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CLIMATE CHANGE SUBCOMMITTEE
of the Minnesota Environmental Quality Board

Friday, March 28, 2014

Meeting Location: MPCA Board Room
520 Lafayette Road
St. Paul, Minnesota
9:00 a.m. – 11:00 a.m.

AGENDA

I. Introductions

II. The 2008 Minnesota Climate Change Advisory Group

III. Minnesota's greenhouse gas emissions profile

IV. Interagency efforts to align clean energy and economic development

V. Overview and open discussion of potential policy options to reduce emissions in Minnesota

VII. Adjourn

This agenda may be made available in other formats, such as Braille, large type or audiotape, upon request. People with disabilities should contact Elizabeth Tegdesch, Board Administrator, as soon as possible to request an accommodation (e.g., sign language interpreter) to participate in these meetings.


Minnesota Climate Change Advisory Group Final Report

A Report to the Minnesota Legislature

April 2008

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Acknowledgments

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Acronyms

\$/MWh	dollars per megawatt-hour
\$/tCO_2e	dollars per ton of carbon dioxide equivalent
AE	architect engineer
AEO2007	*Annual Energy Outlook 2007* [US DOE Energy Information Administration]
AFW	Agriculture, Forestry, and Waste Management [TWG]
AgBMP	[Minnesota] Agriculture Best Management Practices
ANL	Argonne National Laboratory [US DOE]
APU	auxiliary power unit
ASDs	adjustable speed drives
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AURI	Agricultural Utilization Research Institute
BAU	business as usual
BioPET	BioPower Evaluation Tool
BLM	Bureau of Land Management [U.S. Department of the Interior]
BLS	Bureau of Labor Statistics [U.S. Department of Labor]
BMPs	best management practices
BSWR	[Minnesota] Board of Water and Soil Resources
Btu	British thermal unit
BWCAW	Boundary Waters Canoe Area Wilderness
C&T	Cap-and-Trade [TWG]
CAFE	corporate average fuel economy
CAFO	confined animal feeding operation
CARB	California Air Resources Board
CC	Cross-Cutting Issues [TWG]
CCAG	[Minnesota] Climate Change Advisory Group
CCS	Center for Climate Strategies
CCX	Chicago Climate Exchange
CEE	Center for Energy and Environment
CGEE	[Hamline University] Center for Global Environmental Education
CH_4	methane
CHP	combined heat and power
CIP	Conservation Improvement Program
CMAQ	Congestion Mitigation and Air Quality [Improvement Program]
CO_2	carbon dioxide
CREP	Conservation Reserve Enhancement Program [USDA]
CRP	Conservation Reserve Program [USDA]
DDGS	distiller's dried grains with solubles
D/LCE	discounted/levelized cost-effectiveness
DNR	[Minnesota] Department of Natural Resources

DOC	[United States] Department of Commerce
DOE	[United States] Department of Energy
DOLI	[Minnesota] Department of Labor and Industry
EAW	Environmental Assessment Worksheet
ECAR	East Central Area Reliability Coordination Agreement
EE	energy efficiency
EEAB	Environmental Education Advisory Board
EERE	Office of Energy Efficiency and Renewable Energy [US DOE]
eGRID	Emissions & Generation Resource Integrated Database [US EPA]
EF	emission factor
EIA	Energy Information Administration [US DOE]
EIS	Environmental Impact Statement
ELM	Environmental Learning in Minnesota Fund
EPA	[United States] Environmental Protection Agency
ES	Energy Supply [TWG]
EtOH	ethyl alcohol
EU	European Union
FEED	front-end engineering and design
FIA	Forest Inventory and Analysis [USFS/Minnesota DNR]
FRC	[Minnesota] Forest Resources Council
FSA	Farm Service Agency [USDA]
FSC	[Minnesota] Forest Stewardship Council
FTEs	full-time equivalents
gal	gallon
GHG	greenhouse gas
GIS	geographic information system
GM	General Motors
GMAC	General Motors Acceptance Corporation
GPS	generation performance standard
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation [model]
GWP	global warming potential
HDPE	high-density polyethylene
HERS	Home Energy Rating System
HEV	hybridized electric vehicle
HFC	hydrofluorocarbon
HOT	high-occupancy toll
HOV	high-occupancy vehicle
HPGHG	high-potential greenhouse gas
HPGWG	high-potential global warming gas
HUD	[United States Department of] Housing and Urban Development
I&F	Inventory and Forecast
IAC	Industrial Assessment Center

ICC	International Code Council
ICLEI	Local Governments for Sustainability [formerly International Council for Local Environmental Initiatives]
IGCC	integrated gasification combined cycle
ILSR	Institute for Local Self-Reliance
IPCC	Intergovernmental Panel on Climate Change
IPPAT	Interagency Pollution Prevention Advisory Team
IRP	integrated resource planning
kWh	kilowatt-hour
LandGEM	Landfill Gas Emissions Model [US EPA]
LCDA	Livable Communities Demonstration Account
LCE	levelized cost-effectiveness
LCFS	low-carbon fuel standard
LDPE	low-density polyethylene
LDV	light-duty vehicle
LEED	Leadership in Energy and Environmental Design Green Building Rating System™
LEV	low-emission vehicle
LFG	landfill gas
LFGcost	landfill gas cost model [US EPA]
LFGTE	landfill gas-to-energy
LGFS	low-GHG fuel standard
LMOP	Landfill Methane Outreach Program [US EPA]
LNG	liquefied natural gas
LPG	liquefied petroleum gas
M&R	metering and regulating
MAC	[California] Market Advisory Committee
MAEE	Minnesota Association for Environmental Education
MAIN	Mid-America Interconnected Network
MAPP	Mid-Continent Area Power Pool
MC	Metropolitan Council
MCCAG	Minnesota Climate Change Advisory Group
MDA	Minnesota Department of Agriculture
MDOC	[Minnesota] Department of Commerce
MEA	monoethanolamine
MEI	Minnesota Environmental Initiative
MFRC	Minnesota Forest Resources Council
MGA	Midwestern Governors Association
MLS	Multiple Listing Service; Multiple Listing System
MMBtu	million British thermal units
MMGPY	million gallons per year
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MnDOC	Minnesota Department of Commerce
MnDOT	Minnesota Department of Transportation

MnTAP	Minnesota Technical Assistance Program
MOU	memorandum of understanding
MPCA	Minnesota Pollution Control Agency
mpg	miles per gallon
MPUC	Minnesota Public Utilities Commission
MSW	municipal solid waste
Mt	metric ton
MtC/acre	metric tons of carbon per acre
$MtCO_2$/acre	metric tons of carbon dioxide per acre
MVST	motor vehicle sales tax
MW	megawatt
MWh	megawatt-hours [one thousand kilowatt-hours]
N	nitrogen
N_2O	nitrous oxide
NEMA	National Electrical Manufacturers Association
NG	natural gas
NGCC	natural gas combined cycle
NGEA	Next Generation Energy Act
NHTSA	National Highway Traffic Safety Administration [US DOT]
NMSU	Northern Minnesota State University
NO_x	nitrogen oxides
NPV	net present value
NRCS	Natural Resource Conservation Service [USDA]
NREL	National Renewable Energy Laboratory [US DOE]
NRI	National Resources Inventory
NSPS/EG	New Source Performance Standards/Emission Guidelines [US EPA]
O&M	operations and maintenance
ODS	ozone-depleting substance
ORNL	Oak Ridge National Laboratory [US DOE]
PATH	Partnership for Advanced Technology in Housing
PAYD	pay as you drive
PAYT	pay as you throw
PCA	[Minnesota] Pollution Control Agency
PC/LDT	passenger car/light-duty truck
PET	polyethylene terephthalate
PFC	perfluororocarbon
PGF	Project Green Fleet
PHEV	plug-in hybrid electric vehicle
PIRG	Public Interest Research Group
PUC	Public Utilities Commission
PWA	plant-wide assessment

PZEV	partial zero-emission vehicle
R&D	research and development
RCI	Residential, Commercial, and Industrial [TWG]
RDF	refuse-derived fuel
RES	renewable electricity standard
RFS	renewable fuels standard
RGGI	[Northeast States] Regional Greenhouse Gas Initiative
RIM	Reinvest in Minnesota
RIM–CE	Reinvest in Minnesota–Clean Energy
RPS	renewable portfolio standard
SCORE	[Minnesota Governor's] Select Committee on Recycling and the Environment
SEEK	Sharing Environmental Education Knowledge [Partnership]
SF_6	sulfur hexafluoride
SOCCR	*The First State of the Carbon Cycle Report*
SPP	Southwest Power Pool
SULEV	super-ultra-low-emission vehicle
SWCD	Minnesota Association of Soil and Water Conservation Districts
T&D	transmission and distribution
TAB	Transportation Advisory Board
TBRA	Tax Base Revitalization Account
tCO_2/MWh	[metric] tons of carbon dioxide emissions per megawatt-hour
tC/acre	[metric] tons of carbon per acre
tCO_2/acre	[metric] tons of carbon dioxide per acre
TCRP	Transit Cooperative Research Program [Transportation Research Board]
TDM	transportation demand management
TEAP	Technology and Economic Assessment Panel [IPCC]
TIP	Transportation Improvement Plan
TLU	Transportation and Land Use [TWG]
TWG	Technical Work Group
ULEV	ultra-low-emission vehicle
USDA	United States Department of Agriculture
US DOE	United States Department of Energy
US DOT	United States Department of Transportation
USFS	United States Forest Service [USDA]
VMT	vehicle miles traveled
VOC	volatile organic compound
WAP	Weatherization Assistance Program [US DOE]
WARM	WAste Reduction Model [US EPA]
WCI	Western Climate Initiative

WTE	waste to energy

Executive Summary

Background

On December 12, 2006, Minnesota Governor Tim Pawlenty announced the state's "Next Generation Energy Initiative," including "development of a comprehensive plan to reduce Minnesota's emissions of greenhouse gases (GHGs)." In this announcement, the Governor requested assistance from the Center for Climate Strategies (CCS) in the development of a Minnesota Climate Mitigation Action Plan (Action Plan) and formation of the Minnesota Climate Change Advisory Group (MCCAG). This broad-based group of Minnesota citizens and leaders was charged with developing a comprehensive set of state-level policy recommendations to the Governor through a stakeholder-based consensus building process facilitated by CCS in coordination with the Minnesota Department of Commerce (DOC) and Minnesota Pollution Control Agency (PCA). Their work included:

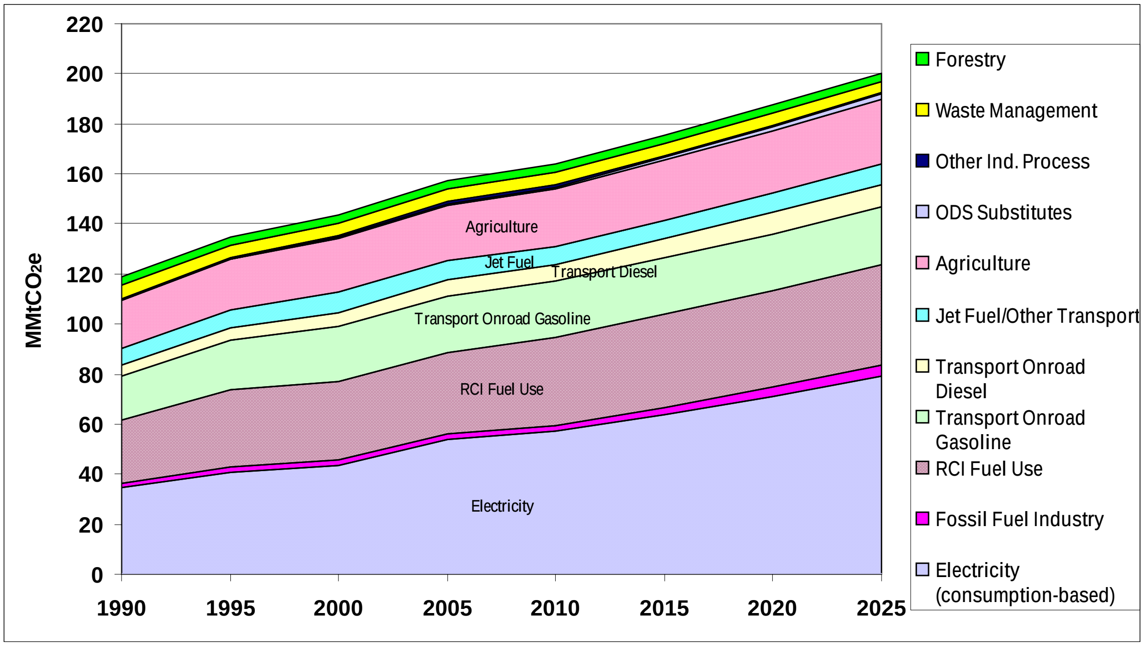
- Development, prioritization, analysis, and approval of a final collection of existing and proposed actions that could contribute to GHG emissions reductions;
- Review and approval of an inventory of historical and forecasted GHG emissions in Minnesota as a basis against which to gauge priorities and progress; and
- Consideration of costs and benefits of recommended options.

This report is the culmination of the work of more than 100 Minnesotans who were members of the MCCAG and the six Technical Work Groups (TWGs) that supported the MCCAG. In order to complete this monumental effort, the MCCAG and TWG members and CCS were required to make numerous estimates and assumptions. They did so with the best intentions, using the best information available in the time given, and using best professional judgment. Many will second guess parts of this report. That is appropriate and to be expected. Reducing GHG emissions will be a long-term effort. Most of the analyses completed for this report will be reexamined from time to time. As that occurs, assumptions should also be reexamined and changed as new information and understanding warrants.

Inventory of Minnesota's Greenhouse Gas Emissions

In July 2007, CCS, with assistance from the Minnesota PCA, prepared a preliminary draft GHG emissions inventory and reference case projection for the MCCAG and its TWGs to assist them in understanding past, current, and possible future GHG emissions in Minnesota and thereby inform the policy development process. The preliminary draft *Inventory and Projections* was improved by incorporating comments provided by the MCCAG and TWGs. As shown in Figure EX-1, the *Inventory and Projections* revealed substantial emissions growth rates and related mitigation challenges. Minnesota's gross emissions of GHGs grew by 32% between 1990 and 2005, twice the national average of 16%. Minnesota's emissions growth was driven largely by the growth of Minnesota's population and emissions associated with imported electricity; the state's emissions on a per capita basis increased by about 11% between 1990 and 2005, while U.S. per capita emissions declined slightly (2%) over this period. In the absence of recent developments that Minnesota has undertaken to control its emissions, Minnesota's gross GHG emissions are projected to rise fairly steeply to about 200 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) by 2025, or 68% over 1990 levels. Minnesota's forests and agricultural lands have been a net source rather than a sink of carbon emissions largely due to the loss of these lands to other uses. Consequently, in Minnesota "net emissions" (in which reductions due to sequestration are subtracted from gross emissions) are equal to gross emissions.

Figure EX-1. Gross GHG emissions by sector, 1990–2020: historical and projected (consumption-based approach) business as usual/base case



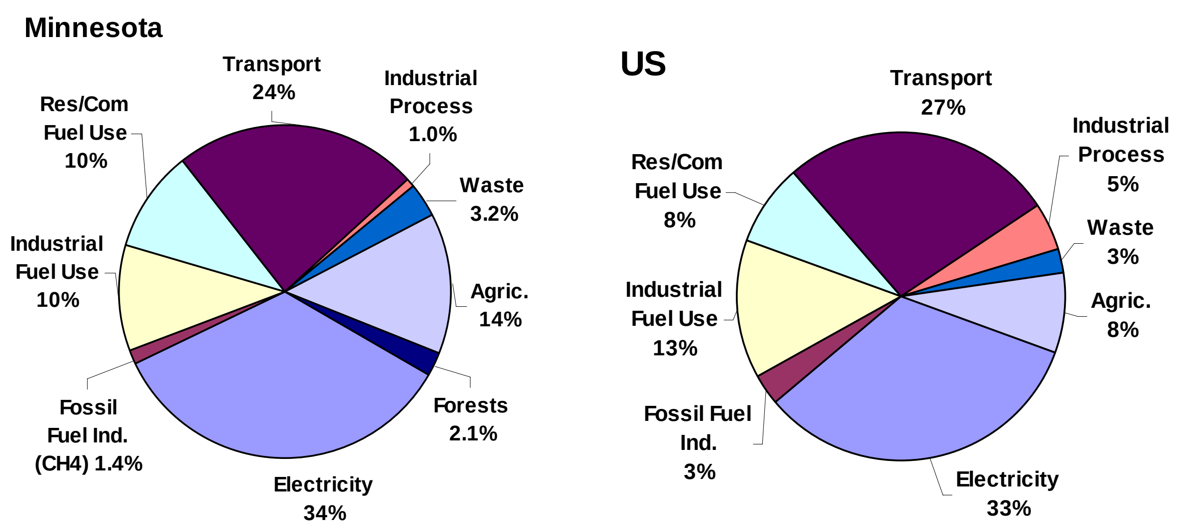
RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone depleting substance.

The principal sources of Minnesota's GHG emissions in 2005 are electricity use (including electricity imports) and transportation, accounting for 34% and 24% of Minnesota's gross GHG emissions, respectively, as shown in Figure EX-2. The use of fossil fuels—natural gas, oil products, coal, and wood—in the residential, commercial, and industrial (RCI) sectors accounted for another 20% of the state's emissions in 2005. Minnesota is slightly higher than the nation as a whole in emissions from electricity production and slightly lower in transportation. Agricultural activities, such as manure management, fertilizer use, livestock (enteric fermentation), and changes in soil carbon due to cultivation practices, result in methane (CH_4) and nitrous oxide (N_2O) emissions that account for another 14% of state GHG emissions. This is greater than the U.S. portion of emissions attributable to agriculture (8%). Landfills and wastewater management facilities produce CH_4 and N_2O emissions that accounted for 3% of total gross GHG emissions in Minnesota in 2005. Emissions associated with the transmission and distribution of natural gas accounted for 1% of the gross GHG emissions in 2005. Industrial process emissions accounted for about 1% of the state's GHG emissions in 2005, and these emissions are rising due to the increasing use of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) as substitutes for ozone-depleting chlorofluorocarbons (CFCs).[1] Other industrial processes emissions result from

[1] CFCs are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Appendix I in the *Inventory and Projections* report for Minnesota.

taconite, lime, and peat manufacturing; PFC use in semiconductor manufacture; CO_2 released during limestone, dolomite, and peat use; sulfur hexafluoride (SF_6) released from transformers used in electricity transmission and distribution systems; and N_2O from medical uses.

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



Note: At a national level, forests act as a net sink of CO_2; therefore, they do not show up in the above graph of gross U.S. emissions sources.

Recent Developments

On May 25, 2007, Governor Tim Pawlenty signed the Next Generation Energy Act of 2007.[2] This state law, coupled with other state initiatives to control GHG emissions, positions Minnesota as a leader on the way toward our nation's energy future. The Next Generation Energy Act of 2007 includes requirements for Minnesotans to increase energy efficiency, expand community-based energy development, and establish a statewide goal to reduce GHG emissions. The state law also supplements the aggressive 25x'25 renewable energy standard proposed by the Governor and signed earlier this year.

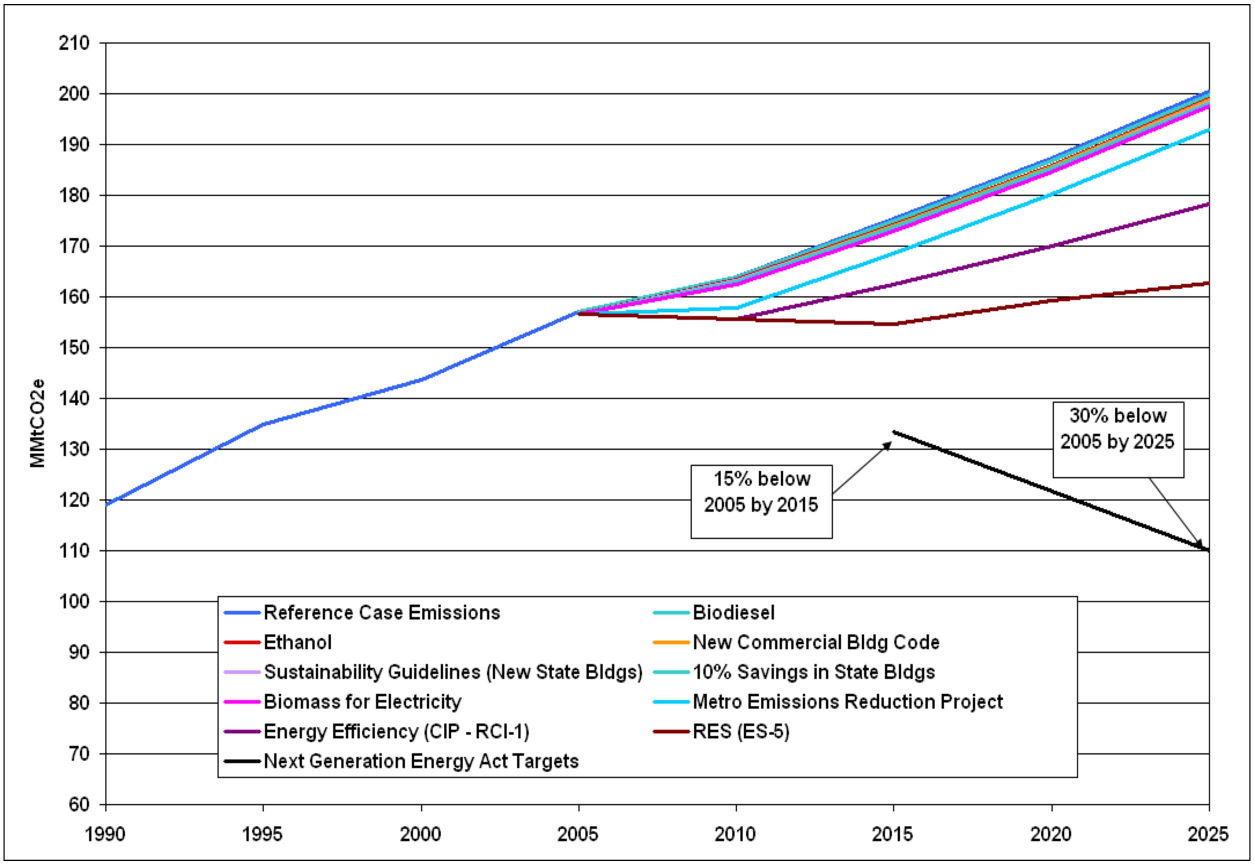
The act established aggressive goals for Minnesotans to reduce statewide GHG emissions across all sectors to a level at least 15% below 2005 levels by 2015, to a level at least 30% below 2005 levels by 2025, and to a level at least 80% below 2005 levels by 2050. This means that to meet the 2015 emissions goal, Minnesotans will have to reduce their emissions to about 131.8 $MMtCO_2e$ (or by about 41.3 $MMtCO_2e$ below 2015 levels). To meet the 2025 emissions goal, Minnesotans will have to reduce their emissions to about 108.5 $MMtCO_2e$ (or by about 89 $MMtCO_2e$ below 2025 levels).

At the beginning of the MCCAG process, DOC and PCA identified more than 40 different actions Minnesota has undertaken to control GHG emissions while at the same time conserving

[2] Next Generation Energy Act, Minnesota Senate File No. 145, at: https://www.revisor.leg.state.mn.us/bin/bldbill.php?bill=S0145.2.html&session=ls85

energy and promoting the development and use of renewable energy sources.[3] These actions also include assessments of both terrestrial and geologic carbon storage opportunities in Minnesota. The MCCAG recognized the importance of these recent actions as essential for setting Minnesota on the path toward meeting its aggressive statewide goals and used these actions to formulate the baseline from which it considered and developed its wide range of recommendations to ensure that Minnesota stays the course toward meeting its goals. A total of nine recent actions were identified for which data were available to estimate the emission reductions and costs/cost savings of the actions relative to the business-as-usual reference case projections. Implementation of the recent actions analyzed indicates that emissions reductions will be about 50% of the total emission reductions needed to meet the state's 2015 goal and about 42% of the total emission reductions needed to meet the state's 2025 goal (see Figure EX-3). These results underscore the importance of the contributions of the recent actions toward Minnesota's ability to meet its statewide reduction goals.[4]

Figure EX-3. Emission reductions associated with recent actions in Minnesota (consumption-basis, gross emissions)



MMtCO$_2$e = million metric tons of carbon dioxide equivalent; CIP = Conservation Improvement Program; RCI = Residential, Commercial, and Industrial [Sectors]; RES = Renewable Energy Standard; ES = Energy Supply.

[3] A summary of these actions can be found on the MCCAG's project Web site under "Background, What MN Is Already Doing" at: http://www.mnclimatechange.us/background-alreadydoing.cfm

[4] Note that actions recently adopted by the state of Minnesota have also been referred to as "existing" actions.

It is important to note that the top line in Figure EX-3 represents total emissions associated with all GHG-emitting activities across all sectors in Minnesota on a consumption basis prior to the implementation of any existing actions. For the electricity supply sector, this assumes the installation of the planned Big Stone 2 and Mesaba coal units and an assumed electricity demand growth rate of 2.04% per year. In making this assumption, the MCCAG is not recommending for or against the need for or merits of the addition of these units in Minnesota. The forecast also assumes a backing down of existing units if the Big Stone 2 and Mesaba units come on line in order to balance the supply of electricity with demand in Minnesota. It is possible that instead of backing down, the existing units that formerly supplied power in Minnesota could be used to supply power in other states, which, in turn, could lead to backing down less efficient units in other states. If built, these two units would have the potential to emit approximately 5.1 million tons of CO_2e per year. Future analyses should reexamine these assumptions.

Minnesota Climate Change Advisory Group Recommendations

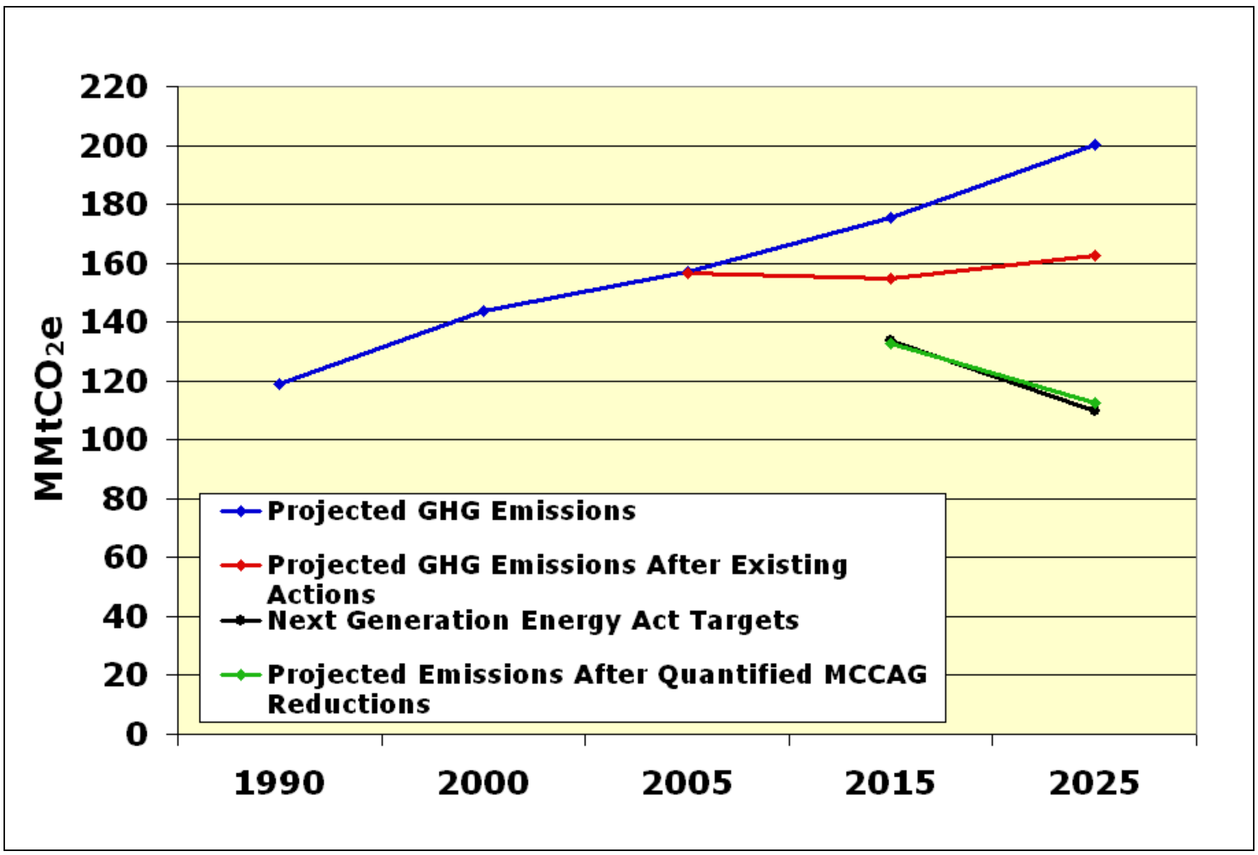
The MCCAG recommended 46 policy actions. The MCCAG members present and voting approved 38 policy actions unanimously, approved 4 by a supermajority (four objections or fewer), and approved 4 by a majority (less than half objected). Explanations of both individual objections and qualifications are in the appendixes to this report containing the detailed accounts of the MCCAG's recommendations.

Figure EX-4 presents a summary of the policy recommendations for which emission reductions were quantified. Table EX-1 provides the numeric estimates underlying Figure EX-3. In Figure EX-3,

- Actual (for 1990, 2000, and 2005) and projected (for 2015 and 2025) levels of Minnesota's gross GHG emissions on a consumption basis are shown by the blue line. (The consumption-based approach accounts for emissions associated with the generation of electricity in-state and imported from out-of-state to meet Minnesota's demand for electricity.)
- Projected emissions associated with Minnesota's existing actions that were analyzed quantitatively are shown by the red line.
- Projected emissions if all of the MCCAG's 31 recommendations that were analyzed quantitatively with respect to their GHG reduction potential are completely implemented and the estimated reductions are fully achieved are shown by the green line. (Note that other MCCAG recommendations would have the effects of reducing emissions, but those reductions were not analyzed quantitatively, and they are not reflected in the green line.)
- Projected emissions associated with Minnesota's statewide GHG reduction targets are shown by the black line.
- To the extent that the calculations of emission reduction in a particular sector or that calculations for a particular recommendation are found to be overstated, then the reductions will be less, and in order to meet the goal, more aggressive action will be needed in other sectors.

The MCCAG approved 46 recommendations to reduce emissions, of which 31 were analyzed quantitatively to estimate their effects on emissions and 25 were analyzed quantitatively to estimate their costs/cost savings. The analyzed measures were estimated to have a cumulative effect of reducing emissions by about 22 MMtCO_2e in 2015 and 50 MMtCO_2e in 2025. Together, the estimated emission reductions associated with the MCCAG's recommendations and recent actions would be enough to achieve Minnesota's GHG reduction goal for 2015 and be within 2.4 MMtCO_2e of meeting Minnesota's goal for 2025. The 25 recommendations analyzed in terms of their cost-effectiveness were estimated to have a total net cost of about $726 million between now and 2025, representing the incremental cost to the recent actions. While the MCCAG's 15 other recommendations were not readily quantifiable, many of them would likely achieve additional reductions and net savings (e.g., recommendations for the Transportation and Land Use [TLU] sector). Should Minnesota implement the MCCAG's recommendations to participate in a cap-and-trade program, opportunities exist for reducing the costs associated with the MCCAG's policy recommendations for the electricity supply sector. In addition, emerging technologies may hold the potential to substantially reduce emissions even more.

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



MMtCO_2e = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; MCCAG = Minnesota Climate Change Advisory Group.

Table EX-1. Annual emissions: reference case projections and impact of MCCAG recommendations (consumption-basis, gross emissions)

Annual Emissions ($MMtCO_2e$)	1990	2000	2005	2015	2025
Reference Case Projections	119.0	143.8	157.1	175.5	200.5
Reductions From Recent Actions	0.0	0.4	0.4	20.8	37.8
Projected GHG Emissions After Recent Actions			156.6	154.7	162.6
Next Generation Energy Act Targets				133.5	110.0
Total GHG Reductions From MCCAG Recommendations				22.2	50.3
Difference Between MCCAG Reductions and Next Generation Energy Act Targets				–1.0	2.4
Projected Annual Emissions After Quantified MCCAG Reductions				132.5	112.4

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; MCCAG = Minnesota Climate Change Advisory Group.

Table EX-2 provides a summary by sector of the estimated cumulative impacts of implementing all of the MCCAG's recommendations. Table EX-3 shows the estimated GHG reductions, costs, or savings from each policy recommendation and the cost-effectiveness (cost or savings per ton of reduction) upon which the cumulative impacts in Table EX-2 are based. Note that the cumulative impacts shown in Table EX-2 account for overlaps between policies by eliminating potential double counting of emission reductions and costs or cost savings.

Table EX-2. Summary by sector of estimated impacts of implementing all of the MCCAG recommendations (cumulative reductions and costs/savings)

Sector	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effectiveness ($/tCO_2e$)
	2015	2025	Total 2008–2025		
Residential, Commercial and Industrial (RCI, non-electricity)	0.76	0.69	10.41	–$464	–$45
Integrated RCI and ES for electricity	1.56	7.34	51.06	–$1,098	–$22
Energy Supply (ES, including RCI options with impacts on electricity consumption, and adjusted for RCI and ES electricity options that overlap)	1.97	3.43	37.55	$462	$12
Transportation and Land Use	4.70	9.30	91.2	–$264	N/A
Agriculture, Forestry and Waste Management	13.2	29.5	279	$2,090	$7
Cross-Cutting Issues	*Non-quantified, enabling options*				
TOTAL (includes all adjustments for overlaps and recent actions)	**20.2**	**50.3**	**469.2**	**$725.8**	**N/A**

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 options. Within each sector, values have been adjusted to eliminate double counting for options or elements of options that overlap. In addition, values associated with options or elements of options within a sector that overlap with options or elements of options in another sector have been adjusted to eliminate double counting.

N/A = not available; for TLU policies, an overall cost-effectiveness value is not provided because costs or cost savings were not estimated for all of the policies (due to the lack of data) for which emission reductions were estimated. Similarly, an overall cost-effectiveness value for all sectors is not provided for the same reason.

Note that the row in Table EX-2 for the RCI sectors includes only that portion of RCI emissions reductions and net cost savings that are from RCI options (or elements of options) that affect fuels that are combusted for purposes other than to generate electricity. RCI emissions reductions and net cost savings that affect electricity use or generation are included in the "Integrated RCI and ES for electricity" row in Table EX-2, because the benefits and costs of electricity-sector options are dependent on the electrical load served, which is affected by RCI electricity savings.

The Agriculture, Forestry, and Waste Management (AFW) sector was found to have substantial opportunities for GHG reductions through 2025 (279 MMtCO_2e through 2025). These reductions are tied to aggressive (and some would say optimistic) policy recommendations within each subsector, including biofuel production programs (both liquid and solid fuel from biomass); forestation, urban forestry and restocking programs; and municipal solid waste source reduction and recycling programs. Overall, the estimated cumulative costs were also estimated to be higher in the AFW sector than in the other sectors, although the reductions are delivered at a modest cost of $7 per metric ton of CO_2e (\$/tCO_2e) reduced. This is largely driven by the methods for implementing these policy recommendations in the AFW sector, as compared with other sectors. Most of the AFW options incur net societal costs, because they are targeting changes in current practices which require incentives, capital investment, or other cost outlays during the policy period. A large contributor to the overall AFW sector costs is the forest restocking component of AFW-5, which has an estimated cost of $2.2 billion through 2025 (see Appendix I for more details). A number of options within the AFW sectors call for the use of biomass as an energy feedstock. The MCCAG recognized that the success of these options depends on Minnesota's ability to supply that biomass, noting that estimates of Minnesota's biomass resources vary (see Appendix I for more details).

In order for the policies recommended by the MCCAG to yield the levels of estimated emission reductions and cost savings shown in Table EX-2, the policies must be implemented in a timely, aggressive, and thorough manner. In some cases, the actions recommended by the MCCAG are precise, concrete steps. In other cases, the recommendations are more general, and work must be done to develop precise, concrete steps to achieve goals recommended by the MCCAG. In the latter case, the additional work to identify precise, concrete actions is needed before they can be implemented. While there are considerable benefits to both the environment and to consumers from implementation of the policy recommendations, 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 EX-5 presents the estimated tons of reductions for each policy recommendation for which estimates were prepared, expressed as a cumulative figure for the period 2008–2025. Figure EX-6 presents the estimated dollars per ton cost (or cost savings, depicted as a negative number) for each policy recommendation for which cost estimates were available. This measure is calculated by dividing the net present value of the cost of the policy recommendation by the cumulative GHG reductions, all for the period 2008–2025.

Table EX-3. Residential, Commercial, and Industrial Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2015	2025	Total (2008–2025)			
RCI-1	Maximize Savings From the Utility Conservation Improvement Program (CIP) *	*Quantified as a "Recent Action"*					Enacted
RCI-2	Improved Uniform Statewide Building Codes	0.004	0.005	0.077	–$44	–$576	Unanimous
RCI-3	Green Building Guidelines and Standards Based on *Architecture 2030*	0.62	0.94	11.1	–$296	–$27	Unanimous
RCI-4	Incentives and Resources to Promote Combined Heat and Power (CHP)	0.96	4.95	33.1	$125	$3.8	Unanimous
RCI-5	Program to Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs	0.02	0.05	0.5	–$2	–$5	Unanimous
RCI-6	Non-Utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions	0.25	1.30	8.3	–$307	–$37	Unanimous
RCI-7	Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency	0.05	0.05	0.7	–$21	–$28	Unanimous
RCI-8	Energy Performance Disclosure	*Not quantified*					Unanimous
RCI-9	Promote Technology-Specific Applications to Reduce GHG Emissions	*Not quantified*					Unanimous
RCI-10	Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards	0.8	1.4	15.3	–$1,895	–$124	Unanimous
	Sector Total After Adjusting for Overlaps (RCI, Non-electricity)	**0.76**	**0.69**	**10.41**	**–$464**	**–$44.6**	
	Sector Total After Adjusting for Overlaps (Integrated RCI and ES for Electricity)	**1.56**	**7.34**	**51.06**	**–$1,098**	**–$21.5**	
	Reductions From Recent Actions	**6.50**	**15.50**	**143.4**	**–$8,454**	**–$59.0**	
	New Commercial Building Code	**0.18**	**0.21**	**3.16**	**–$1.8**	**–$0.6**	
	Sustainability Guidelines (New State Buildings)	**0.22**	**0.46**	**4.72**	**–$1.7**	**–$0.4**	
	10% Savings in State Buildings	**0.09**	**0.11**	**1.75**	**–$0.9**	**–$0.5**	
	RCI-1: New CIP *	**6.01**	**14.72**	**133.8**	**–$8,449**	**–$63.2**	
	Sector Total Plus Recent Actions	**8.82**	**23.5**	**204.9**	**–$10,016**	**–$48.9**	

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

Only the results of recommendations included in the final tabulation of GHG reductions and costs are shown in this table. For discussion of any sensitivity analyses undertaken, please see the discussion in the RCI annex.

* The CIP considered here is based on the CIP requirements (i.e., 1.5% energy savings goal) included in the Next Generation Energy Act of 2007; therefore, the emission reductions and cost savings estimated are included under "recent actions."

Table EX-3 (continued). Energy Supply Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2025	Total (2008–2025)			
ES-1	Generation Performance Standard	0.0	0.0	0.0	$0.0	$0.0	Majority (16 objections)
ES-3	Efficiency Improvements, Re-powering and other Upgrades to Existing Plants	1.8	3.0	33.3	$554.4	$16.7	Unanimous
ES-4	Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss	0.2	0.4	3.9	–$92.2	–$26.1	Unanimous
ES-5	Renewable and/or Environmental Portfolio Standard*	*Quantified as a "Recent Action"*					Enacted
ES-6	Nuclear Power Support and Incentives	*Recommended for further study.*					Unanimous
ES-8	Advanced Fossil Fuel Technology Incentives, Support or Requirements, Including Carbon Capture and Storage	*Recommended for further study.*					Unanimous
ES-10	Voluntary GHG targets	*Not quantified*					Unanimous
ES-12	Distributed Renewable Energy Incentives and/or Barrier Removal	0.021	0.023	0.37	$29.1	$78.1	Unanimous
ES-13	Technology-Based Approaches, Including Research and Development, Fuel Cells, Energy Storage, Distributed Renewable Energy Technologies, etc.	*Not quantified*					Unanimous
	Sector Total After Adjusting for Overlaps	**2.0**	**3.4**	**37.5**	**$462.2**	**$12.3**	
	Reductions From Recent Actions	**12.8**	**20.8**	**225**	**$10,116**	**$45.0**	
	Biomass for Electricity	**0.60**	**0.60**	**11.4**	**$285.3**	**$25.0**	
	Metro Emissions Reduction Project	**4.52**	**4.52**	**80.4**	**$2,330**	**$29.0**	
	ES-5: Renewable Energy Standard *	**7.72**	**15.7**	**133.1**	**$7,502**	**$56.4**	
	Sector Total Plus Recent Actions	**14.8**	**24.2**	**262.5**	**$10,578**	**$40.3**	

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 recommendations. Totals in some columns may not add to the totals shown due to rounding.

All totals are relative to the underlying assumption that electricity expansion in Minnesota proceeds with the recently legislated Conservation Improvement Program (CIP), Renewable Energy Standard (RES), and all planned additions including the Mesaba and Big Stone 2 stations.

* The RES considered here is based on the RES requirements included in the Next Generation Energy Act of 2007; therefore, the emission reductions and costs estimated are included under "recent actions."

Note: A number of MCCAG members have raised concerns about the cost assumptions associated with wind power and believe the costs are too high. A lower wind cost assumption would lower the cost estimates for the Renewable Energy Standard (ES-5) and for the Cap-and-Trade analyses. Future analyses should reexamine the wind cost estimates.

Table EX-3 (continued). Transportation and Land Use Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$) 2015	2025	Total 2008–2025	Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
TLU Area 1: Reduce VMT (VMT goal to be established based on VMT implied by selected strategies)							
TLU-1	Improved Land-Use Planning and Development Strategies	0.7	1.9	14.9	*Net savings*	*Net savings*	Unanimous
TLU-2	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.1	0.3	3.0	$0	$0	Unanimous
TLU-5	Climate-Friendly Transportation Pricing/Pay-as-You-Drive	1.1	2.1	20.9	–$1	–$1	Super-majority (3 objections)
TLU-7	"Fix-it-First" Transportation Investment Policy and Practice	*Not quantified*					Super-majority (2 objections)
TLU-9	Workplace Tools To Encourage Carpooling, Bicycling, and Transit Ridership	0.3	0.4	4.5	*Large net savings*	*Large net savings*	Unanimous
TLU-14	Freight Mode Shifts: Intermodal and Rail	*N/A*					Super-majority (1 objection)
TLU Area 2: Reduce Carbon per Unit of Fuel							
TLU-3	Low-GHG Fuel Standard	1.7	3.6	36.2	*Not quantified*		Unanimous
TLU Area 3: Reduce Carbon per Mile and/or per Hour							
TLU-4	Infrastructure Management	0.04	0.1	0.7	*Not quantified*		Unanimous
TLU-6	Adopt California Clean Car Standards	0.74	1.16	13.1	–$263	–$39	Majority (16 objections)
TLU-12	Voluntary Fleet Emission Reductions	0.4	0.4	6.1	*Not quantified*		Unanimous
TLU-13	Reduce Maximum Speed Limits	0.4	0.4	6.1	*N/A*	$50 at $2.40/gal –$19 at $3.40/gal	Majority (16 objections)
	Sector Total After Adjusting for Overlaps	**4.7**	**9.3**	**91.2**	**–$264**	***Not quantified***	
	Reductions From Recent Actions	**1.4**	**1.5**	**20.2**	***Not quantified***		
	Biodiesel	**0.64**	**0.75**	**8.1**			
	Ethanol	**0.78**	**0.79**	**12.1**			
	Sector Total Plus Recent Actions	**6.1**	**10.8**	**111.4**	**–$264**	***Not quantified***	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent, VMT = vehicle miles traveled; N/A = not available.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

Table EX-3 (continued). Agriculture, Forestry, and Waste Management Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$) 2015	GHG Reductions ($MMtCO_2e$) 2025	GHG Reductions ($MMtCO_2e$) Total 2008–2025	Net Present Value 2008–2025 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
AFW-1	Agricultural Crop Management						Unanimous
	A. Soil Carbon Management	0.72	1.3	15	–$34	–$2	
	B. Nutrient Management	0.79	1.3	15	–$543	–$37	
AFW-2	Land Use Management Approaches for Protection and Enrichment of Soil Carbon						Unanimous
	A. Preserve Land	0.15	0.44	3.7	$120	$33	
	B. Reinvest in Minnesota–Clean Energy (RIM-CE)	0.09	0.19	1.8	$59	$34	
	C. Protection of Peatlands & Wetlands	*Not Quantified*					
AFW-3	In-State Liquid Biofuels Production						Super-majority (4 objections)
	A. Ethanol Carbon Content	1.8	2.2	27	–$242	–$9	
	B. Fossil Diesel Displacement	0.03	0.19	1.4	$74	$55	
	C. Gasoline 35% Displacement	2.8	9.1	73	$336	$5	
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	1.3	3.8	31	$102	$3	Unanimous
AFW-5	Forestry Management Programs to Enhance GHG Benefits						Unanimous
	A. Forestation	0.55	2.2	17	$218	$13	
	B. Urban Forestry	1.2	2.7	26	–$295	–$12	
	C. Wildfire Reduction	*Not Quantified*					
	D. Restocking	2.1	8.4	65	$2,187	$33	
	E. Forest Health and Enhanced Sequestration	*Not Quantified*					
AFW-6	Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover	2.2	2.7	34	$101	$3	Unanimous
AFW-7	Front-End Waste Management Technologies						Unanimous
	A. Source Reduction	0	3.6	20	$59	$3	
	B. Recycling	3.1	3.4	45	–$207	–$5	
	C. Composting	0.29	0.41	4.9	$137	$28	
AFW-8	End-of-Life Waste Management Practices						Unanimous
	A. Landfill Methane Recovery	0.07	0.73	4.4	$5.7	$1	
	B. Residuals Management	0.52	0.63	8.1	$650	$80	
	C. WTE Preprocessing	0.37	0.84	7.9	$257	$32	
	Sector Total After Adjusting for Overlaps*	**13.2**	**29.5**	**279**	**$2,090**	**$7**	
	Reductions From Recent Actions	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
	Sector Total Plus Recent Actions	**13.2**	**29.5**	**279**	**$2,090**	**$7**	

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

*Overlaps include an assumed 100% overlap of AFW-3b&3c with TLU-3 (reductions excluded from AFW totals); an assumed 100% overlap of AFW-4 with ES-5 (reductions and costs excluded from AFW totals); overlap of AFW-7&8 (incremental benefits and costs of AFW-8 included in the AFW totals).

Table EX-3 (continued). Cross-Cutting Issues Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
		2015	2025	Total 2008-2025			
CC-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not quantified*					Unanimous
CC-2	Statewide GHG Reduction Goals and Targets	*Not quantified*					Unanimous
CC-3	State and Local Government GHG Emissions (Lead-by-Example)	*Not quantified*					Unanimous
CC-4	Public Education and Outreach	*Not quantified*					Unanimous
CC-7	Participate in Regional and Multistate GHG Reduction Efforts	*Not quantified*					Unanimous
CC-8	Encourage the Creation of a Business-Oriented Organization to Share Information and Strategies, Recognize Successes, and Support Aggressive GHG Reduction Goals	*Not quantified*					Unanimous
CC-9	Dedicate Greater Public Investment to Climate Data and Analysis	*Not quantified*					Unanimous
	Sector Total After Adjusting for Overlaps	***Not quantified***					
	Reductions From Recent Actions	***Not quantified***					
	Sector Total Plus Recent Actions	***Not quantified***					

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent.

Table EX-3 (continued). Cap-and-Trade (C&T) Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effective-ness* ($/tCO_2e$) 2025	Permit Price† ($/tCO_2e$) 2025	Level of Support
		2015	2025	Total (2008–2025)				
C&T-1	Cap-and-Trade Program							Majority (9 objections)
	MGA Partners C&T *—no RES/CIP in the baseline*		79.82			–$12.17	$48.45	
	MGA Partners C&T *—with both RES/CIP in the baseline*		52.94			$2.65	$45.95	
	MGA Partners C&T *—with only RES in the baseline*		67.35			–$15.42	$46.64	
	MGA Partners+Observers C&T *—no RES/CIP in the baseline*		81.97			–$10.52	$52.44	
	MGA Partners+Observers C&T *—with both RES/CIP in the baseline*		55.45			$4.71	$50.72	
	MGA Partners+Observers C&T *—with only RES in the baseline*		69.45			–$13.48	$51.27	
	MGA plus WCI Partners C&T *—no RES/CIP in the baseline*		72.64			–$17.52	$35.69	
	MGA plus WCI Partners C&T *—with both RES/CIP in the baseline*		46.93			–$2.19	$34.95	
	MGA plus WCI Partners C&T *—with only RES in the baseline*		61.92			–$20.36	$35.07	
	MGA and WCI Partners+Observers C&T *—no RES/CIP in the baseline*		76.17			–$14.92	$41.87	
	MGA and WCI Partners+Observers C&T *—with both RES/CIP in the baseline*		50.41			$0.59	$41.25	
	MGA and WCI Partners+Observers C&T *—with only RES in the baseline*		64.92			–$17.65	$41.39	
C&T-2	MN-Only C&T *—no RES/CIP in the baseline*		89.18			–$2.39	$65.48	Merged into C&T-1
C&T-3	National C&T	*Not quantified*						Merged into C&T-1
C&T-5	Market Advisory Group (Formerly CC-11)	*Not quantified*						Unanimous
C&T-6	Regional and Multistate GHG Reduction Efforts (Formerly CC-7)	*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; MGA = Midwestern Governors Association; C&T = cap-and-trade; RES = renewable electricity standard; CIP = Conservation Improvement Program; WCI = Western Climate Initiative; CC = Cost-Cutting Issues.

Negative numbers represent cost savings.

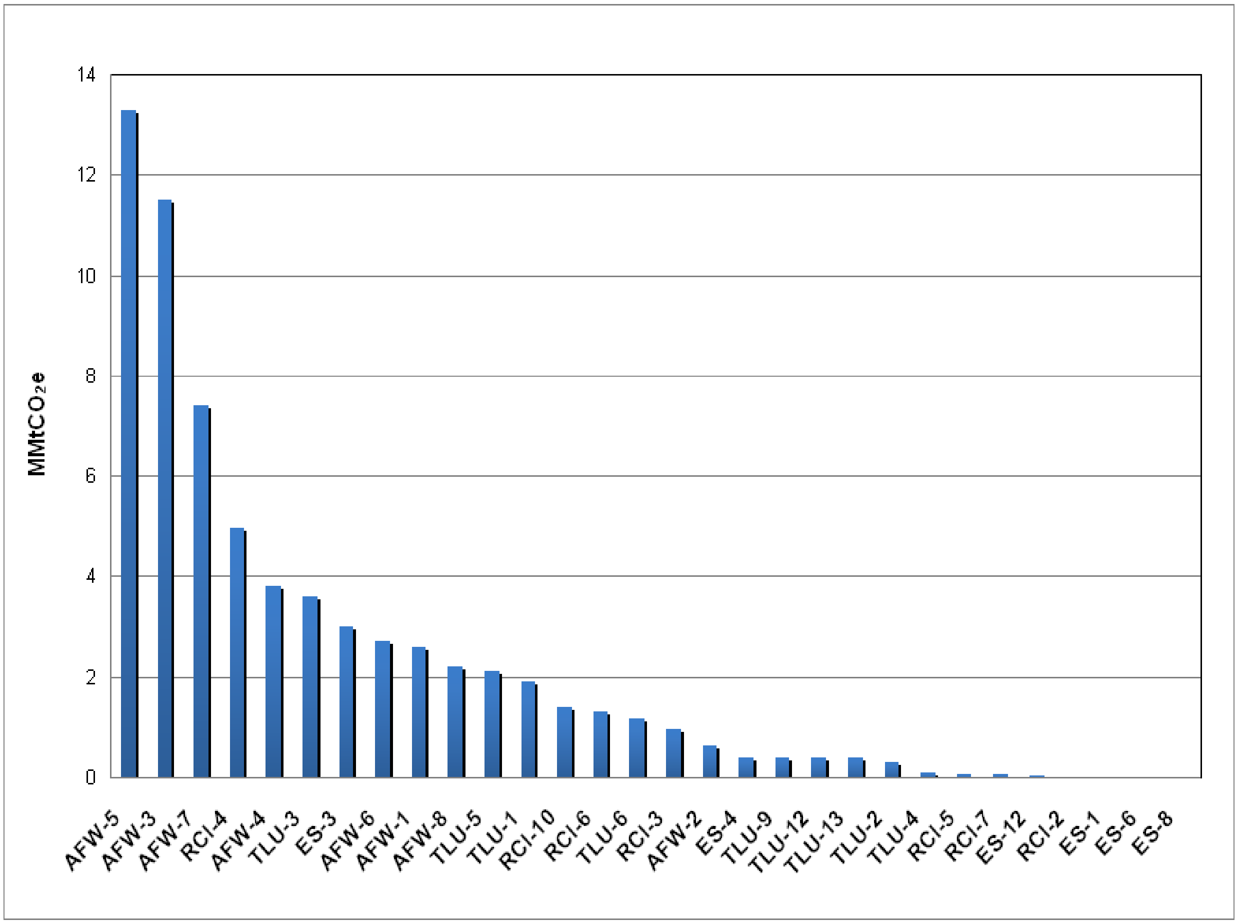
MGA C&T Partners include Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba; MGA C&T Observers include Indiana, Ohio, and South Dakota; WCI Partners include Arizona, California, New Mexico, Oregon, Utah, Washington, British Columbia, and Manitoba; WCI Observers include Colorado, Idaho, Montana, Nevada, and Wyoming. To run simulations including both MGA and WCI states in 2025, the C&T Technical Work Group (TWG) used 2020 marginal cost curves for WCI states for 2025. The emission cap for both MGA and WCI states (or provinces) is assumed to be 30% below the 2005 level in 2025.

* This represents the average $/$tCO_2e$ mitigated/sequestered for Minnesota.

† This represents the marginal cost of the last tCO_2e mitigated/sequestered; it applies to all states involved in trading arrangements.

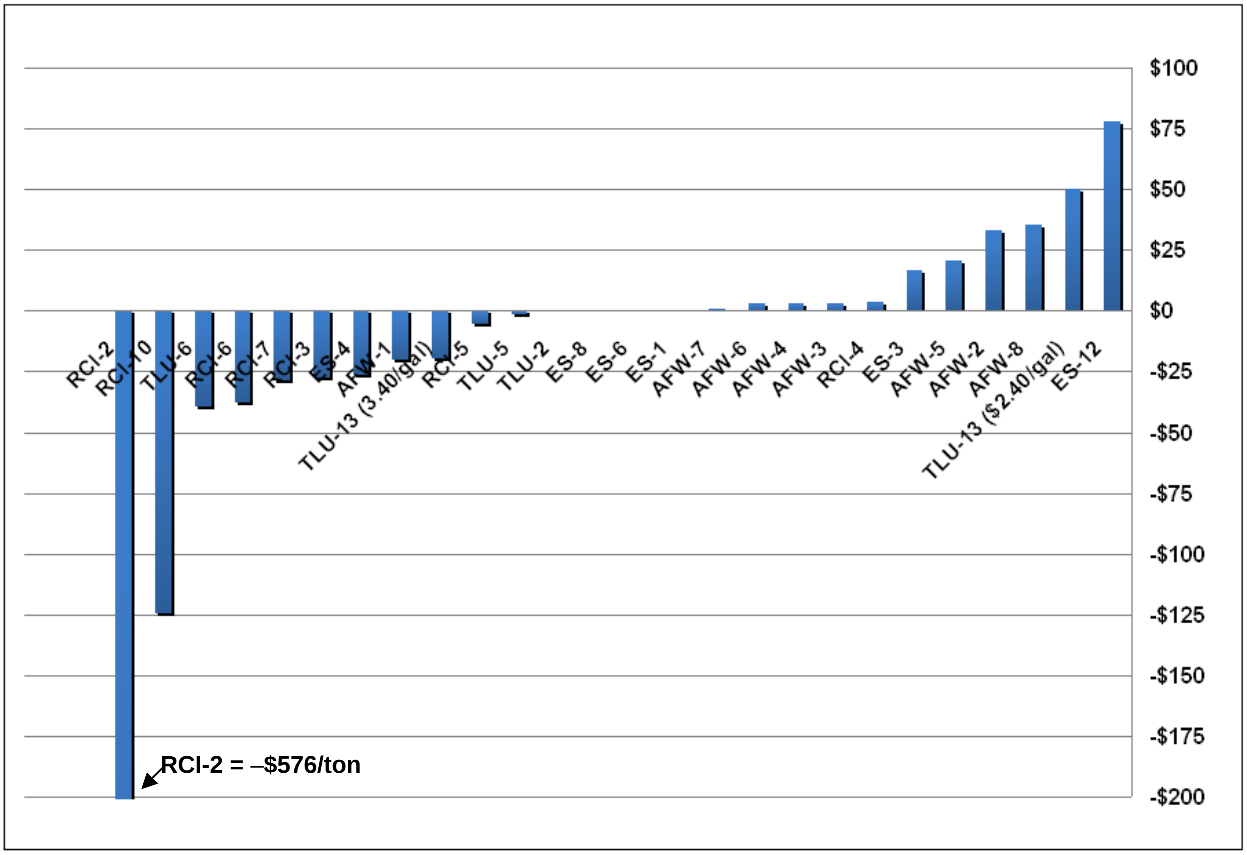
Note: Some MCCAG members have raised concerns about the cost assumptions associated with high cost estimates for wind power. A lower wind cost assumption would lower the cost estimates for the Renewable Energy Standard (ES-5) and for the Cap-and-Trade analyses. Future analyses should reexamine the wind cost estimates.

Figure EX-5. MCCAG policy recommendations ranked by 2025 annual GHG reduction potential



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

Figure EX-6. MCCAG policy recommendations ranked by cost / cost savings per ton GHG removed



RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use; ES = Energy Supply; AFW = Agriculture, Forestry, and Waste Management.

Note: Negative values represent net cost savings and positive values represent net costs associated with the policy recommendation.

Chapter 1
Background and Overview

The Governor's Initiative

On December 12, 2006, Minnesota Governor Tim Pawlenty announced the state's "Next Generation Energy Initiative," including "development of a comprehensive plan to reduce Minnesota's emissions of greenhouse gases (GHGs)." In this announcement, the Governor requested assistance from the Center for Climate Strategies (CCS) in the development of a Minnesota Climate Mitigation Action Plan (Action Plan) and formation of the Minnesota Climate Change Advisory Group (MCCAG). This broad-based group of Minnesota citizens and leaders was charged with developing a comprehensive set of state-level policy recommendations to the Governor through a stakeholder-based consensus building process facilitated by CCS in coordination with the Minnesota Department of Commerce (DOC) and Minnesota Pollution Control Agency (PCA).

This report documents the results of the MCCAG's work. This chapter provides an overview of what Minnesota is already doing to control GHG emissions, lists the MCCAG's recommendations for additional action to control GHG emissions, and evaluates the potential effects of the MCCAG's recommendations (coupled with progress under way) toward meeting Minnesota's statewide GHG reduction goals. Chapter 2 provides a summary of Minnesota's historic and forecasted GHG emissions. Chapters 3 through 8 summarize the MCCAG's recommendations that are documented in detail in Appendixes E through K. Appendix A of the report contains Governor Pawlenty's invitation to CCS to facilitate and provide technical support to Minnesota's process for developing its Action Plan. Appendix B provides a copy of the memorandum that outlines the process. Appendix C provides the list of Technical Work Group (TWG) members, and Appendix D provides the reference to the final report for Minnesota's GHG emissions inventory and reference case projections.

Recent Developments

Next Generation Energy Act of 2007 and Statewide GHG Reduction Goals

On May 25, 2007, Governor Tim Pawlenty signed the Next Generation Energy Act of 2007.[1] This state law, coupled with other state initiatives to control GHG emissions, positions Minnesota as a leader on the way toward our nation's energy future. The Next Generation Energy Act of 2007 includes requirements for Minnesotans to increase energy efficiency and expand community-based energy development. In addition, it established a statewide goal to reduce GHG emissions. The state law also supplements the aggressive 25x'25 renewable energy standard proposed by the Governor and signed earlier this year.

The Act established aggressive goals for Minnesotans to reduce statewide GHG emissions across all sectors to a level at least 15% below 2005 levels by 2015, to a level at least 30% below 2005 levels by 2025, and to a level at least 80% below 2005 levels by 2050. In 2005, Minnesota's

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[1] Minnesota Session Laws 2007, Chapter 136, S.F. (Senate File) No. 145, http://www.revisor.leg.state.mn.us/bin/getbill.php?number=SF145&session=ls85&version=list&session_number=0&session_year=2007

GHG emissions were 152 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) and, if no reducing actions were taken, the state's GHG emissions would be almost 198 $MMtCO_2e$ in 2025.

This means that to meet the 2015 emissions goal, Minnesotans will have to reduce their emissions to about 131.8 $MMtCO_2e$ (or by about 41.3 $MMtCO_2e$ below 2015 levels). To meet the 2025 emissions goal, Minnesotans will have to reduce their emissions to about 108.5 $MMtCO_2e$ (or by about 89 $MMtCO_2e$ below 2025 levels).

Note that MCCAG chose to focus its quantitative analyses on achieving the 2015 and 2025 GHG reduction goals. The MCCAG felt that extending the emissions forecast and estimating the effects of its policy recommendations in 2050 is just too speculative at this time. It is expected that full and complete implementation of all of the recent actions and MCCAG's recommendations will set Minnesota on course to meet the 2050 goal, which will require a transformation in how Minnesotans generate and use energy and identify ways to sequester carbon.

GHG Reductions Associated With Recent Actions[2]

At the beginning of the MCCAG process, DOC and PCA identified more than 40 different actions Minnesota has undertaken to control GHG emissions while at the same time conserving energy and promoting the development and use of renewable energy sources.[3] These actions also include assessments of both terrestrial and geologic carbon storage opportunities in Minnesota. The MCCAG recognized the importance of these recent actions as essential for setting Minnesota on the path toward meeting its aggressive statewide goals and used these actions to formulate the baseline from which it considered and developed its wide range of recommendations to ensure that Minnesota stays the course toward meeting its goals.

A total of nine recent actions were identified for which data were available to estimate the emission reductions and costs/cost savings of the actions relative to the business-as-usual reference case projections. Other actions were not analyzed because they were enabling policies (e.g., studies, technical assistance, loan programs, or program funding), their emission reductions would be double-counted with the emission reductions quantified for one of the nine actions, or because data were not readily available to quantify their reductions. Figure 1-1 illustrates the emission reductions associated with each of the nine recent actions analyzed. Table 1-1 provides the numeric estimates underlying Figure 1-1 and shows the costs or cost savings estimated for each of the actions.

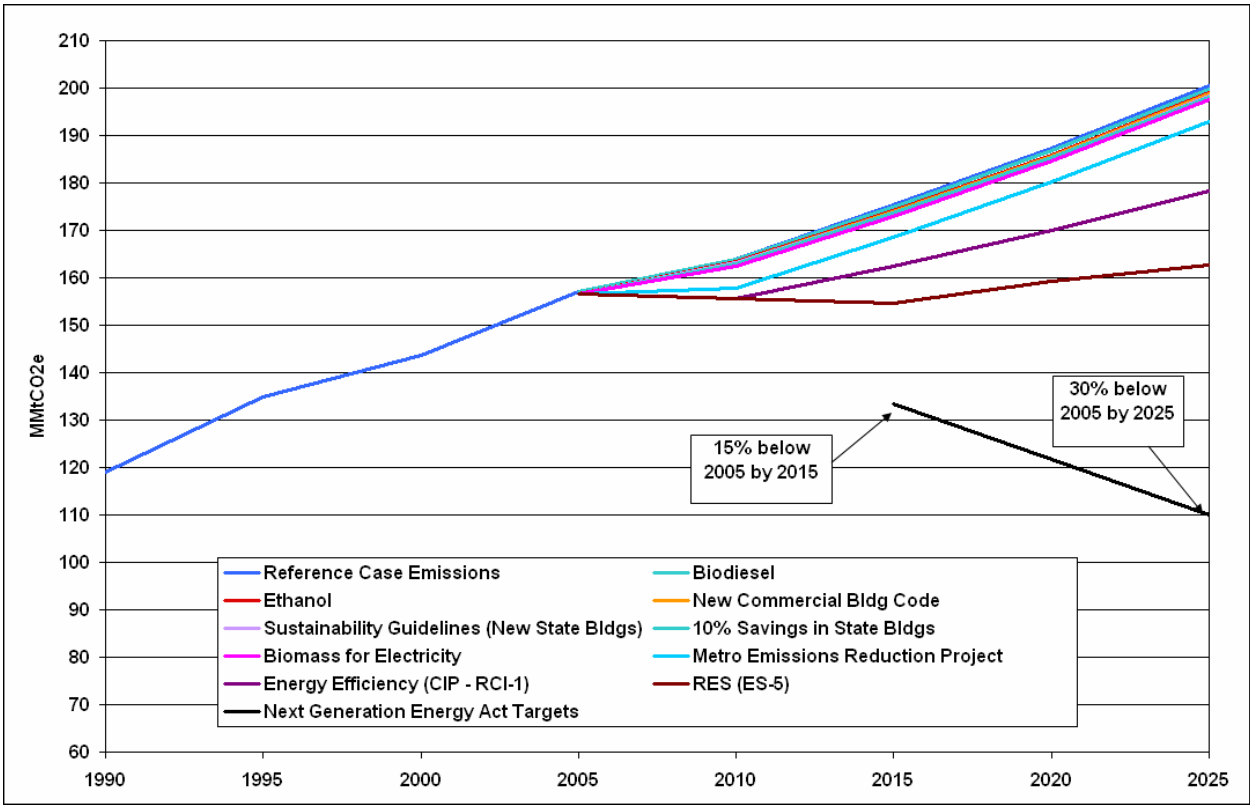
Implementation of the recent actions analyzed indicates that emissions reductions will be about 50% of the total emission reductions needed to meet the state's 2015 goal and about 42% of the total emission reductions needed to meet the state's 2025 goal. These results underscore the importance of the contribution of these recent actions toward Minnesota's ability to meet its statewide reduction goals. Note that the MCCAG selected two of the recent actions as priorities for analysis during its process in order to develop detailed emission reduction and cost/cost

[2] Note that actions recently adopted by the state of Minnesota have also been referred to as "existing" actions.

[3] A summary of these actions can be found on the MCCAG's project Web site under "Background, What MN Is Already Doing?" at: http://www.mnclimatechange.us/background-alreadydoing.cfm

savings estimates for these actions, as well as to consider the possibility of increasing the stringency of the recent actions. These two actions include the Conservation Improvement Program (CIP) and the Renewable Energy Standard (RES). The CIP and RES together account for more than 66% and 80% of the total reductions for all of the recent actions together in 2015 and 2025, respectively. The costs associated with the RES are significantly (but not completely) offset by the cost savings associated with the CIP. The following provides a brief summary of each of the nine recent actions.

Figure 1-1. Emission reductions associated with recent actions in Minnesota (consumption-basis, gross emissions)



CIP = Conservation Improvement Program; RCI = Residential, Commercial, and Industrial [sectors]; RES = Renewable Energy Standard; ES = Energy Supply.

It is important to note that the top line in Figure 1-1 represents total emissions associated with all GHG-emitting activities across all sectors in Minnesota on a consumption basis prior to the implementation of any existing actions. For the electricity supply sector, this assumes the installation of the planned Big Stone 2 and Mesaba coal units and an assumed electricity demand growth rate of 2.04% per year.

New Commercial Building Code: Beginning in 2009, Minnesota will implement one of the most stringent commercial building codes in the country. It will combine best construction practices with acceptance testing to ensure that systems are working properly. Minnesota's new commercial building code will achieve a 30% better energy performance over a typical commercial building.[4]

Sustainable Building Guidelines for New State Buildings: New buildings developed using state bonds must adhere to the State's sustainable design guidelines. These guidelines ensure that all new state buildings initially exceed existing energy code by at least 30%. The guidelines focus on achieving the lowest possible lifetime cost for new buildings and encourage continual energy conservation improvements as well as use of renewable energy systems.[5]

Table 1-1. Emission reductions and costs/cost savings associated with recent actions in Minnesota (consumption-basis, gross emissions)

Sector / Recent Action	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2015	2025	Total 2008–2025		
Residential, Commercial, and Industrial (RCI)					
New Commercial Building Code	0.18	0.21	3.16	–$1.8	–$0.6
Sustainability Guidelines (New State Buildings)	0.22	0.46	4.72	–$1.7	–$0.4
10% Savings in State Buildings	0.09	0.11	1.75	–$0.9	–$0.5
Conservation Improvement Program (CIP)	6.01	14.72	133.8	–$8,449	–$63.2
RCI Totals	6.50	15.50	143.4	–$8,454	–$59.0
Energy Supply (ES)					
Biomass for Electricity	0.60	0.60	11.4	$285.3	$25.0
Metro Emissions Reduction Project	4.52	4.52	80.4	$2,330	$29.0
Renewable Energy Standard (RES)	7.72	15.7	133.1	$7,502	$56.4
ES Totals	12.8	20.8	225	$10,116	$45.0
Transportation and Land Use (TLU)					
Biodiesel	0.64	0.75	8.1	*Not quantified*	*Not quantified*
Ethanol	0.78	0.79	12.1	*Not quantified*	*Not quantified*
TLU Totals	1.4	1.5	20.2		
TOTAL (includes all adjustments for overlaps with MCCAG recommendations)	20.7	37.8	385.7	$995.5	$0.4

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO2e = dollars per metric ton of carbon dioxide equivalent.

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

[4] See the following website for additional information: http://www.doli.state.mn.us/buildingcodes.html

[5] For additional information, see http://www.msbg.umn.edu/

Reduce Energy Use by 10% in State-Owned Buildings: On November 10, 2005, Governor Pawlenty signed Executive Order 05-16 instructing all State agencies to undertake measures including, but not limited to, the measures set forth in this order to reduce energy usage in state-owned buildings by 10% over calendar year 2006 compared with calendar year 2005.[6]

Energy Conservation Improvement Program: The Next Generation Energy Act of 2007 establishes an energy policy goal for Minnesota to achieve annual savings equal to 1.5% of annual retail energy sales of electricity and natural gas. At least 1% of these sales should come directly through energy conservation improvement programs and rate design. The additional 0.5% of savings can come indirectly through energy codes and appliance efficiency standards, programs designed to transform the market or change consumer behavior, energy savings resulting from efficiency improvements to the utility infrastructure and system, and other activities to promote energy efficiency and energy conservation. These savings are based on the average of the last 3 years of sales for the utility.

Biomass for Electricity: District Energy St. Paul operates a new combined heat and power plant that uses clean waste wood to generate steam heat and electricity for downtown St. Paul, reducing its dependence on coal by 80%. In addition, the Hibbing and Virginia [MN] Public Utilities created an energy authority, Laurentian Energy, to re-power their coal-fired district heating boilers in Hibbing and Virginia that produce steam and electricity. Laurentian Energy produces 35 megawatts (MW) of power fueled by renewable biomass and closed-loop hybrid poplars. The PCA is working with an energy-intensive industry in St. Paul—Rock-Tenn—and District Energy St. Paul to build a power plant that relies on renewable energy. Rock-Tenn processes half of all recycled paper in the state. Refuse-derived fuel is being explored as a fuel source.[7]

Metro Emissions Reduction Project: Xcel Energy is in the process of replacing three coal-fired power plants in Minnesota with cleaner solutions such as new natural gas-fired plants or retrofitted technology.[8]

Renewable Energy Standard: The Minnesota legislature overwhelmingly passed a bill on February 2007 requiring the state's utilities to generate at least 25% of their electricity from renewables by 2025. Under the new law, Minnesota will add between 5,000 and 6,000 MW of new renewable energy. The law also establishes a renewable energy trading program for utilities by 2008. This legislation is expected to reduce carbon dioxide (CO_2) emissions by about 16% over what they would otherwise have been.

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[6] For additional information, see http://www.governor.state.mn.us/priorities/governorsorders/executiveorders/2005/PROD005605.html

[7] For additional information see "Minnesota Biomass - Hydrogen and Electricity Generation Potential, A study by the National Renewable Energy Laboratory," Golden, Colorado, for the Minnesota Department of Commerce and the Minnesota Office of Environmental Assistance, February 2005, at: http://www.pca.state.mn.us/oea/p2/forum/MNbiomass-NREL.pdf

[8] For additional information, see http://www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-1_11824_22655-877-0_0_0-0,00.html and http://www.pca.state.mn.us/hot/xcel.html

Biodiesel: As of September 29, 2005, Minnesota requires nearly all diesel fuel sold in the state to contain at least a 2% biodiesel blend. It is estimated that the 2% fuel use requirement for Minnesota will replace 16 million gallons of diesel fuel.[9]

Ethanol: Minnesota established an ethanol production incentive to provide payment to producers to help develop a new market for Minnesota's agricultural products. On the market side, Minnesota requires that all gasoline sold in the state be blended with a 10% ethanol mix. In addition, Minnesota began efforts in 1997 to develop a network of fueling stations for flex-fuel vehicles that could run on an 85% ethanol blend. As of 2007, Minnesota has more than 300 E85 fueling stations around the state that together sold a total of 18,160,000 gallons of E85 blended gasoline during 2006.[10]

The MCCAG Process

The MCCAG first met on April 20, 2007, and met a total of eight times, with the final decisional meeting held on January 24, 2008, and a final meeting for review of this report. In all, more than 80 meetings and teleconference calls of the MCCAG and the six supporting TWGs were held to identify and analyze various potential policy actions in advance of the MCCAG's January 24, 2008, final decisional meeting.

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

- Energy Supply (ES);
- Residential, Commercial, and Industrial (RCI);
- Transportation and Land Use (TLU);
- Agriculture, Forestry, and Waste Management (AFW);
- Cross-Cutting Issues (CC); and
- Cap-and-Trade (C&T).

CCS provided facilitation and technical assistance to each of the TWGs and the MCCAG. The TWGs consisted of MCCAG members as well as individuals who were not on the MCCAG but who did have an interest in and expertise regarding the issues being addressed by each TWG (see Appendix C for a listing of the members of each TWG). The TWGs served as advisers to the MCCAG and helped generate initial recommendations on priority policy recommendations for analysis. They then developed draft proposals on the design characteristics and quantification of the proposed policy recommendations. Where members of a TWG did not fully agree on recommendations to the MCCAG, the summary of their efforts was reported to the MCCAG for further consideration and actions. The MCCAG then made its decisions after reviewing the TWGs' proposals.

The MCCAG process involved a model of informed self-determination through a facilitated, stepwise, consensus-building approach. With oversight by DOC and PCA, the process was

[9] For additional information, see http://www.mda.state.mn.us/renewable/biodiesel/default.htm

[10] For additional information, see http://www.mda.state.mn.us/renewable/ethanol/default.htm

conducted by CCS, an independent, expert facilitation and technical analysis team. It was based on procedures that CCS consultants have used in a number of other state climate change planning initiatives since 2000 but was adapted specifically for Minnesota. The MCCAG process sought but did not mandate consensus, and it explicitly documented the level of MCCAG support for some policies and key findings established through a voting process established in advance.

The 46 policy recommendations (out of more than 300 potential options considered) adopted by the MCCAG and presented in this report underwent two levels of screening by the MCCAG. First, a potential policy recommendation being considered by a TWG was not accepted as a "priority for analysis" and fleshed out for full analysis unless it had a supermajority of support from MCCAG members present at the decisional meetings (with "supermajority" defined as four objections or fewer by MCCAG members attending a meeting). Second, after the analyses were conducted, only policy recommendations that received at least majority support (defined as less than half of those present objecting) from MCCAG members present at the decisional meetings were adopted by the MCCAG and included in this report.

Of the 46 policy recommendations adopted by the MCCAG, 38 were approved unanimously, 4 were approved by a supermajority, and 4 were approved by a simple majority.

The TWGs' recommendations to the MCCAG were documented and presented to the MCCAG at each MCCAG meeting. All of the MCCAG and TWG meetings were open to the public and all materials for and summaries of the MCCAG and TWG meetings were posted on the MCCAG Web site.

Analysis of Policy Recommendations

With CCS providing facilitation and technical analysis, the six TWGs submitted recommendations for policies for MCCAG 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 MCCAG modified and embraced various policy recommendations. The final versions for each sector, conforming to the policy option templates, appear in Appendixes E through K and constitute the most detailed record of decisions of the MCCAG. Appendix E describes the methods used for quantification of the 31 policy recommendations that were analyzed quantitatively. Three key methods are summarized below.

Estimates of GHG Reductions: Using the projection of future GHG emissions (see below) as a starting point, 31 policy recommendations 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 time period 2008–2025.[11] The CCS estimates were prepared in accordance with guidance by the appropriate TWG and the MCCAG, which later reviewed the estimates and, in some cases, directed that they be revised with respect to such elements as goals, data sources, and methodology. Many policies were estimated to affect the quantity or type of fossil fuel combusted; others affected methane (CH_4) or CO_2 sequestered. Among the many assumptions involved in this task was selection 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.[12] The MCCAG took a "production-based" approach in all sectors except the electricity sector, in both forecasting emissions and in estimating the GHG impacts of policies. This issue, along with other GHG estimation issues (e.g., analysis of overlapping or interacting policy impacts), is discussed in detail in Appendix E (Methods for Quantification).

Estimates of Costs/Cost Savings: The analyses of 25 policy recommendations included estimates of the cost of those policies, both in terms of net costs or cost savings during 2008–2025 and a dollars-per-ton cost (i.e., cost-effectiveness).[13] (The other 6 policy recommendations that were analyzed with respect to their GHG reductions were such that their costs or cost savings could not be readily estimated.) While the cap-and-trade policy (C&T-1) was analyzed and resulted in cost savings, those savings are not included in the aggregate results. This is because the analysis was limited to a single year, 2025, which prevented the calculation of a levelized dollars-per-ton cost-effectiveness number consistent with the other options.)[14] The approach used for the 46 policy recommendations was similar to a conventional cost-benefit framework but had some important differences:

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[11] Since the policies recommended by the MCCAG fully satisfy the GHG reduction goals for 2015 and are within 1 $MMtCO_2e$ of meeting the goal for 2025, the cap-and-trade policy (C&T-1) did not generate 'reductions' of its own (i.e., the 'cap' was met). Instead, C&T-1 enabled the achievement of the projected reductions (within the covered sectors) at a lower cost than would have been possible without the cap-and trade-program.

[12] 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). Minnesota imports electric power and must account for the emissions this consumption creates, even though they are not produced in-state.

[13] The analysis addressed the costs / cost savings of each policy recommendation and, with the exception of a few recommendations that address rate structures, did not attempt to estimate specific price changes or utility rate changes that might result from implementation of a policy.

[14] The analysis of a regional cap-and-trade program required the development of marginal cost curves for Minnesota and any other jurisdiction participating in the program, which ultimately totaled 22 states and Canadian provinces. The limitations of time and the demands on the model to provide results of multiple scenarios limited the model's results to the single 'snapshot' year of 2025.

- *Discounted and "levelized" costs*—Fairly standard approaches were taken here. The "net present value" of costs was calculated by applying a real discount rate of 5%. Dollars-per-ton estimates were derived as a "levelized" cost per ton, dividing the "present value cost" by the cumulative GHG reduction measured in tons. As was the case with GHG reductions, the period 2008–2025 was analyzed.
- *Benefits vs. costs*—The principal benefit of the MCCAG policy recommendations is reduced GHG emissions and these were quantified simply as metric tons. There was no attempt to monetize the benefit of these reductions in atmospheric concentration (e.g., health benefits). Many policies did create easily monetized non-GHG benefits (e.g., fuel savings and electricity savings). In these cases, monetized benefits were subtracted from monetized costs, resulting in net costs. These net costs could be positive or negative; negative costs indicated that the policy saved money or produced "cost savings."
- *Direct vs. indirect effects*—Cost estimates were based on "direct effects" (i.e., those borne by the entities implementing the policy).[15] 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).

Contributing Issues: The MCCAG recommendations were guided in part by the GHG reductions and monetized costs and benefits of various options, but members also felt that other considerations (e.g., social, economic, and environmental) should also have weight. The TWGs were asked to examine these qualitative terms where deemed important and quantify them on a case-by-case, as needed, depending on need and where data were readily available.

Minnesota GHG Emissions Inventory and Reference Case Projections

The CCS, with assistance from the Minnesota PCA, prepared a draft of Minnesota's GHG emissions inventory and reference case projections for the MCCAG.[16] The draft inventory and reference case projections, completed in July 2007, provided the MCCAG with an initial, comprehensive understanding of current and possible future GHG emissions. The draft report was provided to the MCCAG and the TWGs to assist the MCCAG in understanding past, current, and possible future GHG emissions in Minnesota and thereby inform the policy recommendation development process. The MCCAG 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 was revised to address the comments approved by the MCCAG and was subsequently approved by the MCCAG at its seventh meeting.

The inventory and reference case projections included detailed coverage of all economic sectors and GHGs in Minnesota, including future emissions trends and assessment issues related to

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

[16] *Draft Minnesota Greenhouse Gas Inventory and Reference Case Projections, 1990–2020*, prepared by the Center for Climate Strategies for the Minnesota Pollution Control Agency, July 2007.

energy, economic, and population growth. The assessment included estimates of total statewide "gross emissions" (leaving aside carbon sequestration[17]) on a production basis for all sources and a consumption basis for the electricity sector (see prior discussion under "Analysis of Policy Recommendations" in this chapter for an explanation of the production versus consumption approach). The assessment found that forests and agricultural lands in Minnesota have been a net source rather than a sink of carbon emissions largely due to the loss of these lands to other uses. Consequently, in Minnesota "net emissions" (in which reductions due to sequestration are subtracted from gross emissions) are equal to gross emissions. Further discussion of the issues involved in developing the inventory and reference case projections is summarized in Chapter 2 (Inventory and Projections of GHG Emissions) and discussed in detail in the final report for the inventory and reference case projections.

The inventory and reference case projections revealed substantial emissions growth rates and related mitigation challenges. Figure 1-2 shows the reference case projections for Minnesota's gross GHG emissions as rising fairly steeply to 200 $MMtCO_2e$ by 2025, growing by 68% over 1990 levels. Figure 1-2 also provides the sectoral breakdown of forecasted GHG emissions.

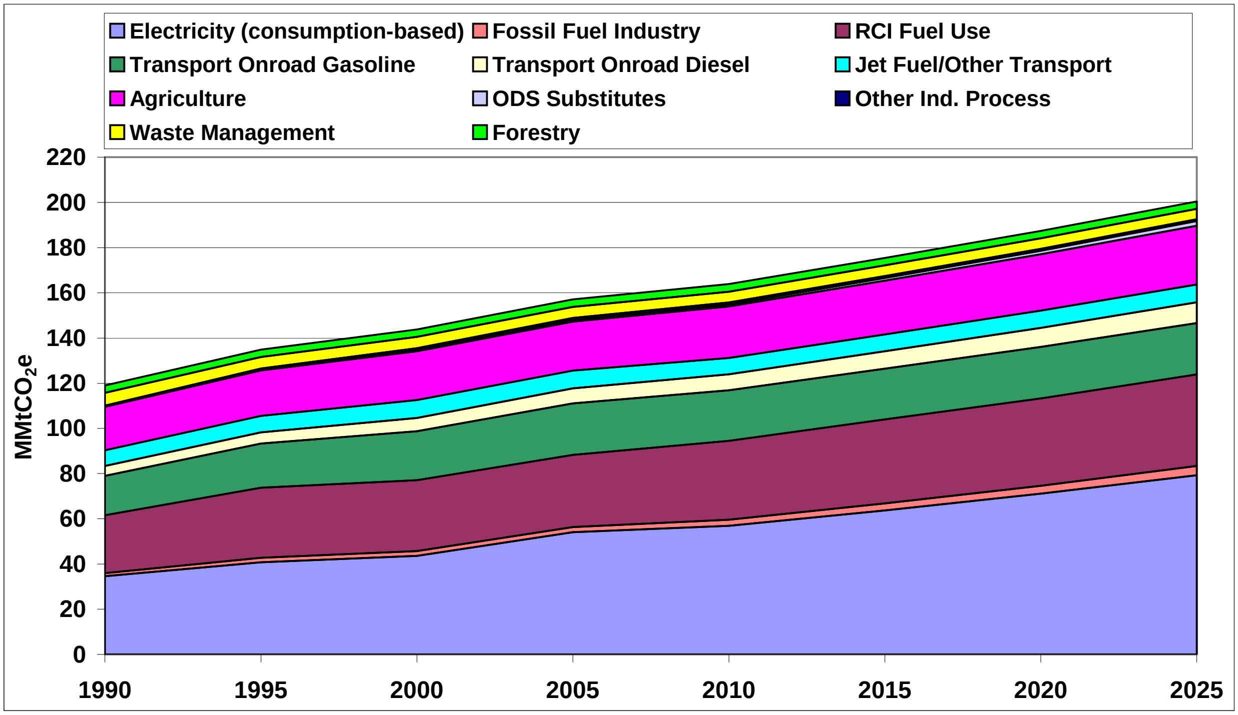
The inventory and projection of Minnesota's GHG emissions provided the following critical findings:

- As is common in many states, the production and consumption of electricity and transportation are the sectors with the largest emissions, and they are expected to continue to grow faster than other sectors.
- Emissions associated with electricity generation and imports to meet in-state demand is projected to be the largest contributor to future emissions growth, followed by emissions associated with the RCI fuel use sectors. Other sources of emissions growth include agriculture, primarily from agricultural soils; transportation fuel use, primarily from on-road diesel; the transmission and distribution of natural gas; and the increasing use of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) as substitutes for ozone-depleting substances (ODSs) in refrigeration, air conditioning, and other applications.

While Minnesota's emissions estimated growth rate (68% from 1990 to 2025 on a gross emissions, consumption basis) presents challenges, it also provides major opportunities. Key choices regarding technologies and infrastructure can have a significant impact on the emissions of a fast growing state. The MCCAG's recommendations document the opportunities for the state to reduce its GHG emissions while continuing its strong economic growth by being more energy efficient, using more renewable energy sources, and increasing the use of cleaner transportation modes, technologies, and fuels.

[17] Sequestration refers to the storing of carbon in mines, brine strata, oceans, plants and soil. As trees and other plants grow they remove CO_2, the principal GHG, from the atmosphere transforming the carbon (C) through photosynthesis into cellulose, starch and sugars, thus sequestering it in their structures and roots. The oxygen (O_2) is released back into the atmosphere. Minnesota's forests and agricultural lands are capable of sequestering much CO_2, as described in Chapter 6 (Agriculture, Forestry, and Waste Management).

Figure 1-2. Gross GHG emissions by sector, 1990–2020: historical and projected (consumption-based approach) business as usual/base case



RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone depleting substance.

MCCAG Policy Recommendations (Beyond Recent Actions)

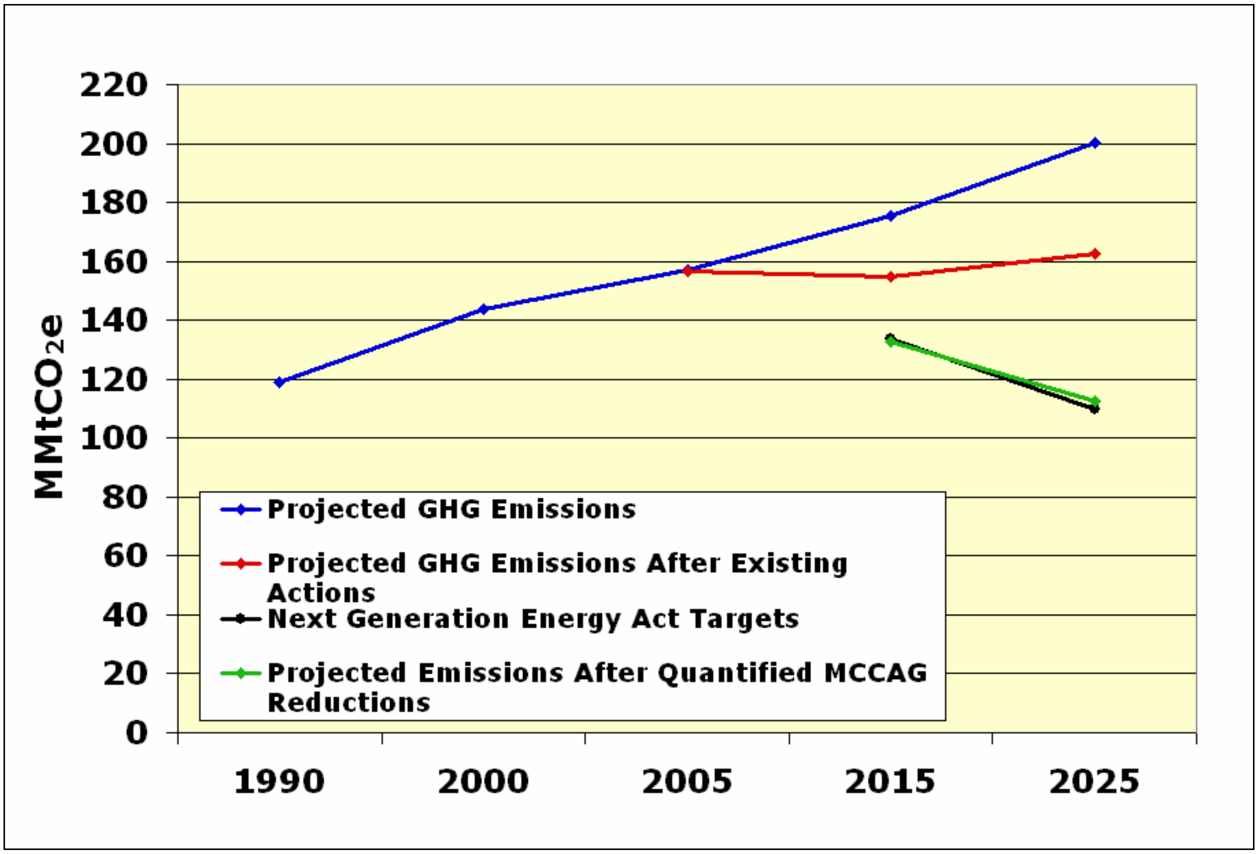
The MCCAG recommended 46 policy actions. The MCCAG members present and voting approved 38 policy actions unanimously, approved 4 by a supermajority (four objections or fewer), and approved 4 by a majority (less than half object). Explanations of both individual objections and qualifications are in the appendixes to this report, which contain detailed accounts of the MCCAG's recommendations.

Figure 1-3 presents a summary of the policy recommendations for which emission reductions were quantified. Table 1-2 provides the numeric estimates underlying Figure 1-3. In Figure 1-3,

- Actual (for 1990, 2000, and 2005) and projected (for 2015 and 2025) levels of Minnesota's gross GHG emissions on a consumption basis are shown by the blue line. (The consumption-based approach accounts for emissions associated with the generation of electricity in-state and imported from out-of-state to meet Minnesota's demand for electricity.)
- Projected emissions associated with Minnesota's existing actions that were analyzed quantitatively are shown by the red line.
- Projected emissions if all of the MCCAG's 31 recommendations that were analyzed quantitatively with respect to their GHG reduction potential are completely implemented and the estimated reductions are fully achieved are shown by the green line. (Note that other MCCAG recommendations would have the effects of reducing emissions, but those reductions were not analyzed quantitatively and they are not reflected in the green line.)

- Projected emissions associated with Minnesota's statewide GHG reduction targets are shown by the black line.

Figure 1-3. Annual GHG emissions: reference case projections and MCCAG recommendations (consumption-basis, gross emissions)



MMtCO$_2$e = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; MCCAG = Minnesota Climate Change Advisory Group.

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

Annual Emissions ($MMtCO_2e$)	1990	2000	2005	2015	2025
Reference Case Projections	119.0	143.8	157.1	175.5	200.5
Reductions From Recent Actions	0.0	0.4	0.4	20.8	37.8
Projected GHG Emissions After Recent Actions			156.6	154.7	162.6
Next Generation Energy Act Targets				133.5	110.0
Total GHG Reductions From MCCAG Recommendations				22.2	50.3
Difference Between MCCAG Reductions and Next Generation Energy Act Targets				–1.0	2.4
Projected Annual Emissions After Quantified MCCAG Reductions				132.5	112.4

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; MCCAG = Minnesota Climate Change Advisory Group.

The MCCAG approved 46 recommendations to reduce emissions, of which 31 were analyzed quantitatively to estimate their effects on emissions and 25 were analyzed quantitatively to estimate their costs/cost savings. The analyzed measures were estimated to have a cumulative effect of reducing emissions by about 22 $MMtCO_2e$ in 2015 and 50 $MMtCO_2e$ in 2025. Together, the estimated emission reductions associated with the MCCAG's recommendations and recent actions would be enough to achieve Minnesota's GHG reduction goal for 2015 and be within 2.4 $MMtCO_2e$ of meeting Minnesota's goal for 2025. The 25 recommendations analyzed in terms of their cost-effectiveness were estimated to have a total net cost of about $726 million between now and 2025, representing the incremental cost to the recent actions. While the MCCAG's 15 other recommendations were not readily quantifiable, many of them would likely achieve additional reductions and net savings (e.g., recommendations for the TLU sector). Should Minnesota implement the MCCAG's recommendations to participate in a cap-and-trade program, opportunities exist for reducing the costs associated with the MCCAG's policy recommendations for the electricity supply sector. In addition, emerging technologies may hold the potential to reduce emissions even more.

Table 1-3 provides a summary by sector of the estimated cumulative impacts of implementing all of the MCCAG's recommendations. Table 1-4 shows the estimated GHG reductions, costs, or savings from each policy recommendation and the recommendation's cost-effectiveness (cost or savings per ton of reduction) upon which the cumulative impacts in Table 1-3 are based. Note that the cumulative impacts shown in Table 1-3 account for overlaps between policies by eliminating potential double counting of emission reductions and costs or cost savings. Chapters 3 through 8 and the Appendixes provide detailed descriptions and analysis of GHG reductions, costs or cost savings, additional impacts, and feasibility for each policy developed by the six TWGs for each sector.

In order for the policies recommended by the MCCAG to yield the levels of estimated emission reductions and cost savings shown in Table 1-3, the policies must be implemented in a timely, aggressive, and thorough manner. In some cases, the actions recommended by the MCCAG are precise, concrete steps. In other cases, the recommendations are more general, and work must be done to develop precise, concrete steps to achieve goals recommended by the MCCAG. In the latter case, the additional work to identify precise, concrete actions is needed before they can be implemented. While there are considerable benefits to both the environment and to consumers from implementation of the policy recommendations, 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. It should be noted that the MCCAG's policy recommendations complement the numerous other climate-related efforts underway in Minnesota outlined at the beginning of this chapter, underscoring the potential co-benefits of their implementation.

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

Sector	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
	2015	2025	Total 2008–2025		
Residential, Commercial, and Industrial (RCI, non-electricity)	0.76	0.69	10.41	–$464	–$44.6
Integrated RCI and ES for electricity	1.56	7.34	51.06	–$1,098	–$21.5
Energy Supply (ES, including RCI options with impacts on electricity consumption, and adjusted for RCI and ES electricity options that overlap)	1.97	3.43	37.55	$462.2	–$12.3
Transportation and Land Use	4.70	9.30	91.2	–$264	N/A
Agriculture, Forestry, and Waste Management	13.2	29.5	279	$2,090	$7
Cross-Cutting Issues	*Non-quantified, enabling options*				
TOTAL (includes all adjustments for overlaps and recent actions)*	**20.2**	**50.3**	**469.2**	**$725.8**	**N/A**

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 options. Within each sector, values have been adjusted to eliminate double counting for options or elements of options that overlap. In addition, values associated with options or elements of options within a sector that overlap with options or elements of options in another sector have been adjusted to eliminate double counting.

N/A = not available; for TLU policies, an overall cost-effectiveness value is not provided because costs or cost savings were not estimated for all of the policies (due to the lack of data) for which emission reductions were estimated. Similarly, an overall cost-effectiveness value for all sectors is not provided for the same reason.

Note that the row in Table 1-3 for the RCI sectors includes only that portion of RCI emissions reductions and net cost savings that are from RCI options (or elements of options) that affect fuels combusted for purposes other than generating electricity. RCI emissions reductions and net cost savings that affect electricity use or generation are included in the "Integrated RCI and ES for electricity" row in Table 1-3 because the benefits and costs of electricity-sector options are dependent on the electrical load served, which is affected by RCI electricity savings.

Table 1-4. Residential, Commercial, and Industrial Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$) 2015	2025	Total (2008–2025)	Net Present Value (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
RCI-1	Maximize Savings From the Utility Conservation Improvement Program (CIP) *	*Quantified as a "Recent Action"*					Enacted
RCI-2	Improved Uniform Statewide Building Codes	0.004	0.005	0.077	–$44	–$576	Unanimous
RCI-3	Green Building Guidelines and Standards Based on *Architecture 2030*	0.62	0.94	11.1	–$296	–$27	Unanimous
RCI-4	Incentives and Resources to Promote Combined Heat and Power (CHP)	0.96	4.95	33.1	$125	$3.8	Unanimous
RCI-5	Program to Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs	0.02	0.05	0.5	–$2	–$5	Unanimous
RCI-6	Non-Utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions	0.25	1.30	8.3	–$307	–$37	Unanimous
RCI-7	Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency	0.05	0.05	0.7	–$21	–$28	Unanimous
RCI-8	Energy Performance Disclosure	*Not quantified*					Unanimous
RCI-9	Promote Technology-Specific Applications to Reduce GHG Emissions	*Not quantified*					Unanimous
RCI-10	Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards	0.8	1.4	15.3	–$1,895	–$124	Unanimous
	Sector Total After Adjusting for Overlaps (RCI, Non-Electricity)	**0.76**	**0.69**	**10.41**	**–$464**	**–$44.6**	
	Sector Total After Adjusting for Overlaps (Integrated RCI and ES for Electricity)	**1.56**	**7.34**	**51.06**	**–$1,098**	**–$21.5**	
	Reductions From Recent Actions	**6.50**	**15.50**	**143.4**	**–$8,454**	**–$59.0**	
	New Commercial Building Code	**0.18**	**0.21**	**3.16**	**–$1.8**	**–$0.6**	
	Sustainability Guidelines (New State Buildings)	**0.22**	**0.46**	**4.72**	**–$1.7**	**–$0.4**	
	10% Savings in State Buildings	**0.09**	**0.11**	**1.75**	**–$0.9**	**–$0.5**	
	RCI-1: New CIP*	**6.01**	**14.72**	**133.8**	**–$8,449**	**–$63.2**	
	Sector Total Plus Recent Actions	**8.82**	**23.5**	**204.9**	**–$10,016**	**–$48.9**	

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

Only the results of recommendations included in the final tabulation of GHG reductions and costs are shown in this table. For discussion of any sensitivity analyses undertaken, please see the discussion in RCI Appendix F, Annex 1.

* The CIP considered here is based on the CIP requirements (i.e., 1.5% energy savings goal) included in the Next Generation Energy Act of 2007; therefore, the emission reductions and cost savings estimated are included under "recent actions."

Table 1-4 (continued). Energy Supply Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2025	Total (2008–2025)			
ES-1	Generation Performance Standard	0.0	0.0	0.0	$0	$0.0	Majority (16 objections)
ES-3	Efficiency Improvements, Re-powering and other Upgrades to Existing Plants	1.8	3.0	33.3	$554.4	$16.7	Unanimous
ES-4	Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss	0.2	0.4	3.9	–$92.2	–$26.1	Unanimous
ES-5	Renewable and/or Environmental Portfolio Standard *	*Quantified as a "Recent Action"*					Enacted
ES-6	Nuclear Power Support and Incentives	0	0	0	$0	$0	Unanimous
ES-8	Advanced Fossil Fuel Technology Incentives, Support or Requirements, Including Carbon Capture and Storage	0.0	0.0	0.0	$0	$0.0	Unanimous
ES-10	Voluntary GHG targets	*Not quantified*					Unanimous
ES-12	Distributed Renewable Energy Incentives and/or Barrier Removal	0.021	0.023	0.37	$29.1	$78.1	Unanimous
ES-13	Technology-Based Approaches, Including Research and Development, Fuel Cells, Energy Storage, Distributed Renewable Energy Technologies, etc.	*Not quantified*					Unanimous
	Sector Total After Adjusting for Overlaps	**2.0**	**3.4**	**37.5**	**$462.2**	**$12.3**	
	Reductions From Recent Actions	**12.8**	**20.8**	**225**	**$10,116**	**$45.0**	
	Biomass for Electricity	**0.60**	**0.60**	**11.4**	**$285.3**	**$25.0**	
	Metro Emissions Reduction Project	**4.52**	**4.52**	**80.4**	**$2,330**	**$29.0**	
	ES-5: Renewable Energy Standard*	**7.72**	**15.7**	**133.1**	**$7,502**	**$56.4**	
	Sector Total Plus Recent Actions	**14.8**	**24.2**	**262.5**	**$10,578**	**$40.3**	

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 recommendations. Totals in some columns may not add to the totals shown due to rounding.

All totals are relative to the underlying assumption that electricity expansion in Minnesota proceeds with the recently legislated Conservation Improvement Program (CIP), Renewable Energy Standard (RES), and all planned additions including the Mesaba and Big Stone 2 stations.

* The RES considered here is based on the RES requirements included in the Next Generation Energy Act of 2007; therefore, the emission reductions and cost s estimated are included under "recent actions."

Table 1-4 (continued). Transportation and Land Use Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$) 2015	2025	Total 2008–2025	Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
TLU Area 1: Reduce VMT (VMT goal to be established based on VMT implied by selected strategies)							
TLU-1	Improved Land-Use Planning and Development Strategies	0.7	1.9	14.9	*Net savings*	*Net savings*	Unanimous
TLU-2	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.1	0.3	3.0	$0	$0	Unanimous
TLU-5	Climate-Friendly Transportation Pricing/Pay as You Drive	1.1	2.1	20.9	–$1	–$1	Super-majority (3 objections)
TLU-7	"Fix-it-First" Transportation Investment Policy and Practice	*Not quantified*					Super - majority (2 objections)
TLU-9	Workplace Tools To Encourage Carpooling, Bicycling, and Transit Ridership	0.3	0.4	4.5	*Large net savings*	*Large net savings*	Unanimous
TLU-14	Freight Mode Shifts: Intermodal and Rail	*N/A*					Super - majority (1 objection)
TLU Area 2: Reduce Carbon per Unit of Fuel							
TLU-3	Low-GHG Fuel Standard	1.7	3.6	36.2	*Not quantified*		Unanimous
TLU Area 3: Reduce Carbon per Mile and/or per Hour							
TLU-4	Infrastructure Management	0.04	0.1	0.7	*Not quantified*		Unanimous
TLU-6	Adopt California Clean Car Standards	0.74	1.16	13.1	–$263	–$39	Majority (16 objections)
TLU-12	Voluntary Fleet Emission Reductions	0.4	0.4	6.1	*Not quantified*		Unanimous
TLU-13	Reduce Maximum Speed Limits	0.4	0.4	6.1	*N/A*	$50 at $2.40/gal –$19 at $3.40/gal	Majority (16 objections)
	Sector Total After Adjusting for Overlaps	**4.7**	**9.3**	**91.2**	**–$264**	***Not quantified***	
	Reductions From Recent Actions	**1.4**	**1.5**	**20.2**	***Not quantified***		
	Biodiesel	**0.64**	**0.75**	**8.1**			
	Ethanol	**0.78**	**0.79**	**12.1**			
	Sector Total Plus Recent Actions	**6.1**	**10.8**	**111.4**	**–$264**	***Not quantified***	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent, VMT = vehicle miles traveled; N/A = not available.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

Table 1-4 (continued). Agriculture, Forestry, and Waste Management Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2015	2025	Total 2008–2025			
AFW-1	Agricultural Crop Management						Unanimous
	A. Soil Carbon Management	0.72	1.3	15	–$34	–$2	
	B. Nutrient Management	0.79	1.3	15	–$543	–$37	
AFW-2	Land Use Management Approaches for Protection and Enrichment of Soil Carbon						Unanimous
	A. Preserve Land	0.15	0.44	3.7	$120	$33	
	B. Reinvest in Minnesota–Clean Energy (RIM-CE)	0.09	0.19	1.8	$59	$34	
	C. Protection of Peatlands & Wetlands	*Not Quantified*					
AFW-3	In-State Liquid Biofuels Production						Super Majority (4 objections)
	A. Ethanol Carbon Content	1.8	2.2	27	–$242	–$9	
	B. Fossil Diesel Displacement	0.03	0.19	1.4	$74	$55	
	C. Gasoline 35% Displacement	2.8	9.1	73	$336	$5	
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	1.3	3.8	31	$102	$3	Unanimous
AFW-5	Forestry Management Programs to Enhance GHG Benefits						Unanimous
	A. Forestation	0.55	2.2	17	$218	$13	
	B. Urban Forestry	1.2	2.7	26	–$295	–$12	
	C. Wildfire Reduction	*Not Quantified*					
	D. Restocking	2.1	8.4	65	$2,187	$33	
	E. Forest Health and Enhanced Sequestration	*Not Quantified*					
AFW-6	Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover	2.2	2.7	34	$101	$3	Unanimous
AFW-7	Front-End Waste Management Technologies						Unanimous
	A. Source Reduction	0	3.6	20	$59	$3	
	B. Recycling	3.1	3.4	45	–$207	–$5	
	C. Composting	0.29	0.41	4.9	$137	$28	
AFW-8	End-of-Life Waste Management Practices						Unanimous
	A. Landfill Methane Recovery	0.07	0.73	4.4	$5.7	$1	
	B. Residuals Management	0.52	0.63	8.1	$650	$80	
	C. WTE Preprocessing	0.37	0.84	7.9	$257	$32	
	Sector Total After Adjusting for Overlaps*	**13.2**	**29.5**	**279**	**$2,090**	**$7**	
	Reductions From Recent Actions	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
	Sector Total Plus Recent Actions	**13.2**	**29.5**	**279**	**$2,090**	**$7**	

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

*Overlaps include an assumed 100% overlap of AFW-3b&3c with TLU-3 (reductions excluded from AFW totals); an assumed 100% overlap of AFW-4 with ES-5 (reductions and costs excluded from AFW totals); overlap of AFW-7&8 (incremental benefits and costs of AFW-8 included in the AFW totals).

Table 1-4 (continued) Cross-Cutting Issues Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2015	2025	Total 2008-2025			
CC-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not quantified*					Unanimous
CC-2	Statewide GHG Reduction Goals and Targets	*Not quantified*					Unanimous
CC-3	State and Local Government GHG Emissions (Lead-by-Example)	*Not quantified*					Unanimous
CC-4	Public Education and Outreach	*Not quantified*					Unanimous
CC-7	Participate in Regional and Multistate GHG Reduction Efforts	*Not quantified*					Unanimous
CC-8	Encourage the Creation of a Business-Oriented Organization to Share Information and Strategies, Recognize Successes, and Support Aggressive GHG Reduction Goals	*Not quantified*					Unanimous
CC-9	Dedicate Greater Public Investment to Climate Data and Analysis	*Not quantified*					Unanimous
	Sector Total After Adjusting for Overlaps	***Not quantified***					
	Reductions From Recent Actions	***Not quantified***					
	Sector Total Plus Recent Actions	***Not quantified***					

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

Table 1-4 (continued) Cap-and-Trade (C&T) Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effective-ness* ($\$/tCO_2e$) 2025	Permit Price† ($\$/tCO_2e$) 2025	Level of Support
		2015	2025	Total (2008–2025)				
C&T-1	Cap-and-Trade Program							Majority (9 objections)
	MGA Partners C&T *—no RES/CIP in the baseline*		79.82			–$12.17	$48.45	
	MGA Partners C&T *—with both RES/CIP in the baseline*		52.94			$2.65	$45.95	
	MGA Partners C&T *—with only RES in the baseline*		67.35			–$15.42	$46.64	
	MGA Partners+Observers C&T *—no RES/CIP in the baseline*		81.97			–$10.52	$52.44	
	MGA Partners+Observers C&T *—with both RES/CIP in the baseline*		55.45			$4.71	$50.72	
	MGA Partners+Observers C&T *—with only RES in the baseline*		69.45			–$13.48	$51.27	
	MGA plus WCI Partners C&T *—no RES/CIP in the baseline*		72.64			–$17.52	$35.69	
	MGA plus WCI Partners C&T *—with both RES/CIP in the baseline*		46.93			–$2.19	$34.95	
	MGA plus WCI Partners C&T *—with only RES in the baseline*		61.92			–$20.36	$35.07	
	MGA and WCI Partners+Observers C&T *—no RES/CIP in the baseline*		76.17			–$14.92	$41.87	
	MGA and WCI Partners+Observers C&T *—with both RES/CIP in the baseline*		50.41			$0.59	$41.25	
	MGA and WCI Partners+Observers C&T *—with only RES in the baseline*		64.92			–$17.65	$41.39	
C&T-2	MN-Only C&T *—no RES/CIP in the baseline*		89.18			–$2.39	$65.48	Merged into C&T-1
C&T-3	National C&T	*Not quantified*						Merged into C&T-1
C&T-5	Market Advisory Group (Formerly CC-11)	*Not quantified*						Unanimous
C&T-6	Regional and Multistate GHG Reduction Efforts (Formerly CC-7)	*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; MGA = Midwestern Governors Association; C&T = cap-and-trade; RES = renewable electricity standard; CIP = Conservation Improvement Program; WCI = Western Climate Initiative; CC = Cost-Cutting Issues.

Negative numbers represent cost savings.

MGA C&T Partners include Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba; MGA C&T Observers include Indiana, Ohio, and South Dakota; WCI Partners include Arizona, California, New Mexico, Oregon, Utah, Washington, British Columbia, and Manitoba; WCI Observers include Colorado, Idaho, Montana, Nevada, and Wyoming. To run simulations including both MGA and WCI states in 2025, the C&T Technical Work Group (TWG) used 2020 marginal cost curves for WCI states for 2025. The emission cap for both MGA and WCI states (or provinces) is assumed to be 30% below the 2005 level in 2025.

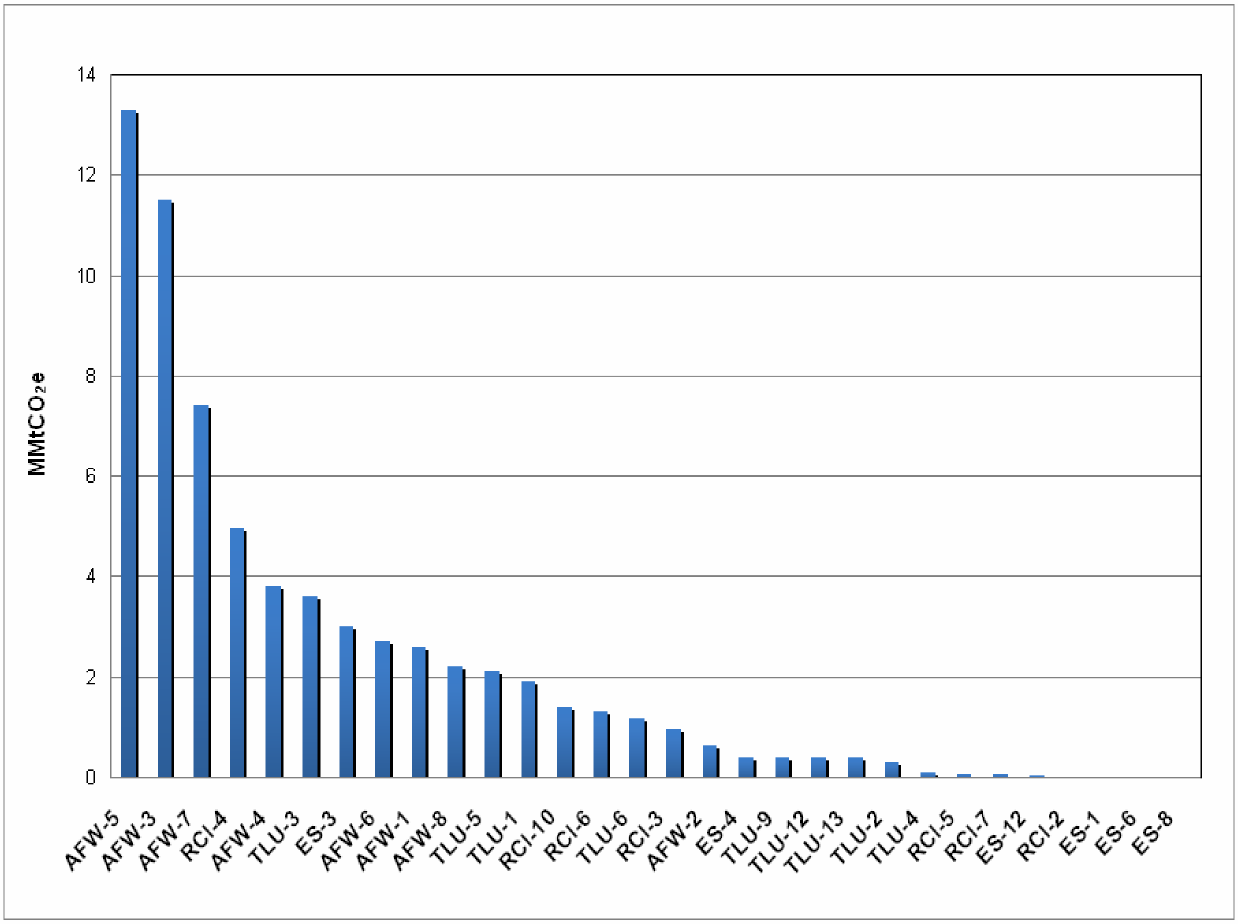
* This represents the average $\$/tCO_2e$ mitigated/sequestered for Minnesota.

† This represents the marginal cost of the last tCO_2e mitigated/sequestered and applies to all states involved in a trading arrangement.

Perspectives on Policy Recommendations

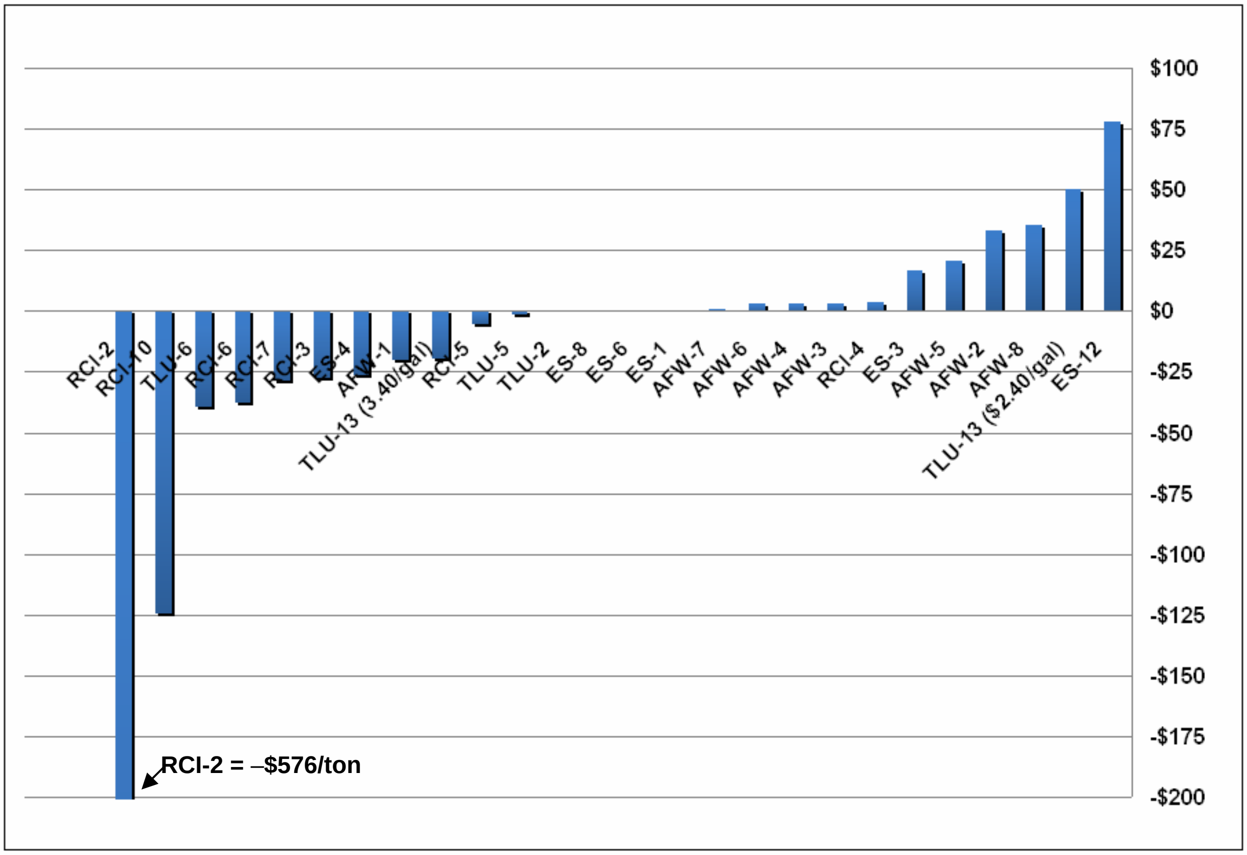
As explained above, the MCCAG considered the estimates of the GHG reductions that could be achieved by 31 of its recommendations, and the costs (or cost savings) of 25 of those 31. Having these analyses was very helpful to the MCCAG, but the MCCAG was mindful that these are estimates. There can be considerable imprecision in the GHG reductions associated with various policy recommendations. Figure 1-4 presents the estimated tons of reductions for each policy recommendation for which estimates were available, expressed as a cumulative figure for the period 2008–2025. In addition to the imprecision in GHG reductions achieved by each policy recommendation, there are also uncertainties in the exact cost (or cost savings) per ton of reduction achieved. Figure 1-5 presents the estimated dollars per ton cost (or cost savings, depicted as a negative number) for each policy recommendation for which cost estimates were available. This measure is calculated by dividing the net present value of the cost of the policy recommendation by the cumulative GHG reductions, all for the period 2008–2025. In some cases, there is a wide variation in the cost-effectiveness of the policy recommendations, depending on the assumptions used in the analysis.

Figure 1-4. MCCAG policy recommendations ranked by 2025 annual GHG reduction potential



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

Figure 1-5. MCCAG policy recommendations ranked by cost/cost savings per ton of GHG removed



RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use; ES = Energy Supply; AFW = Agriculture, Forestry, and Waste Management.

Note: Negative values represent net cost savings and positive values represent net costs associated with the policy recommendation.

The MCCAG recognizes that actions to address climate change have the potential to create unintentional yet significant adverse financial, pollutant exposure, and cultural impacts on low-income populations, communities of color, and/or diverse cultural communities. As Minnesota begins the process of refinement and implementation of actions to reduce GHG emissions, the Office of Energy Security, the Minnesota Pollution Control Agency, the Department of Commerce and other relevant state agencies and partners should actively engage meaningful representation from these communities to better understand the nature of their concerns and to facilitate their effective participation.

Chapter 2
Inventory and Projections of GHG Emissions

Introduction

This chapter presents a summary of Minnesota's greenhouse gas (GHG) emissions and sinks (carbon storage) from 1990 to 2025. The Center for Climate Strategies (CCS) prepared a draft of Minnesota's GHG emissions inventory and reference case projections for the Minnesota Climate Change Advisory Group (MCCAG) of the Office of the Governor of Minnesota.[1] The draft inventory and reference case projections, completed in July 2007, provided the MCCAG with an initial, comprehensive understanding of current and possible future GHG emissions. The draft report was provided to the MCCAG and its Technical Work Groups (TWGs) to assist the MCCAG in understanding past, current, and possible future GHG emissions in Minnesota and thereby inform the policy recommendation development process. The MCCAG 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 MCCAG. In addition, the forecast has been extended to the year 2025 to comport with the Next Generation Energy Act of 2007 recently adopted by the State legislature and signed into law by the Governor of Minnesota.[2] The information in this chapter reflects the information presented in the final inventory and reference case projections report (hereafter referred to as the Inventory and Projections).[3]

Historical GHG emissions estimates (1990 through 2005)[4] were developed using a set of generally accepted principles and guidelines for state GHG emissions inventories, relying to the extent possible on Minnesota-specific data and inputs. The Minnesota Pollution Control Agency's (MPCA's) GHG inventory for 1990 through 2004 provides state-specific estimates for all the source sectors located within Minnesota. Therefore, historical emissions are based on the MPCA inventory. 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. 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

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[1] *Draft Minnesota Greenhouse Gas Inventory and Reference Case Projections, 1990–2020*, prepared by the Center for Climate Strategies for the Minnesota Pollution Control Agency, July 2007.

[2] Minnesota Session Laws 2007, Chapter 136, S.F. No. 145, available at: https://www.revisor.leg.state.mn.us/laws/?id=136&year=2007&type=0

[3] *Final Minnesota Greenhouse Gas Inventory and Reference Case Projections, 1990–2025*, prepared by the Center for Climate Strategies for the Minnesota Pollution Control Agency, February 2008.

[4] The last year of available historical data for each sector varies between 2000 and 2005.

the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential– (GWP–)weighted basis.[5]

It is important to note that the emissions estimates reflect the GHG emissions associated with the electricity sources used to meet Minnesota'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.

Minnesota GHG Emissions: Sources and Trends

Table 2-1 provides a summary of GHG emissions estimated for Minnesota by sector for the years 1990, 2000, 2005, 2010, 2020, and 2025. As shown in this table, Minnesota is estimated to be a net source of GHG emissions (positive, or gross, emissions). No sinks of GHG emissions (removal of emissions, or negative emissions) were identified for Minnesota. As a result, Minnesota's gross GHG emissions are the same as the net emissions. The following sections discuss GHG emission sources, trends, projections, and uncertainties.

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

MMtCO_2e	1990	2000	2005	2010	2020	2025
Energy Use (CO_2, CH_4, N_2O)	**90.3**	**112.5**	**125.5**	**131.2**	**152.1**	**163.7**
Electricity Use (Consumption)	**34.7**	**43.6**	**54.1**	**57.0**	**71.2**	**79.3**
Electricity production (in-state)	29.6	35.2	37.2	38.4	43.5	43.4
Coal	28.1	33.0	34.5	34.5	39.3	39.2
Natural gas	0.48	0.65	1.59	2.77	2.93	3.03
Oil	0.50	0.86	0.63	0.63	0.63	0.63
MSW/landfill gas	0.52	0.69	0.53	0.54	0.57	0.59
Biomass, nuclear (CH_4 and N_2O)	0.003	0.008	0.000	0.001	0.001	0.001
Net imported electricity	5.03	8.41	16.8	18.6	27.7	35.9
Residential/Commercial/Industrial (RCI) Fuel Use	**25.6**	**31.32**	**32.0**	**35.0**	**38.6**	**40.5**
Coal	1.97	3.34	2.54	2.71	2.87	3.00
Natural gas	14.3	17.6	17.5	19.9	22.7	23.8
Petroleum	9.17	10.2	11.7	12.2	12.9	13.4
Wood (CH_4 and N_2O)	0.21	0.18	0.20	0.21	0.23	0.24
Transportation	**28.7**	**35.4**	**37.2**	**36.6**	**38.8**	**39.8**
On-road gasoline	17.3	21.7	22.7	22.3	22.7	22.7
On-road diesel	4.46	5.85	6.67	7.11	8.49	9.18
Marine vessels	2.69	1.97	1.86	1.79	1.76	1.74

[5] 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, 1996). 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), http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm

$MMtCO_2e$	1990	2000	2005	2010	2020	2025
Jet fuel and aviation gasoline	3.45	5.03	4.95	4.61	5.19	5.49
Rail, natural gas, other	0.77	0.85	0.99	0.75	0.67	0.63
Fossil Fuel Industry	**1.37**	**2.12**	**2.25**	**2.60**	**3.50**	**4.07**
Natural gas industry	1.37	2.12	2.25	2.60	3.50	4.07
Industrial Non-Fuel Use Processes	**0.61**	**1.37**	**1.56**	**1.80**	**2.46**	**2.95**
Lime manufacture (CO_2)	0.000	0.04	0.02	0.02	0.02	0.02
Limestone use (CO_2)	0.01	0.02	0.02	0.02	0.02	0.02
Taconite production (CO_2)	0.31	0.58	0.58	0.61	0.67	0.70
Peat mining and use (CO_2)	0.04	0.07	0.06	0.06	0.06	0.06
Ammonia manufacture (CO_2)	0.03	0.000	0.000	0.000	0.000	0.000
ODS substitutes (HFC, PFC, and SF_6)	0.000	0.41	0.65	0.93	1.60	2.06
Semiconductor manufacturing (HFC, PFC)	0.000	0.032	0.021	0.015	0.008	0.007
Electric power T&D (SF_6)	0.21	0.21	0.20	0.14	0.08	0.07
Medical (N_2O)	0.008	0.008	0.008	0.009	0.009	0.010
Agriculture	**19.2**	**21.7**	**21.7**	**22.7**	**24.9**	**26.0**
Enteric fermentation	3.49	3.39	3.25	3.08	2.80	2.68
Manure management	1.96	2.80	2.91	2.96	3.09	3.16
Agricultural soils	9.15	10.7	10.7	11.7	13.8	14.9
Rice cultivation	0.10	0.09	0.11	0.14	0.20	0.24
Residential fertilizer	0.09	0.10	0.12	0.13	0.15	0.16
Agricultural burning	0.00	0.00	0.00	0.00	0.00	0.00
Urea application and liming	0.33	0.50	0.59	0.63	0.73	0.77
Changes in cultivation practices[†]	4.06	4.06	4.06	4.06	4.06	4.06
Waste Management	**5.55**	**4.97**	**4.96**	**4.85**	**4.66**	**4.58**
Solid waste management	5.27	4.64	4.62	4.48	4.23	4.11
Wastewater management	0.28	0.33	0.35	0.37	0.43	0.47
Forestry and Land Use	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**
Total Gross (and Net) Emissions (Consumption Basis)[†]	**119.0**	**143.8**	**157.1**	**163.8**	**187.4**	**200.5**
Increase relative to 1990		21%	32%	38%	57%	68%

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; CH_4 = methane; N_2O = nitrous oxide; MSW = municipal solid waste; 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.

[†] Forest lands and changes in cultivation practices related to agricultural soils are net sources rather than sinks of emissions; therefore, gross and net emissions are the same.

Historical Emissions

Overview

In 2005, on a gross emissions consumption basis (i.e., excluding carbon sinks), Minnesota accounted for approximately 157 million metric tons (MMt) of CO_2e emissions, an amount equal to 2.2% of total U.S. gross GHG emissions. On a net emissions basis (i.e., including carbon sinks), Minnesotans also accounted for approximately 157 $MMtCO_2e$ of emissions in 2005 (the same as gross emissions since no emission sinks were identified in Minnesota), an amount equal to 2.4% of total U.S. net GHG emissions.[6] Minnesota's GHG emissions are rising more quickly than those of the nation as a whole. From 1990 to 2005, Minnesota's gross and net GHG emissions increased by 32% while national gross emissions rose by 16% during this period.[7]

On a per capita basis, Minnesotans emitted about 30 metric tons (t) of gross CO_2e in 2005, greater than the national average of about 24 tCO_2e. Figure 2-1 illustrates the State's emissions per capita and per unit of economic output. It also shows that in Minnesota per capita emissions have increased from 1990 to 2005, while per capita emissions remained fairly flat for the nation as a whole. In both Minnesota 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 Minnesota.[8]

The principal sources of Minnesota's GHG emissions in 2005 are electricity use (including electricity imports) and transportation, accounting for 34% and 24% of Minnesota's gross GHG emissions, respectively, as shown in Figure 2-2. The use of fossil fuels—natural gas, oil products, coal, and wood—in the residential, commercial, and industrial (RCI) sectors accounts for another 20% of the state's emissions in 2005.

Agricultural activities, such as manure management, fertilizer use, livestock (enteric fermentation), and changes in soil carbon due to cultivation practices, result in CH_4 and N_2O emissions that account for another 14% of state GHG emissions. This is greater than the U.S. portion of emissions attributable to agriculture (8%). Landfills and wastewater management facilities produce CH_4 and N_2O emissions that accounted for 3% of total gross GHG emissions in Minnesota in 2005. Emissions associated with the transmission and distribution of natural gas accounted for 1% of the gross GHG emissions in 2005. Industrial process emissions accounted for about 1% of the state's GHG emissions in 2005, and these emissions are rising due to the increasing use of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) as substitutes for ozone-depleting chlorofluorocarbons (CFCs).[9] Other industrial processes emissions result from taconite, lime, and peat manufacturing; PFC use in semiconductor manufacture; CO_2 released during limestone, dolomite, and peat use; SF_6 released from transformers used in electricity transmission and distribution systems; and N_2O from medical uses.

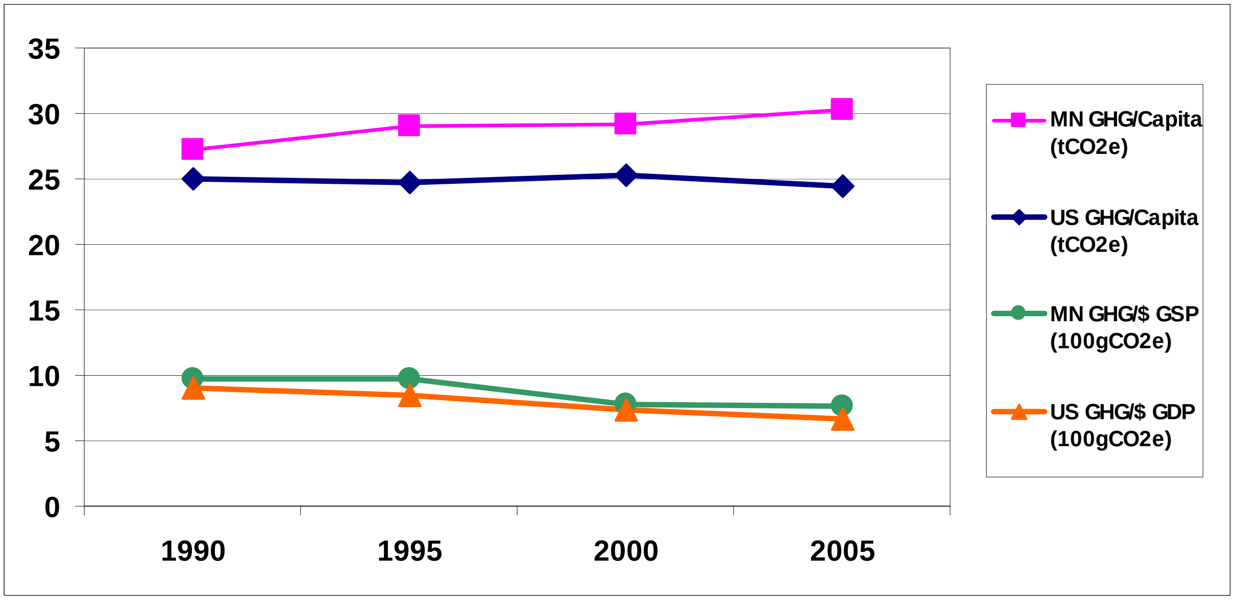
[6] National emissions from *Inventory of US Greenhouse Gas Emissions and Sinks:1990–2005*, April 2007, US EPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html

[7] During this period, population grew by 19% in Minnesota, which is the same as the national increase in population. However, Minnesota's economy grew at a faster rate on a per capita basis (up 71% vs. 57% nationally).

[8] Based on real gross domestic product (millions of chained 2000 dollars), that excludes the effects of inflation, available from the US Bureau of Economic Analysis, http://www.bea.gov/regional/gsp/

[9] CFCs are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Appendix I in the *Inventory and Projections* report for Minnesota, http://www.mnclimatechange.us/ewebeditpro/items/O3F16231.pdf

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



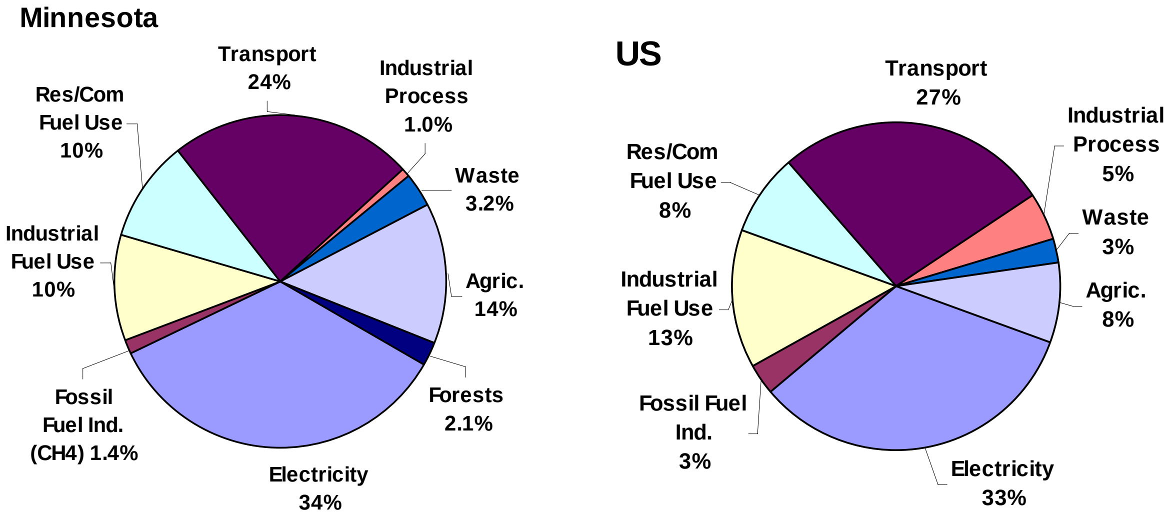
GSP = gross state product; GDP = gross domestic product; g = grams: tCO2e = tons carbon dioxide equivalent

Forestry emissions refer to the net CO_2 flux[10] from forested lands in Minnesota, which account for about 32% of the state's land area.[11] Minnesota's forests are estimated to be net sources of CO_2 emissions in Minnesota, accounting for about 2% of total gross GHG emissions in 2005. Forestry emissions are estimated to be a net source in Minnesota primarily due to a decrease in forested area over the period used to estimate the CO_2 flux for Minnesota (1990 to 2003), based on U.S. Forest Service (USFS) Forest Inventory Analysis data.

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

[11] Total forested acreage is 16.2 million acres in 2003; J. Smith, USFS, personal communication with S. Roe, CCS, April 2007. Acreage by forest type is available from the USFS at: http://nrs.fs.fed.us/pubs/rb/rb_nrs006.pdf. The total land area in Minnesota is 51 million acres, http://www.50states.com/minnesot.htm

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



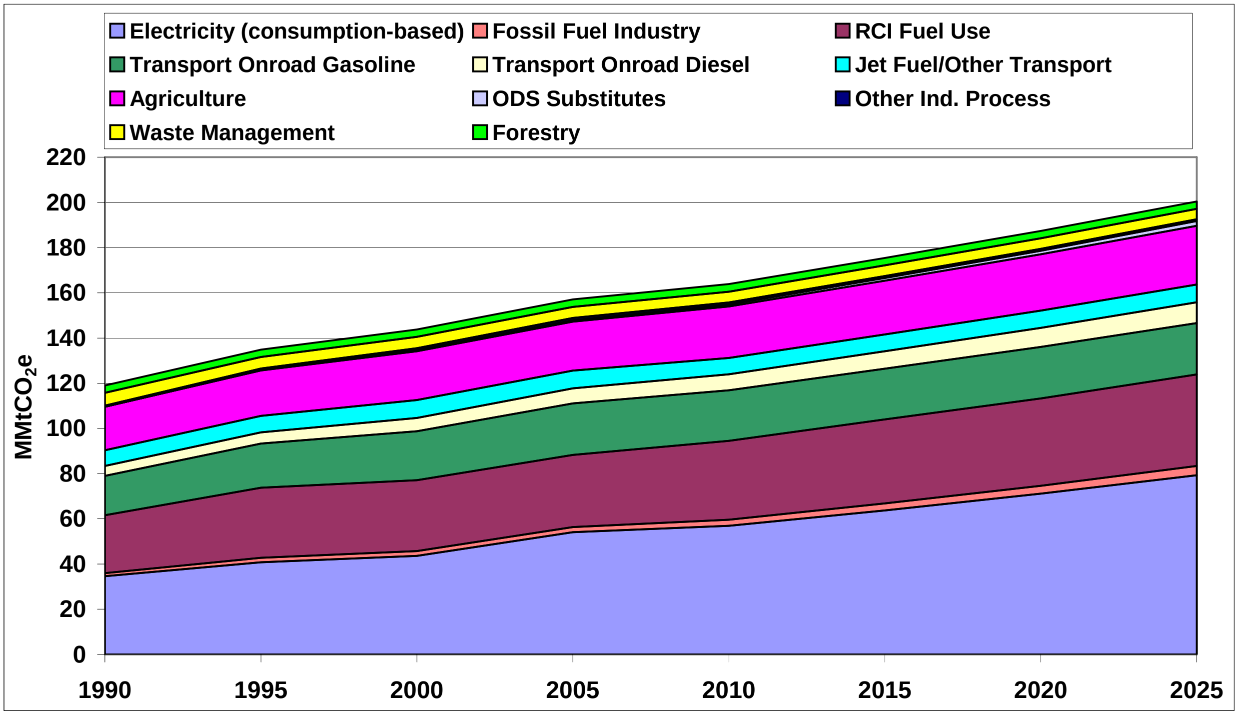
Note: At a national level, forests act as a net sink of CO_2; therefore, they do not show up in the above graph of gross US emissions sources.

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, Minnesota's gross GHG emissions continue to grow steadily, climbing to about 200 $MMtCO_2e$ by 2025, 68% above 1990 levels. This equates to an annual rate of growth of 1.2% per year. By 2025, the share of emissions associated with electricity consumptions grows to 40% of total gross and net GHG emissions. The share of emissions from the RCI fuel use sector increase slightly to 21% of Minnesota's gross and net GHG emissions in 2025, while the share of emissions from the transportation sectors declines somewhat to 20% by 2025, with slightly lower emissions than the RCI fuel use sector.

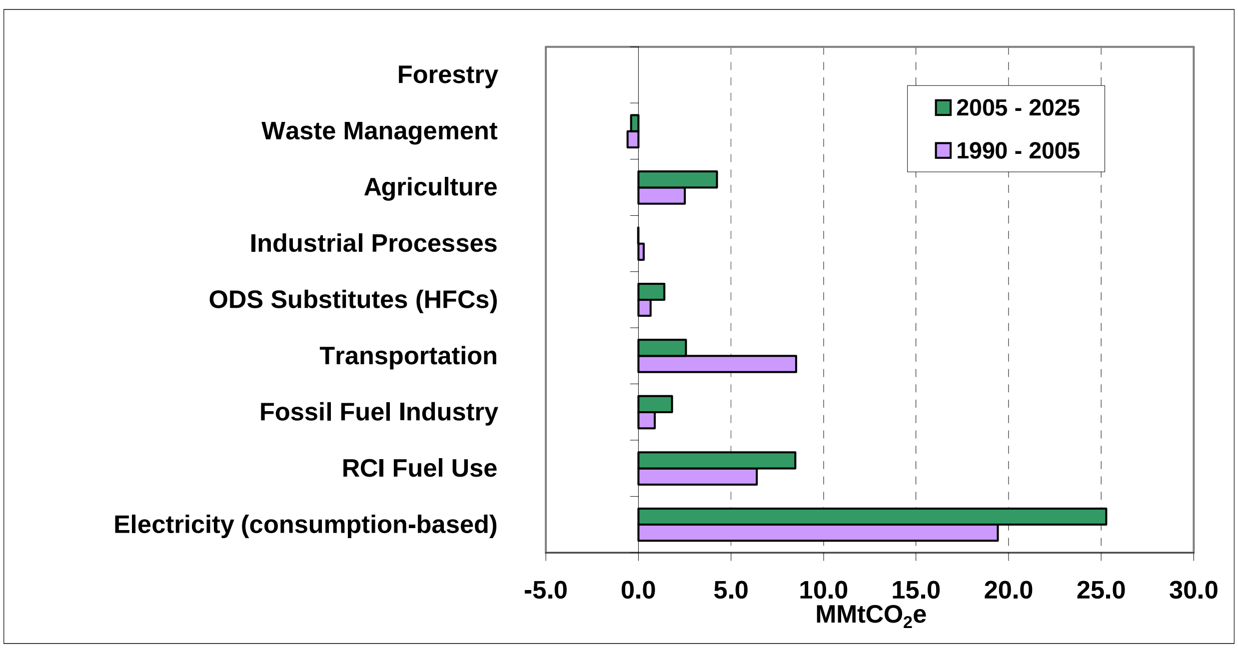
Emissions associated with electricity generation and imports to meet in-state demand is projected to be the largest contributor to future emissions growth, followed by emissions associated with the RCI fuel use, as shown in Figure 2-4. Other sources of emissions growth include agriculture, primarily from agricultural soils; transportation fuel use, primarily from on-road diesel; the transmission and distribution of natural gas; and the increasing use of HFCs and PFCs as substitutes for ozone-depleting substances (ODSs) in refrigeration, air conditioning, and other applications. Table 2-2 summarizes the growth rates that drive the growth in the Minnesota reference case projections as well as the sources of these data.

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



RCI = direct fuel use in residential, commercial, and industrial sectors; ODS = ozone depleting substance.

Figure 2-4. Sector contributions to gross emissions growth in Minnesota, 1990–2025: reference case projections (MMtCO$_2$e basis)



ODS = ozone depleting substance; HFCs = hydrofluorocarbons; RCI = direct fuel use in residential, commercial, and industrial sectors.

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

	1990–2005	2005–2025	Sources
Population*	1.2%	0.8%	Minnesota Department of Administration, Office of Geographic and Demographic Analysis, State Demographic Center
Employment*			Minnesota Department of Employment and Economic Development
Goods	N/A[†]	0.4%	
Services	N/A	1.5%	
Electricity sales	2.3%	2.04%	Inventory: The US DOE Energy Information Administration's (EIA's) Electric Utility Sales data, available at: http://www.eia.doe.gov/cneaf/electricity/esr/esr_sum.html. As approved by the MCCAG, the average annual growth in electricity sales for 2005–2025 was assumed to be equal to the 2.04% per year, which corresponds to the average annual growth rate for the preceding 10-year period in Minnesota. This represents the business-as-usual forecast and does not include the effects of Minnesota's Conservation Improvement Program (CIP), which is addressed in Chapter 3 of this report.
Vehicle miles traveled	2.5%	0.8%	Minnesota Department of Transportation

* For the residential, commercial, and industrial (RCI) fuel consumption sectors, population and employment projections for Minnesota were used together with US DOE EIA's Annual Energy Outlook 2006 (AEO2006) projections of changes in fuel use for the EIA's U.S. West North Central region on a per capita basis for the residential sector, and on a per employee basis for the commercial and industrial sectors. For instance, growth in Minnesota's residential natural gas use is calculated as the Minnesota population growth times the change in per capita natural gas use for the West North Central region.

[†] N/A = not available; historical employment data for Minnesota for the goods producing and services providing sectors could not be identified during development of this report.

A Closer Look at the Two Major Sources: Electricity Supply and Transportation

As shown in Figure 2-2, electricity use in 2005 accounted for 34% of Minnesota's gross GHG emissions (about 54 $MMtCO_2e$), which is slightly higher than the national share of emissions from electricity production (33%). On a per capita basis, Minnesota's GHG emissions from electricity consumption are higher than the national average (in 2005, 10.4 $MMtCO_2e$ per capita in Minnesota vs. 8.1 $MMtCO_2e$ per capita nationally). From 1990 through 2005, electricity generated by coal-fired power plants in Minnesota accounted for 64% to 68% of total in-state generation. Nuclear power accounted for 25% to 30% of total in-state generation from 1990 through 2005. The remaining in-state generation came from a mix of natural gas, oil, refuse-derived fuel, and hydroelectric facilities. The consumption of imported electricity has increased from 12% of total Minnesota demand in 1990 to 27% of total Minnesota demand in 2005.[12]

As noted above, these electricity emissions estimates reflect the GHG emissions associated with the electricity sources used to meet Minnesota demands, corresponding to a consumption-based approach to emissions accounting. For many years, Minnesota power plants have tended to produce less electricity than is consumed in the State. In the year 2005, for example, emissions associated with Minnesota's electricity consumption (54 $MMtCO_2e$) were higher than those associated with electricity production (37 $MMtCO_2e$). The higher level for consumption-based emissions reflects GHG emissions associated with net imports of electricity to meet the State's

[12] Percentages are based on gross generation (including plant fuel use and line losses) associated with imports relative to total gross generation to meet Minnesota demand.

electricity demand.[13] Estimates of electricity sales for 2005 through 2025 indicate that Minnesota will remain a net importer of electricity. For the period covering 2005 through 2025, the reference case projection assumes that production-based emissions associated with electricity generated in-state will increase by about 6 $MMtCO_2e$, while emissions associated with imported electricity will increase by about 19 $MMtCO_2e$.

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 emissions 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' accounts in order to avoid double counting or exclusions.

Like electricity emissions, GHG emissions from transportation fuel use have risen steadily—from 1990 to 2005 transportation GHG emissions have increased at an average rate of 1.7% annually. Gasoline-powered on-road vehicles accounted for about 61% of transportation GHG emissions in 2005, on-road diesel vehicles accounted for another 18%, and aviation fuels for roughly 13%. Marine vessels accounted for 5% of transportation emissions in 2005. Rail and other sources (natural gas- and liquefied petroleum gas- [LPG-] fueled vehicles used in transport applications) accounted for the remaining 3% of transportation emissions. As a result of Minnesota's population and economic growth and an increase in total vehicle miles traveled (VMT), emissions from on-road gasoline use grew at a rate of 1.8% annually between 1990 and 2005. Meanwhile, emissions from on-road diesel use rose 2.7% per year during that period, suggesting an even more rapid growth in freight movement within or across the state. However, the Minnesota Department of Transportation projects a slowing in the VMT growth rate. Given this, emissions from on-road gasoline vehicles are projected to remain nearly the same in 2025 as in 2005, and emissions from on-road diesel vehicles are projected to increase at an annual rate of 1.6% per year from 2005 to 2025.

MCCAG Revisions

The following identifies the revisions that the MCCAG made to the inventory and reference case projections thus explaining the differences between this report and the initial assessment completed during July 2007:

- Forecast for all sectors: Extended the reference case projections for all sectors from 2020 to 2025 to align the forecast with Minnesota's GHG reduction goal for 2025.
- Energy Supply: Revised the electricity sales forecast for 2005 through 2025 for the business-as-usual reference case projections from 1.72% per year to 2.04% per year based on information compiled by the Energy Supply TWG. This revision increased emissions by 2.1$MMtCO_2e$ in 2015 and by 12.4 $MMtCO_2e$ in 2025 relative to the initial forecast presented in the July 2007 draft inventory and forecast report.

[13] 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 estimates reflect some very simple assumptions, as described in Appendix A in the *Inventory and Projections* report.

- Transportation: Revised the VMT forecast for 2005 through 2025 for the business-as-usual reference case projections from 1.9% per year to 0.8% per year based on updated modeling results provided by the Minnesota Department of Transportation. This revision lowered emissions by 2.7 $MMtCO_2e$ in 2015 and by 4.9 $MMtCO_2e$ in 2025 relative to the initial forecast presented in the July 2007 draft inventory and forecast report.
- Agriculture: Revised the inventory and reference case projections for all agriculture sectors (except for enteric fermentation, manure management, and changes in soil cultivation practices).

Key Uncertainties

Some data uncertainties exist in this inventory, and particularly in the reference case projections. Key tasks for future refinement of this inventory and projection include review and revision of key drivers, such as the growth rate assumptions for electricity generation and consumption, transportation fuel use, and the use of renewable versus fossil fuels that will be major determinants of Minnesota's future GHG emissions (see Table 2-2). 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. For the agriculture sector, significant uncertainty exists in the agricultural soil carbon levels, as these are based on a single year (1997) of data. Additionally, growth in many of the agriculture categories is assumed to follow historic emission trends. Significant uncertainties also exist in the forestry sector due to methodological changes in inventory methods over time. All of these issues warrant further investigation and considerable Minnesota-specific research.

Chapter 3
Residential, Commercial, and Industrial Sectors

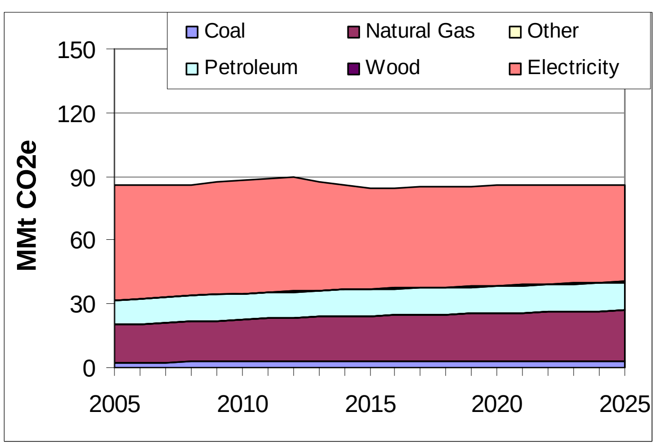
Overview of Sectoral Greenhouse Gas Emissions

The residential, commercial, and industrial (RCI) sectors were responsible for 23% of Minnesota's greenhouse gas (GHG) emissions of carbon dioxide equivalent (CO_2e) in 2005. Direct emissions of GHGs from the RCI sectors result principally from the on-site combustion of natural gas, oil, and coal plus non-energy sources of GHG emissions, the release of CO_2 and fluorinated gases (e.g., perfluorocarbons [PFCs]) during industrial processing, the use of sulfur hexafluoride (SF_6) in the utility industry, and the leakage of hydrofluorocarbons (HFCs) from refrigeration and related equipment.

Considering only the direct emissions that occur within buildings and industries, however, ignores the fact that virtually all electricity sold in Minnesota is consumed as the result of activities in the residential, commercial, and industrial sectors. If the emissions associated with producing the electricity consumed in Minnesota are considered, RCI activities are associated with 58% of the state's gross GHG emissions in 2005. The state's future GHG emissions therefore will depend heavily on future trends in the consumption of electricity and other fuels in the RCI sectors.

Figure 3-1 shows projected RCI GHG emissions by fuel type, and illustrates the large fraction of RCI emissions associated with electricity use. RCI emissions associated with electricity and natural gas use are expected to remain relatively stable between 2005 and 2020, thanks in large part to aggressive conservation and renewable energy policies enacted in 2007. Though reduced from a level of 63% in 2005, the GHG emissions share associated with electricity use is still projected to account for over 50% of total RCI GHG emissions in 2025.

Figure 3-1. Projected RCI GHG emissions by fuel type in Minnesota, 2005 to 2025



MMtCO$_2$e – million metric tons carbon dioxide equivalents

Key Challenges and Opportunities

The principal means to reduce RCI emissions in Minnesota include improving energy efficiency, substituting for electricity and natural gas with lower-emission energy resources (such as wind, solar water heating, photovoltaics, and biomass), reducing industrial-sector process (non-energy) emissions, increasing distributed (consumer-sited) electricity generation based on combined heat and power, and various strategies to decrease the emissions associated with electricity production (see Chapter 4, Energy Supply, for the latter).

The state's aggressive Conservation Improvement Program enacted in 2007, relative to some other states, tempers this challenge but also retains strong opportunities to reduce emissions through programs and initiatives to improve the efficiency of buildings, appliances, and industrial practices. Minnesota's robust population and economic growth, and its evident and growing commitment to carry out significant GHG emissions reductions, places pressure on communities and businesses in Minnesota to make urgent decisions to put in motion changes that will continue to lead to GHG emission reductions. A key challenge lies in the design and implementation of strategies that address State goals and thus ensure that new buildings and industries take full advantage of opportunities to reduce emissions.

Overview of Policy Recommendations and Estimated Impacts

The MCCAG recommends a set of nine new policies and three existing actions for the RCI sector offering the potential for significant GHG emission reductions. A summary of results is shown in Table 3-1. All policy recommendation totals are relative to the underlying assumption that electricity use in Minnesota proceeds with the recently legislated Conservation Improvement Program (CIP).

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

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2025	Total (2008–2025)			
RCI-1	Maximize Savings From the Utility Conservation Improvement Program (CIP)*	*Quantified as a "Recent Action"*					Enacted
RCI-2	Improved Uniform Statewide Building Codes	0.004	0.005	0.077	–$44	–$576	Unanimous
RCI-3	Green Building Guidelines and Standards Based on *Architecture 2030*	0.62	0.94	11.1	–$296	–$27	Unanimous
RCI-4	Incentives and Resources to Promote Combined Heat and Power (CHP)	0.96	4.95	33.1	$125	$3.8	Unanimous
RCI-5	Program to Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs	0.02	0.05	0.5	–$2	–$5	Unanimous
RCI-6	Non-Utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions	0.25	1.30	8.3	–$307	–$37	Unanimous
RCI-7	Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency	0.05	0.05	0.7	–$21	–$28	Unanimous
RCI-8	Energy Performance Disclosure	*Not quantified*					Unanimous
RCI-9	Promote Technology-Specific Applications to Reduce GHG Emissions	*Not quantified*					Unanimous
RCI-10	Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards	0.8	1.4	15.3	–$1,895	–$124	Unanimous
	Sector Total After Adjusting for Overlaps (RCI, Non-Electricity)	**0.76**	**0.69**	**10.41**	**–$464**	**–$44.6**	
	Sector Total After Adjusting for Overlaps (Integrated RCI and ES for Electricity)	**1.56**	**7.34**	**51.06**	**–$1,098**	**–$21.5**	
	Reductions From Recent Actions	**6.50**	**15.50**	**143.4**	**–$8,454**	**–$59.0**	
	New Commercial Building Code	**0.18**	**0.21**	**3.16**	**–$1.8**	**–$0.6**	
	Sustainability Guidelines (New State Buildings)	**0.22**	**0.46**	**4.72**	**–$1.7**	**–$0.4**	
	10% Savings in State Buildings	**0.09**	**0.11**	**1.75**	**–$0.9**	**–$0.5**	
	RCI-1: New CIP*	**6.01**	**14.72**	**133.8**	**–$8,449**	**–$63.2**	
	Sector Total Plus Recent Actions	**8.82**	**23.53**	**204.9**	**–$10,016**	**–$48.9**	

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

Only the results of options included in the final tabulation of GHG reductions and costs are shown in this table. For discussion of any sensitivity analyses undertaken, please see the discussion in the RCI Appendix F, Annex 1.

* The CIP considered here is based on the CIP requirements (i.e., 1.5% energy savings goal) included in the Next Generation Energy Act of 2007; therefore, the emission reductions and cost savings estimated are included under "recent actions."

These options include efforts to improve the energy and GHG profile of buildings (RCI-2, RCI-3), increase the penetration of combined heat and power (RCI-4), reduce emissions from industrial process of strong heat-trapping gases (RCI-5), efficiency/conservation improvement of selected industries (RCI-6, RCI-7), strengthened appliance efficiency standards (RCI-10) and support for energy disclosure and new GHG-reducing technologies (RCI-8, RCI-9). All but the last set of options have been able to be quantified, resulting in substantial reductions from the RCI sectors.

After accounting for overlaps, the RCI mitigation option recommendations, combining fuel and electricity results, yield an annual GHG emission reduction from reference case projections of about 8.7 $MMtCO_2e$ in 2025 and cumulative reductions of 61.5 $MMtCO_2e$ from 2007 through 2025, at a net savings of approximately –$1.6 billion through the year 2025 on an NPV basis. The weighted average cost of saved carbon for all RCI measures is –$25.4/$tCO_2e$ avoided.

The MCCAG has also analyzed a set of three existing actions for the RCI sectors that will contribute to achieving long-term GHG emission reductions in the State. These include a new commercial building code, sustainability guidelines for new state buildings, achieving energy savings of 10%, and, of course, the recently enacted Conservation Improvement Program that calls for annual savings equal to 1.5% of annual retail energy sales of electricity. Starting with the CIP, each of these existing actions contribute to substantial GHG emission reductions over the period through 2025, totaling just nearly 134 $MMtCO_2e$. Notably, Minnesota's existing actions lead to cumulative GHG reductions that are over double those achieved by the recommendation mitigation options.

Overall, the RCI existing actions yield an annual GHG emission reduction from reference case projections of about 15.5 $MMtCO_2e$ in 2025 and cumulative reductions of about 143 $MMtCO_2e$ through 2025, at a net cost of approximately –$8.5 billion through the year 2025 on an NPV basis. The weighted average cost of saved carbon for the energy supply measures is –$59/$tCO_2e$, a net savings.

Residential, Commercial, and Industrial (RCI) Policy Descriptions

RCI-1 Maximize Savings From the Utility Conservation Improvement Program (CIP)

The Next Generation Energy Act establishes an energy policy goal for the State of Minnesota to achieve annual savings equal to 1.5% of annual retail energy sales of electricity and natural gas. At least 1% of these sales should come directly through energy conservation improvement programs and rate design. The additional 0.5% of savings can come indirectly through energy codes and appliance efficiency standards, programs designed to transform the market or change consumer behavior, energy savings resulting from efficiency improvements to the utility infrastructure and system, and other activities to promote energy efficiency and energy conservation. These savings are based on the average of the last 3 years of sales for the utility.

RCI-2 Improved Uniform Statewide Building Codes

Building energy codes specify minimum energy efficiency requirements for new buildings or for existing buildings undergoing a renovation. Given the long lifetime of most buildings, amending state building codes to include minimum energy efficiency requirements and periodically updating energy efficiency codes will provide long-term GHG emission reductions.

RCI-3 Green Building Guidelines and Standards Based on *Architecture 2030*

This option seeks to promote, incentivize, or adopt green building guidelines and standards for the reduction of carbon emissions for all commercial and residential buildings consistent with *Architecture 2030* targets. The option would require state and local government agencies including school districts to adopt required building guidelines and standards for the reduction of carbon emissions for all new public buildings consistent with *Architecture 2030* targets, leading to 90% reduction by 2025.

RCI-4 Incentives and Resources to Promote Combined Heat and Power (CHP)

Combined heat and power (CHP) systems reduce fossil fuel use and GHG emissions, both through the improved efficiency of the CHP systems, relative to separate heat and power technologies, and by avoiding transmission and distribution losses associated with moving power from central power stations that are located far away from where the electricity is used.

RCI-5 Program to Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs

High-global-warming-potential greenhouse gases (HGWP GHGs) are classes of chemicals, some of which have a global warming impact thousands of times that of CO_2. They have a number of commercial and industrial uses. Often substitutes are available. This option recommends that the Minnesota Pollution Control Agency undertake a rulemaking process to identify uses and emission sources of HGWP GHGs and to eliminate the use or escape of such gases where that can be done at a reasonable cost, defined as less than or equal to \$15/tCO_2e.

RCI-6 Non-Utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions

This option calls for the implementation of cost-effective non-utility strategies and incentives for industrial processes in manufacturing and commercial facilities that complement (but not duplicate) utility-based programs to reduce greenhouse gas (GHG) emissions through energy efficiency (E2) and adoption of renewable energy technologies.

RCI-7 Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency

This option calls for the implementation of cost-effective programs to reduce propane and fuel-oil use; target rebates to overcome market barriers; maximize convenience to program participants; capture overall system efficiencies, not just equipment efficiencies; joint efforts to achieve market transformation; ongoing research, evaluation and analysis; complement government, utility and non-utility efficiency programs; and seek to remove any disincentives or regulatory barriers to energy efficiency.

RCI-8 Energy Performance Disclosure

This option calls for utilities to provide an energy performance disclosure to parties owning any public, commercial or residential property, preferably in an electronic format. It is recommended that this information be made available by the property owner to the prospective buyer or renter to allow for energy efficiency and environmental impacts to be an integral part of the decision to buy or rent.

RCI-9 Promote Technology-Specific Applications to Reduce GHG Emissions

This option calls for promotion through incentives, technology-specific applications that reduce GHG emissions in categories such as space heating, lighting, water heating, and plug loads. The option includes a recommendation for a process to determine and clarify which applications work best in reducing GHG emissions, and to clearly communicate the fact that reducing energy use does not always proportionally reduce emissions.

RCI-10 Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards

This option calls for the implementation of State appliance efficiency standards for appliances not covered by federal standards or where higher-than-federal standard efficiency requirements are appropriate. Appliance efficiency standards reduce the market cost of energy efficiency improvements by incorporating technological advances into base appliance models, thereby, thereby creating economies of scale. Minnesota should adopt appliance efficiency standards at the state level not covered by federal standards.

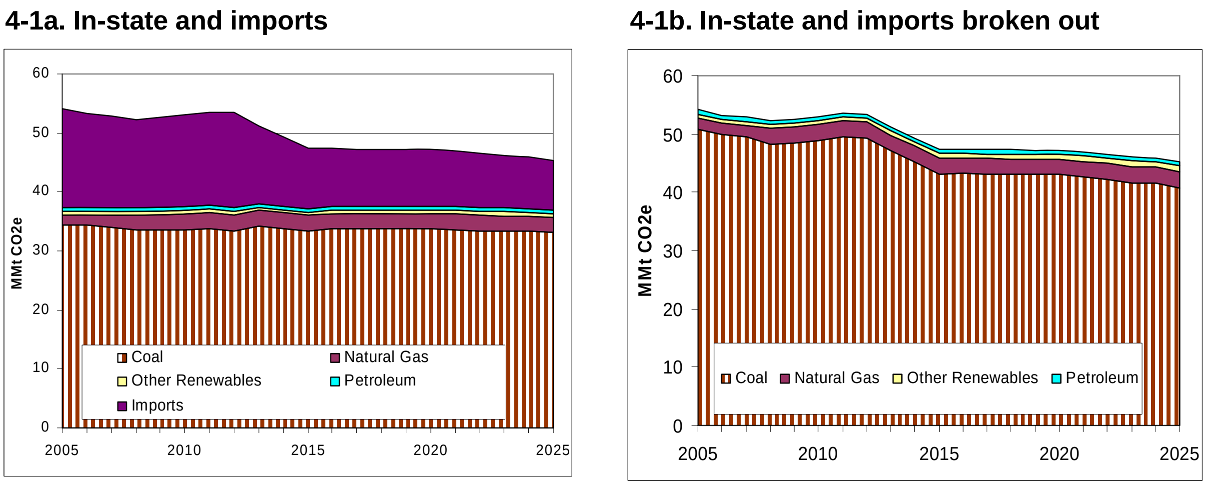
Chapter 4
Energy Supply

Overview of GHG Emissions

Greenhouse gas (GHG) emissions from Minnesota's energy supply sector include emissions from electricity generation and represent a substantial portion of the state's overall GHG emissions (approximately 35% of gross emissions in 2005). A significant portion of Minnesota's gross GHG emissions is associated with electricity imports: roughly 31% of the state's electricity-related fossil fuel emissions were associated with imports in 2005. This percentage is expected to be relatively stable through 2025 based on the reference case forecast.

Overall, emissions from Minnesota's energy supply sector are expected to decrease from 2005 base year levels of 54 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) to about 45 MMtCO_2e by 2025, or by approximately 16% on a consumption basis. It is important to note that these GHG reduction trends are evident prior to the implementation of any of the energy supply mitigation measures discussed in this chapter, thanks in large part to recent actions taken by the state, such as the Renewable Energy Standard (RES) and the Conservation Improvement Program (CIP), both enacted in 2007. These trends are summarized in Figure 4-1a and 4-1b.

Figure 4-1. Recent and projected GHG emissions from the Electricity Sector, Minnesota, 2005–2025 (consumption basis)



MMtCO_2e = million metric tons carbon dioxide equivalent

Key Challenges and Opportunities

The key challenge in addressing GHG emissions from Minnesota's energy supply sector is the state's continued reliance on coal-fired generation from both inside and outside Minnesota. Despite significant additions of renewable energy in Minnesota resulting from an aggressive RES, the share of GHG emissions from coal-fired generation will drop only slightly—from 94% in 2005 to about 90% in 2025.

Unlike many other states, large growth in electricity sales is not the primary driver for Minnesota's GHG emissions. The projected average annual growth rate of electricity sales in Minnesota between 2005 and 2025 is modest—about 0.82%. This reflects the impact of the newly enacted CIP, one of the most aggressive conservation improvement programs in the nation.[1]

Minnesota has several opportunities for reducing the growth in GHG emissions attributable to energy production and supply. For example, the carbon intensity of existing coal-fired electricity generation could be decreased through biomass co-firing and carbon capture and storage technologies for new and existing (through retrofits) coal-fired stations in the state. Significant opportunities to reduce GHG emissions through options to further reduce electricity consumption also exist, and can often provide net cost savings to Minnesota consumers and the state. The Minnesota Climate Change Advisory Group (MCCAG) has identified several demand-side management, energy efficiency, and conservation measures in the residential, commercial, and industrial sector; these are detailed in Chapter 3 of this report.

Overview of Policy Recommendations and Estimated Impacts

The MCCAG analyzed and is recommending six policy options and three existing actions for the energy supply (ES) sector that offer the potential for significant GHG emission reductions, as summarized in Table 4-1. All policy recommendation totals are relative to the underlying assumption that electricity expansion in Minnesota proceeds with the recently legislated CIP, RES, and all planned additions, including the Mesaba and Big Stone 2 stations. As noted in the Executive Summary and Chapter 2, in making this assumption, the MCCAG is not recommending for or against the need for or merits of the addition of these units in Minnesota. The forecast also assumes a backing down of existing units if the Big Stone 2 and Mesaba units come on line in order to balance the supply of electricity with demand in Minnesota. It is possible that instead of backing down, the existing units that formerly supplied power in Minnesota could be used to supply power in other states which, in turn, could lead to backing down less efficient units in other states. If built, these two units would have the potential to emit approximately 5.1 million tons of CO_2e per year. (MCCAG has recommended that future analyses reexamine these assumptions.)

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[1] An accurate estimate of the electricity sales growth rate was a subject of much discussion, with some members of the Minnesota Climate Change Advisory Group (MCCAG) advocating a higher rate (i.e., 1.0%–1.5% per year), and others advocating a lower rate (i.e., about 0.5% per year). The final value used in the analysis of options represents a central estimate, though it may be still objectionable to some MCCAG members.

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

Policy No.	Policy Recommendations	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/t$CO_2$e)	Level of Support
		2015	2025	Total (2008–2025)			
ES-1	Generation Performance Standard	0.0	0.0	0.0	$0.0	$0.0	Majority (16 objections)
ES-3	Efficiency Improvements, Re-Powering and Other Upgrades to Existing Plants	1.8	3.0	33.3	$554.4	$16.7	Unanimous
ES-4	Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss	0.2	0.4	3.9	–$92.2	–$26.1	Unanimous
ES-5	Renewable and/or Environmental Portfolio Standard*	*Quantified as a "Recent Action"*					Enacted
ES-6	Nuclear Power Support and Incentives	*Recommended for further study.*					Unanimous
ES-8	Advanced Fossil Fuel Technology Incentives, Support, or Requirements, Including Carbon Capture and Storage	*Recommended for further study.*					Unanimous
ES-10	Voluntary GHG targets	*Not quantified*					Unanimous
ES-12	Distributed Renewable Energy Incentives and/or Barrier Removal	0.021	0.023	0.37	$29.1	$78.1	Unanimous
ES-13	Technology-Based Approaches, Including Research and Development, Fuel Cells, Energy Storage, Distributed Renewable Energy Technologies, etc.	*Not quantified*					Unanimous
	Sector Total After Adjusting for Overlaps	**2.0**	**3.4**	**37.5**	**$462.2**	**$12.3**	
	Reductions From Recent Actions	**12.8**	**20.8**	**225**	**$10,116**	**$45.0**	
	Biomass for Electricity	**0.60**	**0.60**	**11.4**	**$285.3**	**$25.0**	
	Metro Emissions Reduction Project	**4.52**	**4.52**	**80.4**	**$2,330**	**$29.0**	
	ES-5: Renewable Energy Standard*	**7.72**	**15.7**	**133.1**	**$7,502**	**$56.4**	
	Sector Total Plus Recent Actions	**14.8**	**24.2**	**262.5**	**$10,578.8**	**$40.3**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/t$CO_2$e = dollars per metric ton of carbon dioxide equivalent. (ES Policy Options 2, 7, 9 and 11 were either dropped or merged during the process.)

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

All totals are relative to the underlying assumption that electricity expansion in Minnesota proceeds with the recently legislated Conservation Improvement Program (CIP), Renewable Energy Standard (RES), and all planned additions, including the Mesaba and Big Stone 2 stations.

* The RES considered here is based on the RES requirements included in the Next Generation Energy Act of 2007; therefore, the emission reductions and costs estimated are included under "recent actions."

Note: A number of MCCAG members have raised concerns about the cost assumptions associated with wind power and believe the costs are too high. A lower wind cost assumption would lower the cost estimates for the Renewable Energy Standard (ES-5) and for the Cap-and-Trade analyses. Future analyses should reexamine the wind cost estimates.

These options include efforts to limit new coal-fired generation in Minnesota (ES-1), encourage efficiency improvements at existing coal-fired generating stations (ES-3), upgrade electricity and natural gas transmission facilities (ES-4), explore the role of nuclear energy (ES-6), implement carbon capture and storage technology on new coal-fired generation (ES-8), promote voluntary GHG reductions (ES-10), encourage distributed renewable generation through incentives and barrier removal (ES-12), and encourage the development and eventual deployment of advanced technologies (ES-13). Not all of these policy recommendations contribute to GHG emission reductions during 2007–2025—the period for which recent Minnesota actions and the MCCAG recommendations were estimated—as outlined below.

- **Generation Performance Standard (ES-1):** A strict application of this option would have eliminated any new power stations being built in Minnesota, unless they could meet a stringent GHG emission-intensity threshold. If applied to Minnesota's new coal-fired stations (i.e., Big Stone 2 and Mesaba), the option would have yielded substantial GHG emissions. However, after a close vote, the MCCAG decided to exempt these new power stations, because they are currently undergoing regulatory review. At its final meeting MCCAG voted to recommend further study of this option. Therefore, the quantifications developed by the technical work group throughout the process are not included in the table above.
- **Nuclear Power Support and Incentives (ES-6):** The possibility of a new nuclear power station in Minnesota, though clearly advantageous from the perspective of comparing its GHG emissions to those from coal-fired generation, was an option that the MCCAG believed required more study. Hence, the MCCAG is recommending that the state commission a study on the costs and risks of installing a nuclear power station in Minnesota in the post-2025 period. Therefore, neither the GHG emission reductions achieved by this option over the period ending in 2025 nor the estimated costs for this option are not included here.
- **Advanced Fossil Fuel Technology (ES-8):** The possibility of a new coal-fired power station in Minnesota using carbon capture and storage technology was an option that the MCCAG believed required more study. Hence, the MCCAG is recommending that the state commission and facilitate a study on the viability of implementing this (as yet commercially unavailable) technology, including the use of biomass with carbon capture and storage. Since the MCCAG assumed this technology would not be implemented before 2025, no GHG emission reductions are achieved by this option over the planning period.

Overall, the ES mitigation option recommendations yield an annual GHG emission reductions from reference case projections of about 0.8 MMtCO_2e in 2025 and cumulative reductions of 8.4 MMtCO_2e from 2007 through 2025, at a net savings of approximately \$44 million through 2025 on a net present value (NPV) basis. The weighted-average cost of saved carbon for the ES measures is –\$5.2/tCO_2e avoided.

The MCCAG has also analyzed a set of three existing state actions for the ES sector that will contribute to achieving long-term GHG emission reductions in Minnesota. These actions include a program for increasing biomass use for electricity generation, Xcel's metro reduction project, and the recently enacted RES that calls for 25% of electricity sales in 2025 being met by renewable sources of energy. Starting with the RES, each of these existing actions contributes to substantial GHG emission reductions over the period through 2025, totaling just over 200 MMtCO_2e. In fact, the existing action that achieves the smallest level of cumulative GHG reductions (i.e., 11.4 $MMtCO_2e$ for biomass for electricity) exceeds the cumulative GHG reductions from all mitigation options (i.e., 8.4 $MMtCO_2e$).

Overall, the ES existing actions yield an annual GHG emission reduction from reference case projections of about 19.4 $MMtCO_2e$ in 2025 and cumulative reductions of nearly 202 $MMtCO_2e$ through 2025, at a net cost of approximately $9.5 billion through 2025 on an NPV basis. The weighted-average cost of saved carbon for the ES measures is $46.8/$tCO_2e$ avoided.

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, distributed generation facilities, or imported into the state.

ES-1 Generation Performance Standard

The generation performance standard (GPS) is a mandate that requires entities that deliver electricity to acquire electricity or power plant developers to build and operate new base-load generation, with a per-unit emission rate below 1,100 pounds of CO_2 per megawatt-hour (MWh). For base-load projects that are part of a combined-heat-and-power project, the GPS would be raised to 1,300 pounds of CO_2/MWh. By MCCAG vote, the two proposed new coal stations for meeting Minnesota base-load demand—Big Stone 2 and Mesaba—were exempted from the GPS. At its final meeting, MCCAG decided that this policy required further study.

ES-3 Efficiency Improvements, Re-Powering and Other Upgrades to Existing Plants

This policy would promote the identification and pursuit of cost-effective emission reductions from existing generating units by improving their operating efficiency, adding biomass or other fuel changes, or adding carbon capture technology. This policy complements ES-1 (Generation Performance Standard), which applies to new plants and new units, by applying to existing units. The results reported for this option correspond to increasing the biomass share at existing coal power stations to 1% by 2025 on an energy/Btu basis.

ES-4 Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss

This policy includes energy efficiency measures that can be implemented to reduce the transmission- and distribution-line losses of electricity; leaks during production, processing, and distribution of natural gas; methane and other GHG emissions to the atmosphere; and the waste of a valuable commodity. Regulations, incentives, and/or support programs can be applied to achieve greater efficiency of transmission and distribution system components. While the option covers both electricity transmission/distribution and natural gas transmission/distribution, only the latter was quantified.

ES-5 Renewable and/or Environmental Portfolio Standard

The renewable portfolio standard requires utilities and other load-serving entities to supply a certain, generally fixed, percentage of electricity from eligible (i.e., low-GHG-emitting) renewable energy sources. Prior to this MCCAG process, Minnesota had adopted an RES of 25% of electricity sales by 2025.

ES-6 Nuclear Power Support and Incentives

The role of nuclear power in a GHG-constrained energy supply system is both important and controversial. Today, nuclear power plants provide about 20% of electric power both nationally and in Minnesota. The role of both existing and new nuclear units needs to be considered for a comprehensive climate change policy process. By MCCAG decision, this policy calls for a study on the role of new nuclear power in Minnesota as a GHG reduction option in the post-2025 time period.

ES-8 Advanced Fossil Fuel Technology Incentives, Support, or Requirements, Including Carbon Capture and Storage

For coal to play a significant role in Minnesota's future energy system, its overall environmental profile must improve and must come as close as possible to producing zero CO_2 emissions, while producing energy that is both affordable and reliable. MCCAG calls for a further study of the role of carbon capture and storage technology for new coal stations as a GHG reduction option in the post-2025 time period and also calls for examining the role of carbon capture and storage technology with biomass.

ES-12 Distributed Renewable Energy Incentives and/or Barrier Removal

Distributed renewable energy should be encouraged, as it plays a part in Minnesota's overall goal of reducing carbon emissions. This policy includes subsidies and incentives that encourage investment in small-scale distributed renewable energy resources."

Chapter 5
Transportation and Land Use

Overview of GHG Emissions

The transportation sector accounted for about 25% of Minnesota's gross greenhouse gas (GHG) emissions in 2005 (about 37.2 million metric tons of carbon dioxide equivalent [$MMtCO_2e$]). The GHG emissions associated with Minnesota's transportation sector increased by 8.5 $MMtCO_2e$ between 1990 and 2005, accounting for about 22% of the state's net growth in gross GHG emissions in this period.

From 1990 through 2005, GHG emissions from transportation fuel use have risen steadily at an average rate of about 1.7% annually. Table 5-1 shows historic and projected transportation and land use (TLU) GHG emissions by fuel and source. Figure 5-1 graphically illustrates their growth. In 2005, on-road gasoline vehicles accounted for about 61% of transportation GHG emissions. On-road diesel vehicles accounted for another 18% of emissions, aviation fuels for roughly 13%, and marine vessels for 5%. Rail and other sources (natural gas- and liquefied petroleum gas [LPG]-fueled vehicles used in transport applications) accounted for the remaining 3% of transportation emissions. As a result of Minnesota's population and economic growth and an increase in total vehicle miles traveled (VMT) during the 1990s, on-road gasoline use grew 31% between 1990 and 2005. Meanwhile, on-road diesel use rose 49% during that period, suggesting an even more rapid growth in freight movement within or across the state. Aviation fuel use grew by about 30% from 1990 to 2005.

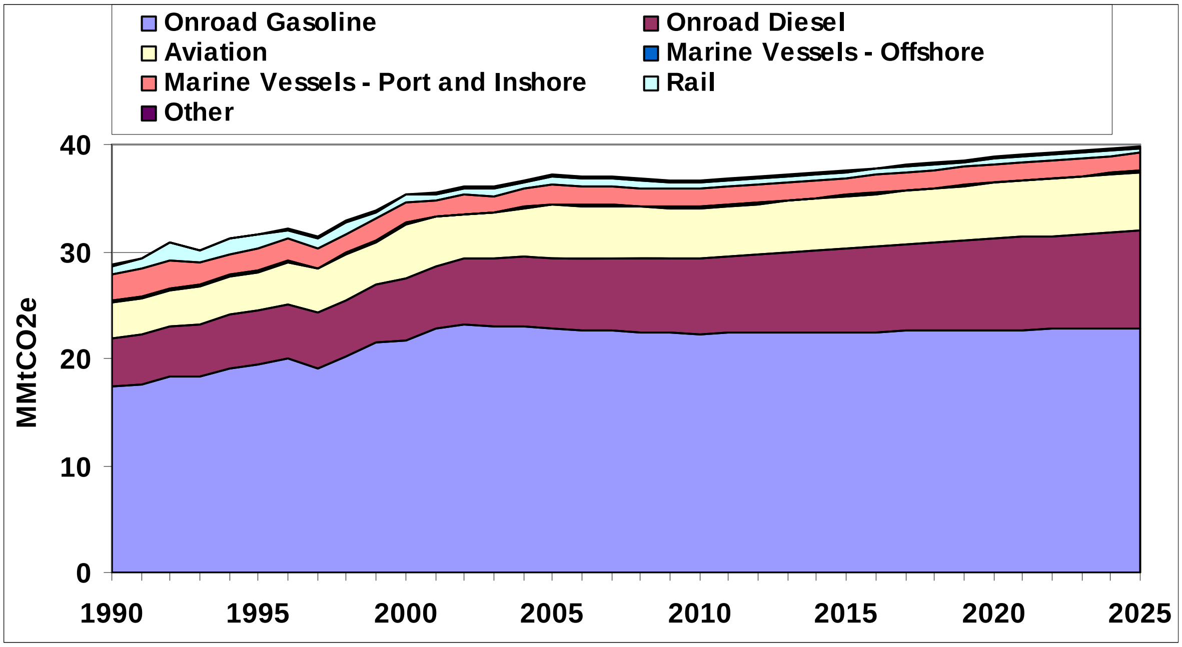
Table 5-1. Historic and projected emissions for the transportation sector ($MMtCO_2e$)

Fuel Source	1990	1995	2000	2005	2010	2015	2020	2025
On-Road Gasoline Vehicles	17.3	19.4	21.7	22.7	22.3	22.5	22.7	22.8
On-Road Diesel Vehicles	4.5	5.0	5.9	6.7	7.1	7.8	8.5	9.2
Aviation Fuels	3.5	3.7	5.0	5.0	4.6	4.9	5.2	5.5
Marine Vessels, Offshore	2.5	2.0	1.9	1.8	1.7	1.7	1.7	1.7
Marine Vessels, Port and Inshore	0.16	0.14	0.13	0.11	0.11	0.10	0.10	0.10
Rail	0.71	1.3	0.70	0.83	0.58	0.53	0.49	0.44
Other	0.08	0.12	0.16	0.16	0.17	0.17	0.18	0.18
Total	**28.7**	**31.7**	**35.4**	**37.2**	**36.6**	**37.6**	**38.8**	**39.8**

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

On-road gasoline consumption accounts for the largest share of transportation GHG emissions. Emissions from on-road gasoline vehicles increased by about 31% from 1990 to 2005 and contributed 61% of total transportation emissions in 2005. GHG emissions from on-road diesel fuel consumption increased by 49% from 1990 to 2005 and, by 2005, accounted for 18% of GHG emissions from the transportation sector. Emissions from aviation grew by 44% between 1990 and 2005 to account for 13% of transportation emissions in 2005, and emissions from boats and ships decreased by 31% during that period, to account for 5% of transportation emissions in 2005. Emissions from all other categories combined (locomotives, natural gas, LPG, and oxidation of lubricants) contributed less than 3% of total transportation emissions in 2005.

Figure 5-1. Transportation GHG emissions by fuel source, 1990–2025



VMT since 1990 have increased statewide by 45%. This is one of the fastest growth rates in the nation, far outpacing the state population growth of 19% in the same period. The regions outside the seven-county metro area are responsible for much of the increase in VMT. While the metro area held 52% of the state population in 1990, it produced only 45% of the annual state VMT. In 2005, the metro area had 54% of the statewide population and 40% of the state VMT. These percentages will continue to diverge.

After years of essentially unbroken growth that outpaced both population and employment growth, VMT was essentially flat during 2004–2006. As a result, the Metropolitan Council and Minnesota Department of Transportation (MnDOT) traffic modelers recently adopted a forecast of statewide VMT growth of 0.9% annually, which is a substantial decrease from historic rates. If this slower rate of growth continues, it will substantially slow the rate of increase in GHG emissions from Minnesota transportation.

However, other sources of transportation GHG emissions will continue to grow rapidly. Historic growth for diesel fuel has been stronger than for gasoline. This trend is expected to continue for the 2005–2030 period, with gasoline and diesel fuel consumption projected to increase by 0.6% and 51.2%, respectively. Jet fuel and aviation gasoline consumption is projected to increase by 17% between 2005 and 2030. The historic negative growth for marine vessels is projected to continue, with a decline of 7% from 2005 to 2030. Figure 5-1 summarizes historic and projected transportation GHG emissions by fuel source.

Key Challenges and Opportunities

Minnesota has substantial opportunities to reduce transportation emissions. In the state, and in the nation as a whole, vehicle fuel efficiency has improved little since the late 1980s, yet many studies have documented the potential for substantial increases consistent with maintaining vehicle size and performance. The use of fuels with lower GHG emissions is growing, and larger market penetration is possible. Minnesota has taken steps to increase transit options and plan for growth that reduces emissions, and the state can absorb growth in development patterns that will produce far lower emissions than forecast.

The Transportation Land Use (TLU) Framework organized these opportunities into three groups:

- **TLU Area 1:** Reduce the number of miles driven.
- **TLU Area 2:** Reduce carbon per unit of fuel (cleaner fuels).
- **TLU Area 3:** Reduce carbon per mile and/or per hour (improved vehicle efficiency).[1]

Taken together, this three-legged stool of TLU policy recommendations can substantially reduce Minnesota's transportation GHG emissions.

Overview of Policy Recommendations and Estimated Impacts

The 12 policy options recommended for the TLU sector offer major economic benefits and emissions savings.

[1] Transportation carbon emissions = miles driven × carbon per mile; carbon per mile = vehicle emissions per unit × carbon per unit of fuel.

Table 5-2. Summary list of policy recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2015	2025	Total 2008–2025			
TLU Area 1: Reduce VMT (VMT goal to be established based on VMT implied by selected strategies)							
TLU-1	Improved Land-Use Planning and Development Strategies	0.7	1.9	14.9	*Net savings*	*Net savings*	Unanimous
TLU-2	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.1	0.3	3.0	$0	$0	Unanimous
TLU-5	Climate-Friendly Transportation Pricing/Pay-as-You- Drive	1.1	2.1	20.9	–$1	–$1	Super -majority (3 objections)
TLU-7	"Fix-it-First" Transportation Investment Policy and Practice	*Not quantified*					Super-majority (2 objections)
TLU-9	Workplace Tools To Encourage Carpooling, Bicycling, and Transit Ridership	0.3	0.4	4.5	*Large net savings*	*Large net savings*	Unanimous
TLU-14	Freight Mode Shifts: Intermodal and Rail	N/A					Super -majority (1 objection)
TLU Area 2: Reduce Carbon per Unit of Fuel							
TLU-3	Low-GHG Fuel Standard	1.7	3.6	36.2	*Not quantified*		Unanimous
TLU Area 3: Reduce Carbon per Mile and/or per Hour							
TLU-4	Infrastructure Management	0.04	0.1	0.7	*Not quantified*		Unanimous
TLU-6	Adopt California Clean Car Standards	0.74	1.16	13.1	–$263	–$39	Majority (16 objections)
TLU-12	Voluntary Fleet Emission Reductions	0.4	0.4	6.1	*Not quantified*		Unanimous
TLU-13	Reduce Maximum Speed Limits	0.4	0.4	6.1	N/A	$50 at $2.40/gal –$19 at $3.40/gal	Majority (16 objections)
	Sector Total After Adjusting for Overlaps	**4.7**	**9.3**	**91.2**	***Not quantified***	***Not quantified***	
	Reductions From Recent Actions	**1.4**	**1.5**	**20.2**	***Not quantified***		
	Biodiesel	**0.64**	**0.75**	**8.1**			
	Ethanol	**0.78**	**0.79**	**12.1**			
	Sector Total Plus Recent Actions	**6.1**	**10.8**	**111.4**	***Not quantified***	***Not quantified***	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; VMT = vehicle miles traveled; N/A = not available.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

The policy recommendations described briefly here not only result in significant emissions and costs savings but also offer a host of additional benefits, such as reduced local air pollution, more livable, healthier communities, and increased transportation choices.

Transportation and Land Use
Policy Descriptions

TLU Area 1: Reduce VMT

The statewide per capita VMT reduction from strategies TLU-1, -2, -5, -7, -9, and -14 taken together would be 15% from 2005 levels by 2025. Despite an 18% increase in Minnesota's population from 2005 to 2025, overall statewide VMT would not increase during this time period.. (This flat VMT is from MDOT projections assuming that higher fuel prices and other factors dampen VMT growth.)

The TLU Area 1 Overall VMT reduction goal is roughly 10.3 billion VMT in 2025, for a 2025 VMT of 56,530,900,000.

TLU-1 Improved Land-Use Planning and Development Strategies

This policy improves land-use planning and development practices to target growth in ways that reduce the number and length of vehicle trips, thus reducing GHG emissions. (It accounts for part of the VMT reduction goal, along with TLU-2, -5, -7, -9, and -14.)

TLU-2 Expand Transit, Bicycle, and Pedestrian Infrastructure

This strategy expands infrastructure and programs to increase transit ridership, carpooling, bicycling, and walking. It will reduce GHG emissions by reducing VMT (fewer vehicle trips and shorter trip distances). (It accounts for part of the VMT reduction goal, along with TLU-1, -5, -7, -9, and -14.)

TLU-5 Climate-Friendly Transportation Pricing/Pay-as-You-Drive

This policy recommends that the state of Minnesota institute requirements and policies ensuring that drivers more fully pay the costs of driving. By doing so, the policy would encourage drivers to choose transportation alternatives, purchase more efficient vehicles, drive less, and/or drive more efficiently (combining trips). This option generally reduces VMT and GHG emissions. (This strategy accounts for part of the VMT reduction goal, along with TLU-1, -2, -7, -9, and -14.)

TLU-7 "Fix-it-First" Transportation Investment Policy and Practice

This policy option recommends that the state legislature require that state and federal transportation investments be prioritized in the following order: (1) maintain existing roads, and (2) design new and expanded roads to serve higher-density, more compact, pedestrian-friendly development in priority growth areas, such as downtowns, town centers, main streets, neighborhood hubs, regional centers, transit corridors, and transit station areas. It also recommends that the state significantly reduce investment in new roads and roadway expansion that accommodate and encourage both low-density development and more and longer vehicle trips.

This strategy will reduce GHGs emissions by increasing bicycling and walking and reducing the number and length of vehicle trips. (It accounts for part of the VMT reduction goal, along with TLU-1, -2, -5, -9, and -14.)

TLU-9 Workplace Tools to Encourage Carpooling, Bicycling, and Transit Ridership

This strategy reduces emissions by requiring certain employers and encouraging other employers to offer a Commuter Benefits program at the workplace to increase the use of transit, ridesharing, and non-motorized transportation. Commuter Benefits can include reducing the amount of free or subsidized parking, providing paid or pre-tax transit passes or mode-neutral transportation allowances, guaranteeing rides home for non-drive-alones, providing bicycle parking and employee lockers, providing telecommuting programs, and/or having employee ID cards serve as transit passes. The strategy also reduces emissions by requiring large employers (more than 200 employees) to develop and implement transit demand management plans that customize commuter benefits and transit-supportive building design to specific building locations. (It accounts for part of the VMT reduction goal, along with TLU-1, -2, -5, -7, and -14.)

TLU-14 Freight Mode Shifts: Intermodal and Rail

Transportation of freight by railroad generally results in less fuel use and GHG emissions than transportation by truck. This strategy recommends that a MnDOT statewide freight study currently underway examine support for expanding intermodal rail service for Minnesota shippers through public–private partnerships; increasing the competitiveness of rail rates for all Minnesota shippers; and developing public–private partnerships to support mode shifts to rail and decrease truck VMT relative to the baseline.

TLU Area 2: Reduce Carbon Per Unit of Fuel

TLU-3 Low-GHG Fuel Standard (Overlap with AFW-7)

Under this policy, the state of Minnesota would adopt a low-GHG fuel standard (LGFS), create a market-based program to reduce the GHG emissions from transportation fuels, and diversify transport fuel options for consumers. The LGFS would be designed to require fuel providers to reduce the GHG intensity of the fuels they sell in Minnesota. Fuel providers are identified as producers, importers, refiners, and blenders. The GHG intensity is specified as a CO_2e[2] per

[2] Each GHG has a global warming potential (GWP) that allows it to be expressed in terms of CO_2. This notation is referred to as carbon dioxide equivalent (CO_2e). For example, methane has a GWP of 23. Therefore, 1 metric ton (Mt) of CH_4 can be expressed as 23 $MtCO_2e$.

British thermal unit (Btu). The LGFS would not be designed to encourage the use of any particular fuel. Instead, it would include fossil and renewable fuels.[3]

The LGFS is not a tailpipe standard for GHGs, because it considers GHG emissions on a full-fuel-life-cycle basis, which includes not only tailpipe emissions but also emissions associated with the production and distribution of fuels. This will result in varying carbon impact values for fuels that would ostensibly be the same to customers.[4]

TLU Area 3: Reduce Carbon Per Mile and/or Per Hour

TLU-4 Infrastructure Management

With the state as a coordinator, this strategy will build on current efforts to create a seamless multimodal system to serve all modes, improve traffic flow, and decrease vehicle idling and congestion (where it will not negatively affect bicycling and walking or induce additional vehicle trips). This strategy will also reduce carbon emissions by reducing the number and length of motor vehicle trips; increasing walking, bicycling, and transit use; and supporting development patterns that use these modes.

TLU-6 Adopt California Clean Car Standards

This policy option reduces GHG emissions from new motor vehicles (cars and light-duty trucks) sold in Minnesota by adopting legislation equivalent to the California Clean Car standards (Assembly Bill 1493 [Pavley], named after the California lawmaker who sponsored the legislation).

California adopted legislation in 2002 (and regulations in 2004) requiring a reduction in GHG emissions from new cars and light-duty trucks sold in that state beginning with model year 2009. California plans an 8-year phase-in. The California standards incorporate the main global warming gases—CO_2, methane, and nitrous oxide—resulting directly from vehicle operation (tailpipe emissions), as well as hydrofluorocarbon emissions resulting from leakage from or operation of vehicle air conditioning systems.

TLU-12 Voluntary Fleet Emission Reductions

Under this policy, Minnesota would create new services and provide additional support to existing voluntary and incentive-based programs that help fleets reduce their GHG emissions.

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[3] Alternative fuels, which are defined in the Energy Policy Act of 1992, include biodiesel, electricity, ethanol, hydrogen, natural gas, and propane.

[4] For example, E10 in which the ethanol is derived from cellulose has the potential to reduce the full-fuel-life-cycle carbon impacts, compared with E10 in which the ethanol is derived from corn. How the ethanol is made affects its life-cycle GHG profile, and not all corn ethanol is the same. Cellulosic E10, while potentially better in its GHG profile than sugar-based (corn) ethanol, will also vary depending on feedstock(s) and thermal heat input source(s).

Approximately 10% of cars and trucks in Minnesota are in fleets. There are many ways for businesses to reduce GHG emissions from their fleets. Typically, fleets will determine a methodology to measure their GHG impact, review their current vehicle mix and vehicle operation parameters, and then analyze options to see where efficiencies can be gained. Efficiencies generally come through improved driver behavior, more efficient vehicles (either new models or technology enhancements to existing models), and/or improved operating processes (e.g., more efficient routing systems).

This current state in fleet efficiency programs points to certain challenges. First, there is no centralized support to help fleets manage these initiatives. Fleets have little support in the selection and implementation of metrics. Second, funding resources for retrofits and other technology-based efficiency solutions are limited and may be restricted to specific vehicle types. Part of this challenge is necessary because some solutions for heavy-duty trucks are inherently different from what a fleet of sedans would be facing. Third, there is no centralized Minnesota-based registry for businesses to post, track, and share fleet-based GHG improvements.

TLU-13 Reduce Maximum Speed Limits

Reduce maximum speed limits on highways in Minnesota to improve fuel economy and reduce GHG emissions per mile traveled.

Chapter 6
Agriculture, Forestry, and Waste Management

Overview of GHG Emissions

The agriculture, forestry, and waste management (AFW) sectors are directly responsible for moderate amounts of Minnesota's current greenhouse gas (GHG) emissions. The total AFW contribution to carbon dioxide equivalent (CO_2e) net emissions in 2005 was 30 million metric tons (MMt) or about 19% of the State's total. Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, manure management, agriculture soils, and agriculture residue burning. These emissions were estimated to be about 22 $MMtCO_2e$ in 2005. As shown in Figure 6-1, emissions from soil carbon losses from agricultural soils, manure management, fertilizer application, and crop residues 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, organic, and livestock) application and production of nitrogen-fixing crops (legumes). There is no significant agricultural burning activity in Minnesota, and so the emissions were estimated to be zero.

Note that, in keeping with EPA methods and international reporting conventions, the inventory and forecast covers anthropogenic sources of GHGs. There could be some natural sources of GHGs that are not represented in the inventory and forecast; however these are not addressed in the CAPAG process. In the forestry sector, all emissions are treated as anthropogenic; since all of the State's forests are managed in some way (GHG reporting conventions are to treat all managed forests as anthropogenic sources). Sources such as carbon dioxide 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, methane emissions from anaerobic decomposition of biomass in forests are not currently captured due to a lack of data.

The contributions from agricultural soils and manure management have grown significantly since 1990, and they are projected to contribute 90% of agricultural emissions by 2020. Emissions from enteric fermentation have stayed the same since 1990 and are projected to stay relatively constant until 2020.

Forestland emissions refer to the net carbon dioxide (CO_2) flux[1] from forested lands in Minnesota, which account for about 32% of the state's land area. As shown in Table 6-1, USFS data suggest that Minnesota forests emitted an average of 3.3 $MMtCO_2e$ per year from 1990 to 2003 (based on recommendations from the USFS). Hence, during this period, forest carbon losses due to forest conversion, wildfire, and disease was estimated to be larger 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 landfilling of forest products. It is important to note that on a per acre basis, forests are a net sink for carbon, not a source. A significant fraction of the carbon losses attributed to forests are likely the result of conversion of forest land to non-forest land between 1990 and 2003. The data show an

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

accumulation of carbon in harvested wood products, but losses in the each of the other forest carbon pools.[2] These rates of sequestration are assumed to remain constant through 2025.

Figure 6-1. Historical and projected net GHG emissions from the Agriculture Sector, Minnesota, 1990–2020

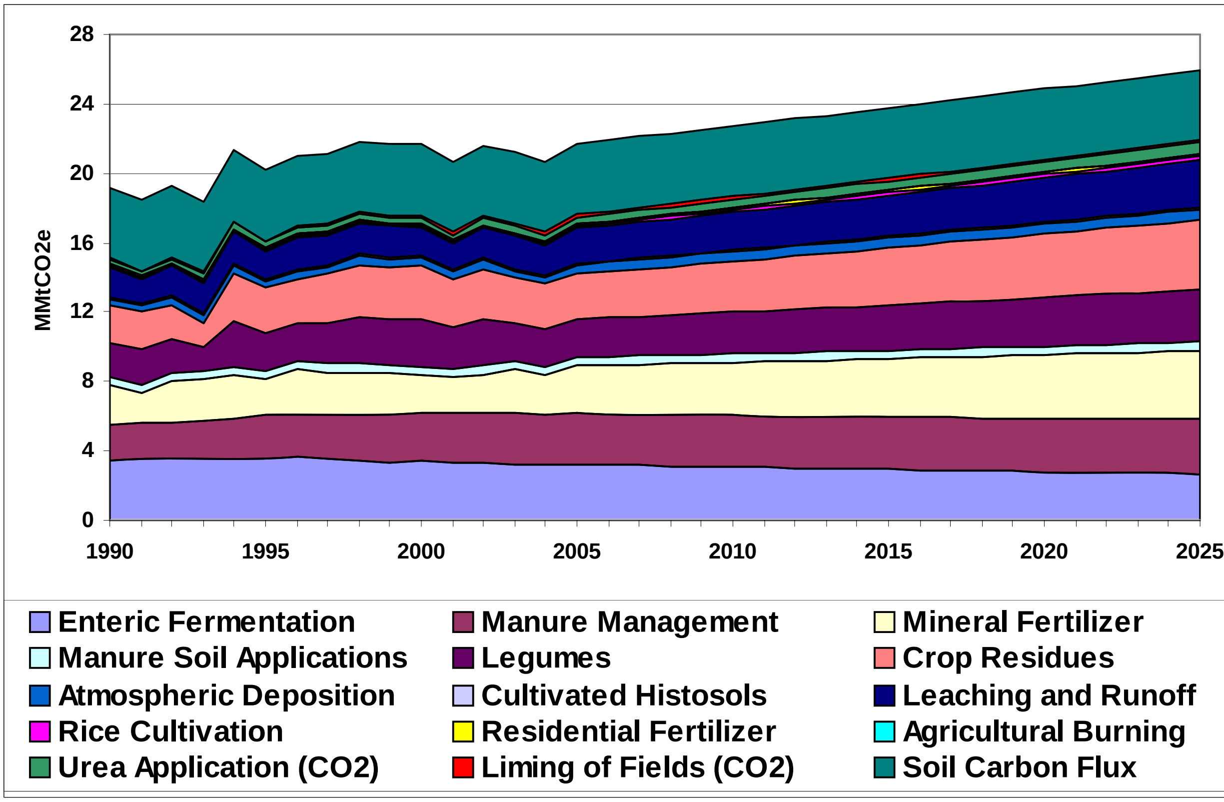


Table 6-1. GHG emissions (sinks) from the Forestry Sector

Forest Pool	1990–2003 Flux (MMtC/year)	1990–2003 Flux ($MMtCO_2$/year)
Forest carbon pools (non-soil)	1.5	5.5
Soil organic carbon	5.9	21.6
Harvested wood products	–0.6	–2.2
Totals	**6.8**	**24.9**
Totals (excluding soil carbon)	**0.9**	**3.3**

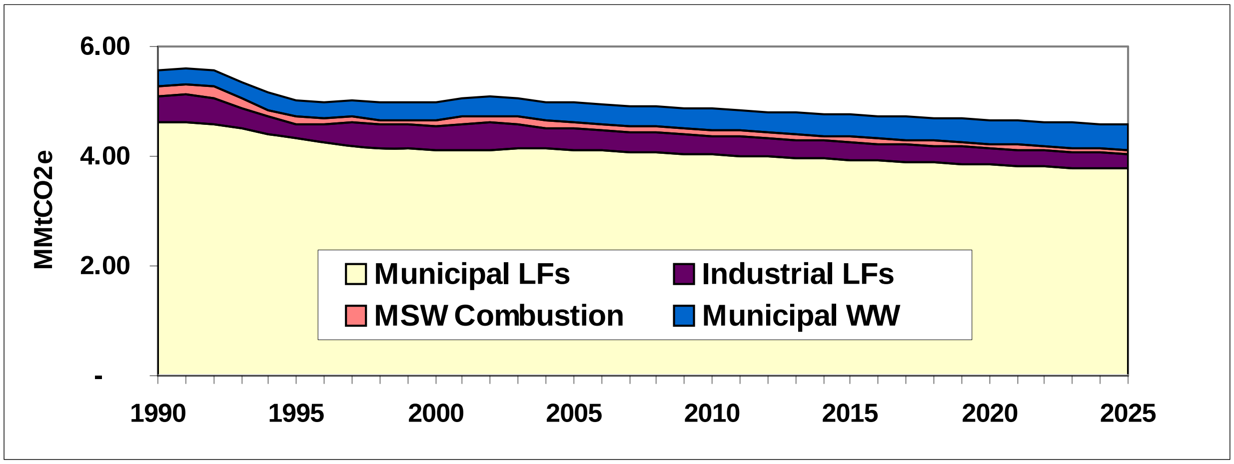
[*] Positive numbers indicate net emission. Based on USFS input, emissions from soil organic carbon are left out of the forestry sector summary due to a high level of uncertainty.

Figure 6-2 shows estimated historical and projected emissions from the management and treatment of solid waste and wastewater. Emissions from waste management consist largely of

[2] This is not to say that the dead carbon pools (e.g., standing dead, forest floor) are sequestering carbon directly from the atmosphere. These pools accumulate carbon from trees/biomass that transition from a live carbon pool to a dead carbon pool.

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 accounts for less than 4% of Minnesota's total gross emissions per year from 1990 through 2020.

Figure 6-2. Estimated historical and projected emissions from waste and wastewater management in Minnesota



MMtCO$_2$e = million metric tons carbon dioxide equivalent; LFs = landfills; WW = wastewater.

The MCCAG acknowledges that there are higher levels of uncertainty in the GHG emissions and forecasts in the AFW sectors compared with those in other GHG sectors (e.g., those where emissions are tied directly to energy consumption). There is a need for continuing investment in research and measurement to refine the AFW I&F (details on key uncertainties are presented in the appendixes of the I&F report).

Opportunities for GHG mitigation in the AFW sector involve measures that can reduce emissions within the sector or reduce emissions in other sectors. Within the sector, changes in crop management practices can reduce GHG emissions by building soil carbon (indirectly sequestering carbon from the atmosphere) or through more efficient nutrient application (reducing N_2O emissions, embedded GHG emissions within the nutrients, and fossil fuel consumption). Reforestation projects can achieve GHG reductions by increasing the carbon sequestration capacity of the State's forests.

For GHG reductions outside of the AFW sector, actions taken within the sector such as production of liquid biofuels can offset emissions in the transportation sector, while biomass energy can reduce emissions in the energy supply (ES) or residential, commercial, and industrial (RCI) sectors. Similarly, actions that promote solid waste reduction or recycling can reduce emissions within the sector (future landfill CH_4), as well as emissions associated with the production of recycled products (recycled products often require less energy to produce than similar products from raw materials). Finally, urban forestry projects can reduce energy consumption within buildings through shading and wind protection.

The following are primary opportunities for GHG mitigation identified by the MCCAG.

- **Agricultural crop management:** Implement programs that incentivize 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.
- **Agricultural land use management approaches to protect/enrich soil carbon:** Incentive programs are needed to protect crop lands from conversion to developed use or the conversion of lands in conservation programs to conventional tillage. By protecting these areas from development, the carbon in above-ground biomass and below-ground soil organic carbon can be maintained and additional emissions of CO_2e to the atmosphere can be avoided. Indirectly, these measures also support the objectives of "smart" development by helping to direct more efficient development patterns (see TLU-1). Also, incentive programs could be used to convert lands with a recent history of annual crop production to perennial crops in order to build additional soil carbon. Peatlands and wetlands are recognized to have large stores of soil carbon. After additional study to gain a full understanding of overall carbon dynamics, peatland/wetland protection and enhancement programs should be initiated to protect this stored carbon and to sequester additional carbon in the future.
- **Production of liquid biofuels:** Production of renewable fuels, such as ethanol from crops, crop residue, forestry residue, or municipal solid waste, and biodiesel from crop seed oils can produce significant reductions when they are used to offset consumption of fossil fuels (e.g., gasoline and diesel in the TLU and RCI sectors). This is particularly true when these fuels are produced using processes and/or feedstocks that emit much lower GHG emissions than those from conventional sources. Significant GHG reductions could also be realized by converting existing in-state ethanol production processes to run on renewable fuels (thereby lowering the embedded GHG content and positioning the State's industry to supply states with low carbon fuels standards; including potentially Minnesota; see TLU-3).
- **Expanded use of forest and agricultural biomass:** Expanded use of biomass energy from residue removed from forested areas during treatments to reduce fire risk, crop residues, or purpose-grown crops can achieve GHG benefits by offsetting fossil fuel consumption (to produce either electricity or heat/steam). Programs to expand sustainably procured biomass fuel production will likely be needed to supply a portion of the fuel mix for the renewable energy goals of ES-5.
- **Enhancement/protection of forest carbon sinks:** Through a variety of programs, enhanced levels of CO_2 sequestration can be achieved and carbon stored in the State's forest biomass. These include reforestation programs, restocking of poorly stocked forests, urban tree programs, wildfire risk reduction, and other forest health programs. Programs aimed at reducing the conversion of forested lands to non-forest cover will also be important to turn what is currently a net forest CO_2 source into a net CO_2 sink.
- **Changes in municipal solid waste management practices:** By concentrating on enhancing the source reduction, recycling, and composting practices in the State, significant GHG emission reductions can be achieved. Also, for waste remaining after full implementation of these "front-end" practices, appropriate GHG-beneficial "end-of-life" practices should be

implemented including enhanced landfill gas collection & utilization and pre-processing of waste being sent to waste to energy recovery facilities.

Key Challenges and Opportunities

In the agricultural sector, the MCCAG found significant opportunity in promoting biofuels production using feedstocks and production methods with superior GHG benefits (superior to conventional starch-based ethanol and soybean oil–based biodiesel). It should be noted that the GHG benefits did not include any indirect impacts associated with emissions resulting from land use change.[3] Along with programs to promote the conversion of the existing Minnesota ethanol industry to the use of more renewable fuels, additional biofuels production programs were found to offer substantial GHG reduction potential with an estimated reduction of more than 11 MMtCO_2e by 2025 (see AFW-3). A large fraction of these reductions is provided by the gasoline displacement element of AFW-3 (35% displaced using ethanol or other biofuels by 2025).[4]

MCCAG members were concerned that a 35% gasoline displacement goal (based on energy content) would stretch the state's agronomic and biomass resources and noted that additional and potentially significant impacts should be evaluated regarding availability of land, biomass, and water, consequences for food production, economic feasibility, and changes in overall fuel costs. The MCCAG recommends that the University of Minnesota and other experts, through the Initiative for Renewable Energy, study the biofuels goals and the low-carbon fuel standard (LCFS) contained in AFW-3 and TLU-3, respectively. The study should analyze the feasibility of the proposals for reducing CO_2 emissions, as well as their impacts on land and water use, food production, fuel costs and availability, and the economic impacts on consumers and businesses.

It should be noted that there is significant overlap in benefits with the TLU-3 LCFS recommendation. However, the MCCAG recognizes the need for programs to promote in-state biofuels production. Examples of biofuels that could be produced with much better GHG impacts are ethanol from cellulosic hydrolysis of biomass fiber. Feedstocks for the fiber needed for this recommendation could come from crop residue, energy crops, or forestry residue. A major challenge for the success of AFW-3 is the production of a viable commercial-scale cellulosic ethanol or other biofuels industry by 2015.

MCCAG recommendation AFW-4 promotes the expanded use of biomass as an energy source for producing electricity, heat or steam. Use of biomass to supplant fossil fuels was estimated to reduce about 4 MMtCO_2e by 2025. The MCCAG conducted a limited assessment of the available biomass resources in the state which indicated that sufficient resources were available through 2025 to achieve the goals for both the liquid biofuels recommendation above and this biomass for energy option. However, the MCCAG also recognized the need for additional research into this issue and noted that there are potentially other biomass resources that were not

[3] Recent research (e.g., Searchinger, T., et al., "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change," *Sciencexpress*, February 2008) has indicated that incorporating land conversion impacts into GHG analysis may remove any GHG benefits.

[4] The state's current plan for gasoline displacement is to have 20% gasoline displacement by 2013. The goal for petroleum diesel fuel is 20% by 2015.

assessed (e.g., fiber in the municipal solid waste stream). Research on sustainable harvest standards is also needed with resulting yields potentially impacting available quantities. It was noted that although the initial assessments show sufficient resources to meet the MCCAG's biomass policies, there are a number of variables that are not taken into consideration, including the assumption that all land that is currently available for biomass will still be available in 2015 and 2025; that all available biomass is actually collected; the technology and process to harvest, and the transportation and storage logistics associated with corn stalk usage for biomass are still in the developmental stages; restrictions regarding haying and grazing on CRP; and weather conditions. It will also be necessary to analyze the impact of biomass harvest on plant nutrient removal.

Within the agriculture sector, the MCCAG also recommends programs to promote soil management programs the increase soil carbon levels, thereby indirectly sequestering carbon from the atmosphere. These programs, combined with additional measure to promote more efficient nutrient application, were estimated to achieve reduction of over 2.5 MMtCO_2e per year by 2025. Programs that would assist farmers in reaching the goals of these recommendations include: the Agricultural Best Management Loan Program administered by the Minnesota Department of Agriculture; carbon credit trading programs coordinated by various farm organizations; and new and existing conservation such as the Reinvest in Minnesota Clean Energy Program (RIM-CE), which provide environmental benefits in addition to new opportunities for farmers in developing feedstock bioenergy production.

Land use management approaches to carbon management in the agriculture and forestry sectors are also recommended to protect existing above and below ground carbon stocks and potentially enhance terrestrial sequestration in the future. These include recommendations for additional study on the benefits of peatlands and wetlands conservation (areas that store substantial soil carbon). By preserving agricultural and forested lands (AFW-2a and 6), the MCCAG estimates GHG savings in 2025 of 3.1 MMtCO_2e. To achieve these reductions, the state will need to work closely with local planning agencies, land owners, and nongovernmental organizations to identify lands suitable for acquisition/conservation easements and funding mechanisms. Some of the support could come through the Forest Legacy Easements Program, which would minimize forest fragmentation and conversion as industrial land owners divest themselves of forest land holdings. Another benefit to these options, which was not quantified, is the reduction in vehicle-miles traveled due to more efficient development patterns (see TLU-1).

Within the forestry sector, forest management programs (AFW-5) have the potential to deliver over 13 MMtCO_2e/year of GHG reductions in 2025. These programs include forestation, urban forestry, wildfire reduction, restocking, and forest health approaches to minimizing terrestrial carbon losses, while enhancing carbon sequestration. The urban forestry component also has the potential to reduce fossil fuel consumption through shading and wind protection of homes and commercial buildings. The overall goal for the forestation option calls for reestablishing forest on one million acres by 2025. For the wildfire risk reduction element, the goals are to identify and prioritize areas where wildfire fuel reduction would substantially reduce the risk of stand-replacing fires and to conduct fuel reduction on 50% of the identified areas by 2015 and 100% by 2025. The MCCAG recommends directing the biomass to the most beneficial uses, including biomass fuel production, where appropriate. For the restocking element, the MCCAG recommends identifying understocked stands on state and county lands by 2010. Then, where appropriate, optimally stock 25% of identified stands by 2015, and all such stands by 2025.

For the forest health and carbon sequestration element of AFW-5, the MCCAG recommends examining the carbon sequestration effects of shifting to desired future forest conditions using carbon-friendly management methods. Further, the state should develop scientific information on forest management options and harvest methods to increase the amount of carbon sequestered in forests. This information should be incorporated into forest management plans for all publicly administered forests by 2015. Also, Minnesota should identify and increase incentives for the durable wood products industry by 2010. Finally, a monitoring program should be established to document the long-term impacts of climate change on Minnesota forests by 2010. While the GHG benefits and costs of this element have not been quantified, GHG benefits over the long-term could be significant.

For urban forestry, the goals are to increase canopy cover in Minnesota communities by 25% by 2025. The costs of tree planting programs can vary substantially depending on whether the labor is paid or unpaid. Hence, strong relationships between all of the related parties are needed (State Department of Forestry, utilities, communities, non-government organizations). Also, the ability to implement these programs in smaller and newer communities on previously cleared land may be limited by the administrative capacity of these communities.

AFW-7 and AFW-8 provide an integrated set of recommendations for future management of municipal solid waste in Minnesota. AFW-7 focuses on "front-end" waste management technologies: source reduction, recycling, and composting, while AFW-8 focuses on "end-of-life" waste management approaches. The recommendations for AFW-7 represent a significant change from BAU waste management in the State: for source reduction, the goal is to achieve 0% increase in waste generation per capita by 2020 and a reduction of 3% in waste generation per capita by 2025;[5] for recycling, a 50% recycling rate should be achieved by 2011 and a 60% recycling rate by 2025;[6] and for composting, a rate of 10% by 2012 and 15% by 2020.[7] The recycling and composting elements achieve a total of 75% diversion of waste from landfilling or waste to energy (WTE) by 2025. The combined "front-end" waste management elements produce substantial GHG savings of 7.4 MMtCO_2e in 2025. These include avoided landfill GHG emissions, as well as avoided product/packaging lifecycle GHG emissions from source reduction and recycling.

Although AFW-7 is estimated in net societal cost savings, successful implementation will require waste management infrastructure investment by communities in the form of material recovery facilities and composting operations. State and local agency costs will also be incurred to develop and implement source reduction programs. Cost savings result from avoided landfill fees and the addition of the value of recycled or composted materials.

[5] Currently, waste generation per capita is increasing by a little less than 1% per year (as shown in the AFW-7 analysis of Appendix I).

[6] This recycling rate includes waste re-use (e.g. use of food waste in livestock feeding programs). The 2005 rate was 41%.

[7] While a full accounting of current composting levels in the State is not available, available data from MPCA suggest that it is no more than one or two percent of total generation (see Appendix I, AFW-7 analysis).

The recommendations provided in AFW-8 are expected to deliver another 0.6 $MMtCO_2e$ by 2025 (after accounting for the overlap with AFW-7). The important incremental “end-of-use” elements of AFW-8 are more stringent landfill gas collection and control requirements in the post-2020 time-frame and a requirement for all waste sent to WTE facilities to be pre-processed prior to combustion to remove non-combustible materials (e.g., metal and glass). This results in higher efficiencies for the WTE plant and lower GHG emissions.

In order to gain a sense of the importance of these two waste management options, the MCCAG also performed an assessment to compare the GHG benefits of current MPCA goals to the goals[8] of AFW-7&8. The following are the results of this comparison: the combined 2025 benefit of AFW-7&8 was 8.0 $MMtCO_2e$ compared with 0.57 $MMtCO_2e$ for the current MPCA waste management goals; the cumulative 2008–2025 benefit was 75 $MMtCO_2e$ for AFW-7&8 compared with 7.4 $MMtCO_2e$ for the current MPCA goals; and there was a cost-effectiveness of –\$4/tCO_2e for AFW-7&8 compared with \$117/tCO_2e for the current MPCA waste management goals.

Overview of Policy Recommendations and Estimated Impacts

As noted above, the 12 policy recommendation for the AFW sector address a diverse array of activities. Taken as a whole, they offer significant cost-effective emission reductions, as shown in Table 6-2.

Table 6-2. Summary list of policy recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2015	2025	Total 2008 2025			
AFW-1	Agricultural Crop Management						Unanimous
	A. Soil Carbon Management	0.72	1.3	15	–$34	–$2	
	B. Nutrient Management	0.79	1.3	15	–$543	–$37	
AFW-2	Land Use Management Approaches for Protection and Enrichment of Soil Carbon						Unanimous
	A. Preserve Land	0.15	0.44	3.7	$120	$33	
	B. Reinvest in Minnesota–Clean Energy (RIM-CE)	0.09	0.19	1.8	$59	$34	
	C. Protection of Peatlands & Wetlands	*Not Quantified*					
AFW-3	In-State Liquid Biofuels Production						Supermajority (4 objections)
	A. Ethanol Carbon Content	1.8	2.2	27	–$242	–$9	
	B. Fossil Diesel Displacement	0.03	0.19	1.4	$74	$55	
	C. Gasoline 35% Displacement	2.8	9.1	73	$336	$5	
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	1.3	3.8	31	$102	$3	Unanimous

[8] As documented in Appendix I (AFW-8, Feasibility Issues), the assumptions of current MPCA waste management goals are: BAU waste generation, as shown in Table 35 of Appendix I, (i.e., no source reduction); recycling rates remain on a BAU track of 41% (38% conventional recycling and 3% organics reuse); and 30% of total waste generation is directed to WTE in 2011 (as shown in Table 35 of Appendix I, current BAU waste management is estimated to direct about 20% of waste generation to WTE in 2011).

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2025	Total 2008 2025			
AFW-5	Forestry Management Programs to Enhance GHG Benefits						Unanimous
	A. Forestation	0.55	2.2	17	$218	$13	
	B. Urban Forestry	1.2	2.7	26	–$295	–$12	
	C. Wildfire Reduction	*Not quantified*					
	D. Restocking	2.1	8.4	65	$2,187	$33	
	E. Forest Health and Enhanced Sequestration	*Not quantified*					
AFW-6	Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover	2.2	2.7	34	$101	$3	Unanimous
AFW-7	Front-End Waste Management Technologies						Unanimous
	A. Source Reduction	0	3.6	20	$59	$3	
	B. Recycling	3.1	3.4	45	–$207	–$5	
	C. Composting	0.29	0.41	4.9	$137	$28	
AFW-8	End-of-Life Waste Management Practices						Unanimous
	A. Landfilled Waste Methane	0.07	0.73	4.4	$5.7	$1	
	B. Residuals Management	0.52	0.63	8.1	$650	$80	
	C. WTE Preprocessing	0.37	0.84	7.9	$257	$32	
	Sector Total After Adjusting for Overlaps*	**13.2**	**29.5**	**279**	**$2,090**	**$7**	
	Reductions From Recent Actions	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
	Sector Total Plus Recent Actions	**13.2**	**29.5**	**279**	**$2,090**	**$7**	

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

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the recommendations. Totals in some columns may not add to the totals shown due to rounding.

*Overlaps include an assumed 100% overlap of AFW-3b&3c with TLU-3 (reductions excluded from AFW totals); an assumed 100% overlap of AFW-4 with ES-5 (reductions and costs excluded from AFW totals); overlap of AFW-7&8 (incremental benefits and costs of AFW-8 included in the AFW totals).

Agriculture, Forestry, and Waste Management Sector Policy Descriptions

The Agriculture, Forestry, and Waste Management Sectors include emissions 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, production of additional biomass energy, forestation on non-forested lands, and an increase in municipal solid waste source reduction, recycling, composting, landfill gas collection, and waste to energy pre-processing.

AFW-1 Agricultural Crop Management

This policy recommendation addresses both agricultural soil carbon management, as well as nutrient management to achieve greenhouse gas (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 carbon dioxide (CO_2) from soil. Each farm operation and each field management unit has unique traits that may allow management practices to influence nutrient, water, and carbon cycling and sequestration. Defining GHG outcomes based upon management indices may allow farmers to incorporate management practices within their specific operational needs to meet desired GHG goals. Providing cropping and management flexibility within each field or tract management unit allows both production and resource management goals to be transparent and readily valued.

The efficient use of agricultural fertilizer, both commercial and animal-based, can be improved through certain management practices and systems. An example is over-application of nitrogen, which can result in plants not fully metabolizing the nitrogen, allowing the nitrogen to leach into groundwater and/or be emitted to the atmosphere as nitrous oxide (N_2O). Better nutrient utilization can lead to lower N_2O emissions from runoff. An example is tile drainage systems that use the latest technology and design models to reduce nitrates leaching into surface water and groundwater.

AFW-2 Land Use Management Approaches for Protection and Enrichment of Soil Carbon

This policy converts marginal or sensitive agricultural land with an immediate history of use for annual crop production to permanent cover, such as grassland/rangeland, orchard, or forest on land that was formerly forested, where the soil carbon and/or carbon in biomass is substantially higher under the new land use. This includes opportunities to keep CRP, Conservation Reserve Enhancement Program (CREP), and Reinvest in Minnesota (RIM) lands in well-managed, continual cover, while also providing opportunities for working lands to increase carbon sequestration through biomass production that can provide feedstocks for in-state bioenergy production.

Incentives need to be created to convert annual row-crop acres to perennial crops that prevent these acres from either returning to conventionally tilled production or to suburban/urban development. Incentives also need to be created for promoting carbon sequestration goals on public lands and lands enrolled in existing conservation programs. Finally, research should be conducted and programs adopted to identify and eliminate threats to the vast carbon pools currently stored in lands that hold high levels of soil organic carbon, such as peatlands and wetlands.

Wetlands have among the highest potential carbon-sequestration capacities for any type of land cover in Minnesota. Peatlands are likely Minnesota's largest single carbon sink, containing 37% of all carbon stored in the state, compared with 3% stored in the state's forests. Protecting these enormous carbon reservoirs from the impacts of warmer and drier conditions and increased fire risk is critical. Early attention should be given to identifying degraded peatlands at risk of re-emitting sequestered CO_2 and CH_4. Additional study is needed to understand GHG dynamics in the full range of wetland types in Minnesota and to apply this understanding to the state's wetland conservation policies to reduce the risk of releases of stored GHGs from these systems.

AFW-3 In-State Liquid Biofuels Production

This policy promotes sustainable in-state production and consumption of transportation biofuels from agriculture and/or agroforestry feedstocks to displace the use of gasoline and diesel. It decreases the use of fossil fuel in the production of these biofuels, which will improve the GHG profile of in-state liquid biofuels production and consumption. Sustainability standards also needed to be developed for low-carbon biofuels, so that producers are rewarded accordingly.

This policy also promotes the in-state development of feedstocks, such as cellulosic material and perennials that are able to be utilized. Recognizing that conversion technologies, such as thermo-chemical Fischer-Tropsch processes and enzymatic conversion, are developing fast in this sector, the policy recommends facilitating, but not requiring, their development.

AFW-3 also promotes multiple biofuel (ethanol, biodiesel, biobutanol) production systems that improve the embedded energy content, life cycle, and carbon profile of biofuels. It focuses on plant material feedstocks that favor energy production, that are carbon neutral or negative, and that have multiple other positive environmental benefits, such as maintaining carbon-sequestration potential and soil productivity, and decreasing water and fossil fuel inputs in their production.

To achieve true gains in reducing GHGs, promoting biofuel production must be coupled with strong policies to reduce overall transportation fuel consumption. Upon successful implementation of this policy, Minnesota consumption of biofuels produced in-state will produce better GHG benefits than these same fuels obtained from a national 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).

Note: This recommendation is linked with the Transportation and Land Use recommendation TLU-3, a Low-Carbon Fuels Standard. It seeks to achieve incremental GHG benefits beyond the TLU recommendation by promoting in-state production of biofuels using feedstocks with greater GHG benefits than the likely BAU national production methods. Further, AFW-3 focuses on the supply elements of the implementation of a biofuels program while TLU-3 focuses on the demand side (e.g., vehicle technology requirements, E10, E85).

AFW-4 Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production

This policy dedicates a sustainable quantity of biomass from agricultural lands, land restoration activity, agricultural industry residues, wood industry process residues, those normally unused forestry residues, and agroforestry resources for efficient conversion to energy and economical production of heat, steam, or electricity. This biomass should be used in an environmentally acceptable manner, considering proper facility siting and feedstock use (e.g., proximity of users to biomass, impacts on water supply and quality, control of air emissions, solid waste management, cropping management, nutrient management, soil and non-soil carbon management, and impacts on biodiversity and wildlife habitat). The objective is to create concurrent reduction of CO_2 due to displacement of fossil fuel considering life cycle GHG emissions associated with viable collection, hauling, and energy conversion and distribution systems.

The potential feedstocks associated with this policy are biomass normally unused under any existing program, meaning:

- Any organic material grown for the purpose of being converted to energy.
- Any organic by-product of agriculture that can be converted into energy.
- Any material that can be converted into energy and is non-merchantable for other purposes, that is segregated from other non-merchantable material, and that is:
  - A forest-related organic resource, including mill residues, pre-commercial thinnings, slash, brush, or by-product from conversion of trees to merchantable material; or
  - A wood material, including pallets, crates, dunnage, manufacturing and construction materials (other than pressure-treated, chemically treated, or painted wood products), and landscape or right-of-way tree trimmings.

Expanded biomass resources can be developed from agricultural industry process residues and agro-forestry products as new industrial facilities are built and through conversion of existing facilities. Analyses project that Minnesota theoretically has enough residual biomass and energy crops that, if collected and fed to the most efficient conversion technologies available, could produce up to 99% of the total electricity currently used in the state. Actual results are highly dependent on economically attractive methods for collection of materials, hauling, and energy conversion and distribution systems, as well as sustainable harvest methods. Current research and increasing numbers of demonstration projects occurring nationally are available to determine which system components are most functional and cost-effective for given locations.

AFW-5 Forestry Management Programs to Enhance GHG Benefits

Forests—public, private, urban, managed, and wild—provide many GHG benefits. The following actions are recommended:

- Protect and enhance the carbon stored in tree biomass by maintaining and improving the health, longevity, and number of trees in urban and residential areas. Emission reductions from reduced heating and cooling as a result of planting shade trees are a significant co-benefit.
- Promote forest cover and associated carbon stocks by establishing forests on former forestland. Additional benefits include public recreation, water quality, wildlife habitat, and enhanced biodiversity. Implement such practices as soil preparation, erosion control, and stand stocking to ensure conditions that support forest growth.
- Encourage activities that promote forest productivity and increase the amount of carbon sequestered in forest biomass and soils and in long-lived wood products. Practices may

include adjusting rotation ages to increase carbon sequestration, increasing the stocking of poorly stocked lands, managing thinning and density, and increasing the acreage of short-rotation woody crops (for fiber and energy) on agricultural lands previously converted from forestland.

Reduce the severity of wildfires to reduce GHG emissions by lowering the forest carbon lost during a fire and by maintaining carbon sequestration potential. Similarly, reducing damage from insects, disease, and invasive plants decreases GHG emissions by maintaining the carbon sequestration potential of healthy forests.

AFW-6 Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover

In the mid- to late 1800s, forests covered 31 million acres in Minnesota. Over the subsequent 100-plus years, 15 million acres of this forestland were converted to other uses, mainly to farmland, but also to developed areas. Between 1990 and 2003, Minnesota forestland acreage was reduced by nearly one-half million acres, from 16.7 million acres to 16.2 million acres.[9] Because forestland captures and stores CO_2 in trees, soil, and other forest biomass at a much higher rate than developed areas and other areas without forest cover, priority should be placed on reducing conversion of forested lands to land uses with lower carbon sequestration potential.

AFW-7 Front-End Waste Management Technologies

Front-end waste management technologies promote the reduction of the sheer volume of waste produced, as well as reduction in consumption through incentives, awareness, and increased efficiency. Three major areas of focus in Minnesota are source reduction, organic waste management, and advanced recycling. Source reduction and recycling provide GHG benefits not only from avoided disposal emissions, but also from product life cycle emission reductions (associated with the manufacture and transport of new packaging and products). Redirecting organic wastes (such as food, yard, and paper) from landfills into composting programs is very effective at reducing GHG emissions.

AFW-8 End-of-Life Waste Management Practices

This policy promotes activities that further reduce GHG production by encouraging the use of energy recovery technologies for materials not managed by AFW-7 (Front-End Waste Management Technologies). It also encourages the use of energy recovery technologies for waste materials for which more desirable front-end waste management alternatives are not available or feasible. These technologies will help reduce GHG emissions from waste management, while producing cleaner energy. They make a two-fold contribution to climate protection, by reducing the discharge of methane and other GHGs into the atmosphere, and replacing fossil fuel burning with recovered energy. For example, the energy created by landfills (methane) can be used to make electric power, space heat, or liquefied natural gas. WTE

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[9] Minnesota Pollution Control Agency and Center for Climate Strategies. Appendix H: Forestry, p. H-3, Table H1, "USFS Carbon Pool Data for Minnesota." June 7, 2007. See http://www.mnclimatechange.us/ewebeditpro/items/O3F12645.pdf

facilities already in existence in Minnesota generate 100 MW of electricity and 150,000 lb/hour of steam for heating and cooling and use by other industries.

Chapter 7
Cross-Cutting Issues

Overview of Cross-Cutting Issues

Some issues relating to climate policy cut across multiple or all sectors. The Minnesota Climate Change Advisory Group (MCCAG) addressed such issues explicitly in a separate Technical Work Group (TWG) as "cross-cutting" issues rather than assigning them to any individual sector. Cross-cutting recommendations typically encourage, enable, or otherwise support emissions 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 cost-effectiveness calculations. Nonetheless, if successfully implemented, they would likely contribute to GHG emission reductions and enhance the economic benefits described for each of the other policy recommendations that were quantified. Those recommendations are described in Chapters 3–6.

The Cross-Cutting Issues (CC) TWG developed recommendations for each of seven policies (see Table 7-1) that were then reviewed, revised, and ultimately adopted by the MCCAG. All of the recommendations are focused on supporting GHG emissions reduction efforts.

The statewide goals and targets recommendation (CC-2) is the overarching MCCAG recommendation, and it is based on the goals established in the Minnesota Next Generation Act of 2007 (S.F. 145). The GHG reduction goals contained in the Act and endorsed by the MCCAG are to reduce statewide GHG emissions across all sectors producing those emissions to levels at least 15% below 2005 levels by 2015, at least 30% below 2005 levels by 2025, and at least 80% below 2005 levels by 2050. MCCAG projects that implementation of the policies contained in this Plan will achieve these levels of reductions.

All of the seven policy recommendations were adopted unanimously by the MCCAG members present and voting.

Table 7-1 Summary List of Cross-Cutting Policy Recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effective-ness ($/$MtCO_2e$)	Level of Support
		2015	2025	Total 2008–2025			
CC-1	GHG Inventories, Forecasting, Reporting, and Registry	*Not quantified*					Unanimous Consent
CC-2	Statewide GHG Reduction Goals and Targets	*Not quantified*					Unanimous Consent
CC-3	State and Local Government GHG Emissions (Lead by Example)	*Not quantified*					Unanimous Consent
CC-4	Public Education and Outreach	*Not quantified*					Unanimous Consent
CC-7	Participate in Regional and Multistate GHG Reduction Efforts	*Not quantified*					Unanimous Consent
CC-8	Encourage the Creation of a Business-Oriented Organization To Share Information and Strategies, Recognize Successes, and Support Aggressive GHG Reduction Goals	*Not quantified*					Unanimous Consent
CC-9	Dedicate Greater Public Investment to Climate Data and Analysis	*Not quantified*					Unanimous Consent
	Sector Total After Adjusting for Overlaps	***Not quantified***					
	Reductions From Recent Actions	***Not quantified***					
	Sector Total Plus Recent Actions	***Not quantified***					

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$MtCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Key Challenges and Opportunities

One of the key challenges facing Minnesota and other states is the lack of clear federal climate change goals, policies and programs. Recent enactment of the federal energy act will provide some direction on auto mileage and energy efficiency requirements but there are many other facets of the climate change problem that may need to wait over a year for federal policy to become more apparent.

In the meantime the state is one of the partners in the Midwestern Governors GHG Reduction Accord and the Energy Security Platform. Participation in these important regional ventures offers the state the clear opportunity to help develop regional goals and collaborative initiatives that will have broader applicability than just within Minnesota borders.

The state has begun to implement a number of activities recognized in the lead by example section of this chapter. The state will need to build on these efforts and take such initiatives to the next level. Additionally, the state will need to organize efforts across state agency boundaries in order to realize some of the reductions anticipated from state government.

Implementation of many elements of the MN Climate Action Plan may entail additional costs to state government that the state will need to determine how to finance. For instance the Plan calls on the state to make greater investments in Climate Data and Analysis upon which the ongoing climate program will depend. Determining how to finance implementation of the Plan will remain an ongoing challenge.

Another opportunity for the state is in the arena of building more business and economic opportunities associated with reducing GHG emissions. The Plan calls for the creation of a business oriented entity to promote such efforts.

The state also needs to make efficient use of many existing programs, particularly in the monitoring arena. The state should be striving to integrate GHG emissions monitoring and tracking into the existing monitoring infrastructure to the extent feasible.

Cross-Cutting Issues
Policy Descriptions

CC-1 GHG Inventories, Forecasting, Reporting, and Registry

GHG emission inventories are essential for understanding the magnitude of all emission sources and sinks (both natural and those resulting from human activities), for estimating the relative contribution of various types of emission sources and sinks to total emissions, for informing state leaders and the public on statewide trends, and for assisting with verifying GHG reductions associated with implementation of action plan initiatives.

GHG forecasts, built on solid inventories, help to predict likely impact scenarios, identify the factors that affect trends over time, and highlight opportunities for mitigating emissions or enhancing sinks.

GHG reporting reflects the measurement and reporting of GHG emissions to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities and reduce risks associated with possible future GHG mandates by moving up the learning curve. Tracking and reporting of GHG emissions can also help in the construction of periodic state GHG inventories. GHG reporting is a precursor for sources to participate in GHG reduction programs, opportunities for recognition, and a GHG emission reduction registry, as well as to secure “baseline protection” (i.e., credit for early reductions).

A GHG registry enables recording of GHG emission reductions in a central repository with transaction ledger capacity to support tracking, management, and ownership of emission reductions; establish baseline protection; enable recognition opportunities; and provide a mechanism for regional, multistate, and cross-border cooperation. Properly designed registry structures also provide a foundation for possible future trading programs.

The state should institute formal GHG inventory and forecast and GHG reporting functions within the Minnesota Pollution Control Agency (MPCA), to be assisted by other state agencies as needed.

Goals:

- Develop a periodic, consistent, and complete inventory of emission sources and sinks at least once every 2 years. To the degree that data and methods allow, the inventory should include all natural and man-made emissions generated within the boundaries of the state (i.e., a production-based inventory approach), as well as emissions associated with energy imported and consumed in the state (i.e., a consumption-based inventory approach). Through performance metrics and differences in year-to-year emissions, the inventory should provide a way of documenting and illuminating trends in state GHG emissions.
- Develop a protocol for use in preparing the statewide emission and sink inventory. This should include a consistent protocol for evaluating the state's progress in meeting the goals of the Next Generation Energy Act of 2007, which should logically form the basis for inventory reporting of electricity sector emissions under a consumption-based approach.
- Biennially provide a summary of statewide emission and sink trends and progress toward the goals of the 2007 Next Generation Energy Act to the legislature.
- Develop a periodic, consistent, and complete forecast of future GHG emissions in at least 5- and 10-year increments extending at least 20 years into the future. MPCA should periodically assemble the GHG forecasts, which should reflect projected growth as well as the implementation of scheduled mitigation projects. In the forecasting of future GHG emissions, the treatment of uncertainties should be transparent, should be as consistent as possible across sectors and time and, to the extent possible, should reflect multiple scenarios. The estimation methods should be consistent with those used to develop the emission inventory and should reflect best practice.
- Develop a standardized protocol for the periodic forecasting of statewide GHG emissions.

CC-2 Statewide GHG Reduction Goals and Targets

Article 5 of the Next Generation Energy Act of 2007 (S.F. No. 145) establishes goals for Minnesota to reduce statewide GHG emissions across all sectors producing those emissions, to levels at least 15% below 2005 levels by 2015, at least 30% below 2005 levels by 2025, and at least 80% below 2005 levels by 2050. The levels will be reviewed based on the Minnesota Climate Action Plan. In addition, Article 1 of the act establishes that Minnesota's energy policy requires (1) that the per capita use of fossil fuel as an energy input be reduced by 15% by 2015 through increased reliance on energy efficiency and renewable energy alternatives, and (2) that 25% of the total energy used in the state be derived from renewable energy resources by 2025.

The MCCAG endorses these goals as part of this Plan.

CC-3 State and Local Government GHG Emissions (Lead-by-Example)

In many areas, the Minnesota state government is already leading by example to obtain GHG emission reductions. State and local governments are responsible for providing a multitude of services for the public that are delivered through very diverse operations and result in wide-ranging GHG emission activities. State and local governments can take the lead in demonstrating that reductions in GHG emissions can be achieved through analysis of current operations, identification of significant GHG sources, and implementation of changes in technology, procedures, behavior, operations, and services provided. State and local governments can also encourage and provide incentives for reducing GHG emissions by others in a variety of ways.

The support of broad-ranging goals for GHG reductions for state government through the goals established below and those that already exist through the Interagency Pollution Prevention Advisory Team (IPPAT) will be helpful for setting an example and building expectations, with actual reductions realized at the state agency level. Disaggregating the state's own GHG emissions to the agency level and showing the results in the annual IPPAT report on GHG reduction progress is an effective way to measure and manage the state's emissions.

State and local governments should establish reduction targets for their own GHG emissions. The establishment of broad-ranging goals for reducing governments' GHG emissions will be helpful both in setting an example and in building expectations. Because actual reductions will typically be realized at the individual agency level, disaggregating individual governments' GHG emissions to the agency or department level and requiring annual agency- or department-specific reports on GHG reduction progress can be effective ways to measure and manage each agency's progress toward reducing its emissions. Government agencies or departments first developed agency- or department-specific GHG emissions inventory data. These data became the baseline data for ongoing emission reduction activities and measurements, which are summarized in annual IPPAT reports by each agency or department. IPPAT oversees the ongoing climate efforts of the state government's agencies and departments; reviews their performance; and provides direction, guidance, resources, shared approaches, and recognition to agencies or departments and their employees who are working to reduce the state government's GHG emissions.

Goals:

- Each state agency will, in consideration of its current and projected building stock,
  - Determine and quantify its current and projected energy consumption and associated GHG emissions from such consumption,
  - Develop and propose a plan to reduce the statewide GHG emissions associated with its building stock commensurate with its pro rata share of the statewide GHG reduction goals established in the 2007 Next Generation Energy Act,
  - Provide the plan to IPPAT, and
  - Report annually to IPPAT on its progress toward its GHG reduction goals in buildings.
- Each state agency will, in consideration of its current and projected transportation stock,
  - Quantify and establish the same goals for its transportation stock described above for its building stock,
  - Provide the plan to IPPAT, and
  - Report annually to IPPAT on its progress toward its GHG reduction goals in transportation.

The state should develop appropriate guidelines and tools for utilizing the environmental impact assessment processes to assess and promote reductions of GHG emissions. Environmental

Assessment Worksheets (EAWs) and Environmental Impact Statements (EISs) are written analyses of the potential environmental impacts of a proposed action or project in Minnesota. Including consideration of GHG emissions as part of EAW and EIS processes and documents would enable comparison of reference case GHG emission levels to future GHG emission levels as a result of proposed projects. Such information could be helpful in targeting development decisions that minimize GHG emissions or in pointing out the need for authority to regulate GHG emissions. Agencies should utilize state-developed guidelines and tools in EAW and EIS documents comparing reference case and estimated future GHG emissions. This information will guide officials and developers in choosing technologies and activities that result in development that protects the environment and reduces additional contributions of GHGs.

Additionally, the existing directives of IPPAT, along with the following Executive Orders, should be continued and enhanced:

04-02, Providing Direction to State Agencies Regarding State Contracting Procedures

04-08, Providing for State Departments To Take Actions To Reduce Air Pollution in Daily Operations (Clean Air Minnesota provisions)

04-10, Providing for State Departments To Improve Fleet and Travel Management

05-16, Providing for Energy Conservation Measures for State-Owned Buildings

06-03, Requiring State Agencies To Increase the Use of Renewable Fuels

CC-4 Public Education and Outreach

Explicitly articulated public education and outreach can support GHG emission reduction efforts at all levels in the context of emission reduction programs, policies, or goals by fostering a broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) and engaging citizens, businesses, and institutions in actions to reduce GHG emissions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state and should make the public aware of GHG emissions associated with products produced outside of Minnesota and the United States. Ultimately, public education and outreach will be the foundation for the long-term success of the policy actions proposed by the MCCAG as well as those that may evolve in the future.

The state should build upon current educational efforts and action campaigns of state agencies, utilities, and nonprofit organizations that understand each other’s offerings and should use these enhanced resources to educate and encourage all sectors within Minnesota—such as residential, commercial, and educational—to take action.

Minnesota has a long history of environmental education. The state should work through existing organizations by encouraging them to incorporate education about climate change and the role of GHG emissions into their existing educational efforts. The states initiatives should focus on being the primary mechanism for providing mitigation, awareness, and understanding of climate change and the role humans play in causing it.

Some of the highlights of these current actions include The Environmental Education Advisory Board, the Environmental Learning in Minnesota Fund, the Minnesota Environmental Literacy Scope and Sequence, and the Sharing Environmental Education Knowledge Partnership. Additional educational initiatives by the utilities and nonprofit sectors are also recommended.

Goals: The overarching goal is to raise awareness about global warming and promote individual action to reduce the Minnesota's overall GHG emissions.

CC-7 Participate in Regional and Multistate GHG Reduction Efforts

Regional approaches undertaken in collaboration with partner states or other organizations can offer broader and more economically efficient opportunities to reduce GHG emissions across Minnesota's economy. Several options for regional, market-based GHG reduction strategies should be considered in Minnesota, such as joining the Western Climate Initiative (WCI)or the Northeast States Regional Greenhouse Gas Initiative (RGGI), instituting a new midwestern states GHG initiative, considering the California vehicle standards, and encouraging cost-sharing on multistate initiatives.

Goals: Ensure the cost-effective reduction of GHG emissions to at least the reduction levels set forth in the Next Generation Energy Act in a manner that maximizes public benefits and induces innovation in energy efficiency and sustainable energy technologies and avoids inequitable impacts.

Near the end of the MCCAG process, Governor Pawlenty signed the state on to the Midwestern Regional Greenhouse Gas Reduction Accord and the Midwestern Energy Security and Climate Stewardship Platform adopted by nine midwestern states and one Canadian province.

CC-8 Encourage the Creation of a Business-Oriented Organization To Share Information and Strategies, Recognize Successes, and Support Aggressive GHG Reduction Goals

Successful state GHG reduction efforts are highly dependent on the active participation of the business community, particularly in the energy, agriculture, transportation, development, and manufacturing sectors. In Minnesota, there are many progressive corporations that are eager to participate in broad-scale efforts to reduce GHG emissions. To facilitate a strategic approach that has a significant impact, a statewide proactive business organization should be formed to promote energy efficiency and GHG reduction opportunities.

Goals: The Next Generation Energy Act of 2007 established general goals for GHG emission reductions and an aggressive specific annual goal of reducing energy consumption by 1.5%. A new business strategy that aggressively promotes options to improve energy efficiency by Minnesota's businesses will help achieve these goals.

CC-9 Dedicate Greater Public Investment to Climate Data and Analysis

To calibrate GHG mitigation policies, it is critical that decision makers and Minnesota citizens understand how climate change is currently affecting and will in the future affect the state's natural resources and economy. Much of the data and information needed to make such an assessment is being collected by various departments and entities in the state. MPCA and the Minnesota Departments of Natural Resources, Agriculture, and Employment and Economic Development should assess and identify the gaps in ongoing data collection that would need to be filled to monitor, track, and assess climate change impacts in Minnesota. The departments should develop recommendations for filling these data gaps and suggest the best approach (possibly by coordinating with the University of Minnesota) for periodically assessing how intensely Minnesota is being and is likely to be affected by climate change.

Goals: Develop a plan for periodically assessing the recent and projected impacts of climate change on Minnesota natural resources and economic activity. The assessment would focus on (but not be limited to) impacts on water resources and quality, air quality, landscape change, forest resources and health, ecosystem health, species diversity, fish and wildlife and their habitats, agricultural productivity, recreation and other amenities, human disease, and settlement. The assessment should treat impacts arising from climate change in the present and recent past and impacts that are likely or possible 30–50 years into the future and should rely on the best available regional climate data and assessments.

Chapter 8
Cap-and-Trade

Overview of Cap-and-Trade

The Cap-and-Trade Technical Work Group (TWG) was formed about midway through the Minnesota Climate Change Advisory Group (MCCAG) process when the Energy Supply TWG observed that the complexity of the issue demanded the full-time attention of a special committee. The first meeting of the Cap-and-Trade TWG was held on October 10, 2007; in total, 11 meetings were held between then and January 18, 2008, including a 6-hour in-person meeting on December 14, 2007. Several policy options were referred to and considered by the Cap-and-Trade TWG, but most of the committee's effort was devoted to the cap-and-trade option itself, C&T-1.

Unlike most of the policies studied by the other TWGs, cap-and-trade is not tied to a specific sector or emissions reduction measure. It is a system by which the sources within covered sectors find and achieve the lowest-cost emissions reduction investments. Cap-and-trade also provides a means of ensuring that total emissions from all covered sources will not exceed the government-set limit, or cap.

Cap-and-trade programs limit emissions by first placing a "cap," or limit, on the total number of tons of pollutants that will be permitted to be released from regulated, or "covered," sources of greenhouse gas (GHG) emissions within a specified geographic area and interval of time. The cap is enforced by the issuance of permits, or "allowances," which must be surrendered by each covered source in an amount equal to its emissions. By setting the total number of allowances equal to the overall cap, total emissions are limited. Moreover, the number of allowances issued over time can be decreased, thereby further reducing total emissions.

Since the government regulates only the total emissions, the means by which the reductions are achieved is left to the individual covered sources (although many reduction activities may be covered by other policies). Sources would individually identify their least-cost options, but creating a market gives these allowances a financial value, which encourages the covered sources to collectively implement the least-cost measures at different levels of mitigation to achieve the capped emission reductions. Through trading, participants with lower costs of compliance can choose to over comply and sell their additional reductions to participants for whom compliance costs are higher. In this fashion, the overall costs of compliance are lower than would otherwise be the case.

The Cap-and-Trade TWG also studied the use of a carbon tax as a substitute for, or in addition to, the cap-and-trade policy, as well as several policies related to regional (interstate) actions. In addition, the TWG considered the creation of a carbon credit system to encourage and enable carbon mitigation and sequestration projects in Minnesota to qualify for offset or other credits from state, regional, national, or international cap-and-trade programs. Unfortunately, the time demands of the cap-and-trade policy analysis prevented the committee from fully examining this option. The MCCAG encourages further study of this policy, especially in the context of the governor's announced intention to pursue a similar program.

Key Challenges and Opportunities

The State of Minnesota, has joined the Midwestern Greenhouse Gas Reduction Accord(MGA), which calls for a number of interstate actions, including the design and implementation of a regional cap-and-trade program covering Minnesota, Michigan, Wisconsin, Iowa, Illinois, Kansas, and the Canadian Province of Manitoba. Three additional states are participating in the project as observers. Two other regions are pursuing cap-and-trade programs to limit GHG emissions: the 10-state northeast Regional Greenhouse Gas Initiative (RGGI) and the 7-state, 2-province Western Climate Initiative (WCI). In addition, there are numerous bills before Congress to create a national cap-and-trade program for this purpose. Minnesota will almost certainly become a participant in a regional, super-regional or national cap-and-trade program to limit and then reduce GHG emissions. The MCCAG's investigation of this issue should offer valuable early guidance to state and regional policy makers who will need to confront the complex policy choices demanded of these programs.

The benefits of the approach, especially when applied on a regional basis, are tangible. First of all, the very basis of a cap-and-trade program is the cap—a specific, numerical limit on the number of tons of GHGs that may legally be released to the atmosphere over a specified period of time. The environmental integrity of a well-designed and operated cap-and-trade program is therefore compelling. The second tangible benefit is the ability to achieve those emission reductions at a reduced cost, even after considering the cost of the program itself. For the recommended configuration of region, sectors, and program design, modeling of the program indicates that in 2025 Minnesota can achieve a 32% reduction in GHG emissions versus a business-as-usual projection at a net cost of $5 million below that which would be possible without the cap-and-trade program.

While many key cap-and-trade program design questions have been addressed through this process, the MCCAG did not have sufficient time to develop policy recommendations regarding all of the major program design alternatives. The MCCAG recommends that a panel of experts be convened by the partners in the Midwestern Greenhouse Gas Reduction Accord (hereafter, Midwestern Accord Partners) to study in greater depth and make recommendations on the multitude of program design features that must be addressed.

Overview of Policy Recommendations

The MCCAG recommends three policy options relating to the use of market-based programs to help achieve emission reductions goals. The creation of a Market Advisory Group (C&T-5) to help the Midwestern Accord Partners sort out the hundreds of complex program design issues addresses the challenge that lies ahead and draws from California's experience with their Market Advisory Committee. This option was not quantified because, in and of itself, it does not reduce emissions. Likewise, the recommendation to seek additional cooperative emission reductions through regional initiatives and agreements (C&T-6) was not quantified, but concern for private sector competitive issues and a desire to maximize emissions reductions through joint action achieved the unanimous endorsement of the MCCAG.

The cap-and-trade policy (C&T-1) was examined with several assumptions regarding design alternatives. Many of these were geographic (e.g., Minnesota-only, MGA Partners, MGA Partners and Observers, MGA Partners and WCI Partners), some were programmatic (e.g., free distribution of allowances to sources, 100% auction of allowances), and some examined the effect of changing assumptions for analysis (whether the Renewable/Environmental Portfolio Standard is an active policy option or assumed to be in the baseline). The result was hundreds of numbers and dozens of graphs, all of which helped guide the C&T TWG to their recommendations. What are presented here are the results as they describe the final recommended configuration for the cap-and-trade program . All of the details of each scenario are presented in full in Appendix K.

The MCCAG recommends that Minnesota join with its regional Midwestern Accord Partners to create a multi-sector cap-and-trade program as soon as possible. MCCAG recommends that sector coverage include power generation, industrial boilers and processes, transportation fuels, fossil fuels used in residential and commercial buildings, municipal waste incinerators, landfills, large confined animal feeding operations, and other large agricultural operations where it is possible to measure emissions with a reasonable degree of precision.

The policies and measures that achieve the required emission reductions under the cap-and-trade program are essentially those recommended by the MCCAG within the covered sectors, plus any measures that the regulated entities choose to undertake at a cost less than that of an allowance.

"The permit price of the MGA partner trading in 2025 is in the range of \$45–\$48 per metric ton of CO_2 equivalent (\$/tCO_2e) across the three baseline scenarios. In all three of the baseline scenarios, the total cost of achieving the carbon emissions reductions is negative for many states. Minnesota's total cost is negative in two of the three scenarios, but positive in the recommended policy scenario (in which a renewable electricity standard [RES] and Conservation Improvement Program [CIP] are assumed to be in the baseline). This is because in the recommended baseline scenario, the substantial cost savings associated with CIP have been incorporated into the baseline condition of Minnesota. States with negative total costs will realize an overall cost savings, due to the extensive range of cost-saving options to reduce emissions (such as improvements in energy efficiency). Notwithstanding the positive total cost result for Minnesota, the cap-and-trade program allows Minnesota to achieve its cap at a lower cost than would be the case without the program."

Modeling of the recommended program design indicates that in 2025, Minnesota will achieve nearly 53 million metric tons of carbon dioxide (MMtCO_2) mitigation at a net cost of \$245 million. This is \$5 million less than the cost of achieving the same reductions without the cap-and-trade program. To realize those savings, in-state regulated entities would purchase a projected 2.27 million allowances from outside Minnesota at a price of \$45.95 per allowance.

It is important to distinguish the difference between the expected cap-and-trade allowance price and the expected cost of mitigating one ton of CO_2e. The allowance price will be equal to the cost associated with mitigating the *last* ton of CO_2 necessary to achieve the cap. This is the marginal, or most expensive, ton mitigated. The expected unit cost would be the total expended to mitigate all the CO_2 to meet the cap divided by the number of tons mitigated. This is the average cost per ton mitigated, and for many scenarios, it turned out to be a negative cost (savings), even while the allowance price was expected to exceed \$40 per ton.

The actual cost of the program to emitters will depend on the allowance allocation mechanism, because under an auction, all tons will be priced at the market price (marginal cost). This cost is simply the price—marginal cost per ton—times the quantity—the total tons auctioned. In any market system, it is the market price, not the production cost, that is the main determinant of initial cash flows. In the auction case, it determines the permit expenditures and government revenues, while cost or cost savings to emitters will be realized during implementation of mitigation and through the application of auction revenues (reduced taxes, rebates, grants or other financial incentives to encourage innovation). For the case where permits are freely granted, the market price will determine the expenditures by permit buyers and revenues by permit sellers, while cost savings will again be realized during implementation. The net costs after auction revenue is expended have not been analyzed for the MCCAG.

Across the MGA region, total emission reductions in 2025 are projected to reach 459 million tons at a total cost savings of $5.7 billion. The region-wide net savings resulting directly from the cap-and-trade program is $520 million.

The MCCAG also studied the implications of a Minnesota-only program, as well as variations of the Midwestern program merged with the WCI region. In every modeling run, the Minnesota-only scenarios proved to be more costly and less effective than the regional configurations. And while results varied, depending on the particular configuration chosen, there is evidence that Minnesota's costs would be further reduced if the WCI region were merged into the MGA program. Cost-effectiveness across the various geographical configurations ranged from $4.71 to –$2.19 per ton of CO_2 that Minnesota mitigated in 2025.

Table 8-1 summarizes the modeling results from the various configurations and assumptions. The first row (MGA Partners C&T—*with both RES/CIP in the baseline*) gives the results from the geographic configuration that reflects the programmatic assumptions preferred by the MCCAG.

The MCCAG also recommends that the cap-and-trade program include, or give credit to, emission reductions achieved by non–cap-and-trade policies and measures within the capped sectors. In addition to keeping the cost of the program low, this approach allows the cap-and-trade program to serve as a backstop to the expected reductions from these other policies and measures. For example, if the non–cap-and-trade policies and measures do not achieve the expected reductions, the cap-and-trade program emissions limit would guarantee that the goals are achieved through additional reductions either in Minnesota or elsewhere in the region.

Table 8-1. Summary list of cap-and-trade policy recommendations

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$) 2015	GHG Reductions ($MMtCO_2e$) 2025	GHG Reductions ($MMtCO_2e$) Total (2008–2025)	Net Present Value (Million $)	Cost-Effective-ness* ($/tCO_2e$) 2025	Permit Price† ($/tCO_2e$) 2025	Level of Support
C&T-1	Cap-and-Trade Program							Majority (9 objections)
	MGA Partners C&T *—with both RES/CIP in the baseline*		52.94			$2.65	$45.95	
	MGA Partners C&T *—no RES/CIP in the baseline*		79.82			–$12.17	$48.45	
	MGA Partners C&T *—with only RES in the baseline*		67.35			–$15.42	$46.64	
	MGA Partners+Observers C&T *—no RES/CIP in the baseline*		81.97			–$10.52	$52.44	
	MGA Partners+Observers C&T *—with both RES/CIP in the baseline*		55.45			$4.71	$50.72	
	MGA Partners+Observers C&T *—with only RES in the baseline*		69.45			–$13.48	$51.27	
	MGA plus WCI Partners C&T *—no RES/CIP in the baseline*		72.64			–$17.52	$35.69	
	MGA plus WCI Partners C&T *—with both RES/CIP in the baseline*		46.93			–$2.19	$34.95	
	MGA plus WCI Partners C&T *—with only RES in the baseline*		61.92			–$20.36	$35.07	
	MGA and WCI Partners+Observers C&T *—no RES/CIP in the baseline*		76.17			–$14.92	$41.87	
	MGA and WCI Partners+Observers C&T *—with both RES/CIP in the baseline*		50.41			$0.59	$41.25	
	MGA and WCI Partners+Observers C&T *—with only RES in the baseline*		64.92			–$17.65	$41.39	
C&T-2	Minnesota-only C&T *—no RES/CIP in the baseline*		89.18			–$2.39	$65.48	Merged into C&T-1
C&T-3	National C&T	*Not quantified*						Merged into C&T-1
C&T-5	Market Advisory Group (Formerly CC-11)	*Not quantified*						Unanimous
C&T-6	Regional and Multistate GHG Reduction Efforts (Formerly CC-7)	*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; MGA = Midwestern Governors Association; C&T = cap-and-trade; RES = renewable electricity standard; CIP = Conservation Improvement Program; WCI = Western Climate Initiative; CC = Cost-Cutting Issues.

Negative numbers represent cost savings.

MGA C&T partners include Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba; MGA C&T observers include Indiana, Ohio, and South Dakota; WCI partners include Arizona, California, New Mexico, Oregon, Utah, Washington, British Columbia, and Manitoba; WCI observers include Colorado, Idaho, Montana, Nevada, and Wyoming. To run simulations including both MGA and WCI states in 2025, the C&T Technical Work Group (TWG) used 2020 marginal cost curves for WCI states for 2025. The emission cap for both MGA and WCI states (or provinces) is assumed to be 30% below the 2005 level in 2025.

* This represents the average $/$tCO_2e$ mitigated/sequestered for Minnesota.

† This represents the marginal cost of the last tCO_2e mitigated/sequestered and applies to all states involved in a trading arrangement.

Note: A number of MCCAG members raised concerns about the cost assumptions associated with wind power and believe the costs are too high. A lower wind cost assumption would lower the cost estimates for the Renewable Energy Standard (see Energy Supply) and for this Cap-and-Trade analysis. Future analyses should reexamine the wind cost estimates.

Cap-and-Trade
Policy Descriptions

The Cap-and-Trade policy measures look at opportunities to use market-based mechanisms and regional actions to limit and reduce GHG emissions through the collective independent actions of covered sources seeking lowest-cost emissions reduction measures.

C&T-1 Cap-and-Trade Program

The MCCAG recommends by majority vote (with 9 objections) of those present and voting that the state of Minnesota work with its MGA Partners to design and implement a multi-sector, regional cap-and-trade GHG emission trading program. The MCCAG recommends that the MGA investigate linking or combining the midwestern program with the WCI, the Northeastern RGGI or other proposed regional programs that may arise in the future.

The MCCAG does not recommend the creation of a Minnesota-only cap-and-trade program. Modeling has confirmed that, as a general rule, larger programs broaden access to lower-cost emission reduction opportunities, thereby reducing the overall cost of achieving the targeted reductions.

The cap-and-trade program should set an initial cap at 2007 emission levels, with gradual annual reductions to achieve the statutory goals of at least 15% below 2005 levels by 2015, 30% below 2005 levels by 2025, and 80% below 2005 levels by 2050. The cap-and-trade program should be implemented as soon as possible to prevent significant increases above current emissions in the meantime and to maximize the time available to meet the 2015 target.

The MCCAG recommends that the electric power sector, large industrial boilers and processes, transportation fuels, and landfills be included in the cap-and-trade program. The MCCAG also recommends that the program include municipal waste incinerators, large confined animal feeding operations, and other large agricultural operations where it is practical to measure emissions beyond some de minimis level. The MCCAG favors the inclusion of fossil fuel for residential and commercial use.

The cap-and-trade program should include emissions from all six GHGs listed in the statute (Minn. Stat. 216H.02)—CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—from the covered sectors.

The cap-and-trade program should include incentives to encourage “early actions,” or GHG-reduction investments within capped sectors prior to the start of the program. Qualifying early-action projects should be subject to stringent standards to ensure their environmental integrity.

The cap-and-trade program should allow unlimited banking of allowances. Banking permits enables holders to withhold their allowances from the market or from surrender for emissions compliance without expiration and to use an allowance issued in any compliance period beyond that period without penalty. Banking is seen as a means of mitigating market volatility.

The cap-and-trade program should vary the point of regulation with the sector covered. The point of regulation is the entity responsible for acquiring and surrendering allowances for emissions. In some sectors, such as major industrial emissions, this is simply the entity operating the facility from which the emissions are released. But for other sectors, it is either impractical or undesirable to use this approach. The MCCAG recommends the following point of regulation for each covered sector:

- **Electric Power Sector:** A load-based system that aligns with current energy planning regulatory requirements is recommended in order to capture the substantial emissions resulting from in-state consumption of imported electricity and to maximize cost-effective emission reductions.
- **Large Industrial Boilers and Processes, Waste Incinerators, Large Agricultural Operations, and Landfills:** A production-based system regulating direct emissions from each source is recommended.
- **Transportation Fuels and Fossil Fuels for Residential and Commercial Buildings:** An indirect or "upstream" system is recommended, requiring allowances from the entities importing or distributing the fuel into the Minnesota market. If a fuel used by a facility that is regulated on a production basis has been covered upstream, the program should be designed to eliminate double counting.

There are several methods through which the program may distribute allowances for use by covered entities, including free distribution to covered sources on some basis (such as historical emissions [grandfathering]) and auction at the market, thus requiring covered sources to purchase the allowances. The MCCAG makes no recommendation on the issue of allowance distribution but recommends further study of five distribution alternatives:

- Partial auction–partial free distribution,
- Shift from free distribution to auction over time,
- Auction for unregulated entities and free distribution for regulated entities,
- Sector-specific distribution systems, and
- Performance-based market systems.

The MCCAG strongly recommends that emission reductions resulting from complementary policies and measures (non–cap-and-trade) within capped sectors be credited toward the achievement of the cap and that the cap be set accordingly.

CC-5 Market Advisory Group (Formerly CC-11)

The MCCAG recommends by unanimous consent of those present and voting that MGA partners create a Market Advisory Group consisting of experts to provide guidance to the region on the design of market-based compliance programs to manage GHG emissions. California has formed a Market Advisory Committee (MAC) to help formulate a GHG cap-and-trade 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 cap-and-trade program. The MCCAG recommends that the MGA convene a similar Market Advisory Group to receive the policy recommendations of the MCCAG and provide expert guidance to the partners on the design of a midwestern regional cap-and-trade program to manage GHG emissions.

The Market Advisory Group could be created by agreement among the MGA partners and should serve for a limited time. The product of the Market Advisory Group's deliberations should be a report or reports recommending in some detail the scope, design, and plan for implementation of the MGA regional cap-and-trade program.

CC-6 Regional and Multistate GHG Reduction Efforts (Formerly CC-7)

The MCCAG recommends by unanimous consent of those present and voting exploration of opportunities for regional market-based approaches to reduce GHG emissions. The MCCAG believes that this recommendation is met through the implementation of a regional multi-sector cap-and-trade program as proposed in C&T-1. However, there may be additional opportunities for enhanced GHG reductions through coordinated regional action. The MCCAG through its C&T TWG has not had sufficient time to fully explore regional opportunities beyond the proposal under C&T-1.

Regional approaches undertaken in collaboration with partner states or other organizations can offer broader and more economically efficient opportunities to reduce GHG emissions across Minnesota's economy. An additional example might be to include cost sharing on multistate initiatives.

Minnesota's participation in a regional GHG emission reduction initiative that meets the state's goals will result in additional environmental and economic co-benefits, including the opportunity to reduce GHG emissions in an economically efficient manner, the identification of additional areas for cooperation within specific sectors, the reduction of interstate competitive challenges, and the reduction of other non-GHG pollutants associated with the production and use of energy.