

Cap and Trade between Sectors in Minnesota

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

Table 1. Minnesota Mitigation Options List

	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Sector
Ag	Agricultural Crop Management_B. Nutrient Management	1.35	-\$37.00	Sequestration
Ag	Agricultural Crop Management_A. No Till	1.3	-\$0.25	Sequestration
Ag	In-state Liquid Biofuels Production_A. Ethanol carbon content	3	\$1.00	Transportation sector
Ag	In-state Liquid Biofuels Production_C. Gasoline Displacement	13.6	\$5.00	Transportation sector
Ag	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	3.8	\$12.00	Other
Ag	Land Use Management Approaches for Protection and Enrichment of Soil Carbon_A. Preserve Land	0.45	\$31.00	Sequestration
Ag	In-state Liquid Biofuels Production_B. Fossil diesel displacement	0.19	\$62.00	Transportation sector
Ag	Land Use Management Approaches for Protection and Enrichment of Soil Carbon_B. Reinvest in Minnesota - Clean Energy (RIM-CE)	0.19	\$110.00	Sequestration
F	Urban Forestry	2.7	-\$12.00	Sequestration
F	Forest Protection - Reduced Clearing and Conversion to Non-Forest Cover	2.7	\$3.00	Sequestration
F	Forestration	2.19	\$13.00	Sequestration
F	Restocking	8.4	\$33.00	Sequestration
W	End of Use Waste Management Practices - Landfilled Waste Methane	0.34	\$1.00	Other
ES	Efficiency Improvements, Repowering and other Upgrades to Existing Plants (with RPS)_Reference Scenerio #2	1.87	\$5.65	Power sector
ES	Generation Performance Standard_Reference Scenerio #3	0.62	\$13.90	Power sector
ES	Renewable and/or Environmental Portfolio Standard_No coal additions	12.83	\$20.10	Power sector
ES	Carbon Capture and Storage and/or Reuse Policies	3.8	\$76.10	Power sector
ES	Advanced Fossil Fuel Technology Incentives, Support or Requirements (with RPS)	0.8	\$106.20	Power sector
RCI	Improved Uniform Statewide Building Codes	0.0037	-\$189.70	Other
RCI	Non-utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions	0.13	-\$37.10	Other
RCI	Maximize Savings from the Utility Conservation Improvement Program (CIP) (with RPS)	8.7	-\$29.10	Power sector
RCI	Green Building Guidelines and Standards Based on Architecture 2030	0.421	-\$0.26	Other
RCI	Incentives & Resources to Promote Combined Heat and Power (CHP) (with RPS)	4.9	\$27.50	Other
TLU	Adopt California Clean Car Standards	7	-\$18.00	Transportation sector
TLU	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.2	\$0.00	Transportation sector

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

Table 2. 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	51.46	53.23	60.93	62.61	64.37
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 Onroad Gasoline	17.32	19.43	21.72	22.74	23.33	24.10	24.87	25.44
5 Transport Onroad Diesel	4.46	4.99	5.85	6.67	7.74	8.82	10.09	11.34
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 Ind. Process	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	187.53

Table 3. Minnesota Gross GHG Emissions from Three Major Sectors, 1990-2025: Historical and Projected
MMTCO_{2e}

Source as in Table 2	1990	1995	2000	2005	2010	2015	2020	2025
1 Power sector	35.03	40.88	43.40	51.46	53.23	60.93	62.61	64.37
4-6 Transportation sector	28.70	31.68	35.42	37.22	38.21	40.30	42.59	44.64
2,3,7-11 Other (Industrial, Commercial, Ag, Forestry, Small Power Generation, etc.)	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	187.53

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.

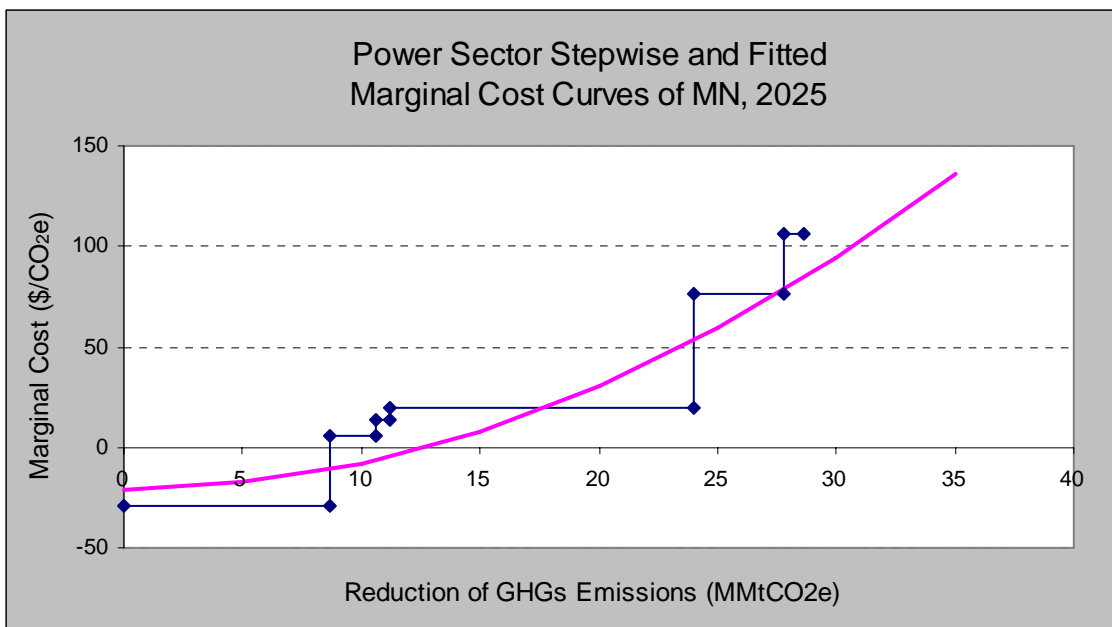
Table 4. Cap in Year 2025: 30% below 2005 level
MMTCO_{2e}

	2025 BAU Emission	Cap	Reduction Goal
Power sector	64.37	36.02	28.35
Transportation sector	44.64	26.06	18.59
Other	78.51	44.62	33.89

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 inter-state simulations, we designated the horizontal axis to represent percentage reduction of emissions. We did not use percentage reduction here because Sequestration Sector has zero emission.

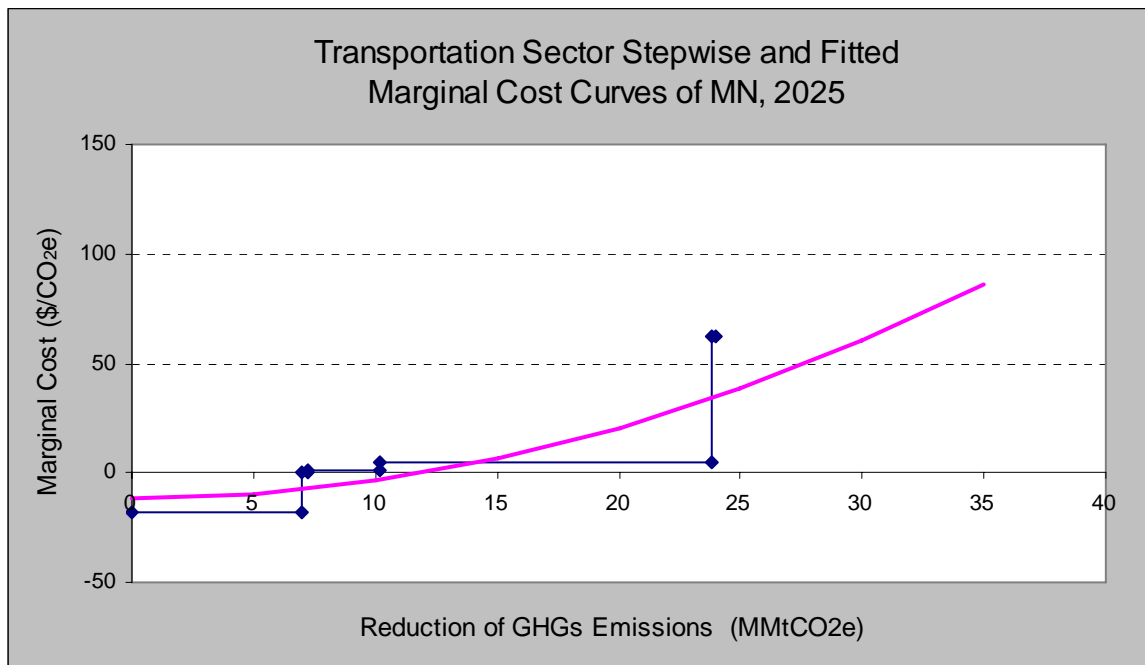
Power Sector

	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential (MMtCO ₂ e)
RCI	Maximize Savings from the Utility Conservation Improvement Program (CIP) (with RPS)	8.7	-\$29.10	8.7
ES	Efficiency Improvements, Repowering and other Upgrades to Existing Plants (with RPS)_Reference Scenerio #2	1.87	\$5.65	10.57
ES	Generation Performance Standard_Reference Scenerio #3	0.62	\$13.90	11.19
ES	Renewable and/or Environmental Portfolio Standard_No coal additions	12.83	\$20.10	24.02
ES	Carbon Capture and Storage and/or Reuse Policies	3.8	\$76.10	27.82
ES	Advanced Fossil Fuel Technology Incentives, Support or Requirements (with RPS)	0.8	\$106.20	28.62



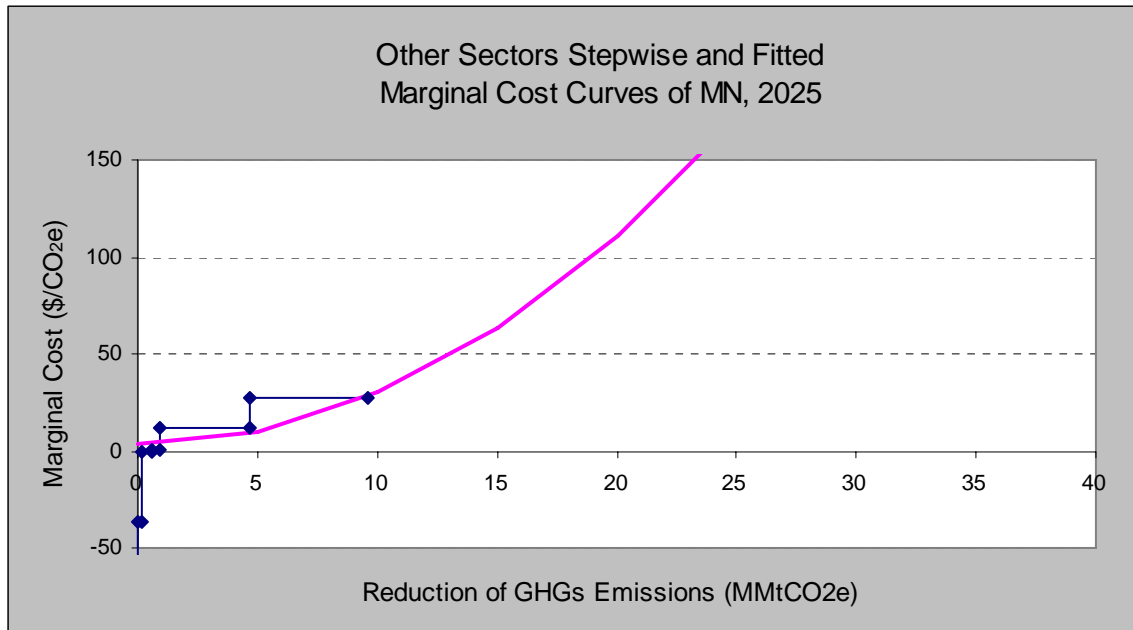
Transportation Sector

	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential (MMtCO ₂ e)
TLU	Adopt California Clean Car Standards	7	-\$18.00	7
TLU	Expand Transit, Bicycle, and Pedestrian Infrastructure	0.2	\$0.00	7.2
Ag	In-state Liquid Biofuels Production _A. Ethanol carbon content	3	\$1.00	10.2
Ag	In-state Liquid Biofuels Production _C. Gasoline Displacement	13.6	\$5.00	23.8
Ag	In-state Liquid Biofuels Production _B. Fossil diesel displacement	0.19	\$62.00	23.99



Other Sectors

	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential (MMtCO ₂ e)
RCI	Improved Uniform Statewide Building Codes	0.0037	-\$189.70	0.0037
RCI	Non-utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions	0.13	-\$37.10	0.1337
RCI	Green Building Guidelines and Standards Based on Architecture 2030	0.421	-\$0.26	0.5547
Waste	End of Use Waste Management Practices - Landfilled Waste Methane	0.34	\$1.00	0.8947
Ag	Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production	3.8	\$12.00	4.6947
RCI	Incentives & Resources to Promote Combined Heat and Power (CHP) (with RPS)	4.9	\$27.50	9.5947



Sequestration

	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Cumulative GHG Reduction Potential (MMtCO ₂ e)
Ag	Agricultural Crop Management_B. Nutrient Management	1.35	-\$37.00	1.35
F	Urban Forestry	2.7	-\$12.00	4.05
Ag	Agricultural Crop Management_A. No Till	1.3	-\$0.25	5.35
F	Forest Protection - Reduced Clearing and Conversion to Non-Forest Cover	2.7	\$3.00	8.05
F	Forestration	2.19	\$13.00	10.24
Ag	Land Use Management Approaches for Protection and Enrichment of Soil Carbon_A. Preserve Land	0.45	\$31.00	10.69
F	Restocking	8.4	\$33.00	19.09
Ag	Land Use Management Approaches for Protection and Enrichment of Soil Carbon_B. Reinvest in Minnesota - Clean Energy (RIM-CE)	0.19	\$110.00	19.28

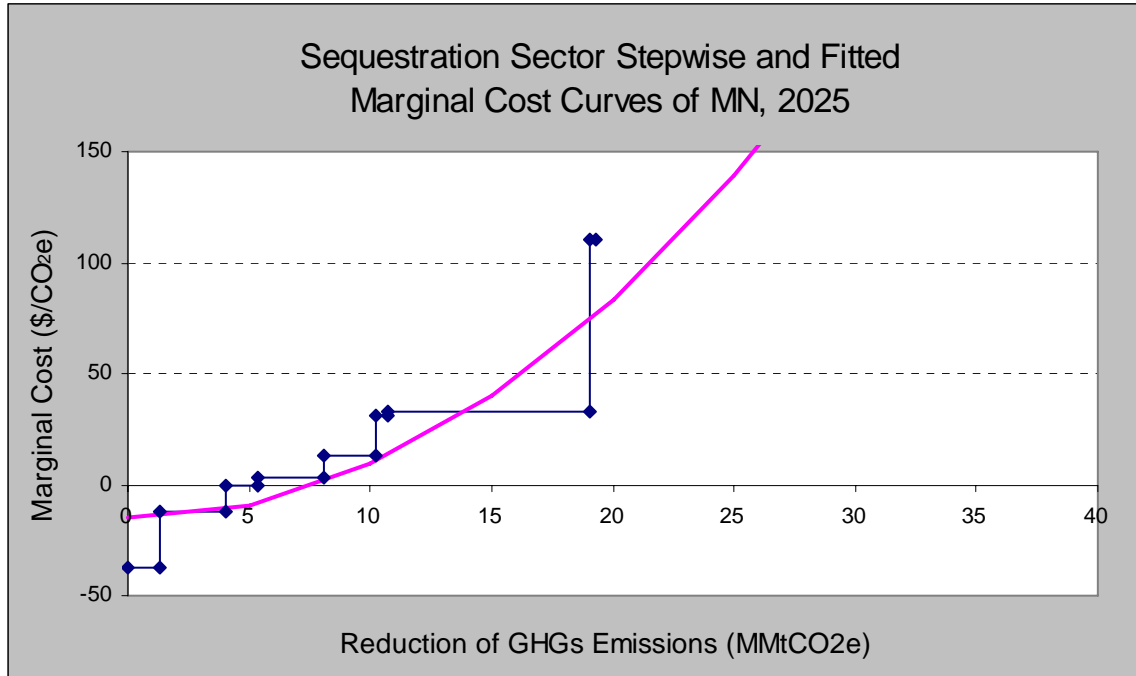


Table 5. Emission Trading Simulation Among Four Sectors in Minnesota
(million dollars or otherwise specified)

State	Before Trading	After Trading ^a			Cost Saving	Permits Traded (million tCO ₂ e)	Emission Reduction After Trading		Emission Reduction Cap (percent from BAU)
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost			(million tCO ₂ e)	(percent from BAU)	
Power Sector	383	68	241	309	74	4.81	23.54	36.58	44.04
Transportation Sector	-42	253	-462	-209	167	-9.22	27.81	62.30	41.64
Other	3,608	248	1,037	1,286	2,322	20.70	13.19	16.80	43.16
Sequestration	0	106	-816	-710	710	-16.28	16.28	n.a.	n.a.
Total	3,949	675	0	675	3,274	25.51^b	80.83	43.10	43.10

^a Permit Price = \$50.10/tonCO₂e.

^b Represents number of permits bought or sold.

The emission reduction Minnesota as a whole needs to accomplish in 2025 is 43.10% of its BAU emission level. If we look at Minnesota economy-wide cost curve below, the marginal cost corresponding to 43.10% reduction of GHG emissions in 2025 is \$50.53/tonCO₂e. This is consistent with our finding that an intra-state permit trading between sectors in Minnesota has an equilibrium permit price at \$50.10/tonCO₂e.

