Preliminary Analysis of MGA Cap and Trade and Carbon Tax for Iowa in 2020

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August 12, 2008

This summary presents the preliminary simulation results of Midwestern Governors Association (MGA) Cap and Trade and the economy wide carbon tax. For the detailed specification of our cap and trade model, the methodology we used to develop the marginal cost curves of states/provinces, and the general assumptions we adopted in the modeling, please refer to the summary "Modeling of Cap and Trade Program" by Adam Rose and Dan Wei.

CRE-3b. MGA Cap and Trade

The MGA partners include six U.S. states: Iowa, Illinois, Kansas, Michigan, Minnesota, and Wisconsin; and one Canadian province: Manitoba. The GHG reduction targets used in the modeling are assumed to be equal to the preliminary short term (2020) goals recommended to the Midwestern Greenhouse Gas Reduction Accord Advisory Group by the Target-Setting, Data and Reporting Subgroup: 15, 20, and 25 percent below 2005 levels by 2020. The MGA Cap and Trade program with these three alternative 2020 targets are analyzed in three scenarios using our model.

There is still considerable debate about what sectors are going to be modeled in the MGA Cap and Trade program. The MGA Greenhouse Gas Reduction Accord has specified a "multi-sector cap and trade mechanism". In this preliminary analysis, we assume the Cap and Trade mechanism covers all economic sectors. Our model is flexible to accommodate any sectoral coverage strategy in the future analysis.

The Cap and Trade simulation results with the three alternative MGA 2020 GHG reduction goals are presented in Tables 1 to 3. The simulation assumes that the permits are grandfathered. The second column in the result tables show the mitigation cost for each partner to achieve the reduction target before it enters the cap and trade program, i.e., the cost of each state's own mitigation activities to achieve the reduction goal. Negative numbers in this column indicate overall cost savings. The next three columns (columns 3 to 5) show the mitigation cost, trading cost, and net cost (the sum of mitigation cost and trading cost) after the partners enter the cap and trade program. Partners that have relatively high mitigation costs will accomplish only part of their reduction obligation by their own mitigation activities, and purchase the remaining permits in the market. Partners that have relatively low costs will have the incentive to mitigate more than their reduction targets indicate, so that they can sell their surplus permits to other partners at a profit. In the Trading Cost column, negative numbers represent revenues from selling permits. Next, the difference in the net cost between the before trading and after trading conditions is presented in the Cost Saving column (column 6). The next two columns (columns 7 and 8) show the permits purchased/sold by each partner and the emissions reduced by in-state mitigation activities in quantity terms. The last two columns (columns 9 and 10) show and compare the emission reductions in percentage terms with and without trading for each partner, respectively.

Under each of the three Cap and Trade results table, the basic data used in the simulation are summarized in the Data Table. The data tables present the 2020 baseline emissions, the emission budget (capped emissions), and reduction target in percentage terms relative to the 2020 baseline level for the MGA partners in the first three numerical columns. The last column in the data tables shows the autarkic (own) marginal mitigation cost level for each state/province to meet the emission budget.

Figure 1 shows the marginal cost curves for all the MGA partner states and province. The Appendix presents in details how we developed the marginal cost curve for Iowa.

Summary of the findings from the preliminary Cap and Trade simulations:

1. The factors that have the greatest influence on all simulations are the absolute levels and the relative levels of the marginal mitigation cost curves. The former has the greatest influence on the potential for cost savings, while the latter has the greatest influence on the extent of permit trading across trading states/provinces, including whether each state/province is a permit buyer or seller.

2. For all the MGA partners, the total cost of achieving the carbon emission caps is negative. This means that compliance with the caps will result in overall cost savings. This result is due to the existence of an extensive range of cost-saving options, such as improvements in energy efficiency.

3. With the MGA GHG reduction goal increases from 15%, to 20%, and to 25% below 2005 level, the equilibrium permit price in the trading market increases from $10.24/tCO2e to $19.76/tCO2e, and to $30.51/tCO2e, respectively. The volume of permits traded among the partners also increase remarkably when the reduction goal gets more and more stringent (from 15.23 MMtCO2e in the 15% case to 49.98 MMtCO2e in the 25% case).

4. In the 15% reduction goal case, Kansas is the biggest permit seller in the market, followed by Iowa and Manitoba. Wisconsin is the biggest permit buyers in the market in this simulation case, closely followed by Illinois. In both the 20% and 25% reduction goal cases, Iowa is the biggest permit seller in the market and Kansas becomes the second biggest seller. On the buyer's side, in these two simulation cases, Illinois becomes the biggest permit purchaser.

5. In all the three simulation cases, if we compare the net cost of each state/province after trading with the before trading mitigation cost, we find that all states/provinces are better off as a result of participating in trading, since all the post-trading net costs are smaller than the pre-trading costs. The gains from trading are shown in the Cost Saving column in the result tables. Compared with the pre-trading situation, Iowa can reduce its net costs (mitigation cost plus permit sales revenue) and achieve savings of $5 million, $68 million, and $210 million in 2020 depending on the MGA GHG reduction goal.

6. The carbon tax cases are equivalent to the cases of a cap and trade program when the allowances are fully auctioned. The tax rate and allowance prices are equivalent and so is the government revenue and mitigation levels by individual emitters.

Please note these are the preliminary simulation results. They are subject to change when we obtain updated quantification analyses for individual mitigation options from the Subcommittees.

TABLE 1. ECONOMY-WIDE EMISSION TRADING SIMULATION AMONG MGA PARTNERS IN YEAR 2020
(with MGA goal 15% below 2005 levels by 2020)

(million dollars or otherwise specified)

State	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Cost[a]	Net Cost		(million tCO_2)	(million tCO_2)	(percent from BAU)	(percent from BAU)
IA	-37	3	-45	-42	5	-4.42	45.13	31.37	28.30
IL	-2,896	-2,981	62	-2,919	23	6.03	81.64	25.07	26.92
KS	-108	-49	-78	-127	19	-7.63	38.65	32.54	26.12
MB	-274	-284	-33	-317	43	-3.18	10.15	41.69	28.61
MI	-2,837	-2,840	2	-2,837	0	0.23	67.14	24.48	24.57
MN	-1,320	-1,351	26	-1,326	5	2.50	51.40	27.42	28.76
WI	-1,224	-1,352	66	-1,286	62	6.46	36.01	24.15	28.48
Total	-8,695	-8,854	0	-8,854	158	15.23[b]	330.12	26.98	26.98

[a] Permit Price = \$10.24/tonCO_2e.
[b] Represents number of permits bought or sold.

DATA TABLE
(with MGA goal 15% below 2005 levels by 2020)

State	2020 BAU Gross Emissions (Consumption-based) (million tCO_2e)	Emissions Cap in 2020 (million tCO_2e)	GHG Mitigation Goal in 2020 (relative to 2020 BAU emissions)	Autarkic Marginal Mitigation Cost (dollars per tCO_2e)
IA	143.9	103.2	28.30%	8.0
IL	325.7	238.0	26.92%	18.0
KS	118.8	87.7	26.12%	5.2
MB	24.3	17.4	28.61%	-16.1
MI	274.2	206.8	24.57%	10.6
MN	187.4	133.5	28.76%	14.3
WI	149.1	106.7	28.48%	29.7
Total	1,223.4	893.3	26.98%	

TABLE 2. ECONOMY-WIDE EMISSION TRADING SIMULATION AMONG MGA PARTNERS IN YEAR 2020
(with MGA goal 20% below 2005 levels by 2020)

(million dollars or otherwise specified)

State	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Cost[a]	Net Cost		(million tCO_2)	(million tCO_2)	(percent from BAU)	(percent from BAU)
IA	21	254	-301	-47	68	-15.22	61.99	43.09	32.51
IL	-2,515	-2,870	249	-2,621	106	12.61	89.04	27.34	31.21
KS	-72	140	-301	-160	88	-15.21	51.40	43.28	30.47
MB	-286	-269	-62	-332	46	-3.16	11.15	45.80	32.81
MI	-2,577	-2,758	138	-2,620	44	6.97	72.58	26.47	29.01
MN	-1,158	-1,264	89	-1,175	17	4.50	57.25	30.55	32.95
WI	-975	-1,304	188	-1,116	140	9.52	39.22	26.30	32.68
Total	-7,563	-8,071	0	-8,071	508	33.59[b]	382.63	31.28	31.28

[a] Permit Price = \$19.76/tonCO_2e.
[b] Represents number of permits bought or sold.

DATA TABLE
(with MGA goal 20% below 2005 levels by 2020)

State	2020 BAU Gross Emissions (Consumption-based) (million tCO_2e)	Emissions Cap in 2020 (million tCO_2e)	GHG Mitigation Goal in 2020 (relative to 2020 BAU emissions)	Autarkic Marginal Mitigation Cost (dollars per tCO_2e)
IA	143.9	97.1	32.51%	11.1
IL	325.7	224.0	31.21%	36.7
KS	118.8	82.6	30.47%	8.6
MB	24.3	16.4	32.81%	-8.2
MI	274.2	194.7	29.01%	32.3
MN	187.4	125.7	32.95%	27.4
WI	149.1	100.4	32.68%	49.7
Total	1,223.4	840.8	31.28%	

TABLE 3. ECONOMY-WIDE EMISSION TRADING SIMULATION AMONG MGA PARTNERS IN YEAR 2020
(with MGA goal 25% below 2005 levels by 2020)

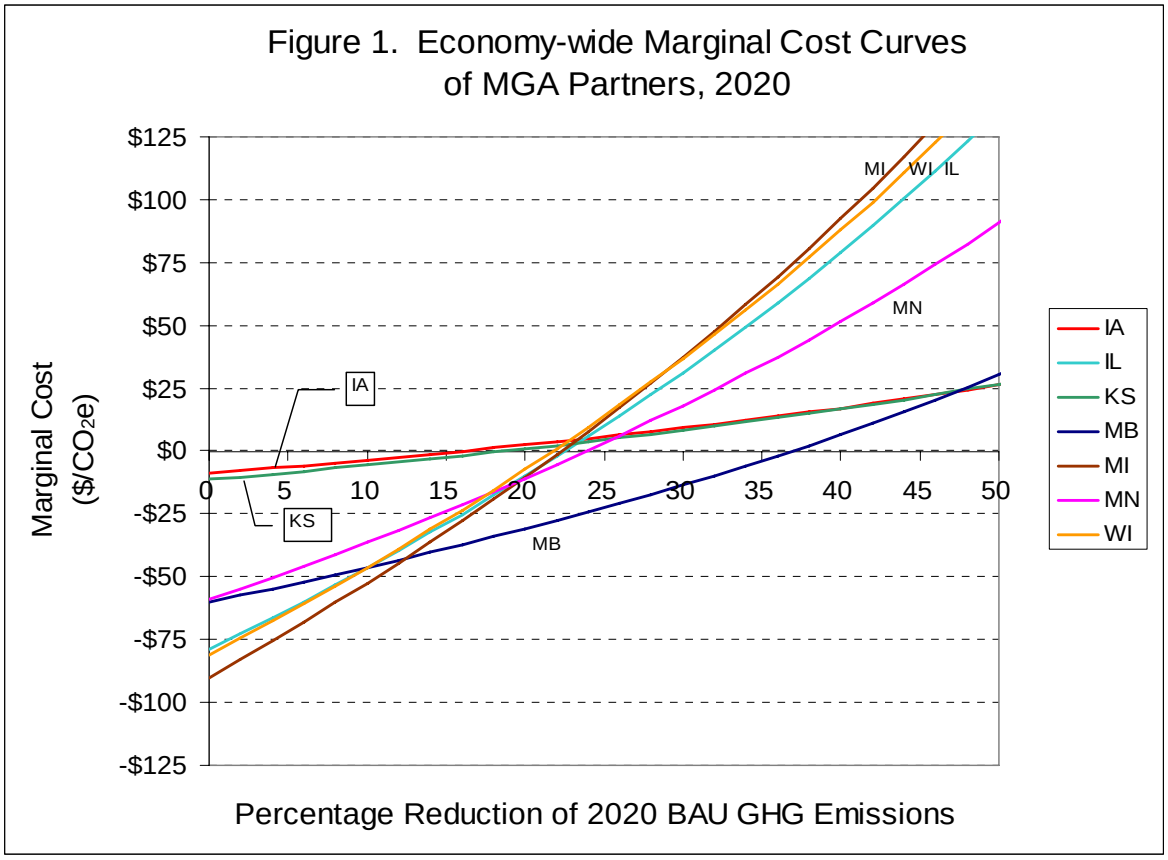
(million dollars or otherwise specified)

State	Before Trading	After Trading			Cost Saving	Permits Traded	Emission Reduction w/ Trading		Emission Reduction Goal
	Mitigation Cost	Mitigation Cost	Trading Cost[a]	Net Cost		(million tCO_2)	(million tCO_2)	(percent from BAU)	(percent from BAU)
IA	98	643	-755	-112	210	-24.75	77.60	53.94	36.73
IL	-1,863	-2,667	565	-2,102	239	18.52	97.13	29.82	35.51
KS	-19	440	-673	-233	214	-22.04	63.39	53.37	34.81
MB	-290	-243	-97	-340	50	-3.19	12.19	50.10	37.01
MI	-2,046	-2,608	401	-2,207	161	13.14	78.55	28.65	33.44
MN	-888	-1,105	184	-921	32	6.04	63.56	33.92	37.14
WI	-597	-1,216	375	-841	244	12.28	42.74	28.66	36.89
Total	-5,606	-6,756	0	-6,756	1,151	49.98	435.16	35.57	35.57

[a] Permit Price = \$30.51/tonCO_2e.
[b] Represents number of permits bought or sold.

DATA TABLE
(with MGA goal 25% below 2005 levels by 2020)

State	2020 BAU Gross Emissions (Consumption-based) (million tCO_2e)	Emissions Cap in 2020 (million tCO_2e)	GHG Mitigation Goal in 2020 (relative to 2020 BAU emissions)	Autarkic Marginal Mitigation Cost (dollars per tCO_2e)
IA	143.9	91.0	36.73%	14.4
IL	325.7	210.0	35.51%	56.6
KS	118.8	77.4	34.81%	12.1
MB	24.3	15.3	37.01%	0.2
MI	274.2	182.5	33.44%	55.4
MN	187.4	117.8	37.14%	41.3
WI	149.1	94.1	36.89%	71.1
Total	1,223.4	788.3	35.57%	



Note: 1. The marginal cost curve of MN is developed based on mitigation options data in the Minnesota State Climate Change Action Plan. The marginal cost curve of IA is developed based on the preliminary quantification analysis results for individual mitigation options provided by the EEC, CRE, TLU, and AFW Subcommittees.

2. The marginal cost curves of MB, MI, IL, and WI are approximated based on MN data. The cost curve of KS is approximated based on IA data.

3. The following assumptions are adopted when we develop the cost curve for one state based on the data from one of its adjacent states. We assume that the list of mitigation options for the adjacent state (state A) is applicable to the state without direct data (state B). Second, for state B, the estimated cost or cost savings per unit GHG removed for each option is assumed to be at the same level as that of state A. Third, the mitigation potentials of each option are assumed to be proportional to the total mitigation potential in each state; this requires that each option be adjusted by the ratio of emissions from the relevant sector of the two states. For example, if the emissions from the power sector are 50 MMtCO2e and 100 MMtCO2e in state A and state B, respectively, the mitigation potentials of the ES options for state A are multiplied by a factor of 2 (100/50=2) for application to state B.

Data Sources:

GHG Mitigation Options Data:

1. Minnesota Climate Change Advisory Group. 2008. *Minnesota Climate Change Advisory Group Final Report: A Report to the Minnesota Legislature*. http://www.mnclimatechange.us/MCCAG.cfm.

2. Iowa Climate Change Advisory Council. 2008. Preliminary Quantification Analysis of Mitigation Options from the EEC, CRE, TLU, and AFW Subcommittees.

Emissions Inventory and Forecast Data:

1. For Manitoba: Williams and Roe. 2008. "Task 0 State-Provincial GHG Summaries Tech Memo 1-31-08.doc" and associated Excel workbooks.

2. For Iowa, Michigan, and Kansas: Draft Inventory and Forecast Analysis by CCS.

3. World Resources Institute. 2007. *Illinois Greenhouse Gas Emissions Inventory and Projections*. Prepared for the Illinois Climate Change Advisory Group. http://www.epa.state.il.us/air/climatechange/documents/07-02-22/il-emissions-overview-v5.pdf.

4. World Resources Institute. 2007. *Wisconsin Greenhouse Gas Emissions Inventory and Projections*. Prepared for the Wisconsin Task Force on Global Warming. http://dnr.wi.gov/environmentprotect/gtfgw/documents/WRI-WI_Inventory_Final.pdf.

CRE-4b. Economy-wide Carbon Tax

In this analysis, a carbon tax is assumed to be imposed on all the emission sources of Iowa. Facing a given carbon tax, the emitter would choose to implement measures to reduce greenhouse gases up to the point where its marginal mitigation cost is equal to the tax rate and would choose to pay the tax for the remaining amount of emissions.

Since we are simulating an economy-wide carbon tax, for any given tax rate, we can estimate reductions by the emission sources, as well as how much tax is paid for the emissions generated, by looking at the economy-wide marginal cost curve of Iowa alone (the pink curve in Figure 1A).

In Table 4, we simulate five carbon tax scenarios for Iowa in 2020. In the first three scenarios, we simulate the tax rate necessary for Iowa to achieve the three MGA goals (15%, 20%, and 25% below the IA 2005 emissions level in 2020). In Scenarios 4 and 5, we simulate two given tax rates at $20/tCO2e and $40/tCO2e, and evaluate the amount of emission reductions achieved by the state through the implementation of the carbon tax.

In Table 4, the second column presents the tax rate in $/tCO2e. Columns 3 and 4 show the emission reductions corresponding to the tax rate in both percentage and quantity terms. Column 5 presents the mitigation cost. The 2020 total emissions in Iowa are 143.87 MMtCO2e. The difference between the total emissions and the emissions reduced will be the amount for which a tax payment will be needed (see Column 6). Column 7 indicates the carbon tax payments by the emitters (or the tax revenue collected by the government), which is the product of the numbers in Column 2 and Column 6. The last column shows the total net cost, which is the sum of the mitigation cost and the tax payment.

In Scenarios 1-3, the three MGA goals are translated to 28.30%, 32.51%, and 36.73% below the Iowa 2020 baseline emissions. In order to achieve these goals, the corresponding tax rate would be $8.02/tCO2e, $11.09/tCO2e, and $32.51/tCO2e, respectively. In Scenarios 4 and 5, when the tax rate is given at the level of $20/tCO2e and $40/tCO2e, the emission reductions that can be achieved in Iowa are 43.35% and 61.77%, respectively, below the 2020 baseline level, or 62.37 MMtCO2e and 88.87 MMtCO2e, respectively.

Please note the tax revenue collected can be re-distributed to low-income consumers or directed to other greenhouse gas mitigation programs in the state, including R&D in new or improved fuels and

technologies. However, in this study, we did not analyze the economic impacts associated with the revenue recycling.

TABLE 4. SIMULATION RESULTS OF ECONOMY-WIDE CARBON TAX

Scenario	Tax Rate ($/tCO2e)	Emission Reduction[a]		Mitigation Cost (million dollars)	Amount of Emissions that Pay Carbon Tax (million tCO2e)	Payment on Carbon Tax (million dollars)	Net Cost (million dollars)[c]
		(percent from 2020 BAU)[b]	(million tCO_{2e})				
1	8.02	28.30%	40.72	-37.04	103.15	826.97	789.93
2	11.09	32.51%	46.77	20.74	97.10	1,077.18	1,097.92
3	14.38	36.73%	52.84	97.95	91.03	1,308.69	1,406.65
4	20	43.35%	62.37	261.25	81.50	1,629.95	1,891.20
5	40	61.77%	88.87	1,038.97	55.00	2,199.84	3,238.81

[a] In equilibrium, the emitter will choose to mitigate to the level where its marginal abatement cost equals the tax rate.
[b] Iowa 2020 BAU emissions level is 143.87 MMtCO2e.
[c] Sum of Mitigation Cost and Tax Payment.

Appendix. Development of the Marginal Cost Curve for Iowa

The marginal cost curve of Iowa is developed based on the reduction potential and mitigation cost/saving data of individual options that are quantitatively analyzed by the EEC, CER, AFW, and TLU Subcommittees. Table 1 presents the list of options that have been analyzed by the Subcommittees in a quantitative manner (please note these are only preliminary analysis results, they are subject to change with the undergoing concurrent stakeholder process).

Table A1. GHG Mitigation Options of Iowa

Sector	Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential (MMtCO2e)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2020 Baseline Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
TLU-7	Fuel Efficient Operations for Light Duty Vehicles	0.65	-$90.00	0.45%	0.45%	0.60
EEC-11	Rate Structures and Technologies To Promote Reductions	0.06	-$16.12	0.04%	0.49%	0.06
EEC-3	Financial Mechanisms for Energy Efficiency	0.98	-$15.97	0.68%	1.18%	0.91
EEC-1	Demand-Side Management (DSM)/Energy Efficiency Programs for Electricity	8.11	-$15.87	5.64%	6.81%	7.50
EEC-5	Incentive Mechanisms for Achieving Energy Efficiency	3.24	-$15.46	2.25%	9.06%	2.99
EEC-6	Promotion and Incentives for Improved Design and Construction in the Private Sector	0.08	-$14.41	0.06%	9.12%	0.07
CRE-4a	Decarbonization Fund	0.00	-$14.31	0.00%	9.12%	0.00
EEC-8	Focus on Specific Residential Market Segments	0.90	-$13.77	0.63%	9.74%	0.83
EEC-4	Improved Building Codes for Energy Efficiency	0.55	-$13.52	0.38%	10.12%	0.50
AFW-8	Waste Management Strategies	4.10	-$8.00	2.85%	12.97%	3.79
EEC-2	Demand-Side Management (DSM) Energy Efficiency Programs for Natural Gas	2.37	-$1.23	1.65%	14.62%	2.19
EEC-9	Midwestern Governors Association Energy Security and Climate Stewardship Platform	0.00	$0.00	0.00%	14.62%	0.00
AFW-9	Landfill Methane Energy Programs	0.78	$0.80	0.54%	15.16%	0.72
AFW-4	Encourage Large-Scale Manure/Methane Management Capture Utilization	2.64	$3.00	1.83%	17.00%	2.44
AFW-6	Cellulosic Fuel Incentives	9.79	$3.50	6.80%	23.80%	9.05
EEC-13	Government Lead-by-Example: Improved Design and Construction in New and Existing State and Local Government Buildings	0.36	$7.10	0.25%	24.05%	0.33
TLU-10	Fuel Strategies	5.19	$14.00	3.61%	27.66%	4.80
CRE-12	Combined Heat and Power	6.05	$15.69	4.21%	31.86%	5.59
AFW-7	Improved On-Farm (or First Point of Purchase) Energy Use and Efficiency	1.02	$29.00	0.71%	32.57%	0.94

CRE-8	Support for Grid-based Renewable Energy & Development	0.13	$31.98	0.09%	32.67%	0.12
CRE-5	Performance Standards	0.00	$33.65	0.00%	32.67%	0.00
CRE-11	Distributed Generation/Co-generation	0.06	$36.23	0.04%	32.71%	0.06
CRE-2	Technology Initiatives, including Renewables	24.54	$38.72	17.05%	49.76%	22.68
CRE-13	Pricing strategies to promote renewable energy and/or CHP	1.05	$39.61	0.73%	50.49%	0.97
AFW-3	Expanded Use of Agriculture and Forestry Biomass Feedstocks for Electricity, Heat or Steam Production	15.36	$41.00	10.68%	61.17%	14.20
AFW-5	Land Management to Promote Sequestration Benefits	10.60	$41.00	7.37%	68.54%	9.80
CRE-7	Policies Related to Nuclear Power	8.85	$43.90	6.15%	74.69%	8.18
TLU-5	Adopt Best Workplaces for Commuters in Iowa	0.02	$84.00	0.01%	74.70%	0.02
AFW-1	Nutrient Management	0.64	$86.00	0.44%	75.15%	0.59
TLU-3	Expand and Improve Transit Infrastructure	0.05	$483.00	0.03%	75.18%	0.05

[1] Iowa 2020 projected consumption-based gross GHG emission level is 143.87 Million Metric Tons of CO_2e.
Note: The overlaps between options within the EEC sector and within the CRE sector have been adjusted. It is assumed that there are no overlaps between AFW options. The overlaps within the TLU sector and the overlaps between sectors have not been adjusted at the time of this preliminary analysis.

In Table A1, Column 3 of the table presents the estimated 2020 annual GHG reduction potential for each option, with reduction potentials translated into percentages of the 2020 BAU emissions level in Column 5. The estimated cost or cost saving per ton of GHG removed by each option in 2020 is presented in Column 4. The options are ordered in ascending sequence in terms of cost, beginning with the cheapest option. Column 6 calculates the cumulative GHG reduction potentials of the first *n* policy options listed in the table. The last column presents the proportion of GHG mitigation contributed by each option.

Based on the data presented in Table A1, the stepwise marginal cost function of Iowa in 2020 is first drawn in Figure A1. The horizontal axis represents the percentage of GHG emissions reduction, and the vertical axis represents the marginal cost or savings of mitigation. In the figure, each horizontal segment represents an individual mitigation option. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost (saving) of reducing one ton of GHG with the application of the option. The figure indicates that, collectively, the reduction potential of options from all economic sectors can avoid about 15% of 2020 baseline emissions in Iowa.

Next, we fit a smooth curve through the data using statistical analysis (also see Figure A1). We weight each policy option based on its GHG mitigation potential to give relatively greater influence to those options that have the potential for higher levels of application. This fitted curve will then be used in our C&T analysis model.

The fitted curve shown in Figure 2 has the following functional form:

$$MC = a + b \times \ln(1 - R)$$

Where, *MC* is the marginal cost; *R* is the percentage reduction of GHG emissions; *a* and *b* are parameters.

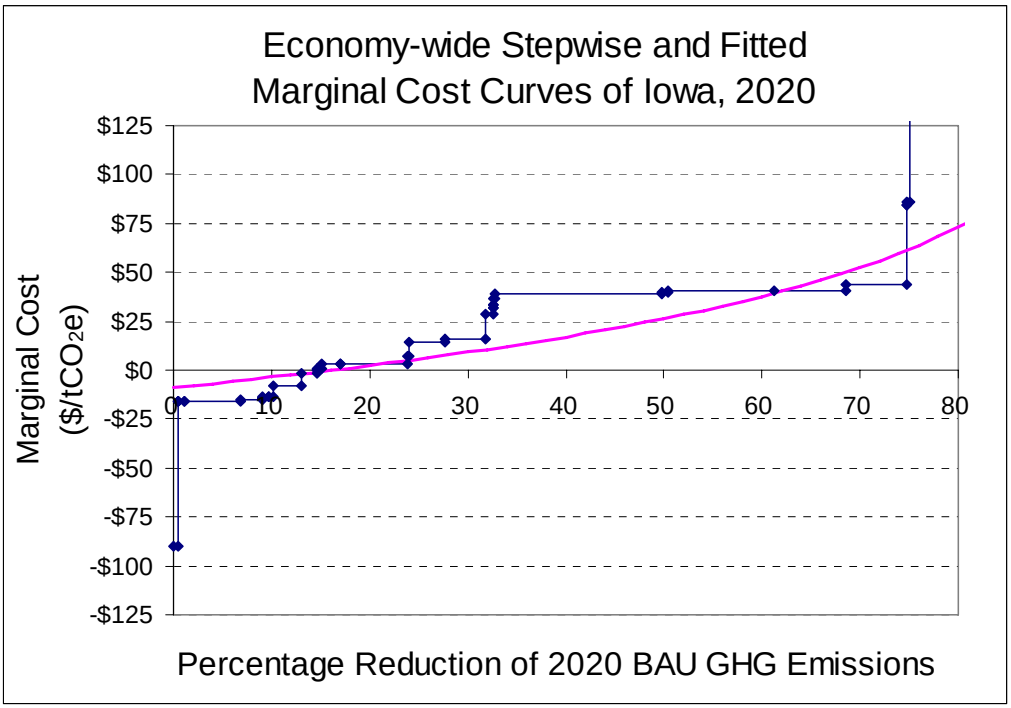


Figure A1. Stepwise and Fitted Marginal Cost Curve of Iowa, 2020

The logarithmic functional form utilized here is consistent with theoretical expectations and empirical findings on diminishing returns of emission control (Nordhaus, 1991; 1994). As the emission reductions increase along the X axis, the cost to reduce one additional unit of emission is increasing in an accelerating speed.

The marginal cost curve of Iowa has the following specification:

$$MC = -8.90 - 50.85 \times \ln(1 - R)$$

The fitted curve has an intercept with the Y-axis at MC = -$8.90. The curve increases to MC=0 at the emission reduction level of 15%, which indicates that Iowa has cost-saving mitigation potentials (such as energy efficiency) up to the level of about 15% of the 2020 BAU emissions.