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The Macroeconomic Impact of the Michigan Climate Action Council Climate Action Plan on the State's Economy

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Table of Contents

EXECUTIVE SUMMARY

This report summarizes the macroeconomic impact evaluation of the Michigan Climate Action Plan as proposed by the Michigan Climate Action Council. Michigan Governor Jennifer Granholm signed Executive Order 2007-42 on November 14, 2007, forming the Michigan Climate Action Council (MCAC). This council was comprised of a broad representation of Michigan interests and charged with inventorying Michigan's greenhouse gas (GHG) emissions and exploring viable options for mitigating climate change across multiple sectors of the economy. The MCAC identified 330 multi-sector policy options and approved 54 policy options for reducing GHG emissions by 80 percent below 2005 levels by 2050. Based on MCAC estimates of the cost of implementation, these policy options are expected to generate a direct net cumulative savings of about $10 billion between 2009 and 2025 and generate direct cost savings of $10.20 per metric ton of carbon dioxide equivalent mitigated (MCAC 2009). This macroeconomic study completes the analysis of the MCAC by projecting the statewide individual and collective impacts of 20 consolidated options that cover the majority of the GHG emission reductions of the original 54-policy option on gross state product, output, income, employment and prices between 2009 and 2025.

Quantified MCAC policy options are divided into four policy sectors: **Energy Supply** (ES), **Residential, Commercial, and Industrial** (RCI), **Transportation and Land Use Management** (TLU) and **Agriculture, Forestry and Waste Management** (AFW). This analysis suggests that implementing all MCAC policy options will stimulate economic growth for Michigan. On a net present value basis, implementing all policies is projected to increase gross state product (GSP) by $25.3 billion and expand employment by about 130 thousand full-time equivalent jobs by the year 2025. Of the sectors evaluated, the RCI sector policy options generate the largest net savings; contributing most of the positive returns in gross state product. The TLU sector and ES sector policies generate additional net cost savings. Alternatively, AFW sector policies are mostly neutral on GSP outcomes.

These economic gains arise primarily through reductions in energy use and expenditures that lead to lower overall costs of production. For example, policy options that improve energy efficiency of businesses and households lower production costs and increases the purchasing power of consumers. Additional macroeconomic stimulus arises from increased investment in energy efficient plant and equipment, and consumer appliances. Table A summarizes the expected cumulative gross state product and employment impacts of implementing the MCAC Climate Action Plan.

Table A. Simultaneous Gross State Product and Employment Impacts of Enacting the Michigan Climate Action Plan Options

	2010	2015	2020	2025	NPV*
Gross State Product (billions of fixed 2000$)	0.07	1.14	3.39	8.35	25.26
Employment (000's full-time equivalent	4.77	31.37	68.31	129.49	n.a.

*Discount factor is five percent

I. INTRODUCTION

On November 14, 2007, Governor Granholm signed Executive Order 2007-42, creating the Michigan Climate Action Council (MCAC) with the tasks of generating 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 (MCAC, 2009). The MCAC began deliberations in December of 2007, with the first of eight meetings leading to the Michigan Climate Action Council, Climate Action Plan (CAP), completed in March of 2009. Members of the public were encouraged to observe and provide input at all MCAC meetings.

The MCAC formed six Technical Work Groups (TWGs) – 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) – to serve as advisors to the MCAC. The TWGs assisted the MCAC by generating initial Michigan-specific policy options to be added to the catalog of existing state actions; developing priority policy options for analysis; drafting proposals on the design characteristics and quantification of the proposed policy options; and reviewing specifications for analysis of draft policy options (including best available data sources, methods and assumptions). The TWGs also provided evaluation of 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. Process facilitation and technical assistance was provided by the Center for Climate Strategies (CCS).

The resulting Michigan Climate Action Plan (CAP) establishes a set of policy options for reducing Michigan GHG emissions to 80 percent of 2005 levels by 2050. Policy options cover all sectors of the Michigan economy and have sweeping implications for the long-term performance of the Michigan economy. From the initial 330 policy options reviewed, the MCAC selected 54 least costly policy options for reducing GHG emissions and addressing related energy and commerce issues in Michigan. Moreover, several policy options are expected to result in net cost savings in that savings generated from implementation are expected to outweigh initial costs. For example, many electricity demand-side management practices translate into less electricity needed to produce a given outcome, such as running an assembly line or cooling a home. When this is accomplished at no cost at all or at a net cost-savings on an electricity bill, this is referred to as an energy efficiency improvement[1]. In other cases, as when new equipment must be purchased, the additional expense may exceed this cost savings in reducing GHG emissions.

Of the 54 policy options approved by the MCAC for action in Michigan, 33 were analyzed quantitatively to calculate both emission reductions and net direct costs. 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 MCAC approved policy options were estimated to generate a net cumulative savings of about $10 billion between 2009 and 2025. Based on MCAC estimates, the

[1] This definition is widely used by economists and employed here; however, the CAP may also include some positive cost demand-side management measures within the meaning of "energy efficiency."

weighted-average cost-effectiveness of these policies was estimated to be a savings of approximately $10.20 per ton of carbon dioxide equivalent reduced.

Expenditures and cost-savings estimates provided by the TWGs are specific to those directly impacted by the change in cash flows. That is, the TWGs provided estimates of direct impacts of policy implementation. However, direct impacts do not take into consideration secondary impacts on the state's economy as a whole. The task of measuring such macroeconomic impacts was beyond the scope of the TWG tasks.

The macroeconomic impacts of CAP include the direct economic impacts as well as all associated ripple effects of spending changes on mitigation and the interaction of demand and supply in various markets. For example, a reduction in consumer demand for electricity reduces the demand for electricity generation by all sources, including both fossil and renewable energy sources. At the same time, businesses and households, whose electricity bills have decreased, have more money to spend on other goods and services. This shift in purchases may or may not generate net positive impacts on other sectors in the economy depending on many factors, including the allocation of expenditures within the state relative to those outside the state.

To further illustrate how macroeconomic outcomes unfold, consider that Michigan imports most of its energy consumption (EIA, 2009b; NextEnergy Center, 2007). Thus, approximately 90 percent of Michigan's household and business purchases of energy leave the state. Reducing purchases on energy would reduce the amount of money leaving the state if alternative purchases are more likely to remain in the state. Consider households, for instance. If the 90 percent ratio holds true for household energy purchases, then for every dollar households spend on energy, only 10 cents re-circulates in the state economy. Alternatively, if that dollar was spent on a restaurant meal, a much larger percent of the initial expenditure will likely stay in the state economy.

Hence, shifting from high import to low import purchases will generate more local transactions. These local transactions also create secondary transactions, which arise as businesses replace sold inventories, pay wages, repay loans, etc. Beneficiaries of these secondary transactions also generate further rounds of transactions, and this process continues, diminishing with each additional round only by the extent to which purchases are made for imported goods and services. The sum total of these "indirect" impacts is some multiple of the original direct impact. Therefore, this is often referred to as the multiplier effect – a key aspect of macroeconomic impact modeling. It applies to both increases and decreases in economic activity, as well as to changes in relative prices.

Calculating economic impacts requires the use of a sophisticated model that captures the major structural features of an economy, the workings of its markets, and all of the interactions between them. This study uses the Regional Economic Models, Inc. Policy Insight^{+} (REMI PI^{+}) model to simulate the indirect and induced impacts of the CAP policy options. Direct effects for modeling macroeconomic outcomes are guided by the CAP from extensive consideration by the MCAC, with the assistance of researchers at The Center for Climate Strategies.

The objective of this study is to utilize TWG direct impacts of the policy options spelled out in the CAP and estimate their macroeconomic impacts. The 54 policy option direct impacts are collapsed into 20 consolidated options for modeling purposes. Both the direct and macroeconomic impacts are modeled over time to include outcomes from 2010 to 2025.

The findings suggest that implementing the MCAC policy options will generate significantly positive net macroeconomic impacts. However, not all policy options are expected to lead to net gains to the economy. Many policy options call for investing in new plant and equipment that is only partially offset with efficiency gains over time. Although, our analyses generally find that cost savings from efficiency gains outweigh initial investment costs. Of the 20 consolidated policy options, 17 are anticipated to generate net increases in employment, and 16 are expected to generate positive gross state product impacts.

The analyses described in this report are based on best estimations of the costs and savings of various mitigation options[2]. However, these costs and savings, and some conditions relating to the implementation of these options are not known with full certainty. Examples include the net cost or cost savings of the options themselves and the extent to which investment in new equipment will simply displace investment in other equipment in the state or will attract new capital from elsewhere. Accordingly, we performed sensitivity analyses to investigate alternative conditions.

The format of this report is as follows. Section 2 summarizes the REMI PI$^+$ model used to estimate the macroeconomic impacts. Section 3 presents an overview of how we translate the TWGs analysis of CAP policy options into REMI simulation policy variables, as well as how the data are further refined and linked to key structural and policy variables in the Model. Section 4 summarizes the set-up process of policy simulations in the REMI PI$^+$ model. The simulation results are discussed in section 5, and Section 6 provides a summary of the process and findings and provides some policy implications of our findings.

II. REMI Model Analysis

Several modeling approaches were considered for this analysis including input-output (I-O), computable general equilibrium (CGE), mathematical programming (MP), and macroeconometric (ME) models. Each model approach has it own strengths and weaknesses. The choice of which model to apply depends on the purpose of the analysis and various other considerations as accuracy, transparency, manageability, and cost. After careful consideration of modeling options, we chose a hybrid-model option provided by Regional Economic Models, Inc. – REMI PI$^+$. This is a hybrid model in that it integrates features of I-O, CGE and ME models. This combination affords it greater accuracy and completeness than would be afforded by a single modeling approach in isolation.

The REMI PI$^+$ Model is a packaged program built around region-specific data. It has been refined and peer-reviewed over the course of thirty years, and applied to a host of policy questions. Government agencies in practically every state in the U.S. have used a REMI Model for a variety of purposes, including evaluating the impacts of the change in tax rates, the exit or entry of major businesses or economic programs, and, more recently, the impacts of energy and/or environmental policy actions (Rose, Wei and CCS, 2009). Several Michigan state agencies rely on the Michigan-specified REMI PI$^+$ model for analysis, including the Michigan Economic Development Corporation, the Department of Treasury and the Department of

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[2] Data used for REMI inputs were provided by the Michigan Climate Action Council, Technical Workgroups: Electricity Supply (ES), Residential, Commercial and Industrial (RCI), Transportation and Land Use (TLU), and Agriculture, Forestry and Waste Management (AFW.

Transportation. Because the REMI PI$^+$ model has been widely adopted for addressing state and local policy questions, it is well documented.

A detailed discussion of the major features of the REMI PI$^+$ model is presented in Appendix A. We simply provide a summary for general readers here. REMI PI$^+$ combines the detailed, economic structure found in cross-sectional I-O models and CGE models with time-series econometric models that statistically estimates relationships over time. Doing so provides that the REMI PI$^+$ model is based on statistical relationships measured over time with known statistical properties, rather than based on a single year's fit of the state data. The REMI PI$^+$ model is especially astute at generating accurate forecasts of economic impacts that fully account for feedback effects and the timing of economic change. The major limitation of the REMI PI$^+$ model versus custom ME or CGE models is that it is pre-packaged and not readily adjustable to any unique features of the case in point. The other models, because they are based on less data and a less formal estimation procedure, can more readily accommodate data changes in technological representations of associations that might be inferred, for example from engineering data. However, our assessment of the REMI model is that these adjustments were not needed for the purpose at hand.

The REMI PI$^+$ model is complete in its coverage of the state economy. Unlike most macroeconometric models that provide little economic detail, this model makes use of the finely-grained sectoring detail of I-O and CGE models; dividing the economy into 169 sectors. This sectoring detail is important in a context like the CAP, where various options were fine-tuned to a given sector or where they directly affect several sectors differently. Similar to a CGE model, but unlike I-O models, the REMI PI$^+$ model is able to accommodate price responses to changes in supply and demand. Economic sectors interact with institutions such as government and households and local labor and capital markets when setting prices. Relative prices with respect to the national and international economies determine the state's competitiveness in the global marketplace.

III. Input Data

A. The Michigan Climate Action Council Climate Action Plan

The MCAC generated 54 policy options to reduce Michigan-generated GHG emissions. The TWGs determined that most policy options would be net-cost negative, in that the direct cost savings of implementing that policy option exceed the costs of implementation. For such policy options, rather than incurring a cost to reduce GHG emissions, a net economic return is generated. Alternatively, in cases where the costs of implementation exceed savings, the net cost per metric ton of carbon dioxide equivalent ($/t$CO_2$e) is negative. The weighted-average cost-effectiveness of the 54 proposed policy options calculated by the MCAC provides an estimated net savings of $10.20 per metric ton of carbon dioxide equivalent (tCO_2e) if all 54 policy options are implements.

Tables 1 through 4 mirror the CAP policy options with corresponding policy option numbers along four quantified policy sectors. Each policy option is accompanied by TWG estimates of the respective policies' expected GHG reductions, net present value of associated investments and cost savings, and cost-effectiveness as measured by net present value of cash flows per metric ton of carbon dioxide equivalent ($/t$CO_2$e) [3]. Summaries of direct impacts for each sector are provided in the grey-shaded rows at the bottom of the tables. Cells shaded in yellow show TWG estimates that warranted updates to account for changes in the baseline projections of economic activity and changes in electricity and fuel prices since the completion of the MCAC report, as discussed below.

Table 1. MCAC Energy Supply Policy Options*

Policy No.	Policy Option	GHG Reductions (MMtCO_2e)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)
		2015	2025	Total 2009–2025		
ES-1	Renewable Portfolio Standard and Distributed Generation "Carve-Out"	5	14.6	137.5	$6,600	$48.00
	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	0.4	2.6	$392	$152
	Plasma Gasification	0	0.3	1.3	$29	$22
	Distributed Generation "Carve-Out"	0.4	0.9	8	$1,054	$131.51
	Solar Hot Water	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	13.6	86.3	–$1,632	–$19
ES-5	Advanced Fossil Fuel Technology (e.g., IGCC, CCSR) Incentives, Support, or Requirements	*Not Quantifiable*				
ES-6	New Nuclear Power	0	6.3	38.5	$1,001	$25.98
ES-7	Integrated Resource Planning (IRP), Including Combined Heat & Power (CHP)	*Not Quantifiable*				
ES-8	Smart Grid, Including Advanced Metering	*Not Quantifiable*				
ES-9	CCSR Incentives, Requirements, R&D, and/or Enabling Policies	*Not Quantifiable*				
ES-10	Technology-Focused Initiatives (Biomass Co-firing, Energy Storage, Fuel Cells, Etc.), Including Research, Development, & Demonstration					
	Co-firing at 5%	0.2	0.2	3.3	$34.48	$10.60
	Co-firing at 10%	0.5	0.5	6.5	$69.43	$10.70
	Co-firing at 20%	0.9	0.9	13	$134.09	$10.30
ES-11	Power Plant Replacement, Energy Efficiency, and Repowering	2.5	2	33.2	$313	$9.40

[3] The MCAC favored discounting future cash flows at 5 percent per annum. Positive Net Present Value and Cost-Effectiveness imply net-cost negative values, where the discounted value of cost savings exceed the discounted values of costs of implementation.

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)
		2015	2025	Total 2009–2025		
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.				
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.4	0.5	7.8	$31.91	$4.09
ES-15	Transmission Access and Upgrades	*Not Quantifiable*				
	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**

* Options selected for update are shaded yellow

Table 2. MCAC Residential, Commercial, and Industrial Policy Options*

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)
		2015	2025	Total 2009-2025		
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0	13.6	86.3	–1,632	–19
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	17.6	53.8	428.6	–12,107	–28
RCI-3	Regulatory (PSC) Changes to Remove Disincentives and Encourage Energy Efficiency Investments by IOUs	*Not Quantifiable*				
RCI-4	Adopt More Stringent Building Codes for Energy Efficiency	3.6	9.8	82	–2,865	–35
RCI-5	MI Climate Challenge & Related Consumer Education Programs	*Not Quantifiable*				
RCI-6	Incentives to Promote Renewable Energy Systems Implementation	0.7	1.5	14	1,958	140
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	15.6	47.6	380	–11,693	–31
RCI-8	Net Metering for Distributed Generation	Fully incorporated into RCI-6				
RCI-9	Training & Education for Bldg. Design, Construction, and Operation	*Not Quantifiable*				
RCI-10	Water Use and Management	*Not Quantifiable*				
	Sector Total After Adjusting for Overlaps*	**21.8**	**64.9**	**523.9**	**–13,014**	**–24.8**

* Options selected for update are shaded yellow

Table 3. MCAC Transportation and Land Use Policy Options*

Policy No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)
		2015	2025	Total 2009–2025		
TLU-1	Promote Low-Carbon Fuel Use in Transportation	2.6	5.9	53	$820	$16
TLU-2	Eco-Driver Program	1.1	2.2	22	–$3,921	–$176
TLU-3	Truck Idling Policies	0.36	0.76	7	–$596	–$85
TLU-4	Advanced Vehicle Technology	0.01	0.03	0.19	$281	$1,458
TLU-5	Congestion Mitigation	0.08	0.18	1.7	–$135	–$81
TLU-6	Land Use Planning and Incentives	0.14	0.43	3.2	–$598	–$189
TLU-7	Transit and Travel Options	0.13	0.54	3.5	$655	$185
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.1	0.19	2	$69	$35
TLU-9	Great Lakes Shipping	0.24	0.27	2.5	NQ	NQ
	Sector Totals	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**
	Sector Total After Adjusting for Overlaps	**4.76**	**10.5**	**95.1**	**–$3,425**	**–$36**

* Options selected for update are shaded yellow

Table 4. MCAC Agriculture, Forestry, and Waste Management Policy Options*

Policy No.	Policy Option		GHG Reductions ($MMtCO_2e$)			Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($/t$CO_2$e)
			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
AFW-2*	In-State Liquid Biofuels Production		*Included in the Results of TLU-1*				
AFW-3	Methane Capture and Utilization From Manure and Other Biological Waste		0.09	0.14	1.5	$4.70	$3
AFW-4	Expanded Use of Bio-based Materials	A. Use of Bio-based Products	0.08	0.21	1.7	–$108	–$62
		B. Utilization of Solid Wood Residues	*Not Quantified*				
AFW-5	Land Use Management That Promotes Permanent Cover	A. Increase in Permanent Cover Area	0.08	0.21	1.8	$63	$34
		B. Retention of Lands in Conservation Programs†	0.05	0.11	1.1	$24	$23
		C. Retention / of Wetlands	*Not Quantified*				
AFW-6	Forestry and Agricultural Land Protection	A. Agricultural Land Protection	0.46	1.1	10	$864	$85
		B. Forested Land Protection	*Not Quantified*				
		C. Peatlands/Protection	*Not Quantified*				
AFW-7	Promotion of Farming Practices That Achieve GHG Benefits	A. Soil Carbon Management	0.7	1.7	15	–$200	–$13
		B. Nutrient Efficiency	0.05	0.12	1.1	–$27	–$26
		C. Energy Efficiency	0.13	0.32	2.9	–$102	–$35
		D. Local Food	*Not Quantified*				

Policy No.	Policy Option		GHG Reductions ($MMtCO_2e$) 2015	2025	Total 2009–2025	Net Present Value 2009–2025 (Million 2005$)	Cost-Effective-ness ($/t$CO_2$e)
AFW-8	Forest Management for Carbon Sequestration and Biodiversity	A. Enhanced Forestland Management	0.53	1.42	12.05	$800	$66
		B. Urban Forest Canopy	1.2	2.9	26	–$346	–$13
		C. Reduce Wildfire	*Not Quantified*				
AFW-9	Source Reduction, Advanced Recycling, and Organics Management						
	In-State GHG Reductions		1.4	3	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
	Sector Totals†		**9**	**23**	**201**	**–$548**	**–$3**
	Sector Total After Adjusting for Overlaps††		**6**	**17**	**147**	**–$1,634**	**–$11**

* Options selected for update are shaded yellow

The CAP provided detailed cost, savings and related information for each of the quantified policy options. However, despite the fact that the Action Plan was released in March of this year, there is a need to revisit the original quantification of the options and the business-as-usual forecast of emissions to reflect changes in the underlying economy since March.

Updates consider three factors that may have changed since the plan was completed and delivered to the Governor:

- The effects of the recession on assumed levels of economic growth and other economy-driven assumptions;
- The effects of changes in fuel prices;
- The impacts of recent state or federal actions on assumed future levels of GHG emissions in the absence of the proposed new GHG reduction policies.

The 33 quantified MCAC options range in GHG reduction potential from 0.03 $MMtCO_2e$ reductions in 2025 for *Advanced Vehicle Technology* (TLU-4) to 53.8 $MMtCO_2e$ for *Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing* (RCI-2). Given the relatively short amount of time available to conduct this study it was decided that only the more significant options would be re-quantified and analyzed through the macroeconomic model. The 21 highlighted policies represent 95 percent of all 2025 projected GHG reductions under the original analysis, after taking into consideration policy overlaps.

These 21 original options were then classified into 20 'consolidated options', which represent policies (1) having the greatest GHG reduction potential; (2) being gateway options with limited near-term reduction potential but holding great promise in later years (carbon capture and storage or reuse, nuclear); or (3) having limited potential statewide but are highly cost-effective and important for other reasons. Table 5 summarizes the consolidated options specified for this study.

Table 5: Specification of Consolidated Options

Consolidated Option Name	Consolidated Option Description
Energy Supply Policy Options (ES)	
ES1	ES Consolidated Option #1: Renewable Portfolio Standard
ES2	ES Consolidated Option #2: Nuclear
ES3	ES Consolidated Option #3: Energy Efficiency, Repowering, Technology
ES4	ES Consolidated Option #4: Combine Heat and Power
Residential, Commercial, and Industrial Policy Options (RCI)	
RCI1	RCI Consolidated Option #1: Demand Side Management Programs
RCI2	RCI Consolidated Option #2: High Performance Buildings (private and public sector)
RCI3	RCI Consolidated Option #4: Building Codes
Transportation and Land Use Policy Options (TLU)	
TLU1	TLU Consolidated Option #1: Anti-Idling Technologies and Practices
TLU2	TLU Consolidated Option #2: Vehicle Purchase Incentives
TLU3	TLU Consolidated Option #3: Mode Shift from Truck to Rail
TLU4	TLU Consolidated Option #4: Renewable Fuel Standard (biofuels goals)
TLU5	TLU Consolidated Option #5: Transit
TLU6	TLU Consolidated Option #6: Land Use
Agriculture, Forestry, and Waste Management Policy Options (AFW)	
AFW1	AFW Consolidated Option #1: Soil Carbon Management
AFW2	AFW Consolidated Option #2: Nutrient Management
AFW3	AFW Consolidated Option #3: Livestock Manure
AFW4	AFW Consolidated Option #4: MSW Landfill Gas Management
AFW5	AFW Consolidated Option #5: Enhanced Recycling of Municipal Solid Waste
AFW6	AFW Consolidated Option #6: Reforestation/Afforestation
AFW7	AFW Consolidated Option #7: Urban Forestry

When the Action Plan was published, it was projected that the 33 quantified options would achieve a 40 percent reduction of GHG emissions in 2025 as compared to business as usual. Given that emissions are no longer expected to grow as fast as assumed when the plan was developed, and that total reductions are now expected to be 121 $MMtCO_2e$ 2025, which compares favorably with the original Action Plan 2025 estimate of 117 $MMtCO_2e$. The updated projections now indicate a 44 percent reduction is possible in 2025.

The MCAC recommended reduction goals of 20 percent below 2005 levels by 2020 and 80 percent below 2005 by 2050. The 2020 goal equates to total emissions no greater than 198 $MMtCo_2e$ in 2020. The revised business-as-usual forecast projects emission of 247.1 $MMtCO_2e$ in 2020, requiring reductions of 49 $MMtCO_2e$. The Action Plan estimated that the implementation of all MCAC policies would result in 78.9 $MMtCO_2e$ in reductions in 2020. Total emissions reductions from policies based upon this update are now expected to total 90 $MMtCO_2e$; therefore, if all updated policies were implemented current projections indicate that the 2020 goal would be met with 41 $MMtCO_2e$ to spare.

Overall, cost effectiveness has shifted since the Action Plan report. It was originally estimated that to implement all recommended policies would result in an average net savings of $10.20 per ton of CO_2e removed. The new estimate for the subset of policies updated here is an average net positive cost of $0.30 per ton CO_2e. There are two reasons for this shift. The first has to do with the methodology of this update, and the second is attributable to updated cost analysis in the forestry and waste sectors.

The first issue relates to the use of the consolidated option approach and its effect on a single TLU option, specifically, TLU-2, Eco-Driver Program. TLU-2 was not included in the update or REMI analysis because it offers unusually high net cost savings for a program that is essentially behavioral, making the projected savings somewhat speculative. Since any additional savings will likely increase macroeconomic benefits, the exclusion of TLU-2 means that any savings derived from this recommendation would result in macroeconomic benefits over and above those projected here.

TLU-2 contributed reductions at a very high cost savings in the original MCAC Action Plan, and its exclusion here 'increases' the net costs in the TLU sector and the plan as a whole. This update, exclusive of TLU-2, finds a TLU sector total cost of positive $5.64 per ton – a decline in cost-effectiveness of more than $41 per ton compared to the original MCAC analysis. If we include the original results for TLU-2 into the update, the sector total result is a savings of $39 per ton, which represents an increase of cost effectiveness of $3 per ton. In other words, the entire reason for the apparent decline in cost effectiveness for the TLU sector is the exclusion of TLU-2 from the analysis.

The cost effectiveness for the updated policy options across all four sectors is $0.30 per ton. If TLU-2 had been included in the updated analysis, the overall cost effectiveness would have been a savings of $3.30 per ton.

Appendix E provides a more detailed discussion of the MCAC Action Plan policy option updates used in this analysis.

REMI model inputs are generated for each of the 20 consolidated options as described in the next section. Each consolidated option is analyzed individually. Additionally, an aggregate run of all consolidated options is generated to assess the overall macroeconomic impact of the CAP in its entirety. The sum of the individual macroeconomic impacts of the 20 consolidated options may not necessarily add up to a single simultaneous analysis of all 20 consolidated options, because REMI PI$^+$ takes into account interactive effects across policy options when they are analyzed together. If the simultaneously estimated macroeconomic impacts exceed the sum of the individual impacts, the interaction of policy options is complementary, and the positive impact of one expands the impact of another. Alternatively, if the sum of the parts exceeds the simultaneously estimated impacts, the interactions are offsetting.

B. REMI PI$^+$ Model Input Development

Estimating the macroeconomic impacts of the 20 consolidated policy options starts with specifying the direct effects from the CAP policy options. This section documents how consolidated options are translated into REMI PI$^+$ inputs for modeling macroeconomic outcomes.

First, the CAP policy options in Tables 1 to 4 are collapsed into 20 consolidated options summarized in Table 6. Collapsing CAP policy options has the potential to generate overlapping direct impacts that will result in double-counting direct effects if not corrected. Such potential for double -counting exists because the TWGs evaluated each policy option in isolation.

However, several CAP policy options have overlapping options that should be accounted for when estimating impacts in isolation, but should be netted out when combining two or more policy options. For example, policy option RCI-7 – in Table 2 overlaps with both RCI-2 and RCI-4 if all three policies are implemented. We remove overlap of consolidated options by applying "overlap factors" developed by the TWGs to both costs and savings of related policy options.

Table 6. CAP Consolidated Options Updated and Quantified for 2025*

Updated MI Consolidated Options	MI				
	GHG Reductions ($MMtCO_2e$) 2025	Cumulative Emissions Reductions ($MMtCO_2e$, 2009-2025)	NPV 2009-2025 ($million)	Cost-Effective-ness ($\$/tCO_2e$)	Notes
Energy Supply	**22.91**	**188.92**	**$5,509.00**	**$29.16**	ES-3 is considered as well. However, since it is entirely overlapped with the RCI options, it is not included in the sectoral total.
ES Consolidated Option #1: Renewable Portfolio Standard (ES-1)	12.88	107.28	$4,413	$41.14	
ES Consolidated Option #2: Nuclear (ES-6)	7.54	46.27	$1,001	$21.63[4]	
ES Consolidated Option #3: Coal Plant Efficiency Improvements and Repowering (ES-10 and ES-11)	2.49	35.38	$95	$2.67	
ES Consolidated Option #4: Combined heat and power (ES-13)	0.51	7.97	$35.40	$4.44	
Carbon Capture and Storage/Sequestration or Reuse	n/a	n/a	n/a	n/a	Not quantified in the original analysis
Residential, Commercial, and Industrial	**64.61**	**522.46**	**-$14,578.13**	**-$27.90**	RCI-1 and RCI-7 are considered as well. However, since they are entirely overlapped with RCI-2, they are not included in the sectoral total.
RCI Consolidated Option #1: Demand Side Management Programs (RCI-2)	28.77	229.23	-$6,278.33	-$27.39	
RCI Consolidated Option #2: High Performance Buildings (private and public sector) (RCI-2)	25.51	203.28	-$5,567.57	-$27.39	
RCI Consolidated Option #3: Building Codes (RCI-4)	9.82	81.98	-$2,767.63	-$33.76	
Appliance standards	n/a	n/a	n/a	n/a	Not quantified in the original analysis

4 The data on new nuclear capital and O&M costs for this option were provided by DTE Energy based upon planning for the proposed Fermi 3 nuclear unit scheduled to come online in 2020. While the cost data was approved by the MCAC after much discussion, the estimates did not include long-term storage of spent fuel. It also should be noted that the cost-effectiveness reported here relies upon these MCAC capital and O&M costs which are significantly lower than those reported by industry and the World Bank.

Updated MI Consolidated Options	MI				
	GHG Reductions ($MMtCO_2e$) 2025	Cumulative Emissions Reductions ($MMtCO_2e$, 2009-2025)	NPV 2009-2025 ($million)	Cost-Effectiveness ($/$tCO_2e$)	Notes
Transportation and Land Use	**7.71**	**68.10**	**$384.34**	**$5.64**	
Clean Cars and CAFE standards	Included in Baseline Forecast				
TLU Consolidated Option #1: Anti-Idling Technologies and Practices (TLU-3)	0.73	6.61	-$316.71	-$47.92	
TLU Consolidated Option #2: Vehicle Purchase Incentives, including rebates (TLU-4)	0.02	0.18	$254.25	$1,411.33	
TLU Consolidated Option #3: Mode Shift from Truck to Rail (TLU-8)	0.20	2.09	$194.53	$93.12	
Low Carbon Fuel Standard	Same as RFS				
TLU Consolidated Option #4: Renewable Fuel Standard (biofuels goals) (TLU-1)	5.90	52.89	$219.71	$4.15	
TLU Consolidated Option #5: Transit (TLU-7)	0.43	3.17	$325.95	$102.86	
TLU Consolidated Option #6: Smart Growth/Land Use (TLU-6)	0.43	3.16	-$293.39	-$92.84	
Agriculture	**2.00**	**18.27**	**-$234.49**	**-$12.83**	
AFW Consolidated Option #1: Soil Carbon Management (AFW-7a)	1.72	15.56	-$209.68	-$13.47	
AFW Consolidated Option #2: Nutrient Management (AFW-7b)	0.14	1.25	-$27.33	-$21.91	
AFW Consolidated Option #3: Livestock Manure - Anaerobic Digestion and Methane Utilization (AFW-3)	0.14	1.46	$2.52	$1.72	
In-State Liquid Biofuel Production	accounted for in TLU Biofuels				
Expanded Utilization of Biomass Feedstocks for Electricity, Heat, or Steam Production	accounted for in ESD Biomass				
Waste	**23.21**	**258.02**	**3842.30**	**$14.89**	
AFW Consolidated Option #4: MSW Landfill Gas Management (AFW-10)	2.71	21.99	-$48.82	-$2.22	
AFW Consolidated Option #5: Enhanced Recycling of Municipal Solid Waste (AFW-9)	20.49	236.02	$3,891.12	$16.49	Name of option includes Source Reduction, but no Source Reduction goal was recommended by TWG
Municipal Solid Waste Source Reduction	n/a	n/a	n/a	n/a	Not quantified in the original analysis
Forestry	**3.97**	**35.22**	**5,355.04**	**$152.04**	
AFW Consolidated Option #6: Reforestation / Afforestation (AFW-8a, part 1)	0.94	7.98	$362.48	$45.44	
AFW Consolidated Option #7: Urban Forestry (AFW-8b)	3.03	27.24	$4,992.56	$183.26	
Forest Retention	n/a	n/a	n/a	n/a	Not quantified in the original analysis
TOTAL	**124.4**	**1,090.00**	**$278.06**	**$0.25**	

*All the within-sector and across-sector overlaps have been adjusted.

The quantification analysis of the costs/savings undertaken by the TWGs was limited to the direct effects of implementing the policy options. For example, the direct costs of an energy efficiency option may include the ratepayers' payment for the program and the energy customers' expenditure on energy efficiency equipment and devices. The direct savings and costs of this policy option are estimated by the TWG and only consider impacts to those incurring additional costs or benefiting in cost savings. Understanding the macroeconomic impacts requires modeling how changes in these initial costs and savings impact other sectors. The direct changes in expenditures generate ripple effects throughout the economy in response to changes in purchases and in relative prices, including production costs. Direct impacts are specified and inserted into the REMI PI$^+$ model that estimates such secondary, or ripple, effects.

Quantifying the consolidated policy options into model inputs compatible with the REMI PI$^+$ model involves selecting appropriate variables, which we refer to as "policy levers" in the model to link to each policy direct effect. The input data include sectoral spending and costs or savings over the full time horizon (2009-2025) of the analysis. Multiple policy levers are specified for each policy option to reflect investment, cost of production, energy usage, and other factors relevant to the policy option. Tables 7-10 provides examples of how we translate – or map –the TWG-estimated direct effects into REMI economic variable inputs from each of the four policy sectors. The Michigan Climate Action Council, Climate Action Plan (MCAC 2009) provides detailed discussions of the methodologies and TWG estimates of direct effects used in this study and translated into REMI policy variables.

Table 7 shows the microeconomic policy levers used to simulate the macroeconomic outcomes of the Renewable Portfolio Standard (RPS) policy option. A RPS requires that utilities supply a

Table 7. Mapping the Quantification Results of ES Consolidated Option #1 Renewable Portfolio Standard into REMI Inputs

Quantification Results	Policy Variable Selection in REMI
Incremental Capital Cost of Electricity Generation (Renewable minus Avoided Traditional)	Compensation, Prices, and Costs Block →Capital Cost (amount) of Electric Power Generation, Transmission, and Distribution sectors→Increase
Incremental O&M Cost of Electricity Generation (Renewable minus Avoided Traditional)	Compensation, Prices, and Costs Block →Production Cost (amount) of Electric Power Generation, Transmission, and Distribution sectors→Increase
Reduction on Fuel Cost of Electricity Generation	Compensation, Prices, and Costs Block →Production Cost (amount) of Electric Power Generation, Transmission, and Distribution sectors→Decrease
Incremental Investment in Generation Technologies (Renewable minus Avoided Traditional)	Output and Demand Block →Exogenous Final Demand (amount) for Construction sector→Increase Output and Demand Block →Exogenous Final Demand (amount) for Engine, Turbine, and Power Transmission Equipment Manufacturing sector→Increase
Interest Payment of Financing Capital Investment	Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase
Fuel Savings	Output and Demand Block →Exogenous Final Demand (amount) for Coal Mining sector→Decrease[a]
Tax Credits to Renewable Electricity Generation	Output and Demand Block →State Government spending (amount) → Decrease

[a] Assume the displaced electricity generations are all coal-fired electricity.

determined proportion of retail sales from eligible renewable energy sources on a progressive scale over time. The CAP RPS option is spelled out in MI PA 295 through the year 2015. Beyond 2015, the policy option follows minimum renewable standards contained in the Midwestern Governors Association goals.[5]

The proposed renewable portfolio standard entails a combination of tax credits and mandates to encourage renewable feedstocks for electricity generation, including biomass, wind, solar and plasma gasification (MCAC, 2009). The direct effect on producers' cost of generating electricity is the incremental costs in capital, and operations and maintenance, and reduction on fuel costs of renewable electricity generation relative to the current processes. The REMI PI$^+$ model captures these costs as the incremental difference in capital costs and production costs of electricity generation. These policy levers are shown in the first two rows of Table 7. The REMI policy variable "Capital Cost" for "Electric power generation, transmission, and distribution" is used to capture incremental costs of capital and equipment, while the "Production Cost" variable is used to capture those of operations and maintenance.

Investment in new plant and equipment will increase construction demand and demand for turbines and transmission capital. Based on assumptions discussed below, up-front investments are paid through debt financing; increasing the demand for financial services and interest payments. The REMI PI$^+$ model uses "Exogenous Final Demand" increases in "Construction," in "Engine, Turbine, and Power Transmission Equipment Manufacturing" and in "Monetary Authorities, Credit Intermediation" to capture these additional expenditures.

Cost savings are incurred through reductions in the use of coal as a feedstock to electricity power generation. This is captured by reducing the policy level "Exogenous Final Demand" for "Coal Mining."

One additional policy lever is specified to recognize government investment in tax credits for renewable electricity generation. The REMI variable for "State Government Spending" of "Total" expenditures is decreased by estimates of state investment, as shown in the last row of Table 7.

Table 8 shows how the microeconomic results of Demand-Side Management (DSM) are translated, or mapped, into REMI economic variable inputs. DSM refers to programs implemented by the utility sectors aimed at reducing electricity, natural gas, and other fuel consumptions in the business and household sectors.

The first set of inputs in Table 8 is the increased cost to the commercial, industrial, and residential sectors due to the purchases of energy efficient equipment and appliances. For the commercial and industrial sectors, this is simulated in REMI by increasing the value of the "Capital Cost" variable of individual commercial sectors and individual industrial sectors under the "Compensation, Prices, and Costs Block." For the residential sector, the program costs are simulated by increasing the "Consumer Spending" on "Kitchen & Other Household Appliances" (and decreasing all the other consumptions correspondingly). The "Consumer Spending

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[5] 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.

(amount)" and "Consumption Reallocation (amount)" variables can be found in the "Output and Demand Block" in the REMI Model.

The second set of inputs is the corresponding stimulus effect to the economy of the spending on efficient equipment and appliances, i.e., the increase in the final demand for goods and services from the industries that supply energy efficient equipment and appliances. This is simulated in REMI by increasing the "Exogenous Final Demand" (in the "Output and Demand Block") of the following sectors: Ventilation, Heating, Air-conditioning, and Commercial Refrigeration

Table 8. Mapping the Quantification Results of RCI Consolidated Option #1 Demand-Side Management into REMI Inputs

Quantification Results		Policy Variable Selection in REMI
Customer Outlay on Energy Efficiency (EE)	Businesses (Commercial and Industrial Sectors)	Compensation, Prices, and Costs Block →Capital Cost (amount) of individual commercial sectors→Increase
	Households (Residential Sector)	Output and Demand Block→Consumer Spending (amount)→Kitchen & other household appliances→Increase
		Output and Demand Block→Consumer Spending (amount)→ Bank service charges, trust services, and safe deposit box rental→Increase
		Output and Demand Block →Consumption Reallocation (amount)→All Consumption Sectors →Decrease
Investment on EE Technologies		Output and Demand Block →Exogenous Final Demand (amount) for Ventilation, Heating, Air-conditioning, and Commercial Refrigeration Equipment Manufacturing sector; Electric Lighting Equipment Manufacturing sector; Electrical Equipment Manufacturing sector; Other Electrical Equipment and Component Manufacturing sector; and Industrial Machinery Manufacturing sector→Increase
Interest Payment of Financing Capital Investment		Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase
Administrative Outlays		Output and Demand Block →Exogenous Final Demand (amount) for Management, Scientific, and Technical Consulting Services sector→Increase
Energy Savings of the Customers	Businesses (Commercial and Industrial Sectors)	Compensation, Prices, and Costs Block→ Electricity and Natural Gas (Commercial Sectors) Fuel Cost (share) of All Commercial Sectors→Decrease
		Compensation, Prices, and Costs Block→ Electricity, Natural Gas, and Residual (Industrial Sectors) Fuel Cost (share) of All Industrial Sectors→Decrease
	Households (Residential Sector)	Output and Demand Block→Consumer Spending (amount)→Electricity and Gas→Decrease
		Output and Demand Block →Consumption Reallocation (amount)→All Consumption Sectors →Increase
Energy Demand Decrease from the Energy Supply Sectors		Output and Demand Block →Exogenous Final Demand (amount) for Electric Power Generation, Transmission, and Distribution sector; Natural Gas Distribution sector; Coal Mining sector; and Petroleum and Coal Products Manufacturing sector→Decrease

Equipment Manufacturing sector; Electric Lighting Equipment Manufacturing sector; Electrical Equipment Manufacturing sector; Other Electrical Equipment and Component Manufacturing sector; and Industrial Machinery Manufacturing sector. The interest payment due to the financing of the capital cost is simulated as the "Exogenous Final Demand" increase of the Monetary Authorities, Credit Intermediation sector. The administrative cost of the DSM program is simulated as the "Exogenous Final Demand" increase of the Management, Scientific, and Technical Consulting Services sector.

The third set of inputs to REMI is the energy savings of the commercial, industrial, and residential sectors resulted from the DSM program. For the commercial and industrial sectors, the energy savings are simulated in REMI by decreasing the value of the "Electricity/Natural Gas/Residual Fuel Cost of All Commercial/Industrial Sectors" variables. These variables can be found in the "Compensation, Prices, and Costs Block." For the residential sector, the energy savings are simulated by decreasing the "Consumer Spending" on "Electricity" and "Gas" (and increasing all the other consumption categories correspondingly). Again, the "Consumer Spending (amount)" and "Consumption Reallocation (amount)" variables can be found in the "Output and Demand Block" in the REMI model.

The last set of inputs is the corresponding damping effects to the energy supply sector due to the decrease in the demand from the customer sectors. These effects are simulated by reducing the "Exogenous Final Demand" of the Electric Power Generation, Transmission, and Distribution sector; Natural Gas Distribution sector; Coal Mining sector; and Petroleum and Coal Products Manufacturing sector in REMI.

Table 9 shows the policy levers used to simulate TLU Consolidated Option 3 of shifting transportation modes from truck to rail. This policy option will generate investment in non-road transportation construction and the purchase of capital equipment to facilitate rail transportation, with a substantial portion paid from borrowing. Investment in rail capacity is captured by increasing the policy variables "Capital Cost" for "Rail transportation" and "Exogenous Final Demand" for the "Construction" sector, as shown in the first two rows. Debt financing of infrastructure investments are captured by increasing "Exogenous Final Demand" for "Monetary authorities, credit intermediation," in the third row.

Operational costs differences are captured by modifying fuel usage as shown in the last two rows of Table 9. Reductions in local demand for diesel fuel will impact the cost and use of truck fuel as captured by a decrease in "Residual Fuel Cost for Truck Transportation Sector" and reductions in the "Exogenous Final Demand" of "Petroleum and Coal Products."

Finally, Table 10 shows the REMI policy levers for AFW Consolidated Option #7 – Public Investment in Urban Forestry. Under this policy option, local governments invest in urban treescaping, drawing down expenditures on other public goods and services. Households, businesses and local governments benefit through lower fuel consumption through summer-time shading and winter windbreaks, reducing total electricity demand.

Table 9. Mapping the Quantification Results of TLU Consolidated Option #3 Mode Shift from Truck to Rail into REMI Inputs

Quantification Results	Policy Variable Selection in REMI
Cost of Additional Terminal and Track Upgrades	Compensation, Prices, and Costs Block→Capital Cost of Rail Transportation sector→Increase
Investment to Improve Rail Transportation System	Output and Demand Block →Exogenous Final Demand (amount) for Construction sector→Increase
Interest Payment of Financing Capital Investment	Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase
Fuel Savings	Compensation, Prices, and Costs Block →Residual Fuel Cost for Truck Transportation sector→Decrease
Fuel Demand Decrease of Fuel	Output and Demand Block →Exogenous Final Demand (amount) for Petroleum and Coal Products Manufacturing sector→Decrease

Table 10. Mapping the Quantification Results of AFW Consolidated Option #7 Urban Forestry into REMI Inputs

Quantification Results		Policy Variable Selection in REMI
Spending Stimulation		Output and Demand Block →Exogenous Final Demand (amount) for Forestry; Fishing, Hunting and Trapping sector and Support Activities for Agriculture and Forestry sector →Increase
Cost of Urban Forestry		Output and Demand Block →Local Government spending (amount) → Decrease[a]
Energy Savings (reduction in electricity consumption)	Commercial Sectors	Compensation, Prices, and Costs Block→ Electricity (Commercial Sectors) Fuel Cost (amount) of All Commercial Sectors →Decrease[b]
	Households (Residential Sector)	Output and Demand Block→Consumer Spending (amount) →Electricity→Decrease[b] Output and Demand Block →Consumption Reallocation (amount) →All Consumption Categories →Increase
	Government	Output and Demand Block →Local Government spending (amount) → Decrease[b]
Electricity Demand Decrease from the Utility Sector		Output and Demand Block→ Exogenous Final Demand (amount) for Electric Power Generation, Transmission, and Distribution sector→Decrease

[a] It is assumed that all the costs of urban forestry program will be borne by the local government. Accordingly, we assume the local government spending elsewhere will be reduced by the same amount of spending on the urban forestry program.

[b] It is assumed that energy savings resulted from shading of structures will be split between the commercial sector, residential sector, and government by 40%, 40%, and 20%.

The first row of Table 10 specifies REMI variables used to capture investment in urban forests, using the "Exogenous Final Demand" variables for "Forestry; Fishing, Hunting and Trapping sector" and "Support Activities for Agriculture and Forestry sector." The second row captures decreases in other local government expenditures using the "Local Government spending" variable. Changes in energy consumption are captured in the next section and the final row.

First, reductions in energy consumption of commercial establishments are reflected in a decrease in "Electricity (Commercial Sectors) Fuel Cost" for all commercial sectors, as estimated by the AFW TWG. Household savings are captured by reducing household electricity consumption and reallocating those expenditures to all other household expenditures. This is accomplished by decreasing the "Consumer Spending" variable for "Electricity" and increasing the "Consumption Reallocation" variable for "All Consumption Categories." This last policy variable reallocates savings to all consumption categories based on relative proportions of total expenditures in each spending category. Finally, "Exogenous Final Demand" for "Electric Power Generation, Transmission, and Distribution sector" is reduced to reflect decrease demand for electricity.

C. CAP Modeling Assumptions

All economic models entail some level of assumptions to facilitate modeling. Several modeling assumptions went into the analysis of the CAP policy options. These assumptions simplify the modeling process and in some cases make the modeling process possible. This section discusses the assumptions used for this analysis.

The major data sources of the analysis below are the TWG quantification results or their best estimation of the cost/savings of various recommended policy options. However, we supplement this with some additional data and assumptions in the REMI analysis where these costs and some conditions relating to the implementation of the options are not specified by the TWGs or are not known with certainty. Below is the list of major assumptions we adopted in the analysis:

1. In the base case analysis, for all the policy options that involve capital investment, we simulated a stimulus from only 50 percent of the capital investment requirements. This is based on the assumption that 50 percent of the investment in new equipment will simply displace other investment in the state[6].

2. Capital investment in power generation is split 60:40 between sectors that provide generating equipment and the construction sector for large power plants (such as coal-fired power plants), and 80:20 for smaller installations (mainly renewables).

3. For the RCI options, the energy consumers' participant costs of energy efficiency programs are computed for the residential, commercial, and/or industrial sectors by the TWGs. For the commercial and industrial sectors, the TWGs' analyses only provide the aggregated costs for the entire commercial sector and the entire industrial sectors. Since in the REMI model, capital cost and production cost variables can only be simulated for individual commercial sectors or industrial sectors, we distributed these costs among the 169 REMI sectors based on the Input-Output data provided in the REMI model in relation to the delivery of utility services to individual sectors.

4. The interest payment and the administrative cost are split out from the levelized cost using the following assumptions:

   a. For the RCI options, it is assumed that 50 percent of the RCI costs will be covered by private sector financing and 50 percent will be covered by the utility

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[6] Model sensitivity to changes in the investment displacement is minimal as described in Section VI.B.2 of this report

expenditure such as public benefit charges. The administrative costs are assumed to account for 10 percent of the 50 percent utility portion of the capital costs.

b. For the ES, AFW, and TLU options that involve capital investment, we assume 100 percent of the total costs will be covered by financing.

5. For the Combined Heat and Power option, the total costs of installing the CHP systems are only computed for the commercial and industrial sectors as a whole by the ES TWG. We used the data on Michigan market potential for CHP in existing facilities of commercial and institutional sectors to distribute the input costs among individual commercial sectors and the government sector (ONSITE SYCOM Energy Corporation, 2000), and used the energy consumption data as the weights to distribute the costs for the industrial sectors in the REMI analysis.

6. For the Restoration/Afforestation option, it is assumed that the costs are borne by the private sector (farmers). The potential future cost savings from forest products (e.g., merchantable timber or bioenergy feedstocks) are not taken into account, since these cost savings would most likely not be realized during the period of this analysis.

7. For the Urban Forestry option, it is assumed that all the costs will be borne by the local government. It is also assumed that increasing the government spending in the urban forestry program will be offset by a decrease in the same amount of government spending on other goods and services. The energy savings breakout is 20 percent government, 40 percent commercial sector, and 40 percent residential sector.

8. For the TLU options related to fuel cost changes for heavy duty trucks, we distribute 45% of the fuel savings (or cost increase) to the Truck Transportation sector based on the Vehicle Inventory and Use Survey data that about 45% of the miles accumulated by heavy trucks are for the "For-Hire" transportation and 55% are for the "Own Account Transportation" (U.S. Census Bureau, 2002). Further, the 55% of the fuel savings (or cost increase) are distributed across sectors other than the Truck Transportation sector in the economy in proportion to the petroleum inputs for each sector.

IV. REMI SIMULATION SET-UP

Figure 1 shows the approach to policy simulations in the REMI PI$^+$ model. A first step is to form a policy question such as, "What would be the economic impact of a RPS." Second, the policy question guides selection of relevant policy variables within the REMI PI$^+$ model. For the RPS example, relevant policy variables may include incremental costs and investment in renewable electricity generation; avoided generation of conventional electricity; and electricity price changes. Third, baseline values for all policy variables are used to generate the control forecast – baseline forecast. Fourth, an alternative forecast is generated by changing policy variables to represent direct effects guided by the policy question. For the RPS example, the costs to the ratepayers, the investments to the renewable electricity generation, and avoided investment in conventional electricity generation represents direct impacts to be entered into the model. Fifth, the effects of the policy scenario are measured by comparing the baseline forecast and the alternative forecast. Sensitivity analysis can be undertaken by running a series of alternative forecasts with different assumptions on the values of the policy variables.

In this study, we first run the REMI model for each of the 20 CAP consolidated policy options *individually*. Next, we run a *simultaneous* simulation in which we assume that all the policy options are implemented together. Then the simple summation of the effects of individual options is compared to the simultaneous simulation results to determine whether the "whole" is different from the "sum" of the parts. Differences can arise from non-linearities and/or

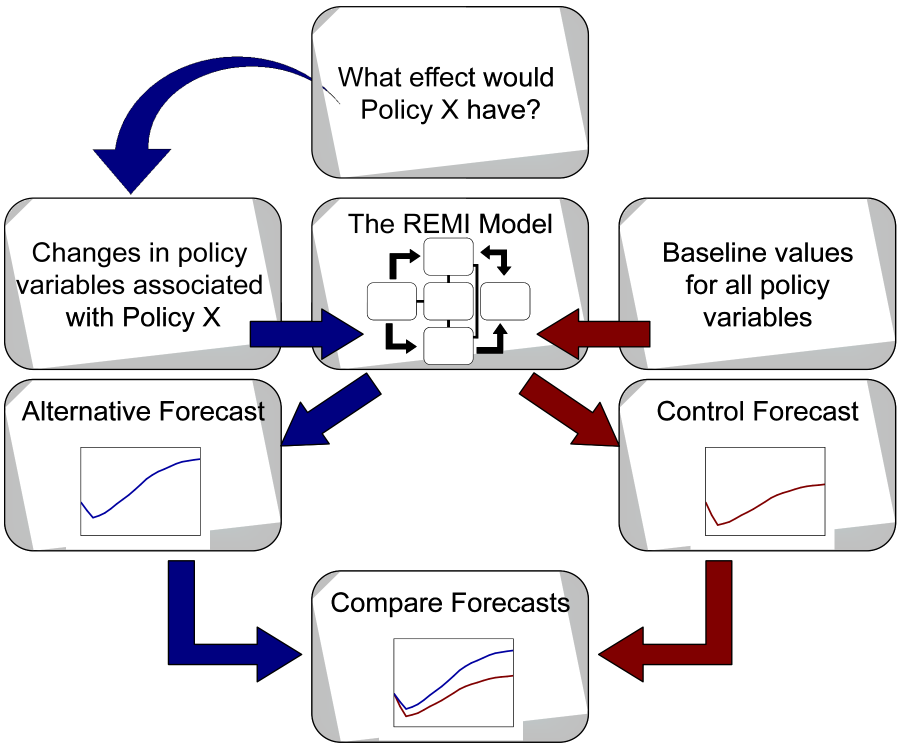

Figure 1: Process of Policy Simulation using REMI PI+
Source: REMI Policy Insight 9.5 User Guide

synergies. The latter would stem from complex functional relationships specified in the REMI Model.

Before performing the simulations in REMI, overlaps between policy options are eliminated as much as possible. This process is conducted by applying "overlap factors" identified by the TWGs to both the costs and savings of the relevant policy options

V. Simulation Results

A. Basic Results[7]

[7] Findings in this study may differ from similar research findings in other states and in Michigan. Such differences in findings may stem from variation in economic structures across states, differences in modeling assumptions, modeling approaches and the underlying economic conditions and projections underlying each study. Hence, comparisons across studies may generate misleading contrasts.

A summary of the basic findings of the REMI PI+ evaluations of macroeconomic impacts of the CAP policy options is presented in Tables 11 and 12. These tables report outcomes for each scenario, broken out into four TWG sectors; AFW, TLU, RCI and ES. Table 11 provides estimated employment impacts for each consolidated option across four selected years, while Table 12 provides estimated impacts on Gross State Product (GSP), as well as a net present value (NPV) calculation for the entire period of 2009 to 2025. The reader is referred to Appendix D for detailed results for each year, as well as the impacts on other economic indicators for the

Table 11: Employment Impacts of the Michigan CAP (Thousands)

Scenario		2010	2015	2020	2025
	AFW1-CO	0.020	0.158	0.266	0.366
	AFW2-CO	0.042	0.061	0.082	0.103
	AFW3-CO	0.002	0.005	0.006	0.007
	AFW4-CO	0.014	0.183	0.495	1.030
	AFW5-CO	0.833	3.871	4.259	3.104
	AFW6-CO	-0.082	-0.206	-0.300	-0.375
	AFW7-CO	1.382	5.643	10.542	15.826
Sub total: AFW		**2.211**	**9.715**	**15.350**	**20.061**
	TLU1-CO	0.037	0.495	0.747	0.985
	TLU2-CO	0.000	-0.517	-0.460	-0.762
	TLU3-CO	0.000	-0.951	-0.404	-0.130
	TLU4-CO	0.094	4.162	7.930	11.158
	TLU5-CO	0.146	1.125	2.268	1.800
	TLU6-CO	0.000	0.358	0.605	1.129
Sub total: TLU		**0.277**	**4.672**	**10.686**	**14.180**
	RCI1-CO	0.734	5.733	12.071	19.120
	RCI2-CO	0.650	5.042	10.481	16.283
	RCI3-CO	0.405	2.515	4.791	7.642
Sub total: RCI		**1.789**	**13.290**	**27.343**	**43.045**
	ES1-CO	0.398	0.662	1.867	2.021
	ES2-CO	0.000	0.000	-0.261	1.520
	ES3-CO	0.026	0.166	0.188	0.208
	ES4-CO	0.024	0.226	0.500	0.751
Sub total: ES		**0.448**	**1.054**	**2.294**	**4.500**
Summation Total		**4.725**	**28.731**	**55.673**	**81.786**
Simultaneous Total		**4.773**	**31.373**	**68.309**	**129.486**

aggregate simulation.

Table 12: Gross State Product Impacts of the Michigan CAP
(Billions of fixed 2000 dollars)

Scenario	2010	2015	2020	2025	NPV
AFW1-CO	0.001	0.009	0.017	0.025	0.124
AFW2-CO	0.000	0.001	0.002	0.004	0.017
AFW3-CO	0.000	0.000	0.000	0.000	0.000
AFW4-CO	0.001	0.013	0.040	0.094	0.289
AFW5-CO	0.058	0.241	0.222	0.105	1.920
AFW6-CO	-0.007	-0.014	-0.021	-0.028	-0.176
AFW7-CO	-0.079	-0.224	-0.307	-0.325	-2.527
Sub total: AFW	**-0.026**	**0.026**	**-0.047**	**-0.125**	**-0.353**
TLU1-CO	0.003	0.043	0.078	0.117	0.554
TLU2-CO	0.000	-0.024	-0.025	-0.044	-0.221
TLU3-CO	0.000	-0.057	-0.021	0.002	-0.334
TLU4-CO	0.005	0.229	0.457	0.660	3.234
TLU5-CO	0.005	0.046	0.099	0.090	0.683
TLU6-CO	0.000	0.014	0.026	0.054	0.207
Sub total: TLU	**0.013**	**0.251**	**0.614**	**0.879**	**4.124**
RCI1-CO	0.018	0.265	0.731	1.402	5.065
RCI2-CO	0.016	0.232	0.632	1.189	4.366
RCI3-CO	0.011	0.092	0.217	0.432	1.617
Sub total: RCI	**0.045**	**0.589**	**1.580**	**3.023**	**11.049**
ES1-CO	0.038	0.070	0.220	0.246	1.407
ES2-CO	0.000	0.000	0.004	0.184	0.472
ES3-CO	0.002	0.016	0.020	0.023	0.163
ES4-CO	-0.001	0.005	0.020	0.035	0.122
Sub total: ES	**0.039**	**0.091**	**0.264**	**0.488**	**2.165**
Summation Total	**0.071**	**0.957**	**2.411**	**4.265**	**16.984**
Simultaneous Total	**0.074**	**1.139**	**3.392**	**8.354**	**25.257**

The REMI PI+ analyses suggest that implementing the CAP will spur private-sector job growth by 129.5 thousand jobs, or 2.7%. These jobs are reflective of increases in economic activity that adds $8.35 billion (fixed 2000 prices) to GSP in year 2025, or a 2.3 percent increase. The increase in future economic activity valued today is $25.3 billion (fixed 2000 prices). As evident In Tables 11 and 12, implementing the CAP in entirety generates larger macroeconomic impacts than the sum of the impacts of individual CAP policies. This tendency for the total impact to exceed the sum of the individual components reflects synergistic associations of policy options, where policy options generate greater cost savings or mitigate indirect expenses when combined.

As anticipated, the macroeconomic impacts of the various consolidated policy options analyzed vary, depending on the individual policies and how they interact with the Michigan economy. While not all scenarios provide positive macroeconomic outcomes, it is clear that the macroeconomic impacts of the aggregate TWG options are positive. These outcomes tend to expand over time; reflecting both, the dynamics of the direct impacts estimated by the respective

TWGs and the dynamic adjustment of the economy. Consider that several policy options call for early investment in capital with the expectation of future returns to efficiency gains, generating cumulative benefits to businesses and households. Such net positive cash flows spillover to other investments and expenditures; amplifying initial impacts over time.

Utility demand-side consolidated options RCI1-CO to RCI3-CO show the largest impacts of the four policy sectors in terms of both GSP and employment. Transportation and Land Use policies generate overwhelmingly positive returns as well. While, for Agricultural, Forestry and Waste Management options, AFW1-CO to AFW7-CO policies tend to incur higher costs relative to returns, but projections indicate that these policies have substantial positive impacts on employment.

Table D2 of Appendix D provides estimated gross state product impacts across industry segments in Michigan of full implementation of the CAP. These gross state product impacts are measured in changes of each respective segment's contribution to statewide gross state product. To facilitate comparisons across segments, Table D3 shows these impacts in terms of percent change from baseline projections. Segments that are expected to experience large increases in economic activity include Agriculture & forestry support activities, Transit & ground passenger transportation and Waste management & remediation services, while those with declines are Utilities, Petroleum & coal product manufacturing and Pipeline transportation.

Most segments are expected to experience increases in activity relative to baseline projections. However, several industries are directly impacted as evident in Appendix D. Namely, Agriculture & forestry support activities are expected to experience steady increases in economic activity up to nearly 225 percent increase in 2025. This is attributed to this sector's contributions to supporting urban forestry and providing feedstock to Michigan's bio-energy sector. Similarly, the transit & ground passenger transportation industry is expected to benefit from productivity gains from deemphasizing truck transportation toward rail transportation, decrease reliance on pipeline transportation of natural gas for heating and electricity-generating feedstock, and greater price competitiveness to transportation sectors in other states. Finally, waste management & remediation services are expecting demand increases for achieving policy mandates for enhanced recycling and processing waste into green energy and transferring agricultural and urban solid waste into energy sources.

However, other segments are expected to experience declines in economic activities including utilities, mining and pipeline transportation. Petroleum & coal production activities and pipeline transportation services will experience decreases in economic activity due to the reduced reliance on coal and natural gas for heating and electricity generation.

These findings show that all policy options with negative macroeconomic outcomes also have net implementation costs (refer to Table 6). However, several policy options with net implementation costs have positive macroeconomic outcomes. Consolidated policy options AFW3-CO, AFW5-CO, and RCI3-CO have negative implementation costs that are offset with energy cost reductions. These energy cost savings translate into production cost savings that allows Michigan firms to become more competitive in global markets, causing Michigan production to expand. Additionally, TLU5-CO has a net cost of implementation. This policy option aimed at reducing traffic congestion through improvements in transportation networks, mass transit and others will reduce household expenditures on motor fuels, which are dominantly imported into Michigan. Households will instead shift such purchases for other goods and services with a greater incidence of generating secondary transactions in the state. By enhancing the multiplier effect, this policy option for GHG reduction ultimately expands the state economy rather than contracts it.

B. Sensitivity Tests

Several model sensitivity tests are performed to assess the sensitivity of results to changes in the modeling assumptions. This section reports the outcomes of these tests. The overall findings suggest that policy simulations are robust to several key assumptions used in the simulations.

B.1. Outcome Sensitivity to Changes in Discount Rate

Because gross state product impacts entail consideration of the timing of cash flows, it is instrumental to discount future cash flows to current values. In discounting cash flows, the present value of payments made or received in the near future are valued more than equal payments in the distant future. For higher the discount rates, individuals place a lower value on distant payments relative to payments in the near future. The middle column of Table 13 replicates the net present value calculations in Table 12, while the first column provides net present value calculation based on a 10 percent discounting rate and the third column, that at a one percent discount rate. The findings suggest that benefit streams are mostly deferred, while costs are mostly incurred in the near future. This is evident when considering that the total net present value calculations decrease at higher discount rates and increase with lower discount rates. Regardless, both the sum of net present values and the simultaneously calculated net present values – which take into consideration interactions across policy options – remain positive across all tested discount rates.

Table 13: Net Present Value Sensitivity to Discount Rates: Gross State Product Impacts (Billions of fixed 2000 dollars)

Discount Rate	10%	5%	1%
Scenario	**NPV**	**NPV**	**NPV**
AFW1-CO	0.078	0.124	0.187
AFW2-CO	0.010	0.017	0.026
AFW3-CO	0.000	0.000	0.000
AFW4-CO	0.169	0.289	0.461
AFW5-CO	1.351	1.920	2.641
AFW6-CO	-0.117	-0.176	-0.256
AFW7-CO	-1.707	-2.527	-3.619
Sub total: AFW	**-0.215**	**-0.353**	**-0.560**
TLU1-CO	0.344	0.554	0.844
TLU2-CO	-0.144	-0.221	-0.325
TLU3-CO	-0.252	-0.334	-0.428
TLU4-CO	2.012	3.234	4.928
TLU5-CO	0.426	0.683	1.039
TLU6-CO	0.126	0.207	0.321
Sub total: TLU	**2.513**	**4.124**	**6.379**
RCI1-CO	3.023	5.065	7.965
RCI2-CO	2.611	4.366	6.856
RCI3-CO	0.979	1.617	2.520
Sub total: RCI	**6.614**	**11.049**	**17.341**
ES1-CO	0.900	1.407	2.105
ES2-CO	0.248	0.472	0.811
ES3-CO	0.108	0.163	0.237
ES4-CO	0.070	0.122	0.197
Sub total: ES	**1.326**	**2.165**	**3.351**
Summation Total	**10.237**	**16.984**	**26.510**
Simultaneous Total	**14.800**	**25.257**	**40.305**

B.2. No Capital Investment Displacement

Throughout this analysis, we have assumed that direct capital investment pursuing CAP policy implementation partially displaces investment that would have taken place in the absence of the CAP policies. That is, the analysis has assumed that only 50 percent of the required capital investment is attributable to CAP policies. The remaining 50 percent is investment in new capital that would have taken place in the absence of the CAP policies. To avoid crediting the CAP policy with all innate investment, policy-induced investment is reduced, such that implementation of the CAP is assumed to account for only 50 percent of the TWG capital investment estimates. Because capital investments are assumed to be funded through debt, policy-induced demand for financial services is also reduced by 50 percent.

This section tests the sensitivity of the macroeconomic impacts to this specification, by comparing impact estimates derived in the analysis to those if there is no assumption of capital displacement. To do so, a second set of REMI PI^{+} analyses are generated that does not halve policy-induced capital investment and demand for financial intermediaries.

Table 14 replicates the salient findings of Tables 5 and 6 and compares them to equal simulations without displacing investment. The findings suggest that capital investment and associated financial activities contribute modestly to the overall findings. However, the estimated policy impacts when relaxing the assumption on capital investment displacement remains consistent with those in Tables 5 and 6.

B.3. Changes to Baseline Projections

Impact projections may be sensitive to the baseline projections of the Michigan economy. As impacts are calculated as differences from baseline values, changes in baseline values may generate different impact estimates. REMI forecasts were compared to those generated by Global Insight to gauge the potential for baseline inaccuracies. Global Insight provides statewide economic forecasts used by various state agencies for planning purposes. Like the REMI model, the Global Insight state forecasting model is widely used by states and has a long track record.

Both Global Insight and REMI projections of Michigan GSP expect annual economic growth below two percent annually. However, Global Insight growth projections exceed REMI's by approximately 0.3 percent annually. Hence, relative to Global Insight projections, REMI projects lower growth throughout the evaluation horizon.

Tests of the model's sensitivity to different growth trajectories are used to gauge the sensitivity of findings to changes in economic growth trajectories. We generate high- and low-growth versions of the baseline projections and compare employment impacts and the net present value calculations up to 2025 of gross state product impacts using one, five and ten percent discounting.

Table 14: Sensitivity Test of Treatment of Capital Displacement (GSP → Billions of fixed 2000 dollars: Employment → Thousands)

	50 Percent Investment Displacement		No Investment Displacement	
Scenario	NPV GSP	2025 Employment	NPV GSP	2025 Employment
AFW1-CO	0.124	0.366	0.124	0.366
AFW2-CO	0.017	0.103	0.017	0.103
AFW3-CO	0.000	0.007	-0.003	0.000
AFW4-CO	0.289	1.030	0.286	1.020
AFW5-CO	1.920	3.104	0.830	1.107
AFW6-CO	-0.176	-0.375	-0.176	-0.375
AFW7-CO	-2.527	15.826	-2.527	15.826
Sub total: AFW	**-0.353**	**20.061**	**-1.449**	**18.047**
TLU1-CO	0.554	0.985	1.373	3.972
TLU2-CO	-0.221	-0.762	-0.421	-0.766
TLU3-CO	-0.334	-0.130	-0.773	-0.523
TLU4-CO	3.234	11.158	2.826	10.583
TLU5-CO	0.683	1.800	0.683	1.800
TLU6-CO	0.207	1.129	0.207	1.129
Sub total: TLU	**4.124**	**14.180**	**3.896**	**16.195**
RCI1-CO	5.065	19.120	4.020	15.729
RCI2-CO	4.366	16.283	3.438	13.271
RCI3-CO	1.617	7.642	1.389	7.403
Sub total: RCI	**11.049**	**43.045**	**8.847**	**36.403**
ES1-CO	1.407	2.021	3.411	6.094
ES2-CO	0.472	1.520	0.553	1.772
ES3-CO	0.163	0.208	0.168	0.196
ES4-CO	0.122	0.751	-0.180	-0.148
Sub total: ES	**2.165**	**4.500**	**3.952**	**7.914**
Summation Total	**16.984**	**81.786**	**15.246**	**78.559**
Simultaneous Total	**25.257**	**129.486**	**22.570**	**123.606**

To generate alternative baseline forecasts, we increased and decreased the growth trajectories of total Michigan production by one-quarter a percent per year over the analysis horizon. The "Industry Sales / Exogenous Production" variables for all industry and commercial sectors is adjusted by first calculating the baseline annual growth, then adding or subtracting one-quarter a percent of that growth and calculating the difference between the alternate projection and the baseline for each REMI sector excluding private households. Figure 2 shows the relative trajectories of state output.

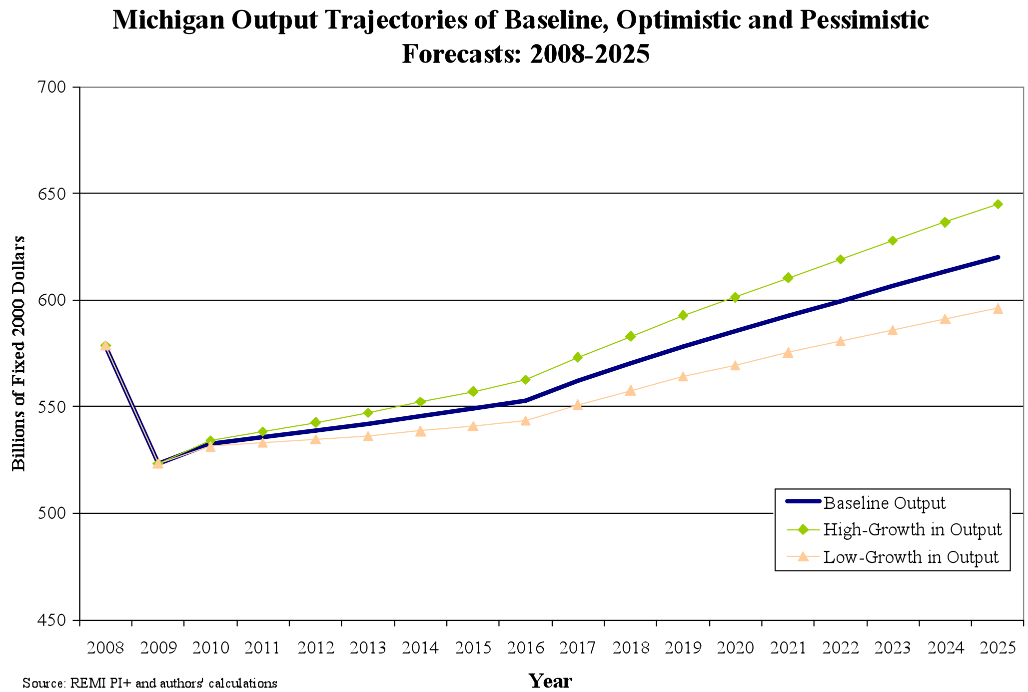

Figure 2: Baseline, Optimistic and Pessimistic Output Projections

Baseline, high-growth and low-growth macroeconomic impacts are gauged against their respective referent projections. That is, macroeconomic impacts are generated by comparing baseline projections to projections that take into account direct effects of the policy variables specified in this study. The referent projections used to calculate impacts reported in Tables 11 and 12 are derived from the baseline projections of the REMI PI^+ model. Similarly, the referent projections of high- and low-growth trajectories are used to estimate CAP impacts under these alternative economic trajectories respectively.

Table 15: Sensitivity to Changes in Baseline Forecast
Net Present Value of Gross State Product: 2009-2025
(Billions of Fixed 2000 dollars)

	Baseline	Optimistic	Pessimistic
1% Discount	40.305	37.085	52.240
5% Discount	25.257	23.390	31.885
10% Discount	14.800	13.817	18.093

Table 16: Sensitivity to Changes in Baseline Forecast
Private Non-Farm Employment: 2025
(Thousands)

	Baseline	Optimistic	Pessimistic
2010	4.8	4.8	4.8
2015	31.4	31.1	31.7
2020	68.3	65.4	71.6
2025	129.5	113.4	206.6

To generate high- and low-growth scenarios, two new REMI PI^+ control models are specified. The aggregate CAP policy variables are introduced and the forecasts are compared to the respective referent forecasts. With this approach, Tables 14 and 15 show the sensitivity of impact findings to changes in baseline forecasts and discounting rates and private employment, respectively. This sensitivity test suggests that implementing the Michigan Climate Action Plan will likely result in positive economic outcomes in terms of GSP and employment growth under both the high- and low-growth scenarios. The low-growth scenario tends to generate relatively higher positive impacts on both GSP and employment, while the high-growth scenario tends to reduce the overall impacts.

Variation in responses across different baseline projections reflects variations in prices. Under the low-growth scenario, declines in product demand and relatively weak population growth creates downward pressure on cost of production, housing and wages and reduces the price of consumer goods and services. This drop in prices offsets cost increasing CAP policies and accentuates cost savings policies; thereby, shifting CAP policy impacts toward greater macroeconomic expansion. Alternatively, the high-growth scenario tends to increase general prices and reduces the macroeconomic expansion of CAP policy.

VI. CONCLUSIONS

This report summarizes the analysis of the macroeconomic impacts of the Michigan Climate Action Plan, using the well-established REMI PI^+ modeling framework. The analysis was based on direct impact estimates supplied by the Michigan Climate Action Council, Technical Work Groups, who vetted them through an in-depth, consensus-based technical assessment and stakeholder process. The results indicate that the majority of the greenhouse gas mitigation and sequestration options have positive impacts on the State's economy individually. On net, the combination of options has a Net Present Value of increasing Gross State Product by $25.3 billion and increasing employment by 129.5 thousand full-time equivalent jobs by the Year 2025. MCAC-designed policies on demand management has the greatest potential for positive economic impacts in Michigan, while estimates suggest that cost savings from market-based initiatives are not likely to fully offset costs of implementation within the project horizon. Policies around agriculture, forestry and waste management are likely to have marginal impacts on the overall economy, but those around transportation and land use will likely generate significantly positive economic impacts.

Most economic gains are derived from mitigation options that lower the cost of production and household expenditures on energy. Such energy efficiency gains decrease production costs and increases consumer purchasing power. The results also stem from the stimulus of increased investment in plant and equipment.

The macroeconomic impact evaluation provided here does not take into consideration several other potential drivers of economic outcomes, including impacts on the stress of GHG-related health outcomes and other environmental health outcomes. They do not include impacts associated with the avoidance of damage from the climate change that continued baseline GHG emissions would bring forth, the reduction in damage from the associated decrease in ordinary pollutants, the reduction in the use of natural resources, the reduction in traffic congestion, etc.

Our findings suggest that the CAP GHG mitigation policies are likely to have net positive economic impacts on Michigan's economy.

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APPENDIX A: DESCRIPTION OF THE REMI POLICY INSIGHT MODEL

REMI Policy Insight is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to wage, price, and other economic factors.

The REMI model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the model. The overall structure of the model can be summarized in five major blocks: (1) Output and Demand, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Wages, Prices and Costs, and (5) Market Shares. The blocks and their key interactions are shown in Figures A1 and A2.

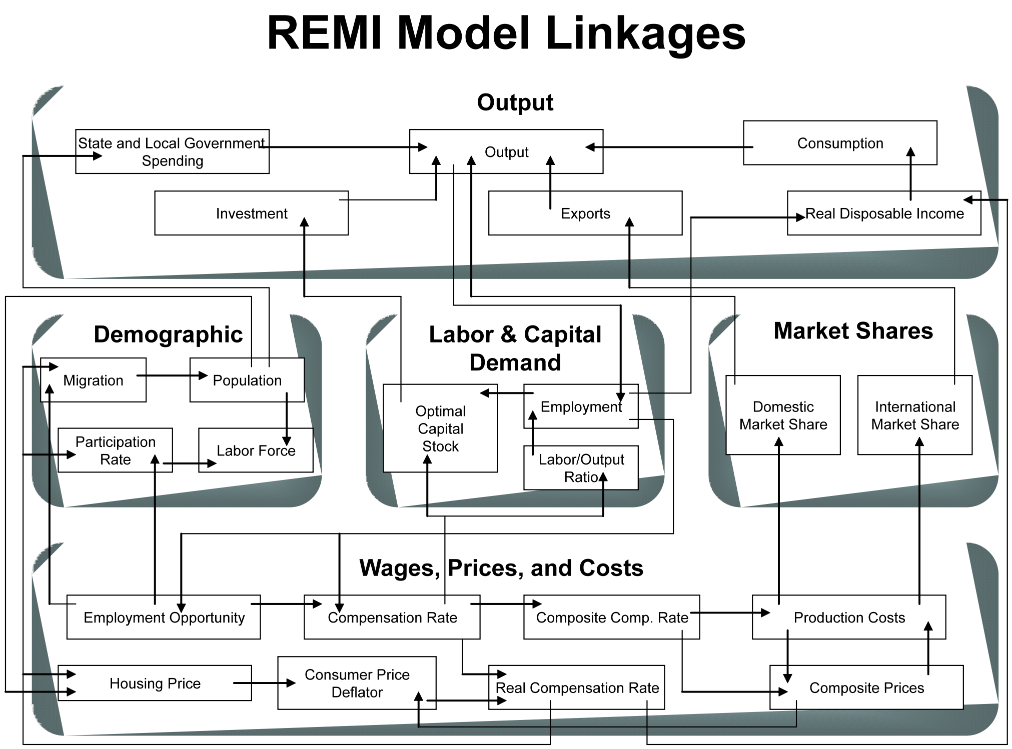

Figure A.1: REMI Policy Insight Linkages (Excluding Geographic Linkages

The Output and Demand block includes output, demand, consumption, investment, government spending, import, product access, and export concepts. Output for each industry is determined by industry demand in a given region and its trade with the US market, and international imports and exports. For each industry, demand is determined by the amount of output, consumption, investment, and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities and population. Input productivity depends on access to inputs because the larger the choice set of inputs, the more likely that the input with the specific characteristics required for the job will be formed. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

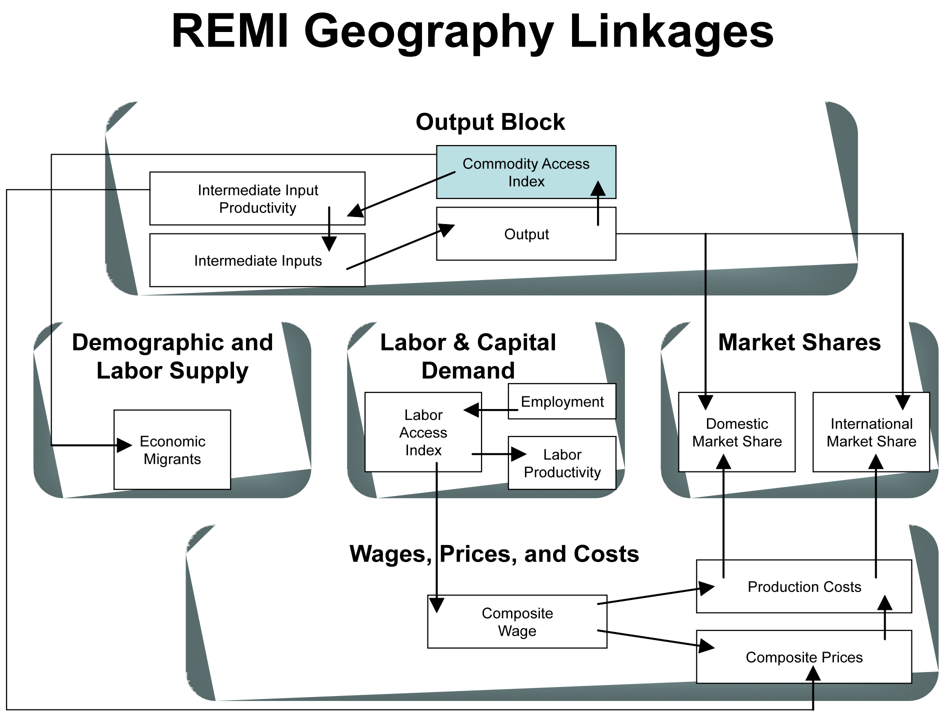

Figure A.2: REMI Policy Insight Geography Linkages

The Labor and Capital Demand block includes the determination of labor productivity, labor intensity and the optimal capital stocks. Industry-specific labor productivity depends on the availability of workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

The Population and Labor Supply block includes detailed demographic information about the region. Population data is given for age and gender, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply. These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after tax compensation rate. Migration includes retirement, military, international and economic migration. Economic migration is determined by the relative real after tax compensation rate, relative employment opportunity and consumer access to variety.

The Wages, Prices and Cost block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the wage equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods and services.

These prices measure the value of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs associated with distance is significant. Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of output in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by cost of labor, capital, fuel and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying compensation rates. Capital costs include costs of non-residential structures and equipment, while fuel costs incorporate electricity, natural gas and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices. Housing price changes from their initial level depend on changes in income and population density. Regional employee compensation changes are due to changes in labor demand and supply conditions, and changes in the national compensation rate. Changes in employment opportunities relative to the labor force and occupational demand change determine compensation rates by industry.

The Market Shares equations measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

As shown in Figure A2, the Labor and Capital Demand block includes labor intensity and productivity, as well as demand for labor and capital. Labor force participation rate and migration equations are in the Population and Labor Supply block. The Wages, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the wage equations. The proportion of local, interregional and international markets captured by each region is included in the Market Shares block.