect such facilities will be addressed in the rate case process.

Type(s) of GHG Reductions

CH_4: Reductions through increased collection and control efficiency or through conversion (preferentially via energy utilization).

CH_4, N_2O and CO_2: Reduction of fossil fuels and associated GHGs through the use of landfill methane for energy.

Estimated GHG Reductions and Net Costs or Cost Savings

GHG Reduction Potential in 2015, 2025 ($MMtCO_2e$): 0.91, 2.7, respectively.

Net Cost per tCO_2e: –$2.

Data Sources:

U.S. EPA, Landfill Methane Outreach Program. "Energy Projects and Candidate Landfills." Online database accessed on May 22, 2008, at: http://www.epa.gov/lmop/proj/index.htm.

U.S. EPA, LMOP, Landfill Gas Energy Cost Model (LFGcost), Version 1.4.

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[131] Similar processes are underway at the Federal Energy Regulatory Commission for improving the interconnection process for larger generators seeking interconnection with the electric transmission grid.

Michigan Greenhouse Gas Inventory and Reference Case Projections, 1990–2025: Waste Appendix. Available online at: http://www.arclimatechange.us/Inventory_Forecast_Report.cfm.

Center for Climate Strategies. *Michigan Draft Inventory and Forecast*. Source Data for Appendix G: Waste Management. Document available online at: http://www.miclimatechange.us/ewebeditpro/items/O46F14881.pdf.

Additional data sources are detailed in the quantification documentation, below.

Quantification Methods:

GHG Benefits

The goal of this policy requires a 50% reduction in the BAU landfill emissions through 2025. As the Michigan I&F shows, Michigan already has succeeded in capturing a high proportion of LFG. Therefore, with few uncontrolled landfills deemed "candidates" by the EPA LMOP,[132] a great deal of the additional methane capture targeted by this policy will need to come from increased collection efficiency at landfills already capturing LFG. The assumed BAU collection efficiency is the EPA default of 75%. Thus, three LFG capture opportunities were examined for this analysis: installing LFG capture technology (75% collection efficiency) at the four uncontrolled landfills identified as candidates by LMOP, increasing the collection efficiency of these same currently uncontrolled landfills from 75% to 90%, and increasing the collection efficiency of the landfills currently utilizing LFGTE technology from 75% to 90%. These projects will also create an indirect GHG benefit through the offset of fossil fuel-generated electricity and direct energy.

The potential GHG benefit from the installation and additional methane captured for LFGTE projects at landfills comes from two sources: the conversion of the methane in LFG to CO_2 (a gas with a lower global warming potential), and the indirect benefit from the offset electricity or natural gas use. The first benefit is calculated by multiplying the baseline CH_4 emissions from uncontrolled landfills from the Michigan I&F by the LFG control goal set by the TWG. The second benefit (offset electricity) is found by converting the methane captured from tCO_2e units to cubic meters of gas, then calculating the electricity generated and the emissions offset through avoided grid-based generation.[133] The grid-based electricity emission factor is calculated from the Michigan I&F. The GHG benefit from offset natural gas combustion for direct energy is calculated by multiplying the captured methane emissions at direct energy facilities by the global warming potential of 21 to yield the GHG benefit in terms of $MMtCO_2e$. The proportion of methane used for electricity generation and direct energy is determined by applying the current ratio of emission reductions provided in the Michigan LMOP data set.[134] The assumed proportion for this quantification is 24% of methane captured at direct-use facilities and 76% of the methane captured at electricity generation facilities.

[132] U.S. Environmental Protection Agency, Landfill Methane Outreach Program. "Energy Projects and Candidate Landfills." Online database accessed on May 22, 2008, at: http://www.epa.gov/lmop/proj/index.htm.

[133] (Fraction of landfill gas used for electricity generation) × (CH_4 captured in $MtCO_2e$) × ($1\ MtCH_4 / 21\ MtCO_2e$) × ($1\ m^3CH_4 / 0.00125\ MtCH_4$) × ($0.00254\ MWh / m^3CH_4$) ×Electricity EF.

[134] U.S. Environmental Protection Agency, Landfill Methane Outreach Program. "Energy Projects and Candidate Landfills." Online database accessed on May 22, 2008, at: http://www.epa.gov/lmop/proj/index.htm.

As mentioned in the Policy Description section above, the implementation of AFW-9 will lead to a reduction in the amount of methane generated at Michigan landfills. CCS used EPA's Landfill Gas Emissions Model (LandGEM) to determine the amount of methane that will be generated under full implementation of AFW-9, relative to the BAU without AFW-9. This reduction is presented in Table J-10-1, along with the results of the AFW-10 GHG benefit quantification.

Table J-10-1. Overall policy results—GHG benefit

Year	TWG LFGTE Goal (% of BAU)	BAU CH_4 Emissions From MSW Landfills (tCO_2e)	CH_4 Emissions From MSW Landfills Adjusted for AFW-9 (tCO_2e)	GHG Benefit: CH_4 Reduction From LFG Control ($MMtCO_2e$)	Electricity Generated (MWh)	Electricity Emissions Factor from ES TWG (tCO_2e/MWh)	GHG Benefit: Avoided Electricity Production ($MMtCO_2e$)	GHG Benefit: Avoided Nat. Gas Combustion for Direct Use ($MMtCO_2e$)	Total GHG Benefit ($MMtCO_2e$)
2009	0	3,196,121	3,196,121	—	—-	0.91	—	—	—
2010	3	3,295,791	3,295,791	0.10	7,578	0.91	0.01	0.0	0.13
2011	6	3,398,569	3,389,985	0.21	15,590	0.91	0.01	0.1	0.28
2012	9	3,504,552	3,478,912	0.33	23,998	0.91	0.02	0.1	0.43
2013	13	3,613,840	3,562,722	0.45	32,768	0.91	0.03	0.1	0.58
2014	16	3,726,537	3,641,520	0.57	41,866	0.91	0.04	0.1	0.74
2015	19	3,842,747	3,715,366	0.70	51,258	0.89	0.05	0.2	0.91
2016	22	3,962,582	3,784,284	0.83	60,911	0.89	0.05	0.2	1.08
2017	25	4,086,153	3,848,265	0.96	70,789	0.88	0.06	0.2	1.25
2018	28	4,213,578	3,907,268	1.10	80,859	0.87	0.07	0.3	1.43
2019	31	4,344,977	3,961,225	1.24	91,084	0.87	0.08	0.3	1.61
2020	34	4,480,474	4,010,044	1.38	101,427	0.87	0.09	0.3	1.80
2021	38	4,620,196	4,053,607	1.52	111,849	0.87	0.10	0.4	1.98
2022	41	4,764,275	4,091,774	1.66	122,311	0.87	0.11	0.4	2.17
2023	44	4,912,847	4,124,383	1.80	132,769	0.85	0.11	0.4	2.35
2024	47	5,066,052	4,151,252	1.95	143,179	0.84	0.12	0.5	2.53
2025	50	5,224,035	4,172,176	2.09	153,495	0.84	0.13	0.5	2.71
Total		**70,253,326**	**64,384,697**	**16.9**	**1,241,730**		**1.1**	**4.0**	**22.0**

Cost-Effectiveness

The data supporting the Michigan I&F were used to determine the potential GHG benefit and energy generation from each type of landfill in Michigan. Under the BAU scenario, 20% of GHG emissions occur at uncontrolled landfills, 71% at LFGTE landfills, and 9% at landfills that capture LFG, but flare it.

Using the results from an LFGcost model run (Table J-10-2), the costs of this policy are estimated based on whether the methane is converted to usable energy by a small engine, through direct use, or by a large engine (800 kW and greater).[135] To develop an overall cost for this policy, CCS used the current mix of methane capture at Michigan LFGTE projects, assuming that this mix would remain constant: 76% of methane is reduced via standard engine/generator set projects (it was assumed that these projects already have implemented gas collection, which is therefore not a part of the capital cost); 24% of methane is controlled by direct-use projects (the number of projects assumed to be limited by the location of end users); and 0% is assumed to be controlled by small-engine/generator-set projects(< 800 kW capacity).[136] The results of this model are applied to the four uncontrolled landfills only (toward the initial equipment needed to capture 75% of emissions), as the costs for current LFGTE projects are considered to be a part of the baseline.

Table J-10-2. Landfill gas (LFG) cost modeling results

EPA LFG cost Modeling Data	Scenario 1 Direct Use (0.5-mi. pipeline)	Scenario 2 Small Engine (< 800 kW)	Scenario 3 Standard Engine (> 800 kW)
Total capital	$1,347,604	—	$3,699,629
Average annual O&M	$320,966	—	$555,896
Annualized costs	$478,406	—	$988,122
Annual revenue	$1,669,494	—	$1,004,019
Annual average reductions ($MMtCO_2e$)	0.082	—	0.078
Project reductions ($MMtCO_2e$)	1.23	—	1.30
Cost-effectiveness ($/$tCO_2e$)	–$1.27	—	$0.31
Net present value	–$1,568,467	—	$404,734
Blended cost-effectiveness (Michigan)			
Baseline share of methane control in Michigan	24%	—	76%
Fractional cost-effectiveness ($/$tCO_2e$)	–$0.30	—	$0.24
Average Cost-Effectiveness ($/$tCO_2e$)	**–$0.07**		

EPA = U.S. Environmental Protection Agency; LFG = landfill gas; kW = kilowatts; O&M = operations and maintenance; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent. Assumes an 8% interest rate over 10 years and a 15-year project life, and includes in the total cost the cost of LFG collection and flaring. Negative numbers represent cost savings.

The modeling assumptions were based on the average opening and closing year of the candidate uncontrolled landfills in Michigan (1995 and 2023, respectively) and the average annual acceptance for large landfills (185,105 tons). The average depth of the landfills was assumed to be 50 feet (LFGcost default). The assumed number of large landfills was 62.[137] The values for the revenue from electricity sold were provided by the TWG, and the default value for revenue

[135] U.S. EPA, Landfill Methane Outreach Program. Landfill Gas Energy Cost Model (LFGcost), Version 1.4. Model run performed by B. Strode on June 24, 2008. More information on LFGcost is available at: http://www.epa.gov/lmop/res/index.htm.

[136] U.S. EPA, Landfill Methane Outreach Program. LMOP Database. Available at: http://www.epa.gov/lmop/proj/xls/opprjslmopdata.xls.

[137] Consistent with LFGcost model run completed by CCS for North Carolina Climate Action Plan Advisory Group process.

from direct energy was used ($0.065/kWh, $4.50/MMBtu). These prices were assumed to increase at 2% per year.

The average cost-effectiveness (–$0.07/t$CO_2$e) is multiplied by the GHG benefit calculated in the GHG benefit section above for each year to determine the annual cost of LFG collection at uncontrolled landfills. An additional cost is necessary to increase the collection efficiencies at landfills from the current assumed 75% efficiency to at least 90%. From a previous similar analysis, an MSW industry contact provided an estimated capital cost of $400,000 per landfill site would be needed to install additional gas wells and collection infrastructure.[138] These costs were applied to the 4 uncontrolled landfill sites and 34 LFGTE landfill sites from EPA's LMOP database that are indicated to be operating during the policy period. These capital costs are annualized over 15 years at 8% using the capital recovery factor method. The energy prices assumed for the LFGcost modeling are also applied to energy generated from the extra LFG captured.

The cost-effectiveness of this policy is presented in Table J-10-3. The NPV of costs incurred through the implementation of this policy is –$35 million, and the discounted cost-effectiveness is –$2/t$CO_2$e.

Table J-10-3. Overall policy results—cost-effectiveness

Year	Avoided Emissions (MMtCO_2e)	Annual Incurred Capital Cost of Advanced LFG Recovery (MM$)	Annualized Capital Cost of Advanced LFG Recovery (MM$)	Net Annual Cost for Initial (75%) Collection From Uncontrolled Landfills (MM$)	Annual Revenue From Produced Energy (MM$)	Net Annual Cost (MM$)	Discounted Costs (MM$)	Cost Effective-ness ($/t$CO_2$e)
2009	—	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
2010	0.13	$0.8	$0.1	$0.0	$0.6	–$0.6	–$0.5	
2011	0.28	$0.8	$0.2	$0.0	$1.4	–$1.2	–$1.1	
2012	0.43	$0.4	$0.2	$0.0	$2.1	–$1.9	–$1.7	
2013	0.58	$1.2	$0.4	$0.0	$3.0	–$2.6	–$2.2	
2014	0.74	$0.8	$0.5	–$0.1	$3.9	–$3.4	–$2.7	
2015	0.91	$0.8	$0.6	–$0.1	$4.8	–$4.3	–$3.2	
2016	1.1	$1.2	$0.7	–$0.1	$5.8	–$5.2	–$3.7	
2017	1.3	$0.8	$0.8	–$0.1	$6.9	–$6.2	–$4.2	
2018	1.4	$1.2	$0.9	–$0.1	$8.1	–$7.2	–$4.7	
2019	1.6	$0.8	$1.0	–$0.1	$9.3	–$8.4	–$5.1	
2020	1.8	$1.2	$1.2	–$0.1	$10.5	–$9.5	–$5.5	
2021	2.0	$0.8	$1.3	–$0.1	$11.9	–$10.7	–$6.0	
2022	2.2	$1.2	$1.4	–$0.1	$13.2	–$12.0	–$6.3	
2023	2.4	$1.2	$1.5	–$0.2	$14.6	–$13.3	–$6.7	

[138] J. Ketchum, Waste Management, personal communication with S. Roe, CCS, December 5, 2007. This is the midpoint of a range of estimated costs of $300,000–$500,000 per site.

Year	Avoided Emissions ($MMtCO_2e$)	Annual Incurred Capital Cost of Advanced LFG Recovery (MM$)	Annualized Capital Cost of Advanced LFG Recovery (MM$)	Net Annual Cost for Initial (75%) Collection From Uncontrolled Landfills (MM$)	Annual Revenue From Produced Energy (MM$)	Net Annual Cost (MM$)	Discounted Costs (MM$)	Cost Effective-ness ($/tCO_2e$)
2024	2.5	$0.8	$1.6	–$0.2	$16.1	–$14.6	–$7.0	
2025	2.7	$1.2	$1.8	–$0.2	$17.6	–$16.0	–$7.3	
Totals	**22**	**$15.2**				**–$117**	**–$35**	**–$2**

LFG = landfill gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; MM = million; $/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent. Negative numbers represent cost savings.

Key Assumptions: The analysis does not factor in the closure of specific landfills or the adoption of LFG controls at specific landfills outside of the BAU forecast. Modeling GHG emissions and reductions at individual sites is beyond the scope of this analysis; however, the approach used is consistent with the methods used to develop the GHG forecast for the waste management sector.

Each of the cost inputs above contains key assumptions; additional study of these inputs could reduce the associated uncertainty in the cost estimates.

Key Uncertainties

LFG collection can be expensive. Methane utilization can also be expensive and can take the site to a new level of complexities. For example, electricity generation is a different industry and requires a skill set different from the waste management industry. The costs that may arise from the added complexity of LFG collection and utilization are not accounted for in the quantification of this option.

It is possible that landfill sites not considered in the quantification of this policy may trigger EPA requirements during the policy period. However, for the purposes of the quantification of AFW-10, this is assumed not to occur.

There are major differences in emissions modeled for different purposes. Landfill industry representatives believe the Michigan collection system efficiency is much higher than that being modeled. They report continuous monitoring tests that show essentially no release of methane from landfills that are producing gas for energy conversion. They say the methane gets converted to CO_2 by bacteria in the soil cover at landfills. If methane release from landfills is overestimated, then the savings the could be attributed to the proposed policy mechanisms could be overstated. Additionally, several projects are already being developed, so the savings anticipated from this policy may be significantly less than modeled.

Growth rates for organic materials being landfilled are highly uncertain and will depend on recycling and composting goals and actual diversions, as well as the disposition of Canadian waste currently being imported.

Increasing the landfill gas system collection efficiency to 90% is not necessarily the only method to reduce emissions to 50% of BAU by 2025. If other types of reductions are found or better inventory numbers reflect a much smaller impact from this sector, then those values should be considered as well.

The offset natural gas benefit estimate is based on the global warming potential of methane, relative to CO_2. It does not account for other life-cycle emissions related to natural gas production and combustion.

Additional Benefits and Costs

Care should be taken to make sure that the state does not inadvertently kill the market for landfill methane capture and conversion to useful energy by ending the voluntary carbon market. If capture and conversion become mandatory, then the payment stream from the voluntary carbon market will dry up immediately. This could probably be replaced by credits from a cap-and-trade program, but may have unintended consequences.

Feasibility Issues

None identified.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

Appendix K
Cross-Cutting Issues
Policy Recommendations

Summary List of MCAC Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2009–2025			
CCI-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not Quantified*					Unanimous Approval
CCI-2	Statewide GHG Reduction Goals and Targets	*Not Quantified*					Unanimous Approval
CCI-3	State, Local, and Tribal Government GHG Emission Reductions (Lead-by-Example)	*Not Quantified*					Unanimous Approval
CCI-4	Comprehensive Local Government Climate Action Plans (Counties, Cities, Etc.)	*Not Quantified*					Unanimous Approval
CCI-5	Public Education and Outreach	*Not Quantified*					Unanimous Approval
CCI-6	Tax and Cap/ Cap and Trade	*MCAC approved creation of a new Market-Based Policies Technical Work Group as the lead for this policy* recommendation.					Transferred
CCI-7	Seek Funding for Implementation of MCAC Recommendations	*Not Quantified*					Unanimous Approval
CCI-8	Adaptation and Vulnerability	*Not Quantified*					Unanimous Approval
CCI-9	Participate in Regional, Multi-State, and National GHG Reduction Efforts	*Not Quantified*					Unanimous Approval
CCI-10	Enhance and Encourage Economic Growth and Job Creation Opportunities Through Climate Change Mitigation	*Not Quantified*					Unanimous Approval
CCI-11	Enhance and Encourage Community Development Through Climate Change Mitigation: Address Environmental Justice	*Not Quantified*					Unanimous Approval

CCI = Cross-Cutting Issues; GHG = greenhouse gas; MCAC = Michigan Climate Action Council; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

CCI-1. GHG Inventories, Forecasting, Reporting, and Registry

Policy Description

Greenhouse gas (GHG) emissions *inventories* track statewide emission trends and quantify emissions from individual sources and sinks (both anthropogenic and natural). They can be used to inform state leaders and the public and to verify GHG reductions associated with GHG reduction programs.

GHG *forecasts* are scenario-based predictions of future emission trends built on inventories and projected economic trends. These forecasts are useful for identifying the factors that affect trends and highlight opportunities for mitigating emissions or enhancing sinks.

Detailed GHG *reporting* is needed from all major GHG sources[1] in order to develop accurate inventories. Reporting is also required for sources to participate in GHG reduction programs, such as market-based systems like cap and trade and carbon taxation. Participation in a reporting program prior to the establishment of a GHG reduction program establishes an early baseline that can be used to avoid disincentives to abate emissions prior to establishment of the reduction program.

A GHG *registry* enables recording of GHG emission reductions in a central repository. Registries can establish "ownership" of emission reductions, protect baselines, and provide a mechanism for regional cooperation. Registries can also provide a foundation for future trading programs and facilitate the identification of opportunities for reductions.

Policy Design

The state should institute formal GHG inventory, forecast, and reporting functions to be carried out by a state agency.

Goals:

- Building on existing state inventory processes and other state-of-the-art methods,[2] utilize a standardized protocol for use in preparing a statewide emission and sink inventory. The protocol should provide guidelines for inventorying all natural and man-made GHG emissions for source- and consumption-based inventories.[3] The Michigan Climate Action

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[1] According to The Climate Registry, individual sources are defined either as "entities" (i.e., any corporation, institution, or organization) recognized under U.S. law, or as "facilities" (i.e., any installation or establishment located on a single site or on contiguous or adjacent sites that are owned or operated by an entity). See http://www.theclimateregistry.org/downloads/GRP.pdf for additional details. The official definition of a "source" is left to MDEQ, but facility-level reporting is strongly recommended.

[2] U.S. Environmental Protection Agency State Inventory Guidelines (e.g., Emissions Inventory Improvement Program [EIIP] Technical Report Series Volume 8, *Estimating Greenhouse Gas Emissions),* U.S. National Inventory Guidelines, and Intergovernmental Panel on Climate Change Guidelines.

[3] Source- and consumption-based inventories typically differ only by emissions associated with the import and export of electricity and steam across state boundaries. The latter can be obtained from the former by adding all GHG emissions associated with the generation of electricity and steam that is imported across state boundaries. The

Council (MCAC) recommends that the responsible agency inventory the six Kyoto Protocol gases—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulfur hexafluoride (SF_6), and weight these gases according to global warming potentials reported by the International Panel on Climate Change (IPCC).

- Follow the inventory protocol to prepare annual inventories of emission sources and sinks that are consistent, complete, and both production- and consumption-based. The annual inventories should be compiled in a report at least once every 5 years and prepared with recommendations for improvements.
- Utilize a standardized protocol for the periodic and complete forecasting of statewide GHG emissions. Forecasting should reflect projected growth as well as the implementation of scheduled mitigation projects. Treatment of uncertainties should be transparent and as consistent as possible across sectors and time. The protocol should specify multiple scenarios. Methods must be consistent with those of the inventory.
- Follow the forecasting protocol to develop forecasts of future GHG emissions in at least 5- and 10-year increments extending at least 20 years into the future.
- Utilize a standardized protocol for the annual reporting of GHG emissions and sinks attributable to direct emissions (and certain indirect emissions)[4] of entities operating within the state. It is recommended that:
  - The protocol follow reporting guidelines being developed by The Climate Registry (TCR);
  - Reporting be conducted at the facility level;
  - To the extent feasible, reporting should build upon existing reporting systems;
  - Reporting include direct emissions as well as consumption of electricity and steam (for the purpose of calculating associated indirect emissions);
  - Direct emissions be reported by entities based upon a means of direct measurement whenever practical and/or required;
  - The reporting protocol include guidelines for third-party verification;
  - Facilities have the opportunity to report emissions sinks, for possible use as offsets in a market-based GHG abatement program (such as CO_2 taxation or cap and trade); and
  - Facilities have the opportunity to report verifiable "potential" emissions.
- When the program reaches maturity, all significant sources of GHGs should be required to report emissions to the Michigan Department of Environmental Quality (MDEQ) according to the protocol. The definition of "significant" is left to the responsible agency to determine.

Michigan Climate Action Council will leave the precise methodology for computing source-based and consumption-based emissions to the Michigan Department of Environmental Quality.

[4] According to The Climate Registry, *direct emissions* (also known as Scope 1) are those "from sources within the reporting entity's organizational boundaries that are owned or controlled by the reporting entity, including stationary combustion emissions, mobile combustion emissions, process emissions, and fugitive emissions"; and *indirect emissions* (also known as Scope 2) are "a consequence of activities that take place within the organizational boundaries of the reporting entity, but that occur at sources owned or controlled by another entity."

- Utilize a standardized protocol by which to register emissions from sources. It is recommended that the state use TCR's services for this purpose.
- Wherever possible, utilize protocols in harmony with inventory, forecast, reporting, and registry activities in other states and regions and nationally.

Timing: This function should be implemented as soon as possible as allowed by current funding and enhanced over time. Because GHG reporting will form the basis for enhanced inventories and forecasts and will be relied upon in the event a market-based program is established, early priority should be placed on developing a reporting program.

Parties Involved: All GHG emission sources and sinks (both anthropogenic and natural) should be included in the inventory and forecast. All entities operating within the state and generating significant emissions should be required to report, and a significant percentage of those emissions should be gathered from direct measurements. The definition of "significant" is left to MDEQ.

Other: Subject to consistently rigorous quantification, voluntary GHG reporting should be open to all sources (e.g., combustion, processes, vehicles), including the state and tribal governments, municipalities, and other jurisdictions.

Reporting should not be constrained to particular sectors, sources, or approaches.

Implementation Mechanisms

- The goals above provide a detailed description of the recommended approach to implementation.
- Consider implementing registry/reporting activities through TCR. However, whether or not TCR is involved in the process, a state agency will need to be given the ultimate responsibility for managing these activities and reporting on outcomes. If TCR is not used, then the state agency will need to provide the registry services. Note that state funds will need to be allocated to manage the four processes described in this policy.
- An entity will need to be assigned to prepare an assessment identifying the details of this package of initiatives, along with the costs to implement it. Stakeholder input should be sought on this assessment.

Related Policies/Programs in Place

Inventory and Forecast

- In 2005, The Center for Sustainable Systems at the University of Michigan submitted an inventory of Michigan GHGs for 1990 and 2002 to MDEQ.
- As required by the Governor's Executive Order No. 2007-42 (which established the MCAC), the Center for Climate Strategies prepared an inventory for 1990–2005 and a forecast through 2020.
- Inventory methodologies are recommended in:
    - *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*,

- IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (2000), and
- IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (2003)

Reporting and Registries

- MDEQ participates on the Steering Committee for the development of TCR, a multi-state program designed to be an essential piece of infrastructure for the development of state and federal climate change programs. More than 30 states in the United States and Mexico, and several Canadian provinces have already signed on to join TCR. For more information about TCR, go to http://www.theclimateregistry.org/.
- Wolverine Power Cooperative, Horizon Environmental Corporation, and Ford Motor Company are the only three entities in Michigan that have joined TCR as "Reporters."
- Signatories of the Midwestern Regional Greenhouse Gas Reduction Accord have pledged to join TCR.
- Point sources regulated under the U.S. Environmental Protection Agency (EPA) Nitrogen Oxides (NO_x) Budget Trading Program and Acid Rain Program currently report CO_2 emissions to EPA.
- Michigan Public Act (P.A.) 451 of 1994, Part 55, Rule 324, Section 5522 of the Air Pollution Control Rules establishes provisions for emission reporting for facilities.
- Michigan P.A. 451 of 1994, Part 55, Rule 336.202 of the Air Pollution Control Rules requires annual reporting from sources of air pollution, as directed by the MDEQ Air Quality Division (AQD), for the purpose of obtaining information on the quantity of air emissions for the proper management of air resources.
- MDEQ-AQD Operational Memorandum No. 13 outlines the pollutant threshold levels (for criteria pollutants) and provides guidance for establishing which emission sources should be included in the annual inventory.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

Costs are uncertain until the assessment is completed.

Additional Benefits and Costs

An estimate of staffing and costs to implement this recommendation is needed.

Feasibility Issues

None identified at this time.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-2. Statewide GHG Reduction Goals and Targets

Policy Description

In Executive Order No. 2007-42, the Governor directed the MCAC to recommend specific short-term, mid-term, and long-term GHG reduction goals or targets for Michigan. Additionally, the Midwestern Regional Greenhouse Gas Reduction Accord, signed by Governor Granholm on November 15, 2007, establishes a requirement for MGA staff and appropriate state agency representatives to set regional GHG reduction targets that are consistent with member states' targets. The establishment of a Michigan statewide goal or target can provide vision and direction, a framework within which implementation of MCAC policy recommendations can proceed effectively, and a basis of comparison for periodic assessments of progress. GHG reduction goals or targets recommended by the MCAC should be consistent with the parallel goal of an efficient, robust Michigan economy. In pursuit of similar climate progress, approximately 20 other states have established GHG reduction goals or targets.

The Intergovernmental Panel on Climate Change (IPCC) determined that atmospheric GHGs must remain below 400–450 parts per million of carbon dioxide equivalent (CO_2e) to have a reasonable chance of staying below 2^oF of warming. This concentration is considered the stabilization target. The IPCC further calculated that the industrialized nations' cumulative emissions over the 2000–2050 period must remain less than 700 gigatons (Gt) of CO_2e. This means that the world's industrialized nations must reduce emissions 70%–80% below 2000 levels by 2050 to help prevent global temperature increases. For its share, the United States needs to reduce its GHG emissions by about 80% by 2050 in order to stay within its estimated "safe" range of 160–265 $GtCO_2e$ for that same 50-year period. That comes to a 20% per decade reduction, or 2% per year.

The target years and GHG reduction goals included in this policy recommendation reflect a high level of uncertainty regarding the costs and benefits of implementing GHG reduction policies in Michigan. These goals have been examined in the second phase of the process and considered in combination with the results of the modeling and evaluation of the selected policy recommendations.

In accordance with the April 30, 2008, *Michigan Climate Action Council Interim Report* (Interim Report)[5], "the strategy development process must evaluate and consider economic and environmental impacts, including the implementation costs or cost savings for individuals, communities, businesses, and jobs in Michigan." The policy recommendations detailed by the six Technical Work Groups (TWGs) (Agriculture, Forestry, and Waste Management, Energy Supply [ES], Residential, Commercial and Industrial, Transportation and Land Use, Cross-Cutting Issues [CCI], and Market-based Policies) include policies to reduce GHG emissions at low net cost, and identify opportunities for substantial net savings. Implementation of carefully crafted policy recommendations should bring significant economic benefits to the Michigan economy, by reducing fuel costs through efficiency measures, by reducing the export of capital

[5] See MCAC web site- www.miclimatestrategies.us

from the state, and by stimulating the Michigan economy through the creation of new opportunities and jobs in energy efficiency, clean energy technologies, renewable energy development, transportation, and land-use planning.

Policy Design

The MCAC originally proposed preliminary target years and GHG reduction goal ranges of 10%–20% for 2015 and 25%–35% for 2025 in the Interim Report. This was consistent with helping Michigan stay just below the upper limit of the U.S. cumulative budget of 265 $GtCO_2e$.

The MCAC has since modified the preliminary target year and GHG reduction goals to be consistent with the goals being considered by the Midwestern Governors Association (MGA). They are presented in the Table K-2.1 below. The policies recommended by the MCAC appear to be able to achieve a 20% reduction below 2005 levels by 2020. To do so however, it will be necessary for the state to move expeditiously forward with near–term implementation of the policy initiatives outlined in this MCAC Final Report. This includes the institution of formal mechanisms to monitor and verify GHG reduction progress and to periodically adjust reduction goals and strategies when needed.

Goals:

Table K-2.1. MCAC-recommended GHG reduction goals

Year %	Reduction from 2005 Levels
2005	Baseline
2020	20%
2050	80%

The MCAC also recommends that a formal performance tracking mechanism be developed to gauge progress in Michigan toward achievement of the goals and targets.

Timing: 2009–2020.

Parties Involved: All parties statewide.

Other: None.

Implementation Mechanisms

The GHG reduction goals and targets should be established through executive or legislative action. Various policy recommendations may also depend on implementing or authorizing executive action or legislation. All such directives or legislation should contain accountability measures for tracking, verifying, and measuring progress toward meeting the specified goal and targets, and should include tracking other information important to policymakers and the public.

A number of standards that define the process for measuring GHGs should be considered for tracking reductions. Two of the most commonly used are:

- The *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (Revised Edition), issued by the World Business Council for Sustainable Development and the World Resources Institute.
- International Standard, ISO 14064-1 Part 1: *Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals*. ISO 14064-1 is based on the GHG Protocol.

The state will need to determine whether this can best be accomplished by assigning these coordination functions to an existing agency in state government or by creating a new organizational entity. The designated lead agency for implementation of the MCAC recommendations will develop specific tracking and verification mechanisms for measuring actual progress toward meeting the specified GHG reduction goals and targets. This will include updates to the energy use and emission inventories identified in CCI-1 and, where applicable, baseline facility-level carbon "footprint" measurements to allow informed business decisions on the potential adoption of suitable GHG reduction options based on analysis of their cost-effectiveness. Such assessments will enable us to:

- Identify opportunities for reductions in emissions, including those likely to result in cost savings;
- Assess potential financial exposure to the introduction of emission trading schemes (and other government-led policies); and
- Assess the relative cost/benefits of seeking carbon neutrality as part of future marketing strategies.

One option for facility-level consideration could be the coupling of GHG reduction goals with energy efficiency. State facilities could be managed by a private energy performance or energy services company (ESCO), which designs, purchases, installs, and maintains energy-saving equipment, and guarantees that the energy savings achieved will pay for project costs. Project examples include replacing lighting equipment, modifying or replacing boilers and chillers, installing modern energy management control systems, and replacing motors. Either the existing or new organizational entity (i.e., office of climate change) could provide services aimed at increasing program participation and aiding those who have made commitments to performance contracting, including technical assistance, education, and information; a state-specific *Guide to Energy Performance (and Contracting With ESCOs)*; financing, opinion measurement, and recording and verifying savings.

The International Performance Measurement and Verification Protocol establishes standards for measurement and verification and allows building owners, ESCOs, and financiers of building energy efficiency projects to quantify energy conservation measure performance and energy savings. Where applicable, energy accounting software, such as METRIX, should be used by facilities to record cost savings (and potential) GHG reductions.

To the extent practicable, the state coordinating entity should also track investments in energy efficiency projects and related implementation efforts. This could include alternative energy sources, their types and use rates, the use of GHG offsets, GHG savings realized, the return on investment for those efforts, jobs created, and other economic improvements or impacts. Impacts to be considered include land-use changes, water resources protected, waste reduction—recycling increases, market changes and increases/decreases/changes in economic sectors.

The designated lead coordinating agency should publish these results biennially. The progress achieved (or lack of adequate progress) should be used to educate the public and policymakers about the effects of efforts to date, and to determine whether additional actions are necessary to meet the goals.

Related Policies/Programs in Place

See the Related Policies/Programs in Place section for CCI-1 (GHG Inventories, Forecasting, Reporting and Registry).

Executive Order No. 2007-42, signed on November 14, 2007, directed the MCAC to recommend specific short-term, mid-term, and long-term GHG reduction goals or targets for Michigan.

Executive Directive No. 2007-22, signed on November 14, 2007, directed the state of Michigan to continue reducing state energy consumption to meet goals specified in the Directive, to improve energy efficiency in the state motor vehicle fleet, to include energy efficiency standards in purchasing, to meet the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards in new construction, and to take other measures to reduce energy use and improve energy conservation.

The Midwestern Regional Greenhouse Gas Reduction Accord, signed by Governor Granholm on November 15, 2007, establishes a requirement for MGA staff and appropriate state agency representatives to set regional GHG reduction targets that are consistent with member states' targets.

Michigan's legislature recently passed a package of energy-related bills (Senate Bill [S.B.] 213, S.B. 1048, and House Bill [H.B.] 5524) that create a renewable portfolio standard (RPS), the Michigan Energy Conservation Fund, energy optimization plans (EOPs), net metering, integrated resource planning (IRP), and numerous other provisions to be required of utilities and the Michigan Public Service Commission (MPSC).

Type(s) of GHG Reductions

The six types of gases included in the U.S. Greenhouse Gas Inventory: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

Whether implementation of the package of recommendations in this *Michigan Climate Action Plan* will achieve the MCAC goals and targets and whether this will result in significant reductions to global climate change impacts in the state, region, nation, and beyond.

The costs of inaction are not quantified.

Additional Benefits and Costs

An entity will need to be assigned to prepare an assessment identifying the necessary staffing and costs to implement the coordination elements of this recommendation along with the accountability and tracking system.

Feasibility Issues

None identified at this time.

Status of Group Approval

Approved.

Level of Group Support

Unanimous, except for one abstention.

Barriers to Consensus

None identified.

CCI-3. State, Local, and Tribal Government GHG Emissions (Lead by Example)

Policy Description

The state of Michigan and many local and tribal governments have undertaken various policy and program actions in several key areas to obtain GHG emission reductions and improve energy efficiency. Many of these ongoing and future efforts can provide practical and working examples of what can be done by nongovernmental organizations (NGOs), academic institutions, and even individual citizens to reduce GHGs. Much more effort is planned and should be carried out to further improve Michigan's energy efficiency and reduce our carbon dependency and emission rate. A small sample of these activities is listed in the Related Policies and Programs in Place section below.

State, local, and tribal governments are responsible for providing a multitude of services for the public that are delivered through very diverse operations. This also makes them responsible for overseeing wide-ranging GHG emission activities and provides leadership opportunities to work with universities, nonprofit organizations, and the private sector to reduce emissions and increase energy efficiency. For example, the state of Michigan is a major consumer of electricity. State government can promote the development of environmentally benign generation and purchase a significant portion of its power through a certified "green power" program.

While the incentive for this will be, in part, market driven as energy costs increase, it will only be achievable through a continued comprehensive analysis of current operations, identification of significant GHG sources, and implementation of changes in technology, procedures, behavior, operations, and the services provided. State, local, and tribal governments must find ways to encourage and provide incentives for reducing GHG emissions in a variety of ways. One of the most important is to link GHG reductions to energy expenditures, and demonstrate that reduction in one leads to reduction in the other.

Policy Design

State and local governments should establish GHG reduction targets for GHG emissions within their own geographic areas and their respective jurisdictions consistent with those established by the Michigan Climate Action Council in its Final Report to the Governor. Tribal governments working with each other, with federal guidelines, and in accordance with agreements with state government will work for similar goals within their geographic areas and respective jurisdictions. In this case, "jurisdictions" is defined as those buildings, transportation vehicles, and associated infrastructure owned and maintained by state and local governments and academic institutions. This will help set an example for industry and the general public and build expectations of continued leadership for a "greener" standard of living. For example, actual governmental GHG emission reductions, and their respective measurements through monitoring, are easier to determine if governmental units disaggregate at the agency, department, facility, and building levels and require agency- or department-specific reports. GHG reduction progress will first require baseline data at whatever granular level is to be monitored and reported.

State, local, and tribal governments and academic institutions will develop additional incentives for energy efficiency and GHG reductions. For example, government and academia should not invest or issue bonds for their capital investments, including infrastructure development and maintenance, transportation fleets, and the like, unless all applicable energy efficiency standards are met.

At this time, no one governmental agency monitors the ongoing climate efforts of Michigan's various agencies, departments, and tribal governments. Such coordination should include reviewing state, local, and tribal government activities and providing direction, guidance, resources, shared approaches, and recognition to agencies or departments and their employees who are working to reduce government GHG emissions. All this will take coordination and an extensive amount of education and outreach by a designated lead agency. The state will need to determine whether this can best be accomplished by assigning these coordination functions to an agency in state government.

Goals:
Each state and local government agency, school district, and college/university, in consideration of its current and projected building stock, will lead by example and do the following:

- Determine and quantify its current and projected energy consumption and associated GHG emissions from such consumption.
- Develop and propose a plan to reduce its GHG emissions associated with its building stock commensurate with the statewide GHG reduction goals established in the Michigan Climate Action Council – Final Report to the Governor.
- Provide the plan to the appropriate state agency.
- Report the state and local government agency, school district, and college/university progress toward their GHG reduction goals in buildings to the appropriate state agency on an annual basis in accordance with established reporting protocols.

Each state and local government agency, school district, and college/university will, in consideration of its current and projected transportation stock:

- Quantify and establish the same goals for transportation stock described above for its building stock.
- Provide the plan to the appropriate state agency.
- Report the state and local government agency, school district, and college/university progress toward their GHG reduction goals in transportation to the appropriate state agency on an annual basis.
- Develop appropriate incentives to promote these endeavors.
- Identify opportunities to promote green power purchasing by state and local agencies.

Each tribal government and tribal government agency, in consideration of its current and projected building stock, will take the actions listed above pursuant to provisions of agreements as negotiated and signed between the tribal governments and the state.

When appropriate, the state should develop and provide guidelines and tools to assess and promote reductions of GHG emissions. Such tools should include instruments to develop baseline energy use, GHG emissions, and potential reductions and efficiencies associated with present and future land perturbations, consumer activities, and building scenarios. These tools and information sources could be helpful in prioritizing decisions that minimize GHG emissions or highlighting the need for some future authority to regulate and/or monitor GHG emissions. This information would also help guide officials and developers in choosing technologies and activities that could also result in development that either protects or minimizes environmental impacts and reduces additional contributions of GHGs.

Timing: The state's (and many local governments') efforts to lead by example in reducing its own GHG emissions have already begun through various independent actions and executive directives. The baseline GHG emission inventories from the prior years are already recorded and will provide a foundation for the effectiveness of future reduction efforts. Future annual reports documenting the state's progress in emission reduction efforts will be forthcoming.

Parties Involved: MDEQ and other relevant state agencies. Coverage should include operations of all state agencies, local governments and school districts, and tribal governments as applicable pursuant to state/tribal agreements.

Other: It is recommended that the state negotiate an accord with the tribal governments within Michigan that outlines shared concerns regarding climate change issues and sets out provisions for coordinating activities and goals in response to those shared concerns.

Implementation Mechanisms

The designated lead agency will communicate to the public, policymakers, businesses, and local, state, federal, and tribal governments regarding the effects and success of various policy recommendations initiated by state, local, and tribal governments to reduce GHG emissions and to implement energy efficiency measures. As such, the designated lead agency will play multiple roles, including coordination among state, local, and tribal government agencies involved in GHG reductions efforts. Some ongoing GHG reduction options and opportunities were discussed in CCI-2 above and outlined in the Related Policies/Programs in Place section of this CCI policy recommendation.

The designated lead agency will also serve as a focal point for public education and outreach to market incentives, and provide assistance and other resources offered by state government to help all interested parties in meeting the state's GHG reduction goals. The designated lead agency will consider all of the following methods to effectively communicate this information:

- Maintain a current inventory of state initiatives, including metrics available to assess the effectiveness of each initiative.
- Maintain a clearinghouse of reliable information on various policy and program actions, technical and financial assistance available, procurement options for low-GHG products, and other relevant information from academic, government, nongovernment, or business sources.
- Actively market state demonstration projects to potentially interested parties, and assist others (including local and tribal governments) in marketing their demonstration projects.

This includes the promotion of quantifiable, sustainable, and measurable building and transportation energy conservation improvements and GHG reductions.

- Provide frequent and effective outreach to stakeholders using a wide variety of methods that actively engage the stakeholders meaningfully, such as:
  - Planning events.
  - Participating in trade shows and conferences.
  - Conducting studies and analysis to assess the potential of alternative technologies for GHG reduction and energy efficiencies.
  - Providing training workshops on integration of GHG reduction and energy efficiency initiatives into local planning and zoning functions, incentives for greater production/utilization of locally grown foods, and other relevant training needs for the public, business, and local or state government.
  - Using public service announcements, other print, TV, or Internet media-related methods.
  - Facilitating GHG reduction performance reviews and recognition of agency progress.
  - Maintaining a Web site containing current information on the inventory of state actions; the clearinghouse of policy and program actions; implementation tool kits; assistance and incentives available; tribal, state, local, and federal contacts; and other relevant information.
  - Serving as a liaison with other climate action-based groups around the state and region.

The designated lead agency will coordinate these efforts with other public education and outreach activities contained in CCI-5, including the Climate Challenge, and other policy recommendations referenced within the other MCAC TWGs. It will also interact with other state and federal agencies to facilitate the development of needed resources, such as suitable geologic maps for carbon sequestration, and wind and solar energy siting. Likewise, tribal implementation of initiatives should be coordinated and linked to the efforts of the designated lead agency.

Related Policies/Programs in Place

- The MDEQ’s participation on the TCR Steering Committee.
- Michigan's membership in the newly formed Midwestern Regional Greenhouse Gas Reduction Accord.
- The Michigan Forest Carbon Offset and Trading Program pilot project.
- Michigan’s ongoing efforts to attract green energy companies.
- Local conservation districts' establishment of tree plantations.
- Property tax advantages to forest landowners for appropriate sustainable management to provide additional carbon sequestration.
- Michigan Department of Labor and Economic Growth’s (MDLEG's) development of the Biomass Energy Program and Michigan Department of Natural Resources’ (MDNR's) Michigan Renewable Fuels Commission to encourage energy alternatives.

- Renewable energy bills requiring utility companies to put information on customers' bills about renewable energy programs and available tax credits.
- The Michigan Wind Manufacturing Working Group (sponsored by a consortium of businesses, state agencies, and universities) advances the designing, engineering, and manufacturing of wind energy systems in Michigan.
- Midwest Regional Carbon Sequestration Partnership, a U.S. Department of Energy (DOE)-sponsored partnership of states, universities, and companies, is a pilot project to test the potential for sequestering CO_2 underground.
- Clean Cities programs support the use of alternative fuels for vehicles.
- Grand Rapids' use of green power for the city's water and sewer system.
- Grand Rapids' and Ann Arbor's replacement of their street lights with light-emitting diode (LED) fixtures.
- Michigan State University's joining the Chicago Climate Exchange.
- Executive Directive No. 2005-4: "Energy Efficiency in State Facilities and Operations": energy use reductions of 10% by 2008 and 20% by the end of 2015, compared to energy use fiscal year (FY) ending September 30, 2002.
- Executive Directive No. 2007-6: Create a plan to reduce FY 2007 state electrical and other energy expenditures by 10% from FY 2006 levels.
- Executive Directive No. 2006-06: "Promotion of Green Chemistry for Sustainable Economic Development and Protection of Public Health."
- Executive Directive No. 2007-22, signed on November 14, 2007, directed the State of Michigan to continue reduction in state energy consumption to meet goals specified in the Directive, improve energy efficiency in the state motor vehicle fleet, include energy efficiency standards in purchasing, meet LEED standards in new construction; and take other measures to reduce energy use and improve energy conservation.
- Executive Order No. 2007-42, signed on November 14, 2007, directed the MCAC to recommend specific short-term, mid-term, and long-term GHG reduction goals or targets for Michigan.
- The Midwestern Regional Greenhouse Gas Accord, signed by Governor Granholm on November 15, 2007, establishes a requirement for MGA staff and appropriate state agency representatives to set regional GHG reduction targets that are consistent with member states' targets.
- Michigan's legislature recently passed a package of energy-related bills (S.B. 213, S.B. 1048, and H.B. 5524) that create an RPS, the Michigan Energy Conservation Fund, EOPs, net metering, IRP, and numerous other provisions to be required of utilities and the MPSC.
- See the Related Policies/Programs in Place for CCI-1 (GHG Inventories, Forecasting, Reporting, and Registry).

Many other examples can be found at: http://www.miclimatechange.us/ewebeditpro/items/O46F17163.PDF

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

It is uncertain if adequate staff resources will be available at this time.

Additional Benefits and Costs

Implementation of energy efficiency measures can lead to resource savings that can be put to other purposes by both public and private entities.

Feasibility Issues

It is a challenge to coordinate numerous local government entities that exist in Michigan.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-4. Comprehensive Local Government Climate Action Plans

Policy Description

A number of local and regional cities and municipalities in Michigan have already taken steps and initiated programs and activities to mitigate climate change in their communities. Many of these cities and communities—23 in Michigan and over 900 cities nationwide—are also signatories to the U.S. Mayors Climate Protection Agreement, with a stated goal of reducing CO_2 emissions by 7% below 1990 baseline levels by 2012 (see note on next page). Additionally cities and communities in Michigan are helping to develop and support additional climate change accountability programs, such as the Midwestern Regional Greenhouse Gas Reduction Accord, TCR, and the Michigan Renewable Energy Program.

The state and tribal governments; regional metropolitan councils, such as the Grand Valley Metro Council; Michigan Municipal League; and others could all help create awareness about climate change issues and lead by example in developing climate change programs that are coordinated with the MCAC. Additionally these organizations and entities could help communicate best practices and success stories through a variety of outlets, such as workshops, conferences, summit meetings, a Web site clearinghouse, education and outreach to public and municipal officials, as well as recognizing local government GHG and CO_2 emission reduction achievements.

Policy Design

The MCAC recommends that Michigan promote the adoption and support of community climate action plans by all local and tribal governments to establish and achieve local GHG reductions as well as set future state GHG reduction goals. The MCAC further recommends that these locally adopted plans be used to stimulate equivalent GHG reduction programs by the private sector and nongovernmental agencies in each community by establishing partnerships and collaborative efforts. These private- and public-sector activities can be considered economic and business development opportunities in concert with policy recommendations CCI-3, CCI-11, and accompanying strategies. Similar to the U.S. Mayors Climate Protection Agreement, the MCAC recommends that local and tribal climate action plans include an impact of the carbon footprint, an inventory of existing GHG emissions, an assessment of economic opportunities for reducing GHG emissions at the community scale, the establishment of specific goals, the determination of target milestones, a timeline for GHG emission reductions, and the adoption of local best practices and strategies to adapt to climate change.

The types of community-scale climate change programs and activities to be considered include, but are not limited to, the following initiatives that are in no particular priority order:

- In-depth assessment of GHG inventories using a standardized recommended inventory process such as International Council for Local Environmental Initiatives (ICLEI)-Local Governments for Sustainability's *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* and *International Local Government GHG Emissions Analysis Protocol*.

- Sustainable urban planning and design, such as the LEED or similar sustainability certification guidelines for neighborhood development.
- Land-use recommendations, such as the need to preserve open space, and the creation of walkable, compact, live and work communities.
- Transportation recommendations, such as increased public transit, bike trails, and carpooling incentives.
- Use of clean renewable and alternative energy, such as solar, wind, hydro, biomass, geothermal, and methane recovery.
- Improved energy efficiency, such as with the use of ENERGY STAR equipment and overall building code improvements.
- Increased use of LEED, ENERGY STAR, or similar energy certification of building and design for the construction of buildings, facilities, homes, and neighborhoods.
- Improved overall fuel efficiency of fleets, such as reducing the number of vehicles, using alternative fuels, and instituting anti-idling policies.
- Improved pumping efficiency of water and wastewater systems, such as with the use of renewable energy sources.
- Healthier urban green space and overall improved forestry techniques, such as reducing the "heat island effect" through replacement and additional plantings of trees.
- Minimization of waste through materials reuse and overall improved recycling rates.
- Enhanced awareness and understanding of climate change strategies and implications in public schools, academic institutions, and the general public.

Goals: Adoption of community climate action plans by a significant number of local governments in Michigan.

Timing: As soon as feasible given available resources.

Parties Involved: Cities, townships, counties, metropolitan districts, regional metropolitan councils, school districts, and other jurisdictions as appropriate.

Note: In Michigan as of August 1, 2008, the following 23 cities have become signatories to the U.S. Mayors Climate Protection Agreement:

Ann Arbor
Battle Creek
Berkley
Dearborn Heights
East Lansing
Ferndale
Grand Rapids
Holland
Kalamazoo

Lansing
Marquette
Meridian Township
Pittsfield Charter Township
Portage
Royal Oak
Saline
Southfield
Southgate
Sturgis
Suttons Bay
Taylor
Traverse City
Warren

Implementation Mechanisms

A number of programs and activities can be accomplished in concert at a state, regional, tribal, and local level to ensure the success of the *Michigan Climate Action Plan*:

- Ensure the creation of an incentive program for local governments through grants, foundations, and/or low-interest loans
- In conjunction with CCI-5, establish a clearinghouse of information for local governments and communities, including climate change best practices, milestones, progress achieved, local GHG inventories, etc. The clearinghouse could also develop and provide collective GHG reductions, key energy efficiencies accomplished, etc.
- Local governments and communities can develop and provide technical assistance for rural communities, tribal governments, etc.

Related Policies/Programs in Place

Executive Directives 2005-4, 2006-6, 2007-6, and 2007-22.

Michigan Climate Challenge.

U.S. Mayors Climate Protection Agreement (www.ci.seattle.wa.us/mayor/climate/).

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

Substantial uncertainties surround future growth rates in GHG emissions, particularly beyond the 2020 timeframe, as well as the timing and scope of implementation of the MCAC policy recommendations. Additional issues surround the implications regarding S.B. 213, which was recently passed by the Michigan Senate regarding a state energy plan.

Additional Benefits and Costs

A well-coordinated climate change plan at local levels will help leverage available resources and assets, as well as help achieve mutually attainable goals and milestones.

Feasibility Issues

Key cities, such as Detroit, Lansing, Ann Arbor, Flint, Grand Rapids, and others, will have to step into community leadership roles for the development of climate change goals and strategies. These cities can help facilitate and coordinate climate change action plans at grassroots neighborhood, community, township, and county levels.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-5. Public Education and Outreach

Policy Description

Public education and outreach is essential to cultivating broad support for GHG reduction activities. Education and outreach will target at least seven specific audiences in Michigan according to policy recommendations made by members of the MCAC. These efforts will seek to create awareness of climate change issues, along with providing justification for policies designed to reduce GHG emissions. Public education and outreach efforts should build upon existing work being done by state, tribal, and local agencies, utility companies, and nonprofit organizations.

Policy Design

The policy recommendations for education and outreach will serve primarily as a means of coordinating existing programs, rather than creating a host of new initiatives. However, there will be some new ideas introduced through the following goals and recommendations. Each item will be presented in light of current or previous efforts and provides details for implementation.

Goals:

5.1 State Government Education and Outreach Actions

The state should lead by example (i.e., walk the talk) regarding education and outreach. Implementation of the Michigan Climate Challenge Program (MCCP) will be one of the key elements of the state's effort in this area. A summary of this program follows.

The MCCP will encourage Michigan businesses, institutions, local and regional governments, and the general public to make a voluntary public commitment to undertake actions to reduce GHG emissions in their communities. MDEQ, working in conjunction and consultation with other state agencies, will develop and launch the MCCP and will include a Web-based "Online Pledge" to encourage voluntary GHG reductions throughout Michigan.

The MCCP will provide Web-based resources and information in the form of a "Climate Action Toolkit" for individuals and organizations to consider implementing as part of their voluntary pledge to reduce GHG emissions. The toolkit will contain specific recommendations for reducing GHG emissions and will also identify measures that can be undertaken to minimize the impacts of climate change, so Michigan can be better prepared to adapt to its effects.

<u>Current or Previous Efforts</u>

MCAC Recommendations (see items 5.1.1–5.1.5 of the CCI TWG Catalog of State Policy Options text below).

Other state actions will include the following: Establish an ongoing education and outreach committee or board charged with educating audiences regarding climate plan policies and overseeing those relating to education. Include a provision to establish age-appropriate testing on the science and economics of climate change. This committee or board would include representatives from Michigan's public and higher education institutions.

Create and maintain one or more "outreach coordinator" positions specifically tasked with climate outreach and coordination among state agencies and outside entities (e.g., nonprofits, utility companies, others).

Institute annual Governor's awards to recognize climate action efforts for several categories. For example, awards might be given to civic groups, small and large businesses, and nonprofit groups making a significant difference in reducing GHG emissions within their community or business. Such awards provide a relatively low-cost program with significant symbolic value and potentially high media visibility.

5.2 Policymakers (Legislators, Regulators, and Executive Branch)

Educate policymakers on climate action recommendations, scientific and technological advances, and progress toward state goals through regular briefings.

Current or Previous Efforts (House Bills pending or passed related to GHG regulation)

MCAC Recommendations (see items 5.2.1 and 5.2.2 of the CCI TWG Catalog of State Policy Options).

5.3 Future Generations

This recommendation calls for integrating climate change into secondary educational curricula, post-secondary programs, and professional licensing.

Current or Previous Efforts

MCAC Recommendations (see items 5.3.1–5.3.8 of the CCI TWG Catalog of State Policy Option).

One of the best ways to disseminate knowledge about climate change mitigation is through Michigan's education system. The process would begin by organizing groups of educators to identify, assemble, and employ climate change curricula appropriate to age groups. It should be noted, however, that implementing large-scale curriculum changes may take a number of years. Understanding this, the state must commit to this for the long term.

The state should develop opportunities to enhance curricula through grant incentives. Also, promoting research into climate change solutions at state universities would likely be very productive. This might include establishing "Centers of Excellence" on climate issues. These centers could work with industry to develop or enhance supply- and demand-side solutions. Climate change issues could also be integrated into existing or new educational competition programs. Programs could range from locally sponsored art competitions in elementary schools to state awards for teachers and schools. Like the Governor's awards referred to earlier, such competitions and awards clearly demonstrate that addressing climate change is highly valued by the state of Michigan and its citizens.

- Work with administrators and student groups in public schools and higher education to integrate "best practices." Implementing such practices might include better building design, turning off computers or other equipment when not in use, or even on-site renewable energy. Implementing renewable energy and energy efficiency measures can be useful in creating thematic learning opportunities to teach science, math, and language skills.

- Introduce core competencies on climate change into professional licensing programs (e.g., energy efficiency in building design and construction, use of recycled materials, etc.)

5.4 Community Leaders and Community-Based Organizations

The importance of working with established institutions, municipalities, service clubs, social and affinity groups, and nongovernmental organizations (NGOs) cannot be overlooked. This recognition of leadership allows for building on successful models and expanding participation with civic society.

Community engagement might include working with community planning and zoning officials about climate change impacts and opportunities, and identifying community leaders who are acting effectively on climate change and showcase their success. There may also be opportunities to include climate change education as part of orientation sessions for newly appointed or elected officials at varying levels of state and local government. Involvement with community-based organizations might mean assisting groups demonstrating expertise or interest in climate-related issues and developing a network of community-based organizations acting on climate change across the state.

<u>Current or Previous Efforts</u>

MCAC Recommendations (see items 5.4.1–5.4.12 of the CCI TWG Catalog of State Policy Options).

5.5 General Public

Assessing the awareness of the public with regard to climate change mitigation will be instrumental in developing effective campaigns for the general public.

<u>Current or Previous Efforts</u>

MCAC Recommendations (see items 5.5.1–5.5.10 of the CCI TWG Catalog of State Policy Options).

Polling and focus group research should be utilized in order to understand the public's perceptions and perhaps misperceptions about climate change. Such research could also assess tolerance for conservation and possible rate increases associated with GHG mitigation (item 5.5.3). Focus group research in particular could be used for developing a branding campaign (item 5.5.5) and for framing legislative issues in the media. Funding for this research could come through DOE or a combination of federal and state grants. There may also be data from existing research that could be helpful in developing effective messages for the general public.

In addition to small group meetings with members of the media, educating broadcasters and editorial boards could be executed on a large scale through presentations at statewide media conferences, like the Great Lakes Broadcasting Expo sponsored by the Michigan Association of Broadcasters (item 5.5.1). These discussions should also help facilitate the development and dissemination of public service announcements (item 5.5.2).

Because modern news media respond very well to events and new announcements, event planning will be important in maintaining a high profile for climate change issues (item 5.5.4).

Events might include regular press conferences from the governor and other public officials, or the release of new data or technology related to GHG mitigation in Michigan.

One way to help coordinate the efforts of environmentally proactive groups in Michigan would be the development of a climate change Web site. This site could act as a clearinghouse for climate change information and provide resources for the mass media and the general public (item 5.5.6). In addition to providing climate change information, the site could provide updates on state and federal legislative action. This site could also support outreach efforts by companies seeking to enhance awareness of cost-saving activities for consumers (items 5.5.7 and 5.5.9) and green power purchasing programs. Such a Web site is already being considered as an important element in the Michigan Climate Action Challenge.

Another featured item in the Michigan Climate Action Challenge is the Climate Action Toolkit. These kits can and should be tailored to address any one of the six target audiences identified by the CCI TWG.

- Work to educate consumers and home designers, builders, and contractors to ensure awareness of different choices for heating and cooling and the environmental and economic impacts of their choices. Perhaps a major building materials retail outlet could sponsor such a program.

5.6 Industrial and Economic Sectors

The strategic approach should be to target specific industrial and economic sectors. Education and outreach to these stakeholders will be designed not only to provide information but also to acquire feedback on new trends in particular sectors, such as utilization of smart grid technology by utility companies. Specific sectors include, but are not limited to, residential, commercial, and industrial power consumers, transportation and land use, energy suppliers, and agriculture and forestry and waste management. Many large corporations like Wal-Mart have already adopted energy efficiency as a means of improving their balance sheets. Helping consumers in all sectors reduce energy costs through increased efficiency will reduce emissions, whether or not reduction is a priority for home or business owners.

<u>Current or Previous Efforts</u>

MCAC Recommendations (see items 5.6.1–5.6.7 of the CCI TWG Catalog of State Policy Options).

5.7 Tribal Governments

While a large portion of the Native American population in Michigan exists within sovereign territories, MCAC members recognize the need to gather input from, interact with, and provide information to Native American tribes. Mechanisms for coordination of these initiatives are described in CCI-3.

Implementation Mechanisms

Reaching the goals for climate change education and outreach will require the creation of one or more outreach coordinator positions. The coordinator(s) will help nonprofit organizations, utility companies, and state agencies maximize their effectiveness in educating the various constituencies throughout Michigan. Coordinating education and outreach efforts will also ensure message consistency and help avoid redundant efforts.

Effective communication on this scale to diverse audiences presents many challenges. However, the ability to meet the goals laid out in this section will be greatly enhanced by vetting messages, whenever feasible, with polling and focus group research. Furthermore, each goal should contain an assessment component to determine if the outreach efforts have achieved their intended outcome. For instance, a one-year program providing outreach to township zoning boards could be assessed by conducting surveys or interviews with a random sample of board members after the campaign.

Related Policies/Programs in Place

The policies recommended by the MCAC can be integrated into the Michigan Climate Action Challenge or stand alone as complimentary actions to increase awareness and reduce emissions.

The University of Michigan has already developed a global change and sustainability curriculum, and Michigan Tech University is offering a 5-day summer institute to help teachers engage middle and high school students in the study of climate change.

Many Michigan universities and community colleges offer courses in renewable energy engineering, maintenance, and/or installation.

Several national organizations, like Focus the Nation, have developed a K-12 curriculum addressing climate change.

Several Michigan utility companies offer green energy pricing and promote these programs as a way for Michigan residents to reduce their carbon footprint.

Numerous nonprofit organizations in Michigan provide information on energy efficiency and adoption of renewable energy.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

It is very difficult to gauge the effectiveness of educational campaigns. Utilization of the assessment approach outlined in the Implementation Mechanisms section should help do so.

Additional Benefits and Costs

An estimate of staffing and costs to implement this recommendation will be needed.

Feasibility Issues

Fortunately, a wealth of education and outreach expertise with regard to climate change and clean technology already exists within Michigan. What seems to be needed is the ability to coordinate these existing resources. Because the education and outreach coordinator position(s) can be dropped into an existing state agency, the cost will be relatively low for the potential benefits derived from more effective public and organizational communication.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-6. Tax and Cap / Cap and Trade

Policy Description

The lead for developing this policy option was transferred by MCAC to the new Market-Based Policies TWG.

CCI-7. Seek Funding for Implementation of MCAC Recommendations

Policy Description

Michigan will seek and stimulate funding and investment to implement the MCAC climate solution recommendations. Accordingly, Michigan will position itself to successfully compete for federal and international assistance and matching funds for adaptation to and mitigation of climate change. Funding decisions will take into account both economic and environmental impacts, including the implementation costs or cost savings for individuals, communities, and businesses, as well as similar funding actions made by other Midwest states and regions. As Michigan allocates funding for MCAC recommendations, the state will work to identify choices that provide the best opportunities for mitigation of, and adaptation to, climate change. Concurrently, Michigan will implement initial funding investments that require few long-term costs. In addition, Michigan aims to reduce the costs associated with climate change activities while fostering economic growth within the state.

Policy Design

Goals: Seek and establish capital investments and other funding sources for the implementation of MCAC recommendations. Such funding options might include any one or all of the options listed in the Implementation Mechanisms section, below.

Timing: The state will address the concern of obtaining funding for the MCAC recommendations immediately. Funding support for the recommendations must account for sustainability through the short-term, mid-term, and long-term target years for the GHG emission reduction goals.

Parties Involved: State government will lead the strategy of generating investment and financial support. Other sectors, including local government, industry, services, agriculture, consumers, and higher education, will be involved.

Other: None.

Implementation Mechanisms

An entity will need to be assigned to prepare an assessment of the alternative financing mechanisms, such as those identified below, and to make recommendations about which ones to pursue and whether legislation is required to effectuate their financing.

- State revolving funds established to provide affordable access to credit,
- Federal and/or Midwestern Accord funds generated as a result of set asides of CO_2 emission allowances via auctions to the private sector,
- Funds earmarked for the Great Lakes, Michigan, and high-energy-use states as a result of regional activities and federal climate legislation,
- Funds resulting from a national or regional cap-and-trade program.

- Funds generated from public benefits charges on utility bills pursuant to S.B. 213.

Related Policies/Programs in Place

Great Lakes Fisheries Trust.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

How much funding will become available to implement the *Michigan Climate Action Plan* recommendations.

Additional Benefits and Costs

Estimates of staffing and costs to implement this recommendation are needed.

Feasibility Issues

Given Michigan's economy, the availability of state funds is limited, so other financing mechanisms are crucial.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-8. Adaptation and Vulnerability

Policy Description

Climate change is a potentially serious threat to communities, natural resources, and wildlife in Michigan, the United States, and around the world. While addressing the source of climate change and related GHG mitigation options is critical, it is also important that decision makers and the citizens of Michigan understand how climate change is affecting and will affect the natural resources and natural resource-based economic activity in the state. Additional attention, research, and funding are needed to assess the impact of climate change on Michigan's fisheries and wildlife and help them adapt, while also reducing the other stressors on their habitats and ecosystems. Communications, research, and funding are also needed to assess and moderate climate change's impact on Michigan's land- and other natural resource-based industries (forestry, agriculture, tourism, and recreation).

The state of Michigan should undertake a comprehensive planning effort to assess and address the state's vulnerability to climate change and adaptation opportunities. Various organizations and agencies in the state are already collecting some of the information needed to make such an assessment and efforts should be made to coordinate and consolidate these information-gathering activities.

Policy Design

Goals:

Undertake a comprehensive planning effort to assess and address the impact of climate change on the Great Lakes, the state's natural resources, and wildlife and fisheries. During 2009 the MCAC should begin the planning process by developing a scoping document that identifies technical and financial resources and research needed to undergo a comprehensive planning process in 2009. When applicable and feasible, the scoping document should identify ongoing and planned research efforts that could contribute to the planning process.

A multi-agency and diverse stakeholder team should be formed to follow through with the planning process in 2009 and beyond. The team's task would be to:

- Integrate climate adaptation into existing and future natural resource management plans and, where possible, related research and assessments. This may include, for example, the State Forest Management Plan; Wildlife Action Plan; Coastal and Estuarine Land Conservation Plan; Aquatic Nuisance Species State Management Plan; fisheries management plans; state/regional watershed management plans; infrastructure assessments, including aging dams, bridges, and sewer infrastructure; and threatened/endangered and species-specific management plans.
- Educate and reach out to groups and organizations associated with the Great Lakes and natural resource-based industries.

- Develop a plan for periodically assessing the ongoing and projected impacts of climate change on Michigan's natural resources and natural resources-based economic activity. The assessment would focus on:
  - *Water Quality and Quantity*—Surface water resources and supply management; changes to seasonal snow and ice cover; groundwater depletion and rate of recharge; increased runoff and pollution of freshwater sources from intense storm events; capacity of water treatment and overflow infrastructure; Great Lakes navigation and water levels.
  - *Air Quality.*
  - *Landscape Change and Land-Resource-Based Industries*—Forest loss due to drought, wildfires, infestation, diseases, species migration and loss; tourism and recreation impacts from a shorter winter recreation season and a longer summer season; agricultural productivity, especially shifting microclimates and crop diversity impacts; recreation and other amenities.
  - *Ecosystem Health*—Species diversity; fish and wildlife and their habitats; habitat fragmentation; invasive species.
  - *Human Health*—Including increased levels of heat stress, respiratory illness, and chronic disease.

  The assessment should treat impacts arising from climate changes of the present and recent past and impacts that are likely or possible 30 to 50 years into the future.

  The assessment should rely on the best available regional climate data and assessments.
- Consider how to *incorporate* climate change adaptation into various state, university, and other field studies, assessments, and research projects where the primary purpose is not necessarily climate change-related, such as ecosystem productivity, population and species diversity, and crop and pest management.

Timing: The MCAC's scoping document should be developed for submittal to the Michigan agencies during 2009.

Parties Involved: MDNR, MDEQ, Michigan Department of Agriculture (MDA), and MDLEG; U.S. Fish and Wildlife Service, U.S. Department of Agriculture (Natural Resources Conservation Service and Forest Service), and EPA; tribal environmental staff, academic researchers at public and private universities and colleges in Michigan (and outside researches as needed); environmental/conservation organizations; natural resource-based industry leaders.

Implementation Mechanisms

Funding will be needed to develop a comprehensive Climate Adaptation Plan for Michigan, and possibly surrounding areas in the Great Lakes Basin, including the Canadian side of the Great Lakes. The state should begin a dialog with other potential interested entities to explore funding options for such a regional or statewide initiative.

The state may want to convene a group of stakeholders to help design the adaptation process.

If funding can be developed, an inventory of related projects or studies either underway or already completed should be prepared. Some examples of these initiatives are included in the

Related Policies and Programs in Place section below. Integration of the ongoing efforts would then need to be considered.

Finally, if the funding can be arranged, a comprehensive assessment of vulnerabilities should be prepared, and that should set the stage for development of a package of adaptation strategies being developed for consideration by the state.

Related Policies/Programs in Place

Many completed or ongoing studies be useful source of information. Some examples include:

- Midwestern Regional Greenhouse Gas Reduction Accord process.
- Healing Our Waters (HOW) Campaign.
- Numerous Tribal studies.
- Great Lakes Fisheries Trust program.
- Great Lakes and St. Lawrence Cities Initiative.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable

Key Uncertainties

A key concern is whether adequate funding can be identified to develop the comprehensive vulnerability and adaptation strategies.

Another issue is the level of interest among other Great Lakes Basin States and other entities in participating in the assessment.

Additional Benefits and Costs

Identification of key vulnerabilities and state or region-wide adaptation strategies will help mitigate most severe impacts. This will also benefit other governmental entities, citizens, and businesses in preparing their own adaptation strategies.

Feasibility Issues

The ability to predict the magnitude of the vulnerabilities.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-9. Participate in Regional, Multi-State, and National GHG Reduction Efforts

Policy Description

The MCAC recognizes that collaboration is a key approach for the successful implementation of the state climate change strategies. Because the execution of policies designed to reduce climate change affects all sectors of society, actions must be broad-based and inclusive. For this reason, collaborative regional and multi-state reduction efforts offer promising possibility for accomplishing MCAC target goals. Joint regional, multi-state, multi-province, and in some cases, national approaches to GHG emission reductions and energy efficiency options can provide greater opportunities for success, particularly because the issue of climate change is not constrained to political boundaries. Accordingly, Michigan recognizes, has considered, and has joined other regional and national market-based GHG reduction strategies. Such strategies propose to mitigate and adapt to climate change in various sectors, including energy supply, residential, commercial and industrial buildings, transportation, land use, agriculture, forestry, and waste management.

The current initiatives include the state's membership in the Midwestern Regional Greenhouse Gas Reduction Accord, whereby the member governors and Canadian premier agreed to establish a regional GHG reduction program with targets and time frames that are consistent with state policies. Also included in this initiative is the development of a market-based, multi-sector cap-and-trade program by November 2008 to achieve reductions. An additional joint initiative is MDEQ's participation on the TCR Steering Committee. The multi-state TCR was designed to be an essential piece of infrastructure for the development of state and federal climate change programs by forming a partnership to produce a protocol for measuring GHG emissions. A third significant initiative offering opportunities for multi-state collaboration is the Chicago Climate Exchange (CCX). Michigan, as well as all other members of the CCX, must achieve a minimum 6% reduction in GHG emissions from 2000 levels by 2010. This goal is in accordance with Michigan reduction targets.

These developments will be continued and will function as models to form the basis of future Michigan GHG reduction programs. Michigan should consider developing supplementary or ancillary registry capacities or opportunities to meet all of the state's needs. Michigan will continue to examine the decisions made by other states and regions, particularly in the Midwest states and in Canada, to identify opportunities for collaboration with other GHG reduction efforts. Michigan will implement regional climate reduction initiatives, such as a regional carbon cap-and-trade system (unless a national system supersedes this need).

The Governor and the Michigan legislature should aggressively push for and continue to encourage federal action to reduce GHG emissions and to ensure that Michigan is well represented and protected at the federal level. An aggressive approach to GHG reductions within the United States will have a significant effect on the international reductions needed to begin reversing global warming trends. Ultimately, many of the climate protection issues need to be addressed at the national level. Michigan must help shape these national initiatives.

Policy Design

Goals: Ensure that the cost effective decrease of GHG emissions complies with the reduction levels adopted by the MCAC. The reduction levels should be adopted in a manner that maximizes public benefits and induces innovation in energy efficiency and sustainable energy technologies while avoiding inequitable impacts. Such impacts will include the avoidance of cross-state transport (or emission "leakages") of GHGs.

Timing: Beginning in 2009, the Governor will annually update the legislature on regional and national GHG reduction progress and other opportunities that have arisen to ensure that Michigan will achieve its goals, as stated above.

Parties Involved: The Governor and administration staff should implement the legislative directive (see below and in CCI-3) and initiatives pertaining to energy and environmental finance and policy. This should also include oversight of pertinent regional and federal climate initiatives as they impact Michigan, to ensure that the state is adequately represented, funded, and protected. Accordingly, the committee chairs with jurisdiction as well as the ranking minority members should be informed of the relevant legislative progress. Additionally, the state should work with relevant federal agencies in the formulation of appropriate strategies to reduce GHG emissions.

Other: None.

Implementation Mechanisms

Michigan will continue its proactive engagement in the Midwestern Regional Greenhouse Gas Reduction Accord process, as described above.

Michigan will also work with the 12 federally recognized tribes in the state to help coordinate local climate change strategies. This will be accomplished through either existing agencies or a designated state entity charged with climate change issues, and through the use of existing MDEQ-tribal agreements, such as the Water Accord and others that allow dialog on environmental issues of mutual interest. Likewise, Michigan will welcome and seek out a mechanism to coordinate its climate change and GHG reduction efforts with national tribal organizations, such as the climate mitigation and adaptation dialog recently initiated by the National Congress of American Indians and others, such as the Council of Energy Resource Tribes.

Michigan should also further investigate and, if it is determined to be in the state's best interest, join the TCR and CCX.

Related Policies/Programs in Place

- As part of the Midwestern Regional Greenhouse Gas Reduction Accord, the Governor agreed to the Midwestern Energy Security and Climate Stewardship Platform, which commits to the following regional goal: Maximize the energy resources and economic advantages and opportunities of midwestern states, while reducing emissions of atmospheric CO_2 and other GHGs.

- Executive Directive No. 2007-22, signed on November 14, 2007, directed the state of Michigan to continue reduction in state energy consumption to meet goals specified in the Directive; improve energy efficiency in the state motor vehicle fleet; include energy efficiency standards in purchasing; meet LEED standards in new construction; and take other measures to reduce energy use and improve energy conservation.
- Michigan's legislature recently passed a package of energy-related bills (S.B. 213, S.B. 1048, and H.B. 5524) that create an RPS, the Michigan Energy Conservation Fund, EOPs, net metering, IRP, and numerous other provisions to be required of utilities and the MPSC.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

There is uncertainty about what the nature and scope of any potential federal GHG program will entail.

Additional Benefits and Costs

An entity will need to be assigned to prepare an assessment identifying the necessary staffing and costs to implement the coordination elements of this recommendation, along with the accountability and tracking system.

Feasibility Issues

None identified at this time.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-10. Enhance and Encourage Economic Growth and Job Creation Opportunities Through Climate Change Mitigation

Policy Description

Michigan's response to climate change can serve as a catalyst for increasing economic activity, in addition to reducing GHG emissions. Michigan is already home to two of the world's leading solar power manufacturers, and over 25 businesses provide components for the growing commercial wind energy industry. Investors in the clean technology sector are constantly seeking locations that offer the most advantageous markets. Texas, Colorado, New York, and Pennsylvania have recently added thousands of green collar jobs by offering start-up capital, tax breaks, and energy policy that welcomes clean energy. Michigan has a capable workforce, engineering expertise, and substantial manufacturing capacity. It also possesses considerable natural resources that could establish it as a leader in renewable energy. Given the intense competition from other states and nations, however, additional incentives and supportive government policies will be necessary to maximize investment in Michigan.

Policy Design

Members of the MCAC recommend the state implement robust measures to retain existing clean tech business and attract new investment. The MCAC also recommends tapping the Michigan congressional delegation for assistance in securing more federal money for training, research, and development.

Goals:

1. *Provide More Attractive Financial Incentives*

Broad-ranging incentive programs might include financial inducements for reactivating underutilized manufacturing space, using renewable energy bonds to leverage more federal dollars for start-up capital, tax breaks like the Emerging Energy Technology Development Credit, guaranteed loan programs for green energy development, and assistance for worker training programs. The details for these and other incentives are offered in the Implementation Mechanisms section of this policy recommendation.

Motivators are also needed to encourage partnerships between green energy companies and more traditional (or retooled) manufacturers. For example, Michigan's solar panel manufacturers could partner with auto manufacturers to create solar recharge kits to be sold at a discount with the purchase of a plug-in hybrid vehicle. Municipalities could partner with renewable energy manufacturers to create green parking spaces where plug-in vehicles can be recharged while at work. It is extremely important that plug-in hybrids be seen not only as a "vehicle" for energy independence, but also as a means of reducing GHG emissions. Similarly, incentives could be offered to utility companies that partner with on-site storage manufacturers to increase distributed on-site power. On-site storage will help address intermittency issues as more wind and solar energy is fed into the grid. These options would all reduce money flowing from Michigan's economy to import carbon-based fuels and would lead to job creation.

2. Implement Policies That Enhance and Encourage Economic Growth

Michigan can improve its competitive position and increase conservation and energy efficiency through policies that simplify grid connection for independent power providers, standardize zoning requirements, create parity with leading states for net metering, and reward energy efficiency. These types of policies have helped other states attract investment in clean energy and reduce the outflow of capital for importing energy.

3. Seek More Federal Support

- Maximize federal funding from current and prospective sources (energy credit allowances) to train and employ low-income/marginally employed people in conservation and energy efficiency projects, including older substandard housing.
- Maximize federal funding to support job training at all levels, and retool industrial facilities to expand opportunities in the clean energy industry. Funding and support should include the advancement of fuel cell research and development (R&D), coal gasification research, carbon capture and sequestration,(CCS), wind, solar, and geothermal energy, and other energy alternatives. If possible, liability issues associated with carbon sequestration pilot projects should be resolved to help stimulate the feasibility of this technology option. Current action in this area is encouraging and includes MDEQ, MDNR, and the Attorney General mapping out regulatory matters pertaining to carbon capture, sequestration, and reuse (CCSR) to identify appropriate actions to address such issues as landowner rights, liability (both short- and long-term), revenue streams, environmental impacts, and others as identified.

4. Utilize Michigan's Existing Resources and Economic Opportunities

Based on input from local economic development organizations throughout Michigan, the major potential growth industries for Michigan's future were independently verified: cellulosic biomass, solar, wind, and advanced energy storage. These sectors have been identified through an objective process involving extensive input from local and state economic development groups in Michigan. Michigan needs to effectively match its resources, talents, and capabilities to what is known about the growth potential in clean technology industries. Michigan Economic Development Corporation (MEDC) Centers of Excellence are one example of how to effectively match up and take advantage of these resources.

- Michigan is uniquely positioned for significant wind generation potential. The American Wind Energy Association (AWEA) nationally ranks Michigan at #14 in terms of wind potential and #4 in terms of industrial capability to manufacture, innovate, and utilize wind turbine products. Michigan is one of the top 10 states for investment and job creation potential for renewable energy development (ranked by investment according to the 2006 Renewable Energy Policy Project).
- The states hosts a world-class manufacturing environment featuring high-quality and cost-competitive manufacturing practices, integrated supply chains focused on innovation, and a workforce that includes thousands upon thousands of skilled engineers, technicians, and manufacturing professionals.
- Michigan ranks second overall in *total* industrial R&D spending, and leads the nation in industrial R&D spending per gross state product.

- Further collaboration options exist in working with Michigan's automotive technology and manufacturing industry, which has significant crossover opportunities into the wind energy industry. More than 330 companies spend $10.7 billion annually on R&D and employ more than 65,000 engineers, technicians, and scientists.
- Michigan is centrally located as a Midwest manufacturing state, and is also the gateway to Ontario's strong manufacturing base and wind power developments.
- Opportunity to partner in efforts involving Michigan's 38,575 square miles of Great Lakes freshwater surface area, which have an estimated offshore wind generation potential of 44,000 megawatts (MW).
- Michigan's unique geologic features may present an opportunity to employ CCS, as outlined in the Energy Supply (ES) TWG recommendations ES-6 and ES-8. DTE Energy is already conducting a pilot CCS project.
- Collaboration and membership in the Consortium for Advanced Manufacturing of Alternative & Renewable Energy Technologies, a five-university consortium formed to centralize manufacturing research expertise and resources necessary in the wind turbine industry, including:
    - Understanding wind product designs and materials;
    - Improving wind manufacturing processes, systems, and facilities;
    - Offering business and supply chain support; and
    - Providing a state government that emphasizes renewable energy as a critical economic driver and aligns government departments to continuously support and improve Michigan's energy efficiency.

5. Protect Michigan's Water

Michigan should protect and maximizing the sustainable and affordable use of its water for the benefit of all Michigan residents and the three traditional segments of our economy, while minimizing the threat of out-of-basin diversions. Michigan has as exceptionally rich—but not unlimited—source of fresh, clean water in the Great Lakes and inland lakes and streams, and should focus investment on the activities and sustainable enterprises that this resource supports. For example, since climate change is contributing to lower lake levels and rising sea levels, mitigating climate change may help stabilize lake levels necessary for the Great Lakes tourism, sport and commercial fishing, shipping, and recreational boating industries to thrive.

6. Invest in Walkable Neighborhoods and Transportation Mode Choices

Michigan should using federal, state, and local support to build a transportation infrastructure appropriate to an economy that is likely to have drastically higher energy costs. This should be accomplished with policies directed toward:

- Creating transit and transit-oriented development opportunities targeting business attraction and neighborhood redevelopment. Lack of affordable, reliable, mass transit in the state's core communities is a major barrier to growing Michigan's 21st century economy. Mass transit in states like Oregon and Colorado has paid for itself many times over with new private-sector development and investment along key transit corridors.

- Supporting better planning and zoning for higher-density and mixed-use development (see the 2003 Michigan Land Use Leadership Council Report called *Michigan's Land, Michigan's Future*, that will result in lower costs of energy for housing and transportation, save tax dollars for water and sanitary sewer systems, and provide less costly access to services for people of all incomes.
- Moving more cargo goods via rail and ship to reduce costly, dirty, energy-consumptive truck traffic, saving businesses' and consumers' money, and making substantial improvements in air quality and the health of individuals, especially those living in poverty.
- Reducing black soot emissions from diesel-emitting mobile sources by creating programs to retrofit engines with diesel particulate filters.

7. Support a Diverse Agricultural Base

The Great Lakes region may incur relatively manageable impacts from climate change, since it is above sea level, close to water, and in a more moderate, northerly climate. Policies should:

- Protect farmland, support crop diversification and farm viability, and improve access to fresh, Michigan-grown agricultural products, especially in underserved urban centers where people are forced to do their shopping in low-volume but expensive convenience store-type markets. (See Michigan Food Policy Council Report 2006.)
- Support better planning and zoning to reduce development pressure on farmland and enable more sensible open space and working land protection (see 2003 Michigan Land Use Leadership Council Report called *Michigan's Land, Michigan's Future*]
- Reduce air and water pollution and provide habitat protection for better hunting, fishing, and other recreational activities.
- Create incentives to promote reforestation and afforestation.
- Promote methane capture from agricultural and waste management activities as long as they do not increase air or water pollution.
- Encourage investments in net-low-carbon fuels and water conservation.

8. Maintain Traditional Support for Michigan's Public Research Universities

Traditional support for Michigan's excellent public research universities is strong, but threatened. This should include support for clean energy research and educational initiatives at our universities and the development and promotion of these initiatives with support for their commercialization in Michigan from federal, state, nonprofit, and foundation programs. The state should also make full use of and encourage collaboration among all of our universities, community colleges, and economic development organizations, such as NextEnergy, Spark, and The Right Place

9. Encourage and Facilitate Michigan's Strong Social Infrastructure

Michigan should encourage and facilitate its strong social infrastructure with its historic participation by diverse populations in educational institutions, labor unions, business organizations, tribal and local governments, religious communities, nonprofit organizations, and charitable foundations.

Timing: As soon as possible.

Parties Involved: Universities, state agencies, chambers of commerce, energy utilities, existing green businesses/industries, energy conservation experts, and individual businesses across the state.

Implementation Mechanisms

Some of the key implementation mechanisms that will need to be further explored for this policy recommendation are as follows:

Multi-Year Extension of the Federal Production Tax Credit for Renewable Energy

The federal Production Tax Credit (PTC) has been a key component in the growth of domestic wind energy use since Congress created it as part of the country's energy policy in 1992. Unfortunately, the "on-again/off-again" status that has historically been associated with the PTC contributes to a boom-bust cycle of development that plagues the wind industry. Federal renewal of the PTC will enable Michigan to capitalize on creating jobs in the emerging renewable energy industry, and economic incentives will attract energy service providers. Key implementation activities are as follows:

- Michigan legislators should pass joint resolutions urging Congress to renew the PTC.
- Governor Granholm and the Michigan congressional delegation should urge Congress to renew the PTC.
- The Midwestern Regional Greenhouse Gas Reduction Accord should speak to state legislatures, members of the media, and the AWEA to address renewing the PTC on a long-term basis.

Expansion of Federal Clean Renewable Energy Bonds

As some key entities are unable to utilize the PTC effectively, other supplementary mechanisms, such as federal renewable energy bonds, should be made available to such entities in order to promote the development of renewable energy in their jurisdictions. This will involve efforts to clarify the benefits of these bonds with key congressional offices and staff. Similar to the PTC, this federal loan program is set to expire on December 30, 2008.

Promotion of Coordination Across States and Assess Policy Mechanisms

The designated state lead agency for implementation of the MCAC recommendations, or the appropriate authorities, should either investigate further or implement the following:

- Study the economic benefits of feed-in tariffs, rate-making incentives, and other financing options for increasing renewable energy in Michigan.
- Investigate and make recommendations about how subsidies and/or incentives for oil and gas could be transferred to renewable energy resources to increase development in the clean energy sector.
- Provide direct state financial incentives (grants, tax credits, loan guarantees, and performance guarantees). Michigan should establish incentives the same as or complementary to those in the Federal Energy Policy Act of 2005 to help reduce the financial cost of the overall project

once engineering and cost studies are completed. Other options to be further explored could include:

  - Alternative Energy and Energy Conservation Patent Exemption (Corporate)—An exemption from state personal income tax or business excise tax could be provided to an individual if the state approves a patent from any resident who has applied or holds a patent for an alternative energy or energy conservation system or device.
  - Renewable Energy Production Incentive—Michigan could offer a payment (for example 1.5 cents) per kilowatt-hour for electricity generated by hydro facilities and on-farm anaerobic manure methane digesters.

- Examine the utilization of various pooled funds, such as securitization monies, bond and trust funds, pension funds, etc., for incentivizing alternative energy development and manufacturing in Michigan.
- Create a regional "turbine pool" to simplify the process of obtaining wind turbines due to their demand-created, worldwide shortage. This would help to guarantee the market by ensuring their availability. Existing policy frameworks in the Midwest or Great Lakes region may be used as a model for similar state legislation. One option would be for Michigan legislators to coordinate the development of regional policy with other states to create a potential "turbine utility."
- In coordination with the MEDC's **SmartZones** and **Centers of Energy Excellence,** and NextEnergy's **NextEnergy Zone**, investigate the possible:
  - Creation of a Recycling Market Development Zone program similar to California's. This combines recycling with economic development to fuel new businesses, expand existing businesses, create jobs, and divert waste from landfills. The California program provides loans, technical assistance, and product marketing to businesses located within these zones that use materials from the waste stream to manufacture their products. Eligible benefits could include loans at below-market rates, fixed rates, streamlined permitting and siting, and technical and marketing assistance. Coordinated local government incentives could include a streamlined local permit processes, reduced taxes and licensing, and increased and consistent secondary material feedstock supply.
  - Establishment of foreign trade zones in Michigan, which may benefit clean technology manufacturers importing parts or products from overseas and allow for the deferral or elimination of import tariffs.

- Support the two parallel implementation mechanisms stated in the Energy Supply TWG policy recommendations, which focus on CCSR and advanced fossil fuel technology. These two policy recommendations are:
  - ES-5 (Advanced Fossil Fuel Technologies Incentives, Support, or Requirements), and
  - ES-9 (CCSR Incentives, Requirements, R&D, and/or Enabling Policies).

- Support the MGA Renewable Electricity and Advanced Coal with Carbon Capture Advisory Group's Policy Template Options.

- Implement a comprehensive, targeted marketing strategy to assist in the creation of an economic growth plan for alternative energy technologies. The Midwest should be marketed as a hub of clean energy within the United States and North America, to raise global awareness by creating a ”brand image” to promote. We all stand to benefit, individually and as a region.
- The MEDC and MDLEG should perform a workforce analysis of the education and job training needed for potential employees in the renewable energy and green collar jobs sector, along with infrastructure development and an inventory of existing capacity in the alternative energy sector, and should identify opportunities for collaboration. These two training and workforce initiatives could include such options as:
    - Coordination of state/local workforce development and investment agencies to assist companies desiring to expand green technologies and alternative energy field operations and retain employment in Michigan. Upon request, these agencies could work with industry to recruit and assess candidates from the region’s major metropolitan areas and coordinate the activities of the service agencies or training institutions required to meet workforce needs.
    - Establishment of an employment training fund to provide up to a specified amount per employee for training in the green technologies and alternative energy field. Such a fund could be used to train Michigan's workforce in the new technology skills necessary for local businesses to successfully compete in the global economy, and specifically targets manufacturers and their suppliers.
- Investigate opportunities for business development based on the manufacture of renewable energy component parts to include an inventory of potentially important component parts.
- Michigan currently has draft siting guidelines for wind energy systems that include height, noise, setback, and other applicable requirements (http://www.michigan.gov/documents/Wind_and_Solar_Siting_Guidlines_Draft_5_96872_7.pdf). While this is a good start, these guidelines were created as recommended language for local governments to use to amend their zoning ordinance. The state should enact legislation establishing onshore and offshore wind energy siting standards that include land use and right-of-way considerations, local zoning ordinances, condemnation procedures, minimum setback distances of turbine towers and related support equipment from residences and public roads, off-site property boundaries, etc. Other crucial offshore issues should also be considered, such as avian, wildlife, and aesthetic considerations, shipping, and lake ecology.
- Catalog current university research efforts and educational programs related to renewable energy.
- Catalog training programs available related to workforce development programs.

Related Policies/Programs in Place

Renewable Portfolio Standard and Energy Efficiency Legislation

States that have adopted an RPS tend to attract renewable energy development and manufacturers in order to meet the demand growth of this sector. Michigan’s legislature recently passed a package of energy-related bills (S.B. 213, S.B. 1048, and H.B. 5524) that create an

RPS, the Michigan Energy Conservation Fund, EOPs, net metering, IRP, and numerous other provisions to be required of utilities and the MPSC. The package had broad support from both major political parties, environmentalists, the major Michigan utilities, and business leaders. IRP is necessary to weigh the economic and environmental costs of traditional energy generation against the benefits of renewable energy.

The MPSC is taking the lead on drafting guidance documentation explaining these various provisions and the subsequent requirements set forth in the legislation. A brief explanation of the bills follows:

- S.B. 213 includes an RPS, creates the Energy Conservation Fund, and requires utility energy optimization plans, wind energy resource zones, and net metering. The RPS will be 10% by 2015. Energy optimization credits and advanced cleaner energy credits can be used to partly meet the RPS requirement. Detroit Edison is required to have at least 300 MW by 2013 and 600 MW by 2015, and Consumers Energy is required to have 200 MW by 2013 and 500 MW by 2015. The enrolled version of S.B. 213 is available at: http://www.legislature.mi.gov/documents/2007-2008/billenrolled/Senate/pdf/2007-SNB-0213.pdf.
- H.B. 5524 amends P.A. 3 of 1949, P.A. 141 of 2000 (Michigan Customer Choice and Electricity Reliability Act) and designates the MPSC, an autonomous entity within MDLEG, to perform a number of actions described in detail in the bill. The enrolled version of HB. 5524 is available at: http://www.legislature.mi.gov/documents/2007-2008/billenrolled/House/htm/2007-HNB-5524.htm.
- S.B. 1048 would amend the Income Tax Act to allow individual taxpayers who purchased and installed certain qualified home improvements for their principal residence during the tax year to claim an income tax credit equal to 10% of the amount they paid in the tax year for the purchase and installation of each qualified home improvement or $100, or for a husband and wife filing a joint return, $200, whichever was less. The bill would apply to the 2008 tax year and subsequent tax years.

  "Qualified home improvement" would mean any qualified ENERGY STAR product intended for residential or noncommercial use that meets or exceeds the applicable EPA and DOE ENERGY STAR energy efficiency guidelines, including windows, doors, insulation, high-efficiency heating and cooling equipment, and any appliances, such as dishwashers, clothes washers, and refrigerators. The enrolled version of S.B. 1048 is available at: http://www.legislature.mi.gov/documents/2007-2008/billenrolled/Senate/htm/2008-SNB-1048.htm.

Centers of Energy Excellence

Governor Granholm signed legislation on July 8, 2008, creating the Centers of Energy Excellence (COEE), a program designed to bring companies, academic institutions, and the state together to create jobs in the alternative and advanced energy industry. The centers will partner university researchers on site at innovative clean tech businesses to speed commercialization. The state will be able to provide matching grants of up to $45 million for COEE.

The MEDC has formed several “cluster teams” in a number of strategic industry sectors well suited for growth in Michigan, including cellulosic ethanol, wind turbine manufacturing, advanced battery design and manufacture, sustainable water technologies, and others. These cluster teams combine private-sector, public-sector, and academic experts and work to proactively seek out and attract new business models that have significant growth potential in Michigan. The first cluster team in advanced biofuels has already successfully attracted one of the world's first commercial-scale cellulosic ethanol plants (using wood products), and has formed a unique partnership with a Swedish company that turns wastewater sludge into biogas.

Related initiatives include S.B. 1380/P.A. 175, which established a COEE program to promote the development, acceleration, and sustainability of energy excellence sectors in Michigan. The program was officially launched following the Michigan Strategic Fund Board meeting on August 27, 2008. Key provisions include:

- The Michigan Strategic Fund Board shall not expend more than $45,000,000 of the money appropriated for programs authorized under this chapter from the 21st Century Jobs Trust Fund for the COEE Program.
- Grants provided through the COEE program shall only be awarded to for-profit companies. Participation of at least one qualified business and at least one institution of higher education is required to operate a Center of Energy Excellence.
- The funds may be used for one of the following purposes: match for foundation funding, federal funding, or international investments up to 50% of the total project cost; accelerating the commercialization of an innovative energy technology or process that will be ready to market within 3 years of the agreement date; and activities of a Center of Energy Excellence, including, but not limited to, workforce development and technology demonstration.

Under the new COEE program:

- **Sakti3** in Ann Arbor will receive $3 million to establish a center focused on next-generation lithium battery technologies and processes. The University of Michigan will contribute to research on battery life cycles.
- **Swedish Biogas International** will utilize $4 million to launch a waste-to-energy biomethane center at Flint's wastewater treatment facility. Kettering University's incubator will also serve as the initial headquarters for the Swedish company's North American subsidiary.
- **Mascoma Corporation** will use $20 million to establish a cellulosic ethanol center in Kinross. Michigan State University and Michigan Tech University will focus on improving the supply chain for woody biomass feedstock.

More information about these Centers of Excellence is available at: www.michiganadvantage.org/21CJF

SmartZones

The MEDC-sponsored SmartZones provide distinct geographical locations where technology-based firms, entrepreneurs, and researchers locate in close proximity to all of the community assets that assist in their endeavors. SmartZone technology clusters promote resource collaborations among universities, industry, research organizations, government, and other community institutions, growing technology-based businesses and jobs.

One of the 12 existing SmartZones is the Michigan Alternative and Renewable Energy Center (MAREC), a self-sustaining distributive energy center that features a high-temperature molten carbonate fuel cell, photovoltaic (PV) solar roof tiles, and nickel metal hydride battery energy storage system. The facility offers business incubator space, energy laboratory, conference center, and classroom facilities. Another SmartZone is the DTE Energy Hydrogen Technology Park in Southfield—a hydrogen energy demonstration project designed to provide insight into the role of hydrogen in our nation's energy system.

21st Century Jobs Fund

The $2 billion 21st Century Jobs Fund uses securitized tobacco settlement proceeds to provide financing to help diversify and grow Michigan's high-tech economy by investing in basic research at the state's universities and nonprofit research institutions; applied research; university technology transfer; and the commercialization of products, processes, and services in four targeted industry sectors, including alternative energy.

Anchor Company Tax Credits

In May 2008, Governor Granholm signed a package of bills to provide incentives to Michigan companies to join with the state in attracting other growing companies. The bills provide tax credits for anchor companies that attract or influence suppliers or customers to expand in Michigan. Michigan also recently passed an aggressive targeted tax cut to attract the next multi-billion expansion of Hemlock Semiconductor, the world's leading supplier of polycrystalline silicon, the primary component of PV solar panels.

Green Jobs Worker Retraining Initiative

The state's workforce employment agency is about to launch one of the nation's most aggressive green jobs worker retraining programs, a $6 million annual commitment, which will work closely with employers to retrain Michigan workers for actual job needs.

Michigan NextEnergy Authority

The Michigan NextEnergy Authority (MNEA) is a nonprofit organization, founded in 2002, with the goal of advancing the alternative energy industry in Michigan. NextEnergy serves as a bridge between the public, private, and academic sectors to promote economic development in the alternative energy industry. One of MNEA's many tasks is to match local firms with outside clean technology companies and investors. For example, MNEA has created an inventory of 35 wind turbine component part manufacturers and over 200 existing manufacturers interested in expanding into the turbine component space, and often coordinates match-making events with large wind turbine manufacturers.

As an additional inducement, the Michigan Strategic Fund designated the NextEnergy Zone a Renaissance Zone in 2002. Businesses certified by the MNEA that locate in the NextEnergy Zone to develop "alternative energy technologies," as defined by the Michigan Next Energy Authority Act, may claim tax benefits, such as the Nonrefundable Business Activity Credit, the Alternative Energy Personal Property Tax Exemption, and the Refundable Payroll Credit. The NextEnergy Zone is located in Detroit at Wayne State University Research and Technology Park. It is home to the NextEnergy Center, which includes laboratory facilities, business incubator space, and other facilities to support Michigan's alternative energy industry.

Michigan Department of Energy, Labor, and Economic Growth

The Governor recently consolidated all activities related to the energy sector into the renamed MDLEG. The new department will include the No Worker Left Behind green jobs training initiatives; Michigan's new energy efficiency building code; the MPSC and energy efficiency programs; the Office of Sustainability; the Renewable Fuels Commission; and the Michigan State Energy Office. It will work in tandem with the MEDC's tax incentives and attraction efforts, and will be strategically partnered with MNEA to further the state's energy agenda. MDLEG will facilitate the development of advanced energy technologies and will assume responsibility for activities related to the development of renewable fuels and "greening" programs like LEED, which assists communities in fostering environmentally sustainable construction. MDLEG's charge will include promoting the use of renewable energy, the development of advanced energy technologies, and the implementation of energy efficiency measures in the state.

Program objectives are advanced through a variety of services, including information dissemination, technical and financial assistance, and demonstration projects. EPA is the primary funding source for Energy Office activities. Some of the assistance includes:

- **Solar and Wind Energy Outreach Grants**: These competitive grants are available to nonprofit or public organizations to conduct outreach projects in Michigan to promote and market solar and wind energy.
- **Large-Scale PV Demonstration Project Grants:** These grants may be available to public and nonprofit organizations for the installation and demonstration of new PV systems with a minimum capacity of 10 kilowatts.
- **Community Energy Project Grants:** These grants may be available to nonprofit and public organizations. Funding categories have included solar and/or wind energy education, bioenergy/biofuels/bioproducts education, green commuting projects, green building projects, and statewide energy conferences.
- **Energy Efficiency and Renewable Energy Outreach Grants:** These grants may be available to nonprofit or public organizations for marketing and promotion efforts. Funding categories have included solar energy, wind energy, ENERGY STAR products, and ENERGY STAR homes.
- **E85 Infrastructure Conversion Incentive Program:** This program assists service stations with a cash incentive covering up to 50% of the cost needed to convert refueling equipment to enable the station to offer E85 fuel (a fuel blend of 85% ethanol and 15% gasoline) to their motorists.
- **Biofuel Signage Rebate Program:** This program offers service stations a rebate to cover 50% of the cost needed to post signs along the freeway displaying the availability of E85 or B20 fuel (a fuel blend of 20% biodiesel and 80% gasoline) at their stations.

Grant for Cutting-Edge Plug-In Hybrid Vehicle Study

On May 8, 2008, the Michigan's Public Service Commission announced a $5,000,000 grant for a partnership between University of Michigan, General Motors Corporation, and DTE Energy. This partnership will study plug-in hybrid electric vehicles (PHEVs) as a Michigan economic development catalyst, the interface between vehicles and utilities, and the environmental and electric utility system impacts of PHEVs.

Michigan Biomass Energy Program

This program regularly provides funding for state bioenergy and biofuels projects. Funding categories typically include biofuels and bioenergy education, biofuels infrastructure, and biomass technology development and demonstrations.

Low-Income and Energy Efficiency Fund

Administered by the MPSC, this fund provides grants for the implementation of energy-efficiency projects and renewable-energy projects in the state.

Agricultural Innovation Fund

Also known as the Julian-Stille Value-Added Agricultural Development Fund) and administered by the Michigan Department of Agriculture, this fund supports projects designed to establish, retain, expand, attract, or develop value-added agricultural processing and related agricultural production operations in the state.

Michigan Economic Growth Authority (MEGA) High-Tech Job Creation Tax Credits

MEGA high-tech job creation tax credits may be awarded against the Michigan Single Business Tax for high-tech companies looking to expand or locate in Michigan rather than another state. To be eligible, companies must be involved in technology fields devoting at least 25% of operating expenses to R&D. Each credit may be awarded for up to 20 years, and for up to 100% of the tax related to the project.

Ethanol & Biodiesel Matching Grant Program

Created by P.A. 274 of 2006, this program provides incentives to service stations and bulk plants to convert existing or create new fuel delivery systems for the distribution of E85 fuel and biodiesel blends.

Midwest Regional Carbon Sequestration Partnership

The MDEQ Office of Geological Survey has been working with the MRCSP, a DOE-sponsored partnership, on a pilot project to test the potential for sequestering CO_2 underground. The MRCSP is made up of seven states, the federal government, universities (Western Michigan University and others), and many companies. The MRCSP is one of seven partnerships nationally. Together the seven partnerships are testing the potential for sequestering CO_2 in the following ways: terrestrial sequestration, brine formation sequestration, and oil and gas field sequestration. More information about the MRCSP is at: www.mrcsp.org.

Clean Cities Program

Clean Cities is a government-industry partnership sponsored by DOE's Vehicle Technologies Program. Clean Cities' mission is to reduce petroleum consumption in the transportation sector by promoting the use of alternative fuel vehicles and alternative fuels. Participating Michigan partnership communities, which include the greater Detroit, Lansing, and Ann Arbor metropolitan areas, are part of 90 local coalitions and 5,700 stakeholders nationwide. Similarly, a $24,500 matching grant was recently awarded to the West Michigan Strategic Alliance to establish a Clean Cities Coalition. The regional initiative's focus will be developing local markets for alternative transportation fuels, refueling sites, and clean vehicle technologies and supporting alternative fuel corridor growth in West Michigan.

Alternative Energy Research and Development

The state's colleges and universities are also heavily invested in alternative energy research and development. Examples include:

- Michigan State University's Biomass Conversion Research Laboratory and Center for Plant Products and Technologies;
- The University of Michigan's Michigan Memorial Phoenix Energy Institute, Transportation Energy Center, and Hydrogen Energy Technology Laboratory;
- Kettering University's Center for Fuel Cell Systems and Powertrain Integration;
- Lawrence Tech University's College of Engineering Alternative Energy;
- Wayne State University's Center for Automotive Research, NextEnergy Center;
- Michigan Technological University's Advanced Power Systems Research Center, Power and Energy Research Center, and Sustainable Futures Institute; and
- Grand Valley State University's Sustainability Initiative and the MAREC.

Types(s) of GHG Reductions

Not applicable.

Estimated GHG Savings and Costs per $MTCO_2e$

Not applicable.

Key Uncertainties

- Most of these options will require approval by the Michigan legislature, Governor. and others. The successful passage of these needed actions and their implications are uncertain at this time.
- Costs for implementation are uncertain until the assessment is completed.
- The education of sustainable development champions (i.e., lenders) who have capital is important work that needs to be undertaken.
- Mapping out an infrastructure for green lending could be a challenge.
- There is uncertainty about what the nature and scope of any potential federal GHG program will entail.
- The costs of inaction are not quantified.

Additional Benefits and Costs

- An estimate of staffing and costs to implement this recommendation is needed.

- Implementation of energy efficiency measures can lead to resource savings that can be put to other purposes by both public and private entities.
- The availability of state funds is limited. Other financing mechanisms, including private investment, are crucial for the success of this recommendation, beyond any potential passage by the legislature.

Feasibility Issues

None identified at this time.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CCI-11. Enhance and Encourage Community Development Through Climate Change Mitigation: Address Environmental Justice

Policy Description

Climate change is predicted to cause significant changes in both the atmosphere and the natural environment, including increases in extreme weather events and droughts, as well as rises in sea level in some regions and lower water levels in the Great Lakes. Although all segments of Michigan's population and economy will be affected by climate change, certain communities run the risk of being disproportionately burdened by costs and challenges, particularly poor communities and communities of color. As evidenced by the impact of Hurricane Katrina in New Orleans, communities in the United States continue to be unprepared—socially, financially, and environmentally—for major natural events.

Even in the absence of a major natural disaster, climate change has the potential to devastate an unprepared economy. Transitional costs will likely be regressive and could further burden populations already suffering from economic hardship with unbearable costs.

To encourage community development through climate change mitigation and ensure that vulnerable communities are protected, the state must engage a range of communities in a collaborative planning process that works toward a transformational response to climate change. This response must be tailored to the regressive costs posed by climate change, and must act to address the economic and health impacts of a warming climate.

Policy Design

Goals:

Collaborative Planning Process

Michigan's climate change mitigation policy must ensure that those populations most vulnerable to a changing climate's effects have a voice in the planning and decision-making process of climate change response. These policy discussions should include informed voices for Michigan's older population, people of color, and those in poverty throughout the state, among others.

Major plans for rebuilding or restructuring economic or physical infrastructure assets should be an open, collaborative effort. Climate response policies should be undertaken with rigorous application of the principles contained in Michigan Executive Directive No. 2007-23: Promoting Environmental Justice, and should ensure that organizations currently working with affected populations are invited to participate in policy development.

Transformational Response: Distribution of Costs and Benefits

The social, environmental, and economic changes posed by climate change and the transformation that will be required in response will result in both costs and benefits to the people of Michigan. The burden of costs is likely to be regressive and could continue to highlight the disproportionate allocation of resources and risks prevalent in today's society.

Therefore, the state's response to these costs and benefits must be cognizant that economic carrying capacities differ among various populations, particularly in a short-term adjustment process. State policy should build in mechanisms to account for the disparate impacts of transitional costs, including a wide array of products and services, from gasoline and electricity to food, mass transit, health care, and other products or services with significant energy inputs. Because the state's physical and economic infrastructure cannot be altered overnight, policy should address the plight of populations affected by economic obsolescence and other changes.

Meanwhile, taxation and pricing strategies specifically designed to limit or reduce GHG emissions, including cap-and-trade programs or CO_2 taxation, should include provisions to mitigate regressive burdens. Putting a price on emissions will raise prices for fossil-fuel energy products, affecting households with limited incomes the most. Climate change policies should provide sufficient revenue to cushion the impact on vulnerable populations and meet other legitimate public needs, such as expanded research on alternative energy sources.

Opportunities for Change

The challenges posed by climate change also present potent opportunities for an economy that is ripe for change. The call to address climate change provides an opportunity to hasten economic and social transformations that could support social and environmental equality and help transform Michigan's urban communities into healthier, more vibrant places in which to live and work.

Michigan's response to climate change should prompt us to make a faster, more successful transition to the new economy. Recognizing the three pillars of Michigan's old economy and moving to build on this foundation with policies appropriate to new economic and environmental conditions, Michigan can refocus our manufacturing base, protect our agriculture and forestry sector, and renew our tourism industry. If investments are made intelligently, Michigan's economy can emerge with stronger opportunities for all business and population sectors.

Timing: Commence in 2009.

Parties Involved: Meeting these various needs will become the responsibility of various departments and agencies within federal, state, tribal, and local governments, NGOs, and others, including the MDEQ Environmental Justice Working Group. These entities will require adequate budgets and infrastructure to plan and respond appropriately. The budget needs to sustain these efforts should be well and frequently communicated to the state's congressional delegation.

Implementation Mechanisms

1. *Collaborative Planning Process*
   A. The state should fully implement Michigan Executive Directive No. 2007-23: Promoting Environmental Justice. MDEQ is directed to develop and implement a state environmental justice plan and assemble an Environmental Justice Advisory Committee (see B below). Plans should incorporate greater levels of interdepartmental cooperation (Michigan Department of Transportation [MDOT], Michigan Department of Community Health, MEDC, MDNR, etc.) on environmental justice and climate change response (see C below). The advisory committee should be charged with facilitating innovation in

Michigan's public engagement practices, including strategies for better identifying and recruiting participation of affected parties in decision making (see Public Engagement below).

B. The Environmental Justice Advisory Committee should be charged with promoting greater cooperation among state agencies, businesses, community groups, and transportation users to better coordinate resources and facilitate equitable development of climate response policy. This committee should consist of stakeholders and an interdisciplinary cross-section of relevant government agency staff, and should be charged with addressing the cumulative impacts on affected communities (MDOT, MEDC, MDA, etc.), especially as it relates to local health impacts, climate change response, and energy investment. The committee will provide a forum for discussions about such issues as green job retraining for low-skilled workers, infrastructure needs, and continuous process improvement.

C. The state should review existing and proposed state programs to increase equity across regions and communities, and reduce disproportionate impacts to minorities and low-income residents. State agencies, including MDEQ, MEDC and MDOT, should review their current programs (including project funding, matching grants and job-training and incentive-based economic development programs) and develop procedures to ensure that environmental justice principals are incorporated into all decisions.

D. The state should focus targeted resources on facilitating greater innovation in Michigan's public engagement practices in anticipation of climate response policy. This initiative should increase the number of high-quality comments gathered and considered in decision making and greatly reduce disproportionate impacts on minority and low-income communities. It should include a strong, cross-departmental focus on developing and implementing innovative strategies for identifying, recruiting, and engaging participation of affected parties in decision making, such as:

- *Problem and Need Identification.* Early and continuous involvement of traditional and nontraditional community members should include the active recruitment of all stakeholders in pre-project "visioning" discussions. This should include direct outreach and consultation with representatives of minorities, people with disabilities, low-income people, children, youth, seniors, religious interests, and homeowners in areas where projects are likely to be proposed.
- *Diversity of Methods.* Include a variety of community engagement methods to gather input on proposed projects, including interactive design charettes as well as both open-house and town hall-style meetings that allow for direct interaction and group question-and-answer formats. On projects that are extensive in scale or impact or that are likely to draw significant controversy, state departments should regularly utilize a "charrette" format for public involvement, offering an intense, interactive public planning process that occurs over several consecutive days. A well-done charrette solicits comments from residents, provides them with tools, and puts them in charge of decision making.

- *Public Advocate or Ombudsman.* At the request of the Environmental Justice Advisory Committee, the state should provide communities with a "public advocate" for select proposed projects and policy development opportunities. The qualified professional would aid and represent the local community, translate technical information, and negotiate with department professionals throughout the process. This innovative concept most likely could create a budget cap based on the size of the proposed project budget.
- *Development and Distribution of Public Engagement Guidelines*. The guidelines will include the methods for identifying stakeholders and maintaining communication throughout the project or policy development process.

2. *Transformational Response*

   A. The state should mitigate regressive energy burdens by offering or subsidizing programs that reduce costs for low-income individuals for home heating and transportation needs, such as:

   - Updated building codes that reduce energy demands for home heating and cooling.
   - Energy efficiency programs that provide funding and job training for home energy audits, insulation and retrofit programs, and appliance replacement opportunities to low-income residents.
   - Live-Where-You-Work programs and location-efficient mortgages that encourage and support home ownership in communities in close proximity to transit and job opportunities and that reduce auto dependency.
   - Pay-As-You-Drive auto insurance to encourage alternative transportation and reduce high auto insurance burdens on minority and low-income communities.
   - Greater investment in mass transit options that provide quick, reliable, low-GHG access to daily needs.
   - Increased number of urban grocers, farmers' markets, and other sources of affordable, healthy food in core urban areas, reducing the need to drive long distances to grocers.

   B. State government should ensure that environmental justice oversight is a key component of statewide GHG reduction plans (see CCI-2). As recognized in CCI-2, the state will need to determine whether this can best be accomplished by assigning these coordination functions to an existing agency in state government or by creating a new organizational entity. Regardless of which state department or agency is assigned to manage such plans, oversight should include a requirement that plans include a clear analysis of both the harms and the benefits to various populations. This analysis should be published prior to implementation, and should be inclusive of both economic and noneconomic considerations.

3. *Opportunities for Change*

   A. The state should invest in clean energy manufacturing and job retraining.

- Implement a robust renewable energy portfolio standard and energy efficiency program to build a market for clean energy solutions.
- Develop a program to support job-training programs for the manufacture and deployment of a variety of clean energy technologies (efficiency upgrades, windmills, etc.). Cooperate with Lawrence Tech and Lansing Community College (LCC), etc.
- Retool and capitalize on Michigan's latent manufacturing capacity. Many of the manufacturing jobs lost in the last several decades in Michigan could be replaced and idled factories retooled to meet the demand for clean energy technologies, such as windmill components, gear boxes, etc.

B. The state should review programs to ensure it achieves maximum efficiency from existing and proposed infrastructure through improved regional land-use planning, transit investment, and regional tax-base sharing. This would support urban redevelopment and tax base in core communities, and relieve some disproportionate burdens on individuals and businesses locating in the state's urbanized areas.

C. The state should review economic development investments to achieve greater efficiency in business recruitment and siting through location targeting that achieves where possible:

- Reduced personal/employee transportation burden (i.e., business located in areas with options for transit, walking and biking, carpooling, etc.); and
- Reuse and updating of already existing housing, schools, and infrastructure (Michigan Land Use Leadership Council, 2003).

Related Policies/Programs in Place

- Michigan Executive Directive No. 2007-23: Promoting Environmental Justice.
- 21st Century Jobs Fund.
- No Worker Left Behind Initiative.
- Michigan State Housing Development Authority Urban Revitalization Program (Cool Cities/Cities of Promise).
- Green jobs programs at Lawrence Tech and LCC
- Michigan Land Use Leadership Council.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

- Timeline of implementation of Michigan Executive Directive No. 2007-23: Promoting Environmental Justice.
- Inaction on renewable portfolio standards and energy efficiency requirements.
- Funding for efficiency upgrades and job retraining.
- Mass transit funding and implementation across regions.
- Local land-use reform but regional needs and opportunities.

Additional Benefits and Costs

Health costs and needs among low-income and minority (high rates of asthma, numerous emergency room visits, etc.).

Focus on maintenance. It's cheaper than replacement for buildings, infrastructure, etc., but total abandonment in recent decades could mean higher costs for replacement, etc.

Feasibility Issues

None identified at this time.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.