Appendix K
Cap-and-Trade Policy Recommendations

Summary List of Priorities for Analysis

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effectiveness* ($/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 —*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 CO_2e; 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 cost per metric ton of carbon dioxide equivalent (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 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.

C&T-1. Cap-and-Trade Program

Policy Description

The Minnesota Climate Change Advisory Group (MCCAG) recommends that the state of Minnesota work with its Midwestern Governors Association (MGA) partners to design and implement a multi-sector regional cap-and-trade greenhouse gas (GHG) emission trading program with the features recommended herein.

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 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 they would otherwise be.

It should be noted that the least-cost approach for some sectors or sources may not be cap-and-trade; it may instead be for technology-forcing or incentive policies that address specific market barriers. A cap-and-trade program will not necessarily remove market barriers or lead to the fastest or broadest adoption of new technologies and practices that save money or stimulate economic performance.

Policy Design

To assist in the evaluation of policy options, the Cap-and-Trade (C&T) Technical Work Group (TWG) created the following principles and guidelines, which are listed in no particular order. The cap-and-trade program

- Must be cost-effective, that is, it must meet GHG reduction targets at a cost comparable to or better than alternative measures;
- Should be open to consideration of other (non–cap-and-trade) measures;
- Should encourage collective actions;
- Should be transparent;

- Should offer covered entities a degree of certainty regarding outcomes;
- Should strive for full coverage of participants;
- Should be fair in the distribution of allowances;
- Should strive for simplicity;
- Should be enforceable;
- Should be administratively efficient; and
- Should reward early actions.

Emission Reduction Goals: The law requires the MCCAG to "recommend the parameters of a cap-and-trade system that includes a cap that would prevent significant increases in greenhouse gas (GHG) emissions above current levels with a schedule for lowering the cap periodically to achieve the goals in subdivision 1 and interim goals recommended under paragraph (a)" (Minn. Stat. 216H.02, subd. 5(b)). Accordingly, 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 may need to be adjusted from these levels to compensate for emissions from non-covered sectors, if projections show those sectors are likely to fall short of or exceed the target reductions.)

Timing: 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. In the event that good historical emissions data are available from some but not all covered sectors, a phased approach can be used, or other policies can be used to address these other sectors and sources of GHG emissions.

In phased approaches, traditionally regulated stationary sources with good emissions data are included in the first phase of the program, which also includes mandatory reporting from sources planned to be covered in future phases. This allows a relatively quick program start and a ramp-up of the administrative, governance, and financial functions of the program. It also achieves greater progress in reducing emissions over time by capping a limited number of large sources early.

Complementary policies play a critical role by reducing the level of emissions that need to be covered by a cap-and-trade program and by reducing emissions directly (e.g., appliance efficiency standards and vehicle efficiency standards). In the process, they can also reduce the costs of cap-and-trade compliance by encouraging low-cost emission reductions through removal of non-price or price barriers to energy efficiency, renewable energy technologies, and other actions. Cap-and-trade programs are typically considered a means of ensuring full attainment of sector-based or economy-wide caps on emissions, or as an enhanced method of providing flexibility to compliance.

The feasibility of specific program start dates has not been closely examined here. The MCCAG recommends further study of the cap-and-trade option at the state level and regionally through

the MGA initiative. Program timing will need to be examined by both groups. The MCCAG encourages an early program start for first-phase sources, such as 2010, to allow time for emitters and regulators to prepare for the program and still allow 5 years under the program to achieve reductions toward the 2015 goal.

Other Key Design Variables

Geographic Coverage: The MCCAG recommends that the geographic scope of the program be, at a minimum, Midwest regional, including the partners in the MGA initiative (Minnesota, Wisconsin, Illinois, Kansas, Iowa, Michigan, and Manitoba). The MCCAG further recommends that linkages with other regional programs such as the Western Climate Initiative (WCI) and the Northeast States Regional Greenhouse Gas Initiative (RGGI) be encouraged and that interregional program mergers be studied.

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 MCCAG has found that Minnesota can achieve its GHG cap-and-trade reduction goals at a lower cost through a midwest regional approach than as a single state. The MCCAG also sees other benefits from taking regional action, including significantly greater overall emission reductions, a more powerful voice during deliberations on a potential national program, and an early opportunity to work out these complex issues in a manner that is most supportive of the special needs of the Midwest prior to the implementation of a federal program. However, the MCCAG has also found that the implementation of a national program could be far preferable to a state or regional program. The Minnesota goal should be to work fervently toward the quick passage of an appropriate national program that would assimilate the regional effort.

The C&T TWG studied a Minnesota-only program, consistent with the requirements of subd. 5(b) of Minn. Stat. 216H.02. Modeling indicates that the cost of carbon dioxide (CO_2) emission reductions sufficient to meet the state goals across all economic sectors under a Minnesota-only cap-and-trade program in 2025 compares unfavorably with all regional programs studied.

Sectors and Sources Covered: 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 also favors the inclusion of fossil fuel for residential and commercial use; however, some MCCAG members disagree with the inclusion of natural gas used in residences and small commercial buildings. Supporters of the policy generally believe that there are emission reduction opportunities within this sector that could be realized through the price signals associated with cap-and-trade inclusion. Supporters also generally subscribe to the view that the cap-and-trade program as a whole benefits from broad inclusion of a large number of sectors and sources, thereby maximizing the number of low-cost emission reduction opportunities and the resources available to achieve them. Dissenters generally believe that while there remain energy efficiency opportunities within the sector, non–cap-and-trade measures are more effective at achieving those reductions. They also argue that these customers have very limited alternative fuel options

that offer lower carbon emissions than natural gas. They believe inclusion would create significant additional costs for small natural gas customers without a corresponding reduction in GHG emissions.

Information provided by the Minnesota Pollution Control Agency (MPCA) indicates that the 700 currently regulated stationary sources in the power generation, industrial, and commercial sectors release approximately 54 million tons of carbon dioxide annually. Within these sectors, the electric power (41.5 million tons) and industrial (11 million tons) sectors are by far the largest contributors. But across all three sectors, the largest 10% of all sources—70 facilities—release approximately 95% of the total emissions. The annual emissions threshold above which these 70 facilities operate is 44,000 tons per year. If fossil fuels are part of the program, the remaining 630 regulated sources and all unregulated sources would also be included indirectly.

A cap-and-trade program that limits and reduces emissions from the recommended sectors could make substantial progress toward achieving the state's goal. In addition, the scope of coverage of a cap-and-trade program is substantially affected by the level of existing and future policies and measures using other mechanisms. It also will be affected by numerous interactions of design feasibility and performance (see later discussion under "Integration with Complementary Policies and Measures").

Pollutants Covered: The MCCAG recommends that the cap-and-trade program include emissions from all six GHGs listed in the statute—CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—from the covered sectors. Most attention in other cap-and-trade programs has been focused on CO_2, which represents 84% of all GHG emissions in the United States that result from human activities. Of this, all but 2% is released as a direct result of the combustion of coal, petroleum, and natural gas. Other gases, such as methane, tend to be sector-specific. Landfills and agricultural operations release significant quantities of methane, which ton-for-ton is 21 times as powerful a GHG as CO_2 over a 100-year time span. Much work has been done to standardize the greenhouse effect forcing potential of the major gases so it is possible to regulate more than one gas under the same cap-and-trade program.

Flexibility and Cost Containment Mechanisms

- *Early-Action Incentives*—The MCCAG recommends that the cap-and-trade program 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. They must be real, surplus (additional), verifiable, permanent, and enforceable. The MCCAG agrees that qualifying early actions must post-date a baseline year; however, there was no agreement on the specific year to use. Some members advocated 1990, while others preferred 2005. The C&T TWG did not have sufficient time to thoroughly study specifics of potential incentives; as a result, it is offering no recommendation on whether the early-action "incentive" should be allowed to increase the emissions cap.

- *Offsets*—The MCCAG makes no recommendation on the issue of offsets. Offsets are out-of-sector emission reduction or carbon sequestration projects that are recognized by the program

as qualifying for allowance credit. By definition, offsets must be measures that are not required by the program and, in most cases, they cannot be required by any emission reduction program. They provide an incentive for low-cost investments in emission reductions as an alternative to higher-cost, in-sector reductions or allowance purchases. Offsets should be subject to stringent standards to ensure their environmental integrity. The C&T TWG was divided on the question of offsets. Nine members supported inclusion of unlimited offsets in lieu of in-sector reductions or allowances, one member supported a strictly limited use of offsets, and five members opposed offsets. Those supporting inclusion stated that rigorously scrutinized offsets create the same environmental benefit at a lower cost. Those opposed expressed concern that unlimited offsets could undermine the integrity of the cap; that with a broad multi-sector program, the opportunities for offsets would be limited; that the requirement that offsets be "additional" is very difficult to prove; and that the administrative burden of certifying offset projects can be excessive.

- *Safety Valve*—The MCCAG makes no recommendation on the issue of a safety valve. A "safety valve" is a program feature designed to limit or moderate the cost of allowances for the purpose of ensuring that the program will not have an unacceptable impact on consumer costs. Safety valves can be as direct and simple as an allowance price cap or as complex and indirect as the RGGI's stepped expansion of offset opportunities triggered by allowance prices. The C&T TWG was divided on the issue of a safety valve. Five members supported a firm price cap, while three supported some measure to moderate, but not cap, allowance prices. Three members were opposed to any form of a safety valve, and three were unprepared to decide. Those supporting the price cap said the feature would simply reflect the political reality that excess allowance prices would doom the program, and a price cap would protect against that result. Opponents stated that there were better tools to mitigate prices (such as banking), and the effect of hitting the cap would be to convert the cap-and-trade program into a carbon tax. Also expressed was the belief that it is more important that the GHG reductions are achieved than that the costs are limited.

- *Banking*—The MCCAG recommends that the cap-and-trade program allow unlimited banking of allowances. Banking permits allowance 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 by allowing holders to hang onto allowances (thereby mitigating supply) when prices are low and to use or sell them (thereby mitigating demand) when prices are high. Nine C&T TWG members supported unlimited banking, two supported limited banking, one opposed banking, and two were unprepared to decide.

- *Borrowing*—The MCCAG makes no recommendation on the issue of allowance borrowing. Borrowing of allowances permits emitters to release excess tons of GHGs in the current compliance period in return for greater reductions in a future compliance period. Borrowing can be temporal (against future allowance distributions) or interparty (between regulated entities). The C&T TWG was divided on the question of borrowing, with two members in favor of unlimited borrowing, six in favor of limited borrowing, four opposed to borrowing, and three unprepared to decide. Supporters favor borrowing as offering greater flexibility for emitters; opponents fear the challenges of policing the practice and generally favor other mechanisms such as multiyear compliance periods.

Integration with Complementary Policies and Measures: 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.

Point of Regulation: 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.

Distribution of Allowances: The MCCAG makes no recommendation on the issue of allowance distribution but recommends further study of five distribution alternatives. There are several models—including free distribution to covered sources on some basis, such as historical emissions (grandfathering), and auction at the market—that require covered sources to purchase the allowances. These options are not mutually exclusive; blends of both auction and free distribution are possible. If allowances are auctioned with proceeds collected by the state, these funds could be used to finance energy efficiency programs, promote development of sustainable low-carbon energy sources, assist low-income energy consumers, help any workers harmed by the transition away from high-carbon technologies, and provide rebates to consumers to offset the cost of the program. The C&T TWG examined both methods.

The members of the C&T TWG were divided between those who supported 100% free distribution (six members) and those who supported 100% auction (four members). In addition one member supported a mix of auction and free distribution, and two supported shifting from free distribution to auction over time. The committee and the MCCAG believe, however, that there should be further exploration of a number of compromise alternatives, including

- 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.

Implementation Mechanisms

Market-based programs include a variety of potential approaches that stimulate market demand for emission reductions, market supply of emission reduction actions, and implementation flexibility. Cap-and-trade is one such program. It is designed to create market demand for emission reductions by establishing a regulatory limit on emissions, stimulating market supply by providing trading opportunities among entities, and providing various flexibility mechanisms to contain costs. The C&T TWG also examined performance-based market approaches in addition to the cap-and-trade approach.

Related Policies/Programs in Place

A wide array of existing policies and measures are in place in Minnesota. New and expanded policies and measures are being recommended through this effort that will have a substantial interactive effect on a cap-and-trade program and vice versa. The MCCAG views a cap-and-trade program and the other recommended policies and measures within each capped sector as "overlapping." Therefore, the role of the cap-and-trade program is seen as reinforcing the implementation of policies needed to reach the emission reduction target or expanding the level of effort needed to reach the target. These policy areas include efficiency and conservation, renewable energy, transportation fuels and efficiency, waste management, and industrial processes.

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

Estimated GHG Reductions and Net Costs or Cost Savings

Model scenarios for multistate options include

- MGA Partners C&T,
- MGA Partners plus Observers C&T,
- MGA Partners plus WCI Partners C&T,
- MGA Partners plus Observers and WCI Partners plus Observers C&T, and
- Minnesota-only C&T.

Each multistate scenario includes three sensitivity cases: (1) assume no renewable electricity standard (RES)/utility conservation improvement program (CIP) in the baseline condition of Minnesota, (2) assume both RES and CIP are in effect in the baseline condition of Minnesota, and (3) assume only RES is in effect in the baseline condition of Minnesota.

The simulation results given below are intended to provide basic insight to the economic implications of a cap-and-trade system. They are based on the best available data at the time of the writing of this report. The accuracy of the simulations will be enhanced as more primary data

become available. Specifically, the most valuable data additions would provide information on GHG reduction capability and cost for mitigation/sequestration options in midwestern states and in WCI states for which primary data are not available at this time.

The cap-and-trade simulations yield the following model outputs and results.

Model outputs:

- Permit price, trading volume, and distribution of trading among states and sectors;
- Emission reductions of states and sectors before and after trading;
- Total cost and average (per ton) cost of compliance;
- Cost savings for each state from joining the cap-and-trade mechanism; and
- Comparison of the scenario effects of alternative GHG emission caps, timing, state coverage, sectoral coverage, allocation methods, flexibility mechanisms, cost curves, emissions baselines, level of complementary measures, and market concentration.

Summary of model results, as presented in Table 1:

- The factors that have the greatest influence on all simulations are the absolute levels and the relative levels of the marginal mitigation/sequestration cost curves. The former has the greatest influence on the potential for cost savings, while the latter has the greatest influence on the extent of permit trading across trading entities (sectors and states), including whether each state is a permit buyer or seller.
- The reference scenario assumes no RES and CIP in the baseline condition of Minnesota. The following are two sensitivity scenarios: (1) assume both RES and CIP are in effect in the baseline condition, and (2) assume only RES is in effect in the baseline condition. When RES and CIP (or only RES) are incorporated in the baseline condition, the Minnesota 2025 business-as-usual (BAU) emission level decreases, which results in a lower emission reduction requirement to reach 30% below the 2005 level, compared with the reference scenario. This also means that the mitigation options of RES and CIP (or only RES option) are removed from the policy option list that is used to develop the marginal cost curve, which results in an upward shift and steepening of the Minnesota marginal cost curve. The simulation results show that the effects of the lower emission reduction goal relative to the BAU level and the higher marginal cost curve nearly offset each other, e.g., the permit prices in the simulations of the sensitivity scenarios are only one or two dollars lower than the corresponding reference scenario.
- However, major differences do exist in total net cost and average mitigation cost of Minnesota between the reference scenario and the scenario with both RES and CIP in the baseline. The latter has both higher total net cost and higher average mitigation cost than the reference scenario. The major reason is that when RES and CIP are assumed to be in effect in the baseline, the CIP option (Residential, Commercial, and Industrial-1 (RCI-1), which has 14.7 $MMtCO_2e$ reduction potential at the cost of –$63.20, is absorbed into the

baseline condition, i.e., the substantial cost savings associated with the implementation of CIP are incorporated into the baseline.

- The second sensitivity scenario, which assumes only RES is in effect in the baseline, yields a similar permit price, total net cost, and average mitigation cost to Minnesota as the reference scenario.

- The permit price of the MGA partner trading is in the range of $45–$48 per ton of CO_2 equivalent ($/t$CO_2$e) 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. Minnesota is a permit buyer in the simulations of all the geographic configurations. The biggest seller among the WCI states is California. The biggest seller in the MGA state simulations is Illinois. California is also the biggest seller in the simulations that include both WCI and MGA states. Kansas is the biggest permit buyer among the MGA states.

- Among the various configurations, the permit price is lower for the case of trading among MGA and WCI partners than in various other configurations. The worst case from Minnesota's standpoint (because the state is a permit buyer and this case would raise the permit price the most) would be to include observers from MGA. These results indicate that (1) WCI partners have overall lower mitigation/sequestration costs than the MGA states; (2) on average, the MGA observers have higher mitigation costs compared with the MGA partners; (3) WCI observers have overall higher mitigation/sequestration costs than WCI partners, but lower costs than MGA states. As a permit buyer, Minnesota would be better off joining a cap-and-trade program with WCI states, because it can buy permits at a lower price than in trading with only MGA states.

- In the Minnesota-only simulations, the model was run for trading among four major sectors within the state. In all three scenarios, the simulation results indicate that it would be better (attain more cost savings) for Minnesota to join a cap-and-trade system with other states than to achieve reduction goals on its own. The simulation results indicate that Power Sector and Other Sector would buy permits from Transportation Sector and Sequestration Sector.

Table K-1. Model results for multistate and Minnesota-only cap-and-trade scenarios

Policy No.	Policy Recommendation	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effectiveness* ($/tCO2e) 2025	Permit Price† ($/tCO2e) 2025	Level of Support
		2015	2025	Total (2008–2025)				
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* (merged into C&T-1)		89.18			–$2.39	$65.48	

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

Data Sources:

Marginal cost curves for states and provinces are developed directly (1) on the basis of assessment of state-level actions developed through state and provincial planning processes in Arizona, Colorado, Montana, New Mexico, and Washington (developed on the basis of mitigation costs of individual policy options presented in Center for Climate Strategies [CCS] reports or other assessments of the respective state climate change action plans); or (2) by approximation methods for other states using a parametric shift method based on cost curves from states with actual data. The C&T TWG developed the marginal cost curves of other western states based on New Mexico's actual cost data and developed the marginal cost curves of midwestern states based on Minnesota's actual cost data. No direct cost curve data are available for other midwestern states at present.

Emission projections data come from (1) CCS inventory and forecast studies of respective states, or (2) the Energy Information Administration's *Annual Energy Outlook 2007* and *Canada's Energy Outlook 2006* (from Natural Resources Canada) for states lacking detailed bottom-up assessments.

Quantification Methods:

The modeling of various cap-and-trade scenarios under C&T-1 used a nonlinear programming model of emission allowance trading. This model is based on the well-established principles of the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities.[1] The model requires equalization of the marginal cost of all trading participants with the equilibrium permit price. This ensures minimization of total net compliance costs for each state and minimization of total abatement costs for the cap-and-trade program as a whole.[2]

Key Assumptions:

The purpose of the simulations is to illustrate the economic impacts of a cap-and-trade program to Minnesota under particular design scenarios. It does not intend to define the final details of a prospective cap-and-trade regulatory program, but rather stands ready to model any design configuration proposed by the TWG.

All emissions considered are consumption-based and are gross emissions (excluding sinks).

The economic modeling conducted in this study helps to analyze the potential GHG reductions and associated costs for Minnesota under several scenarios of different design configurations using the following variables: emission caps, timing, state coverage, sectoral coverage, allocation methods (auctioning versus free granting of permits), flexibility mechanisms, cost curves, emission baselines, level of complementary measures, and market concentration.

A full list of assumptions adopted in the simulation model is presented in the annex.

Key Uncertainties

A number of design variables and the quality of data for cost curves and emission projections can affect permit prices, volume and distribution, including targets, timing, state coverage, sectoral coverage, allocation methods, flexibility mechanisms, cost curves, emission baselines, trade/no trade, level of complementary measures, and market concentration.

[1] See, for example, T. Tietenberg (1985), *Emissions Trading: An Exercise in Reforming Pollution Policy,* Washington, DC, Resources for the Future.

[2] See, for example, B. Stevens and A. Rose (2002), "A dynamic analysis of the marketable permits approach to global warming policy: A comparison of spatial and temporal flexibility," *Journal of Environmental Economics & Management* 44(1):45–69; A. Rose, T. Peterson, and Z. Zhang (2006), "Regional Carbon Dioxide Permit Trading in the United States: Coalition Choices for Pennsylvania," *Penn State Environmental Law Review* 14(2):203–229.

Additional Benefits and Costs

In addition to direct costs of compliance and GHG emission reductions, other potential impacts are possible on labor, value added, income, market share of industries, energy independence, energy prices, air quality, and other environmental or economic outcomes.

Feasibility Issues

A number of technical feasibility issues relate to cap-and-trade program implementation, including transaction costs and point of regulation.

Status of Group Approval

Complete.

Level of Group Support

Majority (9 objections).

Barriers to Consensus

Those objecting to this option expressed concern that industries in the MGA region, and therefore within Minnesota, would be placed at a competitive disadvantage relative to counterparts operating outside the MGA jurisdictions. Also expressed was the concern that the time and effort devoted to the creation of a regional program would divert attention away from the development of a comprehensive national program, which was preferred.

Another objection to the policy was due to the inclusion of fossil fuels used in residential and small commercial buildings. It was stated that natural gas customers have very limited alternative fuel options offering lower carbon emissions. It was feared that inclusion of this sector would create significant additional costs for small natural gas customers without a corresponding reduction in GHG emissions. Finally, some expressed concern for the inclusion of large agricultural operations.

C&T-4. Carbon Tax

Policy Description

The MCCAG does not support the creation of a carbon tax. The C&T TWG was divided between those who opposed a carbon tax and those who felt there was insufficient time to thoroughly consider the option. Most members of the TWG believe that by recommending a broad, regional, multi-sector cap-and trade-program, any need for or benefit from a complementary carbon tax is satisfied.

A carbon tax sets a fee, or tax, for the release of carbon to the atmosphere. It does not set a limit on, reduce, or otherwise control the tons of carbon released. The tax raises the cost of carbon-based emissions; therefore, it encourages investment in low-carbon or no-carbon alternatives. It also generates revenue for the government that could be directed toward energy efficiency, the development and use of renewable energy, climate change adaptation investments, and other measures to mitigate or address the impacts of climate change. A carbon tax could be implemented as a tax on fossil fuels according to the amount of CO_2 emitted by their combustion. One of the benefits is that it can be more easily applied across all sectors.

It is assumed that the cost of the tax would be passed down to the ultimate consumer, such as residential and commercial utility ratepayers for electricity. To achieve the stated goal, the amount of the tax must be high enough to trigger financial and behavioral decisions toward conservation or a shift to lower-emitting fuels.

Policy Design

Goals: Make the cost of inefficient or higher-CO_2-emitting activities more expensive than alternatives, thereby creating a financial incentive to change behavior away from activities that result in CO_2 emissions. The tax should include safety valves to reduce impacts on low-income citizens and minimize detrimental economic consequences. One option is to make the tax "revenue neutral" (an equal amount of other state taxes would be reduced so that the "net" to the state is zero), or the revenue from the tax could be used to develop or promote alternatives that reduce CO_2 emissions. The amount of the tax should be high enough to contribute to the reduction targets specified in the statute.

Timing: Not applicable (this policy is not recommended).

Parties Involved: Major payers would be utilities that generate or distribute electricity in Minnesota, refiners or distributors of transportation and heating fuels in Minnesota, and commercial and industrial sources creating energy for production or other commercial use.

Other: Not applicable.

Implementation Mechanisms

This option requires legislation and the creation or expansion of administrative tax collection and enforcement capabilities.

Related Policies/Programs in Place

None, although policy option C&T-1 (Cap-and-Trade) is seen as sufficiently comprehensive to make a carbon tax unnecessary.

Type(s) of GHG Reductions

Reductions in emissions of CO_2 from combustion sources.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable (this policy is not recommended).

Data Sources: Not applicable (this policy is not recommended).

Quantification Methods: Not applicable (this policy is not recommended).

Key Assumptions: Not applicable (this policy is not recommended).

Key Uncertainties

Not applicable (this policy is not recommended).

Additional Benefits and Costs

Not applicable (this policy is not recommended).

Feasibility Issues

Not applicable (this policy is not recommended).

Status of Group Approval

Not recommended.

Level of Group Support

Not applicable (this policy is not recommended).

Barriers to Consensus

Not applicable (this policy is not recommended).

C&T-5. Market Advisory Group (Formerly CC-11)

Policy Description

The MCCAG recommends 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 Midwest regional cap-and-trade program to manage GHG emissions.

Several members of the C&T TWG also support the creation of a Minnesota Market Advisory Group to advise the state on cap-and-trade program design.

Policy Design

Goals: The MCCAG recommends the creation of a regional, multi-sector cap-and-trade program to help manage GHG emissions. This recommendation contains policy guidance in the areas of jurisdictional coverage, sector coverage, timing, early actions, and banking. Before a program can be implemented, however, this guidance must be refined into a detailed program design. The appointment of a Market Advisory Group is recommended for this purpose.

Timing: To provide the earliest possible guidance to covered sectors, the Market Advisory Group should be appointed as soon as possible after the MCCAG recommendations are received by the MGA partners.

Parties Involved: Unlike the MCCAG, which is stakeholder-driven, the Market Advisory Group should be composed of individuals with particular expertise in key areas, such as economics, markets, climate science and policy, cap-and-trade programs in other jurisdictions or for other pollutants, key covered sectors, and finance.

Other: The Market Advisory Group should encourage public comment throughout its deliberations.

Implementation Mechanisms

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.

Related Policies/Programs in Place

No related policies or programs are currently in place. However, MCCAG policy options C&T-1 (Cap-and-Trade Program) and C&T-6 (Participate in Regional or Multistate GHG Reduction Efforts) could both be related to the creation of a Market Advisory Group.

Type(s) of GHG Reductions

If the recommendations contained under C&T-1 (Cap-and-Trade Program) are adopted, all six major GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) would be reduced.

Estimated GHG Reductions and Net Costs or Cost Savings

Not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Not applicable.

Additional Benefits and Costs

Not applicable.

Feasibility Issues

Not applicable.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

Not applicable.

C&T-6. Participate in Regional and Multistate GHG Reduction Efforts (Formerly CC-7)

Policy Description

As a general policy, the MCCAG encourages 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. As has been demonstrated through the investigation of a regional cap-and-trade program, the cost to achieve targeted reductions in Minnesota can be lower through a regional effort than would be the case if Minnesota pursued a similar policy on its own. An additional example might be to include cost sharing on multistate initiatives.

Policy Design

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

Timing: The Pawlenty administration has already announced its intention to participate in the Midwest Governor's Regional Greenhouse Gas Reductions Accord (MGA), a six-state and one Canadian province initiative to design and implement a regional cap-and-trade program for GHG emission reductions. On February 1, 2008, the administration reported to the legislature on its investigation into regional GHG reduction opportunities and the decision to participate in the accord. The recommendations of the MCCAG have informed that report.

Parties Involved: The Governor and his staff should implement the legislative directive (see below) and inform the chairs and ranking minority members of the legislative committees with jurisdiction over energy and environmental finance and policy.

Other: None.

Implementation Mechanisms

Next Generation Energy Act, S.F. No. 145, Article 5, Sec. 2, Subd. 6 (Regional activities). To the extent possible, the state must develop and implement, with other midwestern states, a regional approach to reducing GHG emissions from activities in the region, including consulting on a regional cap-and-trade system.

Related Policies/Programs in Place

Next Generation Energy Act, S.F. No. 145, Article 5, Sec. 2, Subd. 6 (Regional activities). See above.

Type(s) of GHG Reductions

If the MGA adopts the policy design recommended by the MCCAG, the reductions will occur across multiple sectors (power, transportation, industrial, agricultural, waste management, residential, and commercial) and will include the reductions resulting from a suite of policies and mechanisms designed to reduce emissions across these sectors.

Estimated GHG Savings and Costs per tCO_2e

See C&T-1 for cap-and-trade savings and costs.

Key Uncertainties

Joining another regional entity should not compromise the achievement of Minnesota's goal.

Additional Benefits and Costs

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 (e.g., transportation), and the reduction of other non-GHG pollutants associated with the production and use of energy.

Feasibility Issues

Given that Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba have agreed to pursue a major regional program, and other regions are undertaking similar initiatives, the feasibility issues have been considered and are being satisfactorily addressed by the participants.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

Not applicable.

C&T-7. Facilitate the Development of an Effective Carbon Credit System for Minnesota (Formerly CC-10)

Policy Description

The MCCAG believes its C&T TWG has not had sufficient time to thoroughly study or consider this option. Also, lacking the opportunity to study the administration's recently announced plan to pursue a similar policy, the MCCAG declines to offer a recommendation on this policy.

GHG reductions from a wide variety of sources and actors could be undertaken in order to participate in offset programs or markets. Minnesota could develop an offset program as a state-led or private effort. Under this policy, one approach is for entities to participate in an official state-recognized registry. However, for entities not covered by the registry, the policy should allow for offsets to be submitted as a way to opt in to GHG emission allowance markets or trading systems. Such offsets would be registered using approved protocols or, in the absence of protocols, an application for approval of specific projects on a case-by-case basis. The effectiveness of such offsets is likely to help determine their value and utility for participants. In particular, concerns about measurement, permanence, additionality, and enforceability must be resolved in the protocol-setting process. Such measures as categorical exclusions and temporary credits for certain types of emission-reducing actions should be considered. However, the administrative burden and/or transaction costs that could be imposed could have a countervailing (dampening) effect, leading to an overall increase in costs.

Policy Design

Goals: Enable a wide range of quality offsets to be generated in Minnesota, with the applicability of such offsets to be determined as state, regional, national, and international GHG reduction efforts continue to develop. Criteria for such an offset system in Minnesota might include real, surplus (additional), verifiable, permanent, and enforceable.

Timing: By January 1, 2009, establish an offset program for use by Minnesota entities, including at a minimum the major sectors for which existing GHG emission reduction protocols exist or are developed. To the extent that Minnesota's participation in *The Climate Registry* will enable certain sectors and/or entities to participate in offset creation, those sectors and/or entities would not be included in the separate offset program under this policy.

Parties Involved: Minnesota Department of Commerce and the MPCA, along with other appropriate partners. The offset program tracking and administration could be formed with the same agency structure as envisioned for the state's participation in *The Climate Registry*. A stakeholder and public comment process should be employed during 2008 to determine types of offsets and relevant protocols for inclusion.

Other: Consider a state purchase of offsets using an RFP (request for proposals) process to jump-start the market versus strong advocacy for rapid development of national or regional offset systems.

Implementation Mechanisms

Legislative authorization for the agency-based offset program, including funding for staff and associated stakeholder processes will be required. The need for protocol development, approval processes, such as applications or third-party verification, and possible participant funding for protocols and/or verification should be considered.

Related Policies/Programs in Place

Climate inventories and registries, county or municipal offset efforts.

Type(s) of GHG Reductions

A wide variety, including forestry and land use, process and end-use efficiency, innovative technologies (e.g., hybrid vehicle conversions).

Estimated GHG Savings and Costs per tCO_2e

Savings are unknown at this time. Note that offsets, if sold to out-of-state emission markets with such binding regulatory regimes as the European Union's, could be used by others and would not lead to overall (global or Minnesota) emission reductions. Only emissions that are recorded and retired permanently in Minnesota or sold into voluntary emission markets, such as the Chicago Climate Exchange, are actually "real and additional" GHG reductions. Concerns about the permanence of land use and other behaviors introduce further uncertainty, as does the permissibility of offsets for use in a potential mandatory GHG emission reduction program.

Key Uncertainties

Key uncertainties include the willingness of Minnesota actors to undertake offset investments, the stringency of offset accounting and the resulting quality of offsets, ties to external markets and pricing, and public (agency) versus private (nonprofit or for-profit organization) oversight and program administration.

Additional Benefits and Costs

Probably include unquantifiable co-benefits from emission reduction actions; benefits for actors to develop GHG accounting, option evaluation, and institutional infrastructure to facilitate GHG emission reduction efforts; and the potential to pave the way for other policies.

Feasibility Issues

The time and resources to develop an offset program and any required protocols or verification methods are unknown. In addition, offset evaluation and verification can be administratively demanding.

Status of Group Approval

Due to time constraints limiting MCCAG analysis and development, this policy is not recommended.

Level of Group Support

Not applicable.

Barriers to Consensus

Not applicable.

Annex

1. The following is a summary of the full list of assumptions we adopted in our simulation model.

Geographical Configurations

- **M1:** Midwestern C&T partners—Iowa, Illinois, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba
- **M2:** Midwestern C&T partners and observers—Iowa, Illinois, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba plus Indiana, Ohio, and South Dakota
- **W1:** WCI partners—Arizona, California, New Mexico, Oregon, Utah, Washington, British Columbia, and Manitoba
- **W2:** WCI partners and five observers—Arizona, California, New Mexico, Oregon, Utah, Washington, British Columbia, and Manitoba plus Colorado, Idaho, Montana, Nevada, and Wyoming

Multistate Cap-and-Trade Cases

Case I—Assume no RES and CIP in the baseline condition of Minnesota.

- The simulation target year is 2025 and the emission mitigation target is 30% below 2005 level in year 2025.
- All sectors are included in the emission accounting and mitigation effort.
- All GHG emissions are considered.
- All gross emissions (excluding sinks) are considered.
- All emissions are consumption-based.
- Emission data for WCI states come from CCS inventories and forecasts studies for respective states; emission projections in 2025 are estimated based on the assumption that the annual growth rate between 2020 and 2025 is the same as the annual growth rate between 2005 and 2020 projected by CCS.
- Emission projections in 2025 for Minnesota come from CCS inventory and forecast estimates.
- Emission projections in 2025 for Midwestern states other than Minnesota are calculated based on Energy Information Administration (EIA) regional projected emission growth rates: Iowa, Kansas, and South Dakota belong to West North Central Region; Indiana, Illinois, Ohio, Michigan, and Wisconsin belong to East North Central Region.

- Emission projections for the two Canadian provinces come from *Canada's Energy Outlook 2006* by Natural Resources Canada; again, we assume the same annual growth rate of total emissions in 2020–2025 as in 2005–2020.
- Offsets are not included.
- No safety valve (permit price limit) is included.
- The allowance auction is simulated only for the MGA partner case. In the auction case, there would be no permit trading among states; however, in equilibrium, each state will choose to mitigate the same level of emission as it would in a permit trading market; each state would buy its total allowances from the auctioneer. The auction price would be the same level as the equilibrium price in a permit trading market.
- Recycling of auction revenues is not analyzed in the simulations.
- Marginal cost curves embody direct mitigation costs only.
- Marginal cost curves do not include various transactions costs.
- Marginal cost curves do not distinguish between producer vs. consumer allocation of permits.
- Marginal cost curves for Arizona, New Mexico, Colorado, Montana, Washington, and Minnesota are developed based on mitigation costs of individual policy options presented in CCS reports of the respective State Climate Change Action Plans.
- Marginal cost curves of other WCI states (provinces) are developed by a parametric shift method using New Mexico's marginal cost curve as a reference; marginal cost curves of other midwestern states (provinces) are developed by a parametric shift method using Minnesota's marginal cost curve as a reference; the parametric shift rule assumes a direct relationship between the slope of the marginal cost curve and the carbon intensity of a state.
- In order to run simulations including both MGA and WCI states in year 2025, we used 2020 marginal cost curves for WCI states for 2025; we also assumed that the same emission cap in 2025 (30% below the 2005 level) for MGA states applies to WCI states as well.

Case II—Assume both RES and CIP are in effect in the baseline condition of Minnesota.

- Same assumptions as for Case I, except,
    - When RES and CIP are already factored in the BAU case, the corresponding policy options are excluded from the option list to develop the Minnesota marginal cost curve: (1) RCI-1: Maximize Savings from the Utility Conservation Improvement Program and (2) ES-5: Renewable and/or Environmental Portfolio Standard
    - Marginal cost curves for other midwestern states are still developed based on Minnesota's curve in Case I.

Case III—Assume only RES are in effect in the baseline condition of Minnesota.

- Same assumptions as for Case I, except,

- When RES is already factored in the BAU case, the corresponding policy option is excluded from the option list to develop the Minnesota marginal cost curve: ES-5: Renewable and/or Environmental Portfolio Standard
- Marginal cost curves for other midwestern states are still developed based on Minnesota's curve in Case I.

Minnesota-only Cap-and-Trade

- Assume the cap-and-trade is undertaken among four major sector categories: (1) Power Sector, (2) Transportation Sector, (3) Sequestration Sector, and 4) Other Sector.
- Assume the cap of 30% below the 2005 level in 2025 applies to Power Sector, Transportation Sector, and Other Sector, i.e., in 2025 each sector has an emission cap of 70% of its emission level in 2005.
- Assume the BAU emission from the Sequestration Sector in 2025 is zero, and this sector does not have a cap.

2. The model yields the following general results:

- GHG emission reductions for each state (sector) before and after permit trading
- Cost of GHG emission reductions for each state (sector) before and after trading
- Auction value of permits (relevant cases)
- Number of permits traded (bought and sold) by each state (sector)
- Equilibrium permit price
- Cost savings for each state (sector) of joining the Cap-and-Trade mechanism

Multistate Cap-and-Trade Simulations

Key

States in the United States

- AZ = Arizona
- CA = California
- CO = Colorado
- IA = Iowa
- ID = Idaho
- IL = Illinois
- IN = Indiana
- KS = Kansas
- MI = Michigan
- MN = Minnesota
- MT = Montana
- NM = New Mexico
- NV = Nevada
- OH = Ohio
- OR = Oregon
- SD = South Dakota
- UT = Utah
- WA = Washington
- WI = Wisconsin
- WY = Wyoming

Canadian Provinces

- BC = British Columbia
- MB = Manitoba

Sensitivity Analysis #1: CIP and RES are not in effect in the baseline condition.

Table A-1. (I-M1)—Economy-wide emission trading simulation among six midwestern states plus Manitoba in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction With Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
IA	–$478	–$910	$344	–$565	$87	7.10	47.91	38.01	43.65
IL	–$1,581	–$941	–$756	–$1,697	$116	–15.61	138.64	43.02	38.18
KS	–$621	–$1,392	$510	–$882	$261	10.53	42.27	34.94	43.65
MI	–$1,663	–$1,445	–$234	–$1,679	$16	–4.83	109.06	39.95	38.18
MN	–$439	–$972	$451	–$521	$81	9.31	79.82	40.38	45.09
WI	–$915	–$706	–$233	–$939	$24	–4.81	67.32	41.11	38.18
MB	–$178	–$122	–$83	–$204	$26	–1.70	8.10	39.29	31.02
Total	**–$5,876**	**–$6,487**	**$0**	**–$6,487**	**$611**	**26.94**[†]	**493.11**	**40.28**	**40.28**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $\$48.45/tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is $–\$12.17/tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 40.38% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-2. (I-M2)—Economy-wide emission trading simulation among nine midwestern states plus Manitoba in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
IA	–$478	–$850	$310	–$539	$61	5.92	49.10	38.95	43.65
IL	–$1,581	–$737	–$1,030	–$1,767	$186	–19.64	142.67	44.28	38.18
KS	–$621	–$1,348	$506	–$842	$221	9.65	43.15	35.67	43.65
MI	–$1,663	–$1,298	–$406	–$1,704	$41	–7.74	111.97	41.01	38.18
MN	–$439	–$863	$375	–$488	$49	7.15	81.97	41.47	45.09
WI	–$915	–$612	–$350	–$962	$47	–6.67	69.19	42.25	38.18
MB	–$178	–$111	–$100	–$211	$33	–1.92	8.31	40.31	31.02
IN	–$2,954	–$3,357	$362	–$2,995	$41	6.91	113.91	36.00	38.18
OH	–$3,018	–$3,056	$38	–$3,019	$0	0.72	148.29	38.00	38.18
SD	–$64	–$553	$295	–$258	$195	5.62	17.13	35.49	47.13
Total	**–$11,911**	**–$12,785**	**$0**	**–$12,785**	**$874**	**35.96**†	**785.69**	**39.70**	**39.70**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $\$52.44/tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is $–\$10.52/tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 41.47% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-3. (I-M1W1)—Economy-wide emission trading simulation among six midwestern states, six western states, and two Canadian provinces in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
AZ	$2,954	–$1,579	$1,756	$177	$2,778	49.19	70.39	37.17	63.14
CA	$459	$3,847	–$4,893	–$1,046	$1,505	–137.09	443.29	68.41	47.25
NM	$421	–$296	$459	$162	$259	12.85	35.33	35.50	48.41
OR	$89	$401	–$395	$7	$82	–11.06	54.38	59.18	47.15
UT	$528	$161	$304	$465	$62	8.52	50.14	46.79	54.74
WA	$3,666	–$792	$1,268	$476	$3,190	35.53	30.52	23.04	49.86
BC	$29	$96	–$71	$25	$4	–1.99	37.07	45.67	43.22
IA	–$478	–$1,074	$393	–$681	$202	11.01	44.00	34.91	43.65
IL	–$1,581	–$1,508	–$75	–$,583	$2	–2.09	125.12	38.83	38.18
KS	–$621	–$1,514	$479	–$1,035	$414	13.43	39.37	32.55	43.65
MI	–$1,663	–$1,850	$172	–$1,678	$15	4.82	99.41	36.41	38.18
MN	–$439	–$1,273	$588	–$685	$245	16.48	72.64	36.75	45.09
WI	–$915	–$967	$50	–$917	$2	1.40	61.12	37.33	38.18
MB	–$178	–$151	–$36	–$187	$9	–1.01	7.40	35.90	31.02
Total	**$2,271**	**–$6,499**	**$0**	**–$6,499**	**$8,770**	**153.23†**	**1,170.19**	**45.46**	**45.46**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $35.69/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is –$17.52/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 36.75% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-4. (I-M2W2)—Economy-wide emission trading simulation among nine midwestern states, eleven western states, and two Canadian provinces in 2020 (million $ or otherwise specified)

State	Before Trading	After Trading*				Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost	Cost Saving	($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
AZ	$,954	–$1,458	$1,929	$471	$2,483	46.07	73.51	38.82	63.14
CA	$459	$4,995	–$6,983	–$1,988	$2,446	–166.77	472.96	72.98	47.25
NM	$421	–$216	$451	$235	$186	10.77	37.41	37.59	48.41
OR	$89	$555	–$630	–$74	$163	–15.04	58.36	63.51	47.15
UT	$528	$303	$203	$507	$21	4.86	53.80	50.21	54.74
WA	$3,666	–$738	$1,430	$691	$2,975	34.14	31.90	24.08	49.86
BC	$29	$200	–$195	$4	$25	–4.67	39.75	48.97	43.22
CO	$1,611	–$1,059	$1,239	$180	$1,431	29.59	48.82	30.56	49.08
ID	$26	$163	–$165	–$2	$28	–3.94	24.53	52.58	44.13
MT	$33	–$104	$110	$6	$27	2.63	14.73	34.03	40.10
NV	$354	$443	–$93	$350	$5	–2.22	49.54	60.43	57.72
WY	$506	–$571	$522	–$49	$555	12.47	23.22	31.11	47.82
IA	–$478	–$999	$381	–$619	$140	9.10	45.92	36.43	43.65
IL	–$1,581	–$1,250	–$367	–$1,616	$36	–8.76	131.79	40.90	38.18
KS	–$621	–$1,459	$503	–$956	$335	12.01	40.79	33.72	43.65
MI	–$1,663	–$1,666	$3	–$1,663	$0	0.08	104.16	38.15	38.18
MN	–$439	–$1,136	$542	–$594	$155	12.95	76.17	38.54	45.09
WI	–$915	–$848	–$69	–$918	$3	–1.66	64.18	39.19	38.18
MB	–$178	–$138	–$56	–$194	$16	–1.35	7.74	37.57	31.02
IN	–$2,954	–$3,657	$556	–$3,101	$147	13.27	107.55	33.99	38.18
OH	–$3,018	–$,490	$415	–$3,075	$56	9.92	139.09	35.64	38.18
SD	–$64	–$597	$274	–$323	$259	6.55	16.20	33.57	47.13
Total	**–$1,235**	**–$12,727**	**$0**	**–$12,727**	**$11,492**	**204.40†**	**1,662.13**	**44.50**	**44.50**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $41.87/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is –$14.92/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 38.54% below the baseline level in 2020 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-5. Summary Data Table

State	Cap: 30% Below 2005 Emissions in 2025 ($MMtCO_2e$)	2025 BAU Gross Emissions (Consumption-Based) ($MMtCO_2e$)	GHG Mitigation Goal in 2025 (Relative to BAU Emissions)	Autarkic Marginal Mitigation Cost ($/$tCO_2e$)	Gross State Product in 2025 (million $ 2000)
AZ	69.8	189.4	63.14%	$159.6	$481,628
CA	341.8	648.0	47.25%	$15.5	$2,923,222
NM	51.3	99.5	48.41%	$77.6	$94,564
OR	48.6	91.9	47.15%	$21.5	$297,081
UT	48.5	107.2	54.74%	$50.8	$204,725
WA	66.4	132.5	49.86%	$229.0	$471,781
BC	46.1	81.2	43.22%	$31.3	$146,610
CO	81.3	159.8	49.08%	$143.8	$563,455
ID	26.1	46.7	44.13%	$28.1	$98,835
MT	25.9	43.3	40.10%	$63.1	$41,520
NV	34.7	82.0	57.72%	$37.8	$236,707
WY	39.0	74.7	47.82%	$135.2	$39,577
IA	71.0	126.0	43.65%	$73.4	$206,621
IL	199.2	322.2	38.18%	$33.8	$768,315
KS	68.2	121.0	43.65%	$99.2	$146,593
MI	168.8	273.0	38.18%	$42.0	$524,088
MN	108.5	197.7	45.09%	$66.2	$392,084
WI	101.2	163.8	38.18%	$38.5	$342,743
MB	14.2	20.6	31.02%	$18.5	$37,581
IN	195.6	316.5	38.18%	$64.3	$396,501
OH	241.3	390.3	38.18%	$53.3	$590,200
SD	25.5	48.3	47.13%	$124.2	$57,361
Total	**2,073.1**	**3,735.2**	**44.50%**		**$9,061,793**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

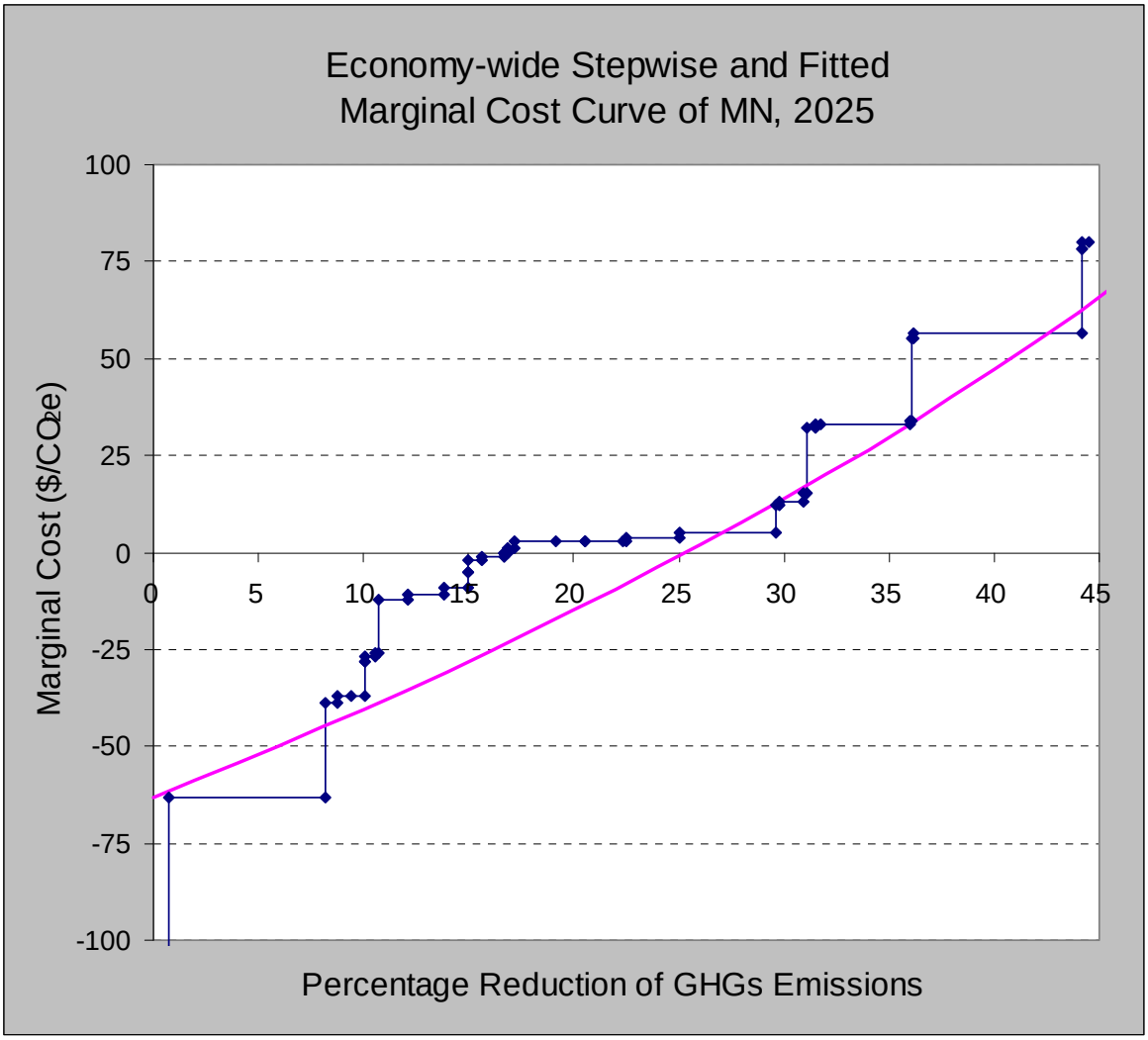
Table A-6. Reduction Potential and Cost/Saving of Individual Policy Option

Recom-mendation No.	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions	Cumulative GHG Reduction Potential
RCI-2	Improved Uniform Statewide Building Codes	0.005	–$576.00	0.00%	0.00%
RCI-10	Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards	1.4	–$124.00	0.71%	0.71%
RCI-1	Maximize Savings From the Utility Conservation Improvement Program (CIP)	14.7	–$63.20	7.44%	8.15%
TLU-6	Adopt California Clean Car Standards	1.16	–$39.00	0.59%	8.74%
AFW-1b	Agricultural Crop Management–B. Nutrient Management	1.3	–$37.00	0.66%	9.39%
RCI-6	Non-Utility Strategies and Incentives To Encourage Energy Efficiency and Reduce GHG Emissions	1.3	–$37.00	0.66%	10.05%
RCI-7	Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency	0.05	–$28.00	0.03%	10.08%
RCI-3	Green Building Guidelines and Standards Based on *Architecture 2030*	0.94	–$27.00	0.48%	10.55%
ES-4	Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss—Natural Gas Transmission and Distribution Upgrades	0.4	–$26.10	0.20%	10.75%
AFW-5b	Forestry Management Programs To Enhance GHG Benefits–B. Urban forestry	2.7	–$12.00	1.37%	12.12%
AFW-7b	Front-End Waste Management Technologies–B. Recycling	3.4	–$11.00	1.72%	13.84%
AFW-3a	In-State Liquid Biofuels Production–A. Ethanol Carbon Content	2.2	–$9.00	1.11%	14.95%
RCI-5	Program To Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs	0.05	–$5.00	0.03%	14.98%
AFW-1a	Agricultural Crop Management–A. Soil Carbon Management	1.3	–$2.00	0.66%	15.64%
TLU-5	Climate-Friendly Transportation Pricing / Pay-as-You-Drive	2.1	–$1.00	1.06%	16.70%
ES-1	Generation Performance Standard	0	$0.00	0.00%	16.70%
ES-6	Nuclear Power Support and Incentives—Installation of a Nuclear Power Station in 2020	0	NQ*	NQ*	16.70%

Recom-mendation No.	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions	Cumulative GHG Reduction Potential
ES-8	Advanced Fossil Fuel Technology Incentives, Support, or Requirements	0	NQ*	NQ*	16.70%
TLU-2	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.3	$0.00	0.15%	16.85%
AFW-8a	End-of-Life Waste Management Practices–A. Landfilled Waste Methane	0.73	$1.00	0.37%	17.22%
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	3.8	$3.00	1.92%	19.14%
AFW-6	Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover	2.7	$3.00	1.37%	20.51%
AFW-7a	Front-End Waste Management Technologies–A. Source Reduction	3.6	$3.00	1.82%	22.33%
AFW-7c	Front-End Waste Management Technologies–C. Composting	0.41	$3.00	0.21%	22.54%
RCI-4	Incentives and Resources To Promote Combined Heat and Power (CHP)	4.95	$3.80	2.50%	25.04%
AFW-3c	In-State Liquid Biofuels Production–C. Gasoline Displacement	9	$5.00	4.55%	29.60%
ES-3	Efficiency Improvements, Repowering and other Upgrades to Existing Plants—Biomass Co-firing	0.4	$12.00	0.20%	29.80%
AFW-5a	Forestry Management Programs To Enhance GHG Benefits–A. Forestation	2.2	$13.00	1.11%	30.91%
TLU-13	Reduce Maximum Speed Limits	0.4	$15.50	0.20%	31.11%
AFW-8c	End-of-Life Waste Management Practices–C. WTE Preprocessing	0.84	$32.00	0.43%	31.54%
AFW-2a	Land Use Management Approaches for Protection and Enrichment of Soil Carbon–A. Preserve Land	0.44	$33.00	0.22%	31.76%
AFW-5d	Forestry Management Programs to Enhance GHG Benefits–D. Restocking	8.4	$33.00	4.25%	36.01%
AFW-2b	Land Use Management Approaches for Protection and Enrichment of Soil Carbon–B. Reinvest in Minnesota–Clean Energy (RIM-CE)	0.19	$34.00	0.10%	36.11%
AFW-3b	In-State Liquid Biofuels Production–B. Fossil Diesel Displacement	0.19	$55.00	0.10%	36.20%
ES-5	Renewable and/or Environmental Portfolio Standard	15.7	$56.40	7.94%	44.15%
ES-12	Distributed Renewable Energy	0.023	$78.10	0.01%	44.16%
AFW-8b	End-of-Life Waste Management Practices–B. Residuals Management	0.63	$80.00	0.32%	44.48%

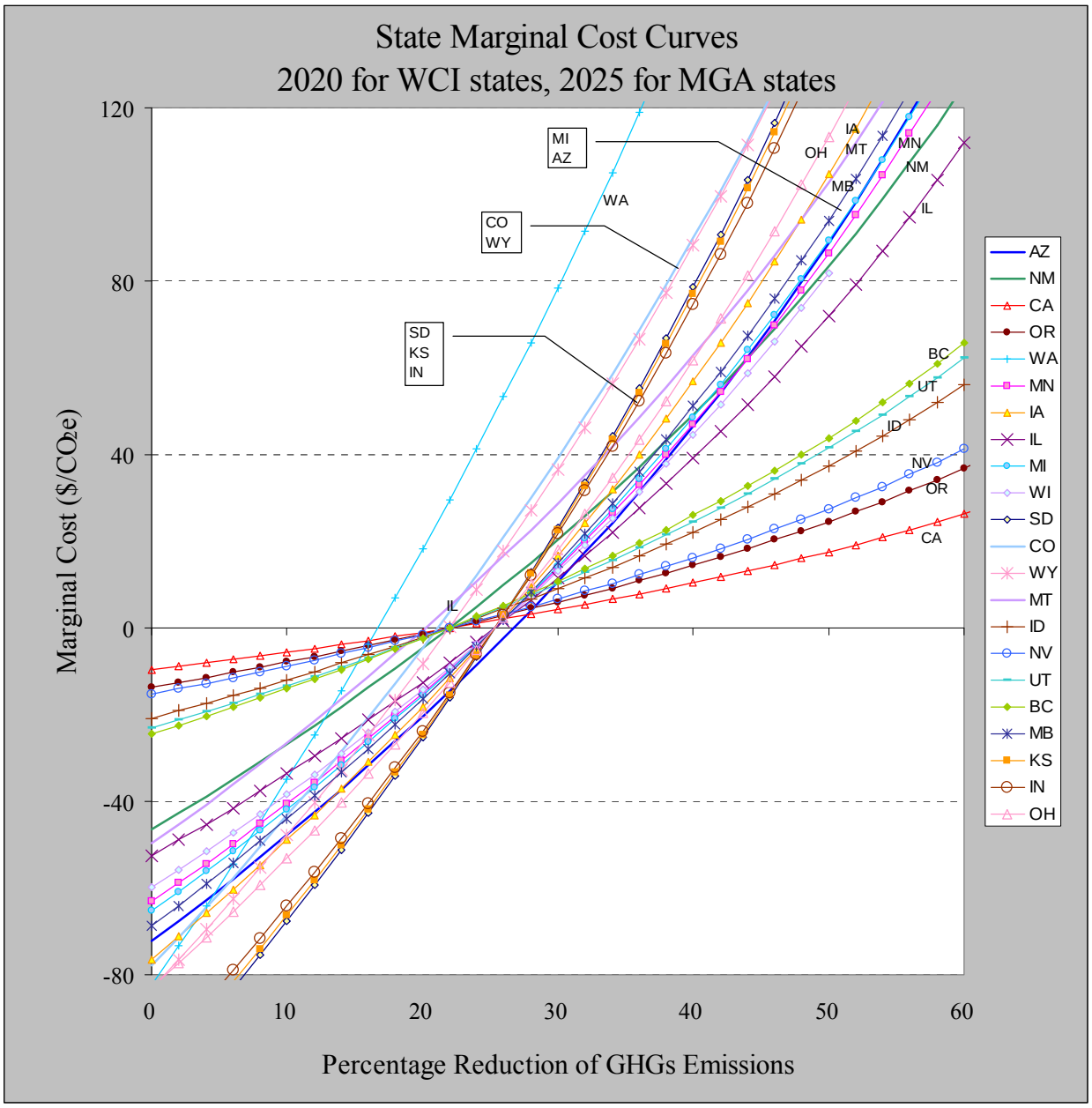
GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; WTE = waste-to-energy; NQ* =

Figure A-1. Economy-wide Stepwise and Fitted Marginal Cost Curve of MN, 2025 (no RES and CIP in the Baseline)



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

Figure A-2. State marginal cost curves, 2020 for WCI states, 2025 for MGA states



WCI = Western Climate Initiative; MGA = Midwestern Governors Association; $/$CO_2$e = dollars per carbon dioxide equivalent; GHG = greenhouse gas.

Note: Marginal cost curves of midwestern states are developed based on the Minnesota 2025 curve. Marginal cost curves of WCI states other than for AZ, CO, MT, and WA are developed based on the NM 2020 curve. In order to run simulations including both MGA and WCI states in 2025, we used 2020 marginal cost curves for WCI states for 2025. These marginal cost curves are presented for a range of mitigation levels, including those higher than required to meet the cap in 2025. We anticipate that there will be technology innovations in the future, i.e., the marginal cost curves will shift downward over time before higher levels of mitigation are necessary.

Sensitivity Analysis #2: both CIP and RES are in effect in the baseline condition.

Table A-7. (II-M1)—Economy-wide emission trading simulation among six midwestern states plus Manitoba in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction with Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(percent from BAU)	(percent from BAU)
IA	–$478	–$945	$361	–$584	$106	7.85	47.16	37.42	43.65
IL	–$1,581	–$1,062	–$599	–$1,661	$80	–13.04	136.07	42.23	38.18
KS	–$621	–$1,419	$510	–$909	$288	11.09	41.71	34.48	43.65
MI	–$1,663	–$1,532	–$137	–$1,669	$6	–2.99	107.22	39.27	38.18
MN	$249	$140	$104	$245	$5	2.27	52.94	32.33	33.72
WI	–$915	–$762	–$166	–$929	$14	–3.62	66.14	40.39	38.18
MB	–$178	–$128	–$72	–$200	$22	–1.57	7.96	38.64	31.02
Total	**–$5,187**	**–$5,707**	**$0**	**–$5,707**	**$520**	**21.22†**	**459.21**	**38.58**	**38.58**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $45.95/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is $2.65/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 32.33% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-8. (II-M2)—Economy-wide emission trading simulation among nine midwestern states plus Manitoba in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
IA	–$478	–$876	$326	–$550	$72	6.43	48.59	38.55	43.65
IL	–$1,581	–$826	–$909	–$1,735	$154	–17.92	140.95	43.74	38.18
KS	–$621	–$1,367	$509	–$858	$238	10.03	42.77	35.36	43.65
MI	–$1,663	–$1,363	–$329	–$1,692	$29	–6.49	110.72	40.56	38.18
MN	$249	$261	–$12	$249	$0	–0.24	55.45	33.86	33.72
WI	–$915	–$653	–$298	–$951	$36	–5.87	68.39	41.77	38.18
MB	–$178	–$116	–$93	–$208	$30	–1.83	8.22	39.88	31.02
IN	–$2,954	–$3,410	$402	–$3,007	$54	7.93	112.89	35.67	38.18
OH	–$3,018	–$3,132	$111	–$3,021	$3	2.19	146.82	37.62	38.18
SD	–$64	–$561	$293	–$268	$205	5.77	16.98	35.18	47.13
Total	**–$11,223**	**–$12,042**	**$0**	**–$12,042**	**$819**	**32.34†**	**751.78**	**38.65**	**38.65**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $\$50.72/tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is $\$4.71/tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 33.86% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-9. (II-M1W1)—Economy-wide emission trading simulation among six midwestern states, six western states, and two Canadian provinces in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
AZ	$2,954	–$1,592	$1,733	$140	$2,814	49.57	70.01	36.96	63.14
CA	$459	$3,709	–$4,656	–$946	$1,405	–133.21	439.40	67.81	47.25
NM	$421	–$305	$458	$153	$269	13.11	35.07	35.24	48.41
OR	$89	$383	–$369	$15	$74	–10.55	53.87	58.63	47.15
UT	$528	$145	$314	$459	$69	8.97	49.69	46.37	54.74
WA	$3,666	–$798	$1,248	$450	$3,217	35.70	30.35	22.91	49.86
BC	$29	$84	–$58	$26	$3	–1.65	36.73	45.26	43.22
IA	–$478	–$1,082	$393	–$689	$211	11.25	43.77	34.73	43.65
IL	–$1,581	–$1,537	–$45	–$1,581	$1	–1.28	124.31	38.58	38.18
KS	–$621	–$1,520	$475	–$1,045	$424	13.60	39.20	32.41	43.65
MI	–$1,663	–$1,871	$189	–$1,682	$19	5.40	98.83	36.20	38.18
MN	$249	–$103	$290	$187	$63	8.29	46.93	28.66	33.72
WI	–$915	–$980	$62	–$918	$3	1.77	60.75	37.10	38.18
MB	–$178	–$152	–$34	–$186	$8	–0.96	7.36	35.70	31.02
Total	**$2,959**	**–$5,619**	**$0**	**–$5,619**	**$8,578**	**147.65**†	**1,136.28**	**44.74**	**44.74**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $\$34.95/tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is $–\$2.19/tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 28.66% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-10. (II-M2W2)—Economy-wide emission trading simulation among nine midwestern states, eleven western states, and two Canadian provinces in 2020 (million $ or otherwise specified)

State	Before Trading	After Trading*				Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost	Cost Saving	($MMtCO_2e$)	($MMtCO_2e$)	(percent from BAU)	(percent from BAU)
AZ	$2,954	–$1,471	$1,913	$442	$2,512	46.38	73.20	38.65	63.14
CA	$459	$4,879	–$6,764	–$1,885	$2,343	–163.98	470.17	72.55	47.25
NM	$421	–$224	$453	$229	$193	10.98	37.20	37.38	48.41
OR	$89	$540	–$604	–$65	$154	–14.65	57.98	63.10	47.15
UT	$528	$288	$215	$503	$24	5.22	53.44	49.87	54.74
WA	$3,666	–$744	$1,414	$670	$2,996	34.28	31.77	23.98	49.86
BC	$29	$189	–$182	$7	$22	–4.40	39.48	48.64	43.22
CO	$1,611	–$1,067	$1,229	$162	$1,449	29.80	48.61	30.43	49.08
ID	$26	$156	–$156	$0	$26	–3.78	24.37	52.23	44.13
MT	$33	–$108	$112	$4	$29	2.71	14.65	33.84	40.10
NV	$354	$429	–$78	$351	$3	–1.89	49.21	60.02	57.72
WY	$506	–$575	$518	–$57	$563	12.57	23.13	30.98	47.82
IA	–$478	–$1,007	$383	–$624	$146	9.29	45.73	36.28	43.65
IL	–$1,581	–$1,277	–$334	–$1,611	$30	–8.10	131.13	40.69	38.18
KS	–$621	–$1,465	$501	–$964	$343	12.15	40.65	33.60	43.65
MI	–$1,663	–$1,686	$23	–$1,663	$0	0.55	103.68	37.98	38.18
MN	$249	$30	$198	$228	$22	4.81	50.41	30.79	33.72
WI	–$915	–$861	–$56	–$917	$2	–1.35	63.87	39.01	38.18
MB	–$178	–$139	–$54	–$193	$15	–1.31	7.71	37.40	31.02
IN	–$2,954	–$3,673	$563	–$3,110	$156	13.65	107.17	33.87	38.18
OH	–$3,018	–$3,513	$432	–$3,081	$63	10.47	138.53	35.50	38.18
SD	–$64	–$599	$272	–$327	$263	6.60	16.15	33.45	47.13
Total	**–$546**	**–$11,900**	**$0**	**–$11,900**	**$11,354**	**199.46†**	**1,628.23**	**43.99**	**43.99**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $41.25/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is $0.59/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 30.79% below the baseline level in 2020 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

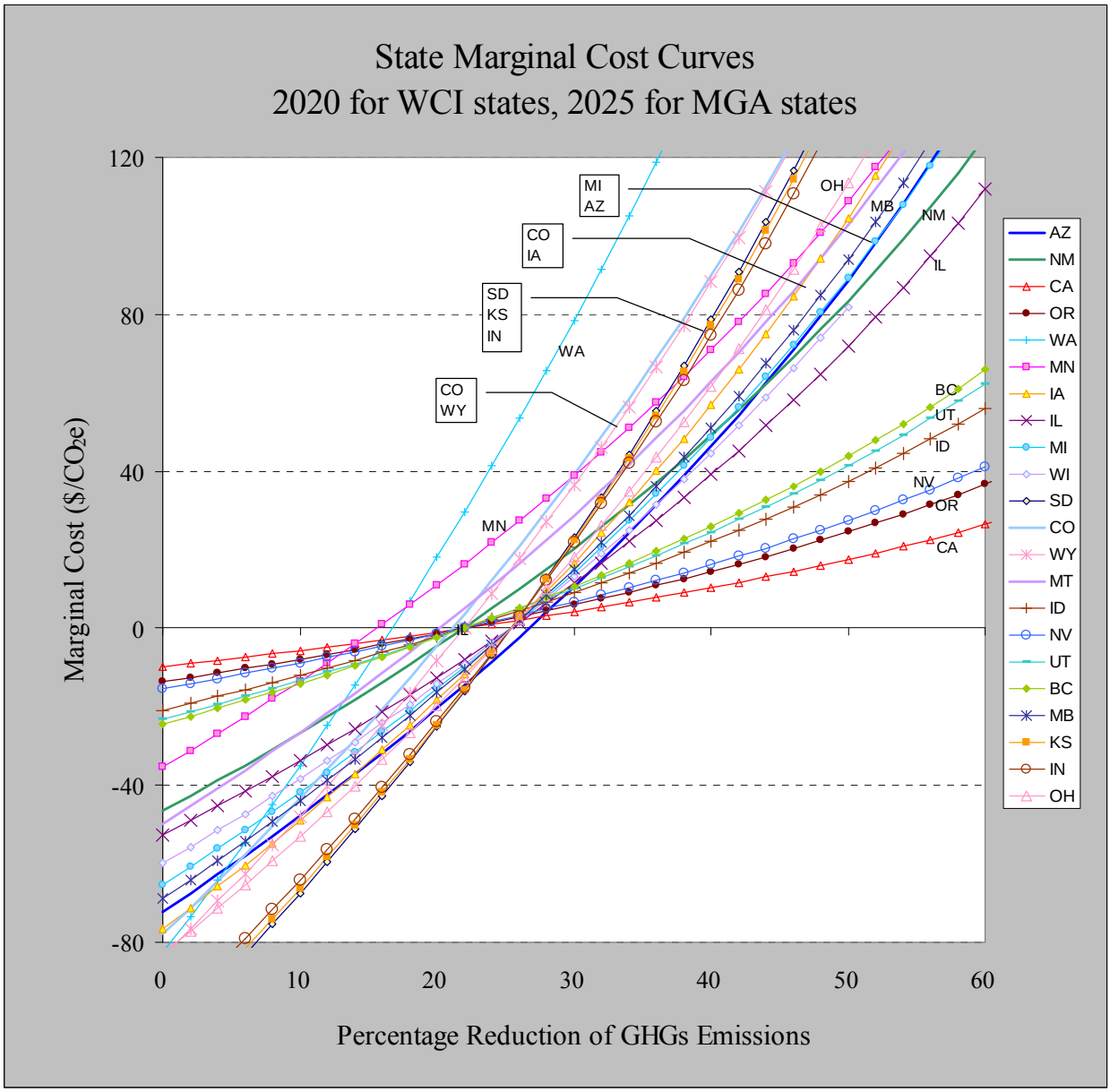
† Represents number of permits bought or sold.

Table A-11. Summary Data Table

State	Cap: 30% Below 2005 Emissions in 2025 ($MMtCO_2e$)	2025 BAU Gross Emissions (Consumption-based) ($MMtCO_2e$)	GHG Mitigation Goal in 2025 (relative to BAU emissions)	Autarkic Marginal Mitigation Cost ($/tCO_2e$)	Gross State Product in 2025 (million $ 2000)
AZ	69.8	189.4	63.14%	$159.6	$481,628
CA	341.8	648.0	47.25%	$15.5	$2,923,222
NM	51.3	99.5	48.41%	$77.6	$94,564
OR	48.6	91.9	47.15%	$21.5	$297,081
UT	48.5	107.2	54.74%	$50.8	$204,725
WA	66.4	132.5	49.86%	$229.0	$471,781
BC	46.1	81.2	43.22%	$31.3	$146,610
CO	81.3	159.8	49.08%	$143.8	$563,455
ID	26.1	46.7	44.13%	$28.1	$98,835
MT	25.9	43.3	40.10%	$63.1	$41,520
NV	34.7	82.0	57.72%	$37.8	$236,707
WY	39.0	74.7	47.82%	$135.2	$39,577
IA	71.0	126.0	43.65%	$73.4	$206,621
IL	199.2	322.2	38.18%	$33.8	$768,315
KS	68.2	121.0	43.65%	$99.2	$146,593
MI	168.8	273.0	38.18%	$42.0	$524,088
MN	108.5	163.8	33.72%	$50.3	$392,084
WI	101.2	163.8	38.18%	$38.5	$342,743
MB	14.2	20.6	31.02%	$18.5	$37,581
IN	195.6	316.5	38.18%	$64.3	$396,501
OH	241.3	390.3	38.18%	$53.3	$590,200
SD	25.5	48.3	47.13%	$124.2	$57,361
Total	**2,073.1**	**3,701.3**	**43.99%**		**$9,061,793**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual; $/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Figure A-3. State marginal cost curves, 2020 for WCI states, 2025 for MGA states



WCI = Western Climate Initiative; MGA = Midwestern Governors Association; $/$CO_2$e = dollars per carbon dioxide equivalent; GHG = greenhouse gas.

Note: Marginal cost curves of midwestern states are developed based on the Minnesota 2025 curve assuming no CIP and RES in effect in the baseline condition. The Minnesota 2025 curve shown in this figure assumes that both CIP and RES are in effect in the baseline condition. Marginal cost curves of WCI states other than for AZ, CO, MT, and WA are developed based on the NM 2020 curve. In order to run simulations including both MGA and WCI states in 2025, we used 2020 marginal cost curves for WCI states for 2025. These marginal cost curves are presented for a range of mitigation levels, including those higher than required to meet the cap in 2025. We anticipate that there will be technology innovations in the future, i.e., the marginal cost curves will shift downward over time before higher levels of mitigation are necessary.

Sensitivity Analysis #3: RES is in effect, but no CIP in the baseline condition

Table A-12. (III-M1)—Economy-wide emission trading simulation among six midwestern states plus Manitoba in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction with Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
IA	–$478	–$935	$357	–$579	$100	7.65	47.37	37.58	43.65
IL	–$1,581	–$1,029	–$641	–$1,670	$89	–13.75	136.78	42.45	38.18
KS	–$621	–$1,411	$510	–$901	$280	10.94	41.86	34.61	43.65
MI	–$1,663	–$1,508	–$163	–$1,671	$8	–3.50	107.73	39.46	38.18
MN	–$822	–$1,039	$197	–$842	$20	4.22	67.35	37.40	39.74
WI	–$915	–$747	–$184	–$931	$16	–3.95	66.47	40.59	38.18
MB	–$178	–$126	–$75	–$201	$23	–1.61	8.00	38.82	31.02
Total	**–$6,258**	**–$6,796**	**$0**	**–$6,796**	**$537**	**22.81**†	**475.57**	**39.41**	**39.41**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $46.64/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is –$15.42/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 37.40% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-13. (II-M2)—Economy-wide emission trading simulation among nine midwestern states plus Manitoba in 2025 (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(percent from BAU)	(percent from BAU)
IA	–$478	–$868	$321	–$546	$68	6.26	48.75	38.68	43.65
IL	–$1,581	–$798	–$947	–$1,745	$164	–18.47	141.50	43.91	38.18
KS	–$621	–$1,361	$508	–$853	$232	9.91	42.89	35.46	43.65
MI	–$1,663	–$1,342	–$353	–$1,696	$32	–6.89	111.12	40.70	38.18
MN	–$822	–$936	$109	–$827	$5	2.12	69.45	38.56	39.74
WI	–$915	–$640	–$314	–$955	$40	–6.13	68.65	41.92	38.18
MB	–$178	–$114	–$95	–$209	$31	–1.85	8.25	40.02	31.02
IN	–$2,954	–$3,393	$390	–$3,003	$49	7.61	113.21	35.78	38.18
OH	–$3,018	–$3,108	$88	–$3,020	$2	1.72	147.29	37.74	38.18
SD	–$64	–$558	$293	–$265	$202	5.72	17.03	35.28	47.13
Total	**–$12,294**	**–$13,119**	**$0**	**–$13,119**	**$825**	**33.34**†	**768.14**	**39.16**	**39.16**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $51.27/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is –$13.48/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 38.56% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-14. (II-M1W1)—Economy-wide emission trading simulation among six midwestern states, six western states, and two Canadian provinces in 2025 (million dollars or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
AZ	$2,954	–$1,590	$1,736	$146	$2,808	49.51	70.07	37.00	63.14
CA	$459	$3,732	–$4,695	–$963	$1,421	–133.86	440.05	67.91	47.25
NM	$421	–$304	$458	$154	$267	13.07	35.12	35.28	48.41
OR	$89	$386	–$373	$13	$75	–10.63	53.96	58.72	47.15
UT	$528	$148	$312	$460	$68	8.90	49.76	46.44	54.74
WA	$3,666	–$797	$1,251	$454	$3,212	35.67	30.38	22.93	49.86
BC	$29	$86	–$60	$26	$3	–1.71	36.79	45.33	43.22
IA	–$478	–$1,081	$393	–$688	$209	11.21	43.81	34.76	43.65
IL	–$1,581	–$1,532	–$50	–$1,582	$1	–1.41	124.44	38.62	38.18
KS	–$621	–$1,519	$476	–$1,043	$422	13.57	39.23	32.43	43.65
MI	–$1,663	–$1,867	$186	–$1,681	$18	5.30	98.93	36.24	38.18
MN	–$822	–$1,261	$339	–$922	$100	9.65	61.92	34.38	39.74
WI	–$915	–$978	$60	–$918	$3	1.71	60.81	37.14	38.18
MB	–$178	–$152	–$34	–$186	$8	–0.97	7.36	35.73	31.02
Total	**$1,888**	**–$6,728**	**$0**	**–$6,728**	**$8,616**	**148.59**†	**1,152.64**	**45.09**	**45.09**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $35.07/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is –$20.36/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state which, for this case, is 34.38% below the baseline level in 2025 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

† Represents number of permits bought or sold.

Table A-15. (II-M2W2)—Economy-wide emission trading simulation among nine midwestern states, eleven western states, and two Canadian provinces in 2020 (million $ or otherwise specified)

State	Before Trading	After Trading*				Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost	Cost Saving	($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
AZ	$2,954	–$1,468	$1,917	$449	$2,505	46.31	73.27	38.69	63.14
CA	$459	$4,905	–$6,813	–$1,908	$2,366	–164.61	470.81	72.65	47.25
NM	$421	–$222	$452	$230	$191	10.93	37.25	37.43	48.41
OR	$89	$543	–$610	–$67	$156	–14.74	58.07	63.19	47.15
UT	$528	$292	$213	$504	$24	5.14	53.52	49.95	54.74
WA	$3,666	–$743	$1,418	$675	$2,991	34.25	31.80	24.00	49.86
BC	$29	$191	–$185	$6	$23	–4.46	39.54	48.72	43.22
CO	$1,611	–$1,066	$1,231	$166	$1,445	29.75	48.65	30.46	49.08
ID	$26	$158	–$158	$0	$26	–3.81	24.41	52.31	44.13
MT	$33	–$107	$111	$4	$29	2.69	14.66	33.88	40.10
NV	$354	$432	–$81	$351	$4	–1.96	49.28	60.11	57.72
WY	$506	–$574	$519	–$55	$561	12.55	23.15	31.01	47.82
IA	–$478	–$1,006	$383	–$623	$145	9.24	45.77	36.32	43.65
IL	–$1,581	–$1,271	–$341	–$1,612	$32	–8.25	131.28	40.74	38.18
KS	–$621	–$1,463	$502	–$962	$341	12.12	40.68	33.63	43.65
MI	–$1,663	–$1,682	$18	–$1,663	$0	0.44	103.79	38.02	38.18
MN	–$822	–$1,146	$276	–$870	$48	6.66	64.92	36.04	39.74
WI	–$915	–$858	–$59	–$917	$2	–1.42	63.94	39.05	38.18
MB	–$178	–$139	–$55	–$193	$15	–1.32	7.72	37.44	31.02
IN	–$2,954	–$3,669	$562	–$3,108	$154	13.57	107.25	33.89	38.18
OH	–$3,018	–$3,508	$428	–$3,079	$61	10.35	138.66	35.53	38.18
SD	–$64	–$599	$273	–$326	$262	6.59	16.16	33.48	47.13
Total	**–$1,618**	**–$12,999**	**$0**	**–$12,999**	**$11,381**	**200.59†**	**1,644.58**	**44.24**	**44.24**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

* Permit Price = $41.39/$tCO_2e$. This is the price of the last permit sold, which is also equal to the price of the last ton of CO_2e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO_2e in this simulation differs for each state. For Minnesota, for example, it is –$17.65/$tCO_2e$. Please note that the average mitigation cost is related to mitigation level of a state, which for this case is 36.04% below the baseline level in 2020 for Minnesota. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state.

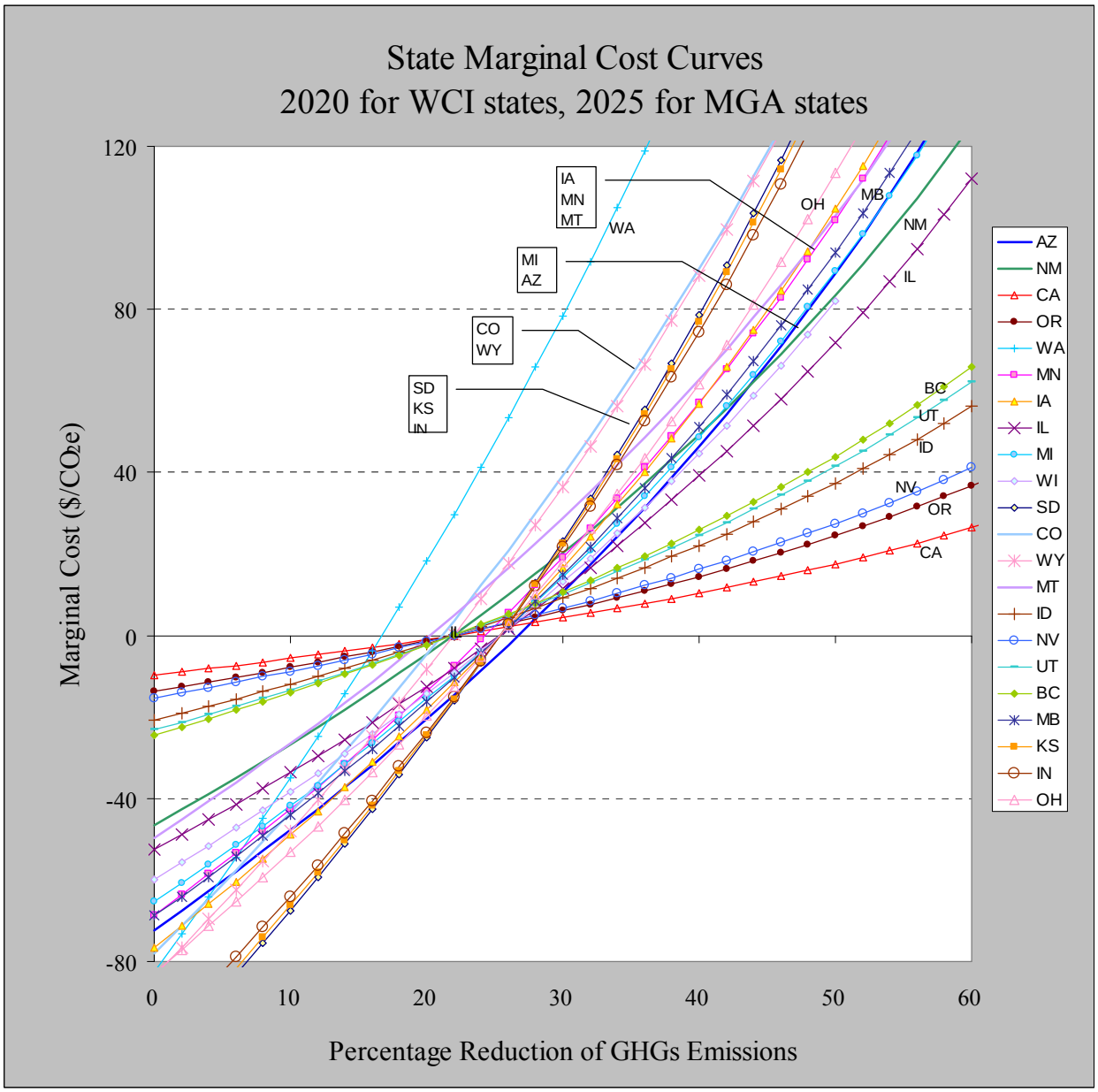
† Represents number of permits bought or sold.

Table A-16. Summary Data Table

State	Cap: 30% Below 2005 Emissions in 2025 ($MMtCO_2e$)	2025 BAU Gross Emissions (Consumption-Based) ($MMtCO_2e$)	GHG Mitigation Goal in 2025 (Relative to BAU Emissions)	Autarkic Marginal Mitigation Cost ($/$tCO_2e$)	Gross State Product in 2025 (Million $ 2000)
AZ	69.8	189.4	63.14%	$159.6	$481,628
CA	341.8	648.0	47.25%	$15.5	$2,923,222
NM	51.3	99.5	48.41%	$77.6	$94,564
OR	48.6	91.9	47.15%	$21.5	$297,081
UT	48.5	107.2	54.74%	$50.8	$204,725
WA	66.4	132.5	49.86%	$229.0	$471,781
BC	46.1	81.2	43.22%	$31.3	$146,610
CO	81.3	159.8	49.08%	$143.8	$563,455
ID	26.1	46.7	44.13%	$28.1	$98,835
MT	25.9	43.3	40.10%	$63.1	$41,520
NV	34.7	82.0	57.72%	$37.8	$236,707
WY	39.0	74.7	47.82%	$135.2	$39,577
IA	71.0	126.0	43.65%	$73.4	$206,621
IL	199.2	322.2	38.18%	$33.8	$768,315
KS	68.2	121.0	43.65%	$99.2	$146,593
MI	168.8	273.0	38.18%	$42.0	$524,088
MN	108.5	180.1	39.74%	$56.0	$392,084
WI	101.2	163.8	38.18%	$38.5	$342,743
MB	14.2	20.6	31.02%	$18.5	$37,581
IN	195.6	316.5	38.18%	$64.3	$396,501
OH	241.3	390.3	38.18%	$53.3	$590,200
SD	25.5	48.3	47.13%	$124.2	$57,361
Total	**2,073.1**	**3,717.7**	**44.24%**		**$9,061,793**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

Figure A-4. State marginal cost curves, 2020 for WCI states, 2025 for MGA states



WCI = Western Climate Initiative; MGA = Midwestern Governors Association; $/$CO_2$e = dollars per carbon dioxide equivalent; GHG = greenhouse gas.

Note: Marginal cost curves of midwestern states are developed based on the Minnesota 2025 curve assuming no CIP and RES in effect in the baseline condition. The Minnesota 2025 curve shown in this figure assumes that RES is in effect in the baseline condition, but no CIP in the baseline. Marginal cost curves of WCI states other than for AZ, CO, MT, and WA are developed based on the NM 2020 curve. In order to run simulations including both MGA and WCI states in year 2025, we used 2020 marginal cost curves for WCI states for 2025. These marginal cost curves are presented for a range of mitigation levels, including those higher than required to meet the cap in 2025. We anticipate that there will be technology innovations in the future, i.e., the marginal cost curves will shift downward over time before higher levels of mitigation are necessary.

Auction Case

- In an auction case, we assume there would be no permit trading among states.
- According to the Coase Theorem, in equilibrium, each state will choose to mitigate the same level of emissions as it would in a permit trading market.
- Each state would buy its total allowances from the auctioneer.
- The auction price would be the same level as the equilibrium price in a permit trading market.
- The auction revenues can be used ("recycled") to fund research and development in clean energy technologies, subsidize business expenditures on mitigation, and reduce various taxes. However, the impacts of recycling those revenues are not included in the simulation below.

Table A-17. An auction case among MGA partners (assume no RES/CIP in the baseline)

State	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by the State*		Emission Allowances Bought From Auctioneer	Auction Cost (billion $)†	Mitigation Cost (billion $)	Total Cost (billion $)
		(Percent From BAU)	($MMtCO_2$)				
IA	126.04	38.01	47.91	78.13	$3.79	–$0.91	$2.88
IL	322.24	43.02	138.64	183.60	$8.90	–$0.94	$7.95
KS	120.96	34.94	42.27	78.69	$3.81	–$1.39	$2.42
MI	273.00	39.95	109.06	163.94	$7.94	–$1.45	$6.50
MN	197.65	40.38	79.82	117.83	$5.71	–$0.97	$4.74
WI	163.75	41.11	67.32	96.43	$4.67	–$0.71	$3.97
MB	20.61	39.29	8.10	12.51	$0.61	–$0.12	$0.48
Total	**1,224.25**	**40.28**	**493.11**	**731.14**	**$35.42**	**–$6.49**	**$28.93**

BAU = business as usual; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

* In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

† The auction price would be the same level ($48.45/tCO_2e$) as the equilibrium price in a permit trading market.

Table A-18. An auction case among MGA partners (assume both RES and CIP are in effect in the baseline)

State	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by the State*		Emission Allowances Bought From Auctioneer	Auction Cost (billion $)†	Mitigation Cost (billion $)	Total Cost (billion $)
		(Percent From BAU)	($MMtCO_2$)				
IA	126.04	37.42	47.16	78.88	$3.62	–$0.94	$2.68
IL	322.24	42.23	136.07	186.17	$8.56	–$1.06	$7.49
KS	120.96	34.48	41.71	79.25	$3.64	–$1.42	$2.22
MI	273.00	39.27	107.22	165.78	$7.62	–$1.53	$6.09
MN	163.75	32.33	52.94	110.81	$5.09	$0.14	$5.23
WI	163.75	40.39	66.14	97.61	$4.49	–$0.76	$3.72
MB	20.61	38.64	7.96	12.65	$0.58	–$0.13	$0.45
Total	**1,190.35**	**38.58**	**459.21**	**731.14**	**$33.60**	**–$5.71**	**$27.89**

BAU = business as usual; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

* In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

† The auction price would be the same level ($45.95/tCO_2e$) as the equilibrium price in a permit trading market.

Table A-19. An auction case among MGA partners (assume only RES is in effect in the baseline)

State	Total BAU Emissions in 2025 ($MMtCO_2$)	Emission Reduction Undertaken by the State*		Emission Allowances Bought From Auctioneer	Auction Cost (billion $)†	Mitigation Cost (billion $)	Total Cost (billion $)
		(Percent From BAU)	($MMtCO_2$)				
IA	126.04	37.58	47.37	78.67	$3.67	–$0.94	$2.73
IL	322.24	42.45	136.78	185.46	$8.65	–$1.03	$7.62
KS	120.96	34.61	41.86	79.10	$3.69	–$.41	$2.28
MI	273.00	39.46	107.73	165.27	$7.71	–$1.51	$6.20
MN	180.11	37.40	67.35	112.76	$5.26	–$1.04	$4.22
WI	163.75	40.59	66.47	97.28	$4.54	–$0.75	$3.79
MB	20.61	38.82	8.00	12.61	$0.59	–$0.13	$0.46
Total	**1,206.71**	**39.41**	**475.57**	**731.14**	**$34.10**	**–$6.80**	**$27.31**

BAU = business as usual; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

* In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.

† The auction price would be the same level ($46.64/tCO_2e$) as the equilibrium price in a permit trading market.

Minnesota-Only Cap-and-Trade Scenario

GHG mitigation policy options are proposed and designed for Minnesota in the following four sectoral categories: (1) ES, Energy Supply, (2) RCI, Residential, Commercial, and Industrial, (3) TLU, Transportation and Land Use, and (4) AFW, Agriculture, Forestry, and Waste Management. Table A-19 presents a list of options that currently have quantified mitigation potential and cost information. In this section, we study a cap-and-trade program between major sectors in Minnesota. In the last column of Table A-19, we classify the options into four major sectors: (1) Power Sector, (2) Transportation Sector, (3) Sequestration, and 4) Other (including Industrial, Commercial, Agriculture, Forestry, and Small Power Generation).

Table A-20. Minnesota Mitigation Policy Recommendations List

Recom-mendation No.	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	Sector
AFW-1a	Agricultural Crop Management—A. Soil Carbon Management	1.3	–$2.00	Sequestration
AFW-1b	Agricultural Crop Management—B. Nutrient Management	1.3	–$37.00	Sequestration
AFW-2a	Land Use Management Approaches for Protection and Enrichment of Soil Carbon—A. Preserve Land	0.44	$33.00	Sequestration
AFW-2b	Land Use Management Approaches for Protection and Enrichment of Soil Carbon—B. Reinvest in Minnesota–Clean Energy (RIM-CE)	0.19	$34.00	Sequestration
AFW-3a	In-State Liquid Biofuels Production—A. Ethanol Carbon Content	2.2	–$9.00	Transportation
AFW-3b	In-State Liquid Biofuels Production—B. Fossil Diesel Displacement	0.19	$55.00	Transportation
AFW-3c	In-State Liquid Biofuels Production—C. Gasoline Displacement	9	$5.00	Transportation
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	3.8	$3.00	Other
AFW-5a	Forestry Management Programs to Enhance GHG Benefits —A. Forestation	2.2	$13.00	Sequestration
AFW-5b	Forestry Management Programs to Enhance GHG Benefits—B. Urban Forestry	2.7	–$12.00	Sequestration
AFW-5d	Forestry Management Programs to Enhance GHG Benefits—D. Restocking	8.4	$33.00	Sequestration
AFW-6	Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover	2.7	$3.00	Sequestration
AFW-7a	Front-End Waste Management Technologies—A. Source Reduction	3.6	$3.00	Other
AFW-7b	Front-End Waste Management Technologies—B. Recycling	3.4	–$11.00	Other

Recom-mendation No.	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	Sector
AFW-7c	Front-End Waste Management Technologies—C. Composting	0.41	$3.00	Other
AFW-8a	End of Life Waste Management Practices—A. Landfilled Waste Methane	0.73	$1.00	Other
AFW-8b	End of Life Waste Management Practices—B. Residuals Management	0.63	$80.00	Other
AFW-8c	End of Life Waste Management Practices—C. WTE Preprocessing	0.84	$32.00	Other
ES-1	Generation Performance Standard	0	$0.00	Power
ES-3	Efficiency Improvements, Repowering, and Other Upgrades to Existing Plants—Biomass Co-firing	0.4	$12.00	Power
ES-4	Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss—Natural Gas Transmission and Distribution Upgrades	0.4	–$26.10	Power
ES-5	Renewable and/or Environmental Portfolio Standard	15.7	$56.40	Power
ES-6	Nuclear Power Support and Incentives—Installation of a Nuclear Power Station in 2020	NQ*	NQ*	Power
ES-8	Advanced Fossil Fuel Technology Incentives, Support, or Requirements	NQ*	NQ*	Power
ES-12	Distributed Renewable Energy	0.023	$78.10	Power
RCI-1	Maximize Savings From the Utility Conservation Improvement Program (CIP)	14.7	–$63.20	Power
RCI-2	Improved Uniform Statewide Building Codes	0.005	–$576.00	Other
RCI-3	Green Building Guidelines and Standards Based on *Architecture 2030*	0.94	–$27.00	Other
RCI-4	Incentives and Resources To Promote Combined Heat and Power (CHP)	4.95	$3.80	Other
RCI-5	Program To Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs	0.05	–$5.00	Other
RCI-6	Non-Utility Strategies and Incentives To Encourage Energy Efficiency and Reduce GHG Emissions	1.3	–$37.00	Other
RCI-7	Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency	0.05	–$28.00	Other
RCI-10	Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards	1.4	–$124.00	Other
TLU-2	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.3	$0.00	Transportation
TLU-5	Climate-Friendly Transportation Pricing / Pay-as-You-Drive	2.1	–$1.00	Transportation
TLU-6	Adopt California Clean Car Standards	1.16	–$39.00	Transportation
TLU-13	Reduce Maximum Speed Limits	0.4	$15.50	Transportation

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management; ES = Energy Supply; RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use; NQ* = Not quantified as these options were recommended for further study.

Table A-21 presents historical and projected GHG emissions from various sources in Minnesota. In Table A-22, we aggregate the GHG emission sources into three major sectors corresponding to the sector classification we used for mitigation options in Table A-20: (1) Power Sector, (2) Transportation Sector, and (3) Other. Emission from Sequestration is zero.

Table A-21. Minnesota gross GHG emissions by sector, 1990–2025: historical and projected

	MMtCO_2e Source	1990	1995	2000	2005	2010	2015	2020	2025
1	Electricity (consumption-based)	35.03	40.88	43.40	54.14	57.06	63.82	71.27	79.45
2	Fossil fuel industry	1.37	1.95	2.12	2.25	2.60	3.02	3.50	4.07
3	RCI fuel use	25.61	31.08	31.32	32.00	34.99	37.17	38.64	40.48
4	Transport on-road gasoline	17.32	19.43	21.72	22.74	22.31	22.48	22.69	22.75
5	Transport on-road diesel	4.46	4.99	5.85	6.67	7.11	7.76	8.49	9.18
6	Jet fuel/other transport	6.91	7.25	7.85	7.81	7.15	7.39	7.62	7.86
7	Agriculture	15.53	17.53	19.50	19.68	20.51	21.36	22.24	23.13
8	ODS substitutes	0.00	0.08	0.41	0.65	0.93	1.23	1.60	2.06
9	Other industrial processes	0.61	0.79	0.96	0.91	0.87	0.85	0.87	0.89
10	Waste management	5.55	5.03	4.97	4.96	4.85	4.75	4.66	4.58
11	Forestry	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
	Total	**115.69**	**132.31**	**141.40**	**152.43**	**159.50**	**172.92**	**180.00**	**197.76**

MMtCO_2e = million metric tons of carbon dioxide equivalent; RCI = Residential, Commercial, and Industrial; ODS = ozone-depleting substance.

Table A-22. Minnesota gross GHG emissions from three major sectors, 1990–2025: historical and projected

	MMtCO_2e Source as in Table A-21	1990	1995	2000	2005	2010	2015	2020	2025
1	Power sector	35.03	40.88	43.40	54.14	57.06	63.82	71.27	79.45
4–6	Transportation sector	28.70	31.68	35.42	37.22	36.57	37.62	38.80	39.79
2, 3, 7–11	Other (e.g., Industrial, Commercial, Agriculture, Forestry, and Small Power Generation)	51.96	59.76	62.58	63.75	68.06	71.69	74.80	78.51
	Total	**115.69**	**132.31**	**141.40**	**152.43**	**159.50**	**172.92**	**180.00**	**197.76**

MMtCO_2e = million metric tons of carbon dioxide equivalent.

The 2025 emission cap in Minnesota is 30% below the 2005 level. We assume this emission cap applies to each of the three major sectors, i.e., each sector has an emission cap of 70% of its emission level in 2005. Sequestration does not have a cap.

Table A-23. Cap in 2025: 30% below 2005 level

$MMtCO_2e$	2025 BAU Emission	Cap	Reduction Goal
Power sector	79.45	37.90	41.56
Transportation sector	39.79	26.05	13.73
Other	78.51	44.62	33.89

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual.

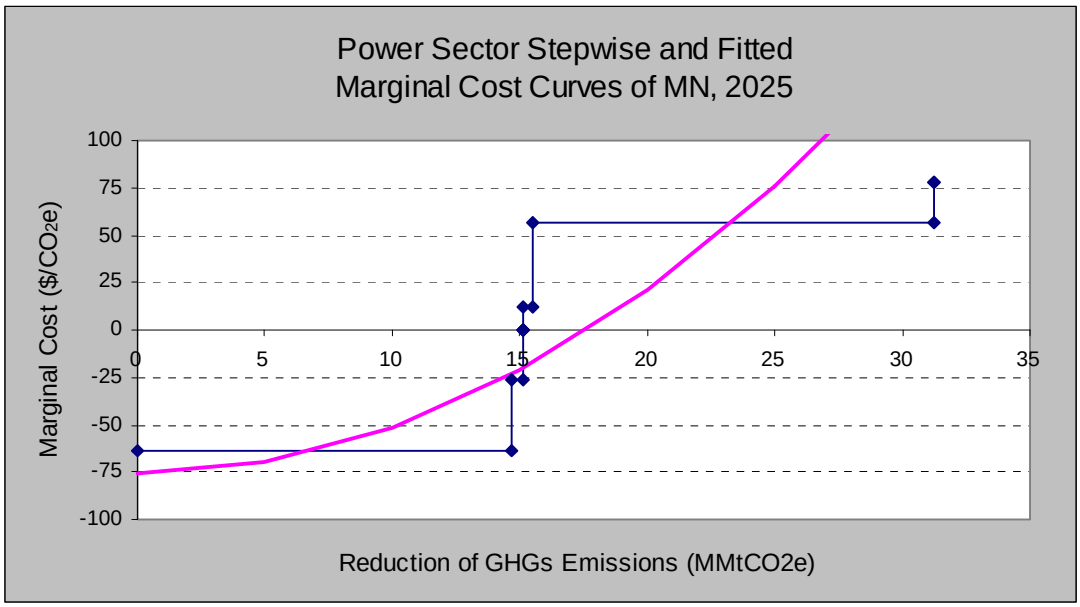
Next, we develop marginal cost curves for each of the four sectors. In the following figures of sector by sector cost curves, the horizontal axis represents the amount of GHG emission reduction. In previous interstate simulations, we designated the horizontal axis to represent percentage reduction of emissions. We did not use percentage reduction here but rather the actual amount of emission reduction along the horizontal axis because the emission from the Sequestration Sector is zero, and thus the percentage reduction cannot be defined for this sector.

Table A-24. Power sector

	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential ($MMtCO_2e$)
RCI-1	Maximize Savings From the Utility Conservation Improvement Program (CIP)	14.7	–$63.20	14.7
ES-4	Transmission System Upgrading, Including Reducing Transmission Line and Distribution System Loss–Natural Gas Transmission and Distribution Upgrades	0.4	–$26.10	15.1
ES-1	Generation Performance Standard	0	$0.00	15.1
ES-6	Nuclear Power Support and Incentives–Installation of a Nuclear Power Station in 2020	0	NQ*	15.1
ES-8	Advanced Fossil Fuel Technology Incentives, Support or Requirements	0	NQ*	15.1
ES-3	Efficiency Improvements, Repowering and Other Upgrades to Existing Plants–Biomass Co-firing	0.4	$12.00	15.5
ES-5	Renewable and/or Environmental Portfolio Standard	15.7	$56.40	31.2
ES-12	Distributed Renewable Energy	0.023	$78.10	31.223

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; RCI = Residential, Commercial, and Industrial; ES = Energy Supply; NQ* = Not quantified as these options were recommended for further study.

Figure A-5. Power sector stepwise and fitted marginal cost curves of Minnesota, 2025



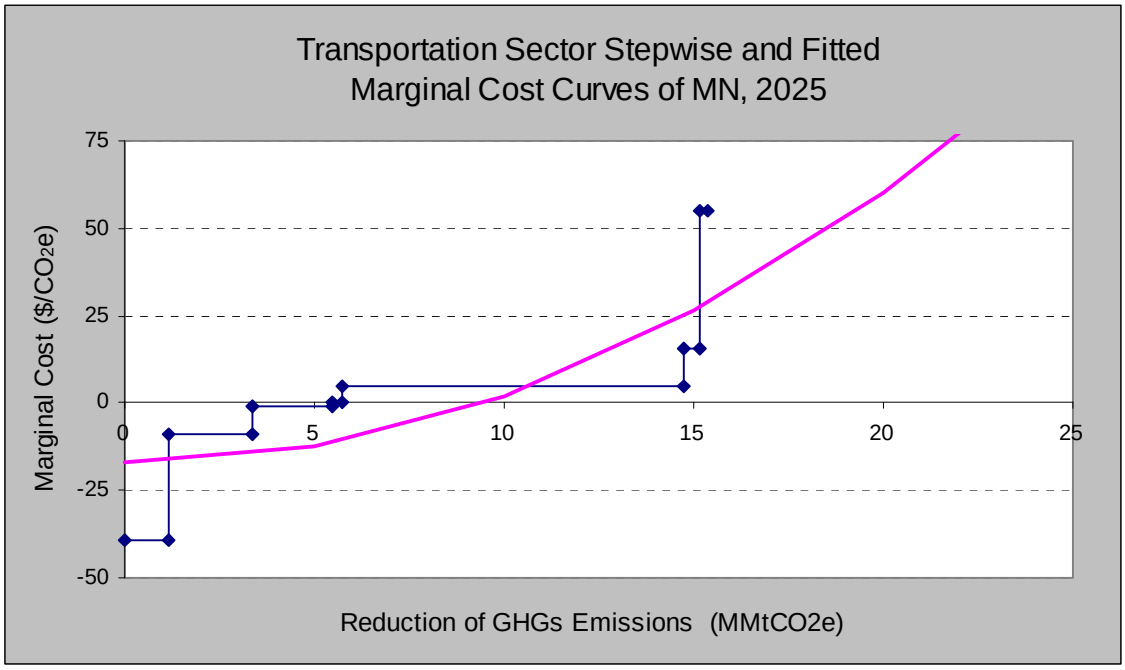
$/$CO_2$e = dollars per carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table A-25. Transportation sector

	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential ($MMtCO_2e$)
TLU-6	Adopt California Clean Car Standards	1.16	–$39.00	1.16
AFW-3a	In-State Liquid Biofuels Production–A. Ethanol Carbon Content	2.2	–$9.00	3.36
TLU-5	Climate-Friendly Transportation Pricing / Pay-as-You-Drive	2.1	–$1.00	5.46
TLU-2	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.3	$0.00	5.76
AFW-3c	In-State Liquid Biofuels Production–C. Gasoline Displacement	9	$5.00	14.76
TLU-13	Reduce Maximum Speed Limits	0.4	$15.50	15.16

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; TLU = Transportation and Land Use; AFW = Agriculture, Forestry, and Waste Management.

Figure A-6. Transportation sector stepwise and fitted marginal cost curves of Minnesota, 2025



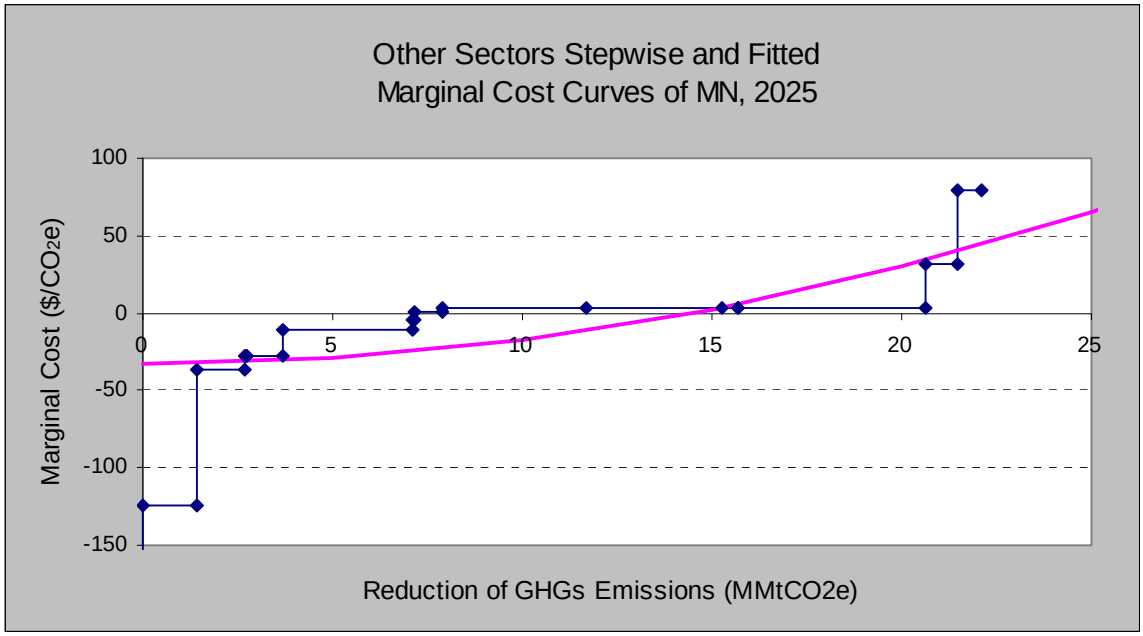
$/$CO_2e$ = dollars per carbon dioxide equivalent; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table A-26. Other sectors

	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential ($MMtCO_2e$)
RCI-2	Improved Uniform Statewide Building Codes	0.005	–$576.00	0.005
RCI-10	Support Strong Federal Appliance Standards and Require High State Standards in the Absence of Federal Standards	1.4	–$124.00	1.405
RCI-6	Non-Utility Strategies and Incentives To Encourage Energy Efficiency and Reduce GHG Emissions	1.3	–$37.00	2.705
RCI-7	Conservation Improvement-Type Program for Propane and Fuel Oil Efficiency	0.05	–$28.00	2.755
RCI-3	Green Building Guidelines and Standards Based on Architecture 2030	0.94	–$27.00	3.695
AFW-7b	Front-End Waste Management Technologies—B. Recycling	3.4	–$11.00	7.095
RCI-5	Program To Reduce Emissions of Non-Fuel, High-Global-Warming-Potential GHGs	0.05	–$5.00	7.145
AFW-8a	End of Life Waste Management Practices—A. Landfilled Waste Methane	0.73	$1.00	7.875
AFW-4	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	3.8	$3.00	11.675
AFW-7a	Front-End Waste Management Technologies—A. Source Reduction	3.6	$3.00	15.275
AFW-7c	Front-End Waste Management Technologies—C. Composting	0.41	$3.00	15.685
RCI-4	Incentives and Resources To Promote Combined Heat and Power (CHP)	4.95	$3.80	20.635
AFW-8c	End of Life Waste Management Practices—C. WTE Preprocessing	0.84	$32.00	21.475
AFW-8b	End of Life Waste Management Practices—B. Residuals Management	0.63	$80.00	22.105

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; RCI = Residential, Commercial, and Industrial; AFW = Agriculture, Forestry, and Waste Management; WTE = waste to energy.

Figure A-7. Other sectors stepwise and fitted marginal cost curves of Minnesota, 2025



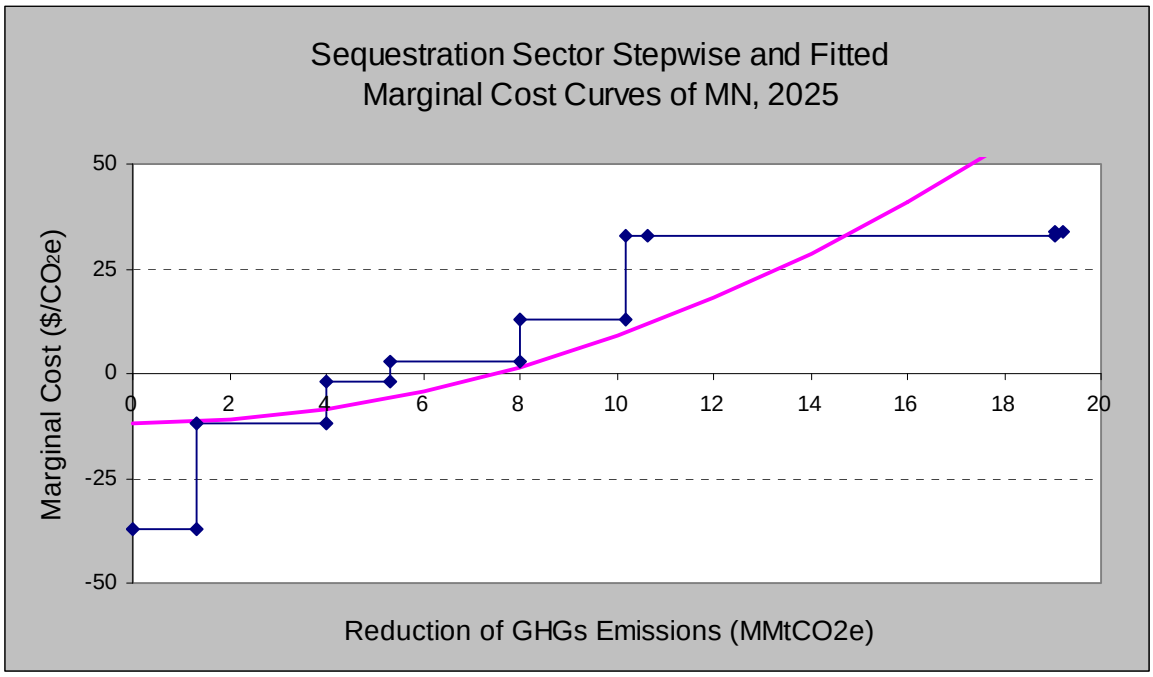
$/$CO_2$e = dollars per carbon dioxide equivalent; GHG = greenhouse gas; MMtCO_2e = million metric tons of carbon dioxide equivalent.

Table A-27. Sequestration

	Climate Mitigation Recommendation	Estimated 2025 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential ($MMtCO_2e$)
AFW-1b	Agricultural Crop Management—B. Nutrient Management	1.3	–$37.00	1.3
AFW-5b	Forestry Management Programs to Enhance GHG Benefits—B. Urban forestry	2.7	–$12.00	4
AFW-1a	Agricultural Crop Management—A. Soil Carbon Management	1.3	–$2.00	5.3
AFW-6	Forest Protection—Reduced Clearing and Conversion to Non-Forest Cover	2.7	$3.00	8
AFW-5a	Forestry Management Programs to Enhance GHG Benefits—A. Forestation	2.2	$13.00	10.2
AFW-2a	Land Use Management Approaches for Protection and Enrichment of Soil Carbon —A. Preserve Land	0.44	$33.00	10.64
AFW-5d	Forestry Management Programs to Enhance GHG Benefits—D. Restocking	8.4	$33.00	19.04
AFW-2b	Land Use Management Approaches for Protection and Enrichment of Soil Carbon— B. Reinvest in Minnesota–Clean Energy (RIM-CE)	0.19	$34.00	19.23

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; AFW = Agriculture, Forestry, and Waste Management.

Figure A-8. Sequestration sector stepwise and fitted marginal cost curves of Minnesota, 2025



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

Table A-28. Emission trading simulation among four sectors in Minnesota (assume no CIP/RES in baseline) (million $ or otherwise specified)

State	Before Trading	After Trading*			Cost Saving	Permits Traded	Emission Reduction After Trading		Emission Reduction Cap
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		($MMtCO_2e$)	($MMtCO_2e$)	(Percent From BAU)	(Percent From BAU)
Power Sector	$2,653	–$692	$1,141	$449	$2,203	17.42	24.14	30.38	52.31
Transportation Sector	–$68	$216	–$457	–$241	$173	–6.98	20.71	52.06	34.51
Other	$928	–$9	$584	$575	$352	8.92	24.97	31.80	43.16
Sequestration	$0	$272	–$1,268	–$996	$996	–19.36	19.36	N/A	N/A
Total	**$,512**	**–$213**	**$0**	**–$213**	**$725**	**26.35†**	**89.18**	**45.10**	**45.10**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; BAU = business as usual; N/A = not applicable.

* Permit Price = $65.48/$tCO_2e$.

† Represents number of permits bought or sold.

The simulation results show that Power Sector and Other Sector would buy permits from Transportation Sector and Sequestration Sector.