



The Center for Climate Strategies

Helping States and the Nation Tackle Climate Change

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To: Minnesota Cap & Trade Technical Work Group Members
From: Adam Rose & Dan Wei, CCS
CC: Minnesota DOC, PCA
Re: Updated Cap and Trade Simulations for Review and Discussion
Date: October 31, 2007

Please find this week's MN Cap & Trade simulation results in the attachment. We have merged 4 sets of simulations into one document:

1. We added the cost to emitters associated with auctioning permits into previous Table IA and Table IB (Western States and WS + MN).
2. Power sector only simulations that include only a limited numbers of options that are directly designed for power sector.
3. MC curves for the power sector are developed based on all relevant mitigation/sequestration options. Since the cap can be attained at negative cost, there is no need for trading.
4. C&T simulation results for Midwestern States (all emission sources).

We include both marginal cost curves and a related basic data table for each set of simulations.

AGAIN, THE RESULTS ARE PRELIMINARY AND ARE INTENDED TO ILLUSTRATE THE WORKINGS OF THE MODEL.

We have very limited data on mitigation/sequestration options for most states at this time. Better data will yield improved results.

TABLE IWA. ECONOMY-WIDE EMISSION TRADING SIMULATION AMONG FIVE WESTERN STATES IN YEAR 2020
(Assume Auction of Permits)
(million dollars or otherwise specified)

State	Before Trading		After Trading ^a				Cost Saving	Permits Traded	Emission Reduction	Emission Reduction
	Mitigation Cost	Auction Cost ^b	Mitigation Cost	Trading Cost	Net Cost	Auction Cost ^b		(million tCO ₂ e)	(million tCO ₂ e)	(percent from baseline)
AZ	-1,455.44	1,271.84	-1,678.81	102.08	-1,576.73	1,271.84	121.28	12.81	60.11	37.5
CA	-449.17	4,798.48	-289.06	-190.54	-479.6	4,798.48	30.43	-23.91	200.16	33.15
NM	-280.41	732.50	-498.02	72.2	-425.83	732.50	145.42	9.06	20.66	22.41
OR	-138.38	717.54	-182.6	31.96	-150.63	717.54	12.25	4.01	23.45	25.97
WA	-72.37	813.68	-57.96	-15.7	-73.66	813.68	1.29	-1.97	33.22	32.44
!!										
Total	-2,395.77	8,334.04	-2,706.45	0	-2,706.45	8,334.04	310.68	25.88 ^c	337.6	32.18

^a Permit Price = \$7.97/tonCO₂e. This is the price of the last permit sold, which is also equal to the price of the last ton of CO₂e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO₂e equivalent in this simulation differs for each state. For CA, for example, it is -\$1.44/tonCO₂e. Please note that the average mitigation cost is related to mitigation level of a state, which for this case is 33.15% below the baseline level in 2020 for CA. Multiplying the average mitigation cost by the number of tons of CO₂e mitigated will equal the *total* mitigation cost for each state.

^b There should be a separate market for permit auction. Here, we assume the auction price equals the equilibrium price of permit in the permit trading market. We also assume that the amount of permits each state obtained from auction at the initial stage equals the emission cap of this state.

^c Represents number of permits bought or sold.

TABLE IWB. ECONOMY-WIDE EMISSION TRADING SIMULATION AMONG FIVE WESTERN STATES AND MINNESOTA IN YEAR 2020
(Assume Auction of Permits)

(million dollars or otherwise specified)

State	Before Trading		After Trading ^a				Cost Saving	Permits Traded	Emission Reduction	Emission Reduction
	Mitigation Cost	Auction Cost ^b	Mitigation Cost	Trading Cost	Net Cost	Auction Cost ^b		(million tCO ₂ e)	(million tCO ₂ e)	(percent from baseline)
AZ	-1,455.44	1,348.37	-1,676.03	105.36	-1,570.66	1,348.37	115.22	12.47	60.45	37.71
CA	-449.17	5,087.19	-253	-239.13	-492.12	5,087.19	42.95	-28.3	204.55	33.88
NM	-280.41	776.57	-496.86	75.35	-421.52	776.57	141.11	8.92	20.8	22.56
OR	-138.38	760.71	-179.97	31.18	-148.79	760.71	10.41	3.69	23.77	26.32
WA	-72.37	862.63	-52.14	-22.64	-74.78	862.63	2.41	-2.68	33.93	33.14
MN	-275.65	1,548.45	-337.83	49.88	-287.95	1,548.45	12.3	5.9	49.13	26.73
!!										
Total	-2,671.42	10,383.92	-2,995.82	0	-2,995.82	10,383.92	324.4	30.98 ^c	392.63	31.85

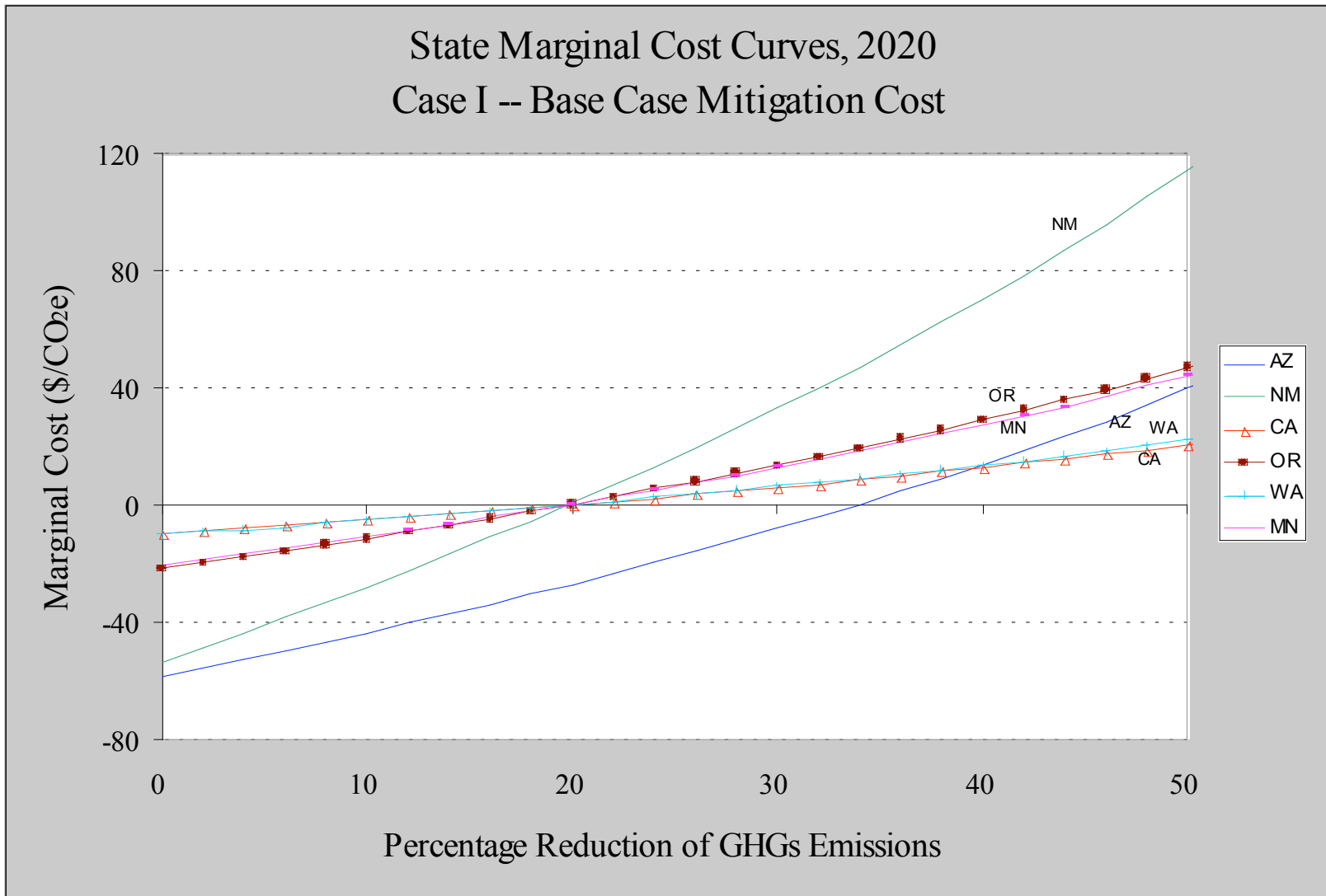
^a Permit Price = \$8.45/tonCO₂e. This is the price of the last permit sold, which is also equal to the price of the last ton of CO₂e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO₂e equivalent in this simulation differs for each state. For MN, for example, it is -\$6.88/tonCO₂e. Please note that the average mitigation cost is related to mitigation level of a state, which for this case is 26.73% below the baseline level in 2020 for MN. Multiplying the average mitigation cost by the number of tons of CO₂ mitigated will equal the *total* mitigation cost for each state.

^b There should be a separate market for permit auction. Here, we assume the auction price equals the equilibrium price of permit in the permit trading market. We also assume that the amount of permits each state obtained from auction at the initial stage equals the emission cap of this state.

^c Represents number of permits bought or sold.

DATA TABLE

State	Cap: 15% Below 2005 Emissions in 2020 (million tCO ₂ e)	Baseline 2020 Gross Emissions (Consumption-based) (million tCO ₂ e)	GHG Mitigation Goal in 2020 (relative to baseline emissions)	Autarkic Marginal Mitigation Cost (dollars per tCO ₂ e)	Gross State Product in 2020 (million 2000 dollars)
AZ	87.38	160.3	45.49%	27.35	343,077
CA	427.55	603.8	29.19%	5.45	2,646,412
NM	62.45	92.2	32.23%	40.82	72,944
OR	62.84	90.3	30.41%	14.15	173,774
WA	71.12	102.4	30.52%	6.66	422,766
MN	128.78	183.8	29.94%	12.65	376,731
Total	840.12	1,232.7			4,035,704



Note: These marginal cost curves are presented for a range of mitigation levels, including those much higher than required to meet the cap in year 2020. 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.

TABLE IWAP. POWER SECTOR EMISSION TRADING SIMULATION AMONG FIVE WESTERN STATES IN YEAR 2020
(million dollars or otherwise specified)

State	Before Trading	After Trading ^a			Cost Saving	Permits Traded	Emission Reduction	Emission Reduction
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		(million tCO ₂ e)	(million tCO ₂ e)	(percent from baseline)
AZ	-56.01	-414.66	81.41	-333.24	277.23	15.07	24.08	33.35
CA	13.02	83.65	-97.68	-14.02	27.05	-18.08	49.98	38.12
NM	89.71	-8.79	31.66	22.86	66.85	5.86	4.40	15.41
OR	-4.26	0.69	-6.69	-5.99	1.73	-1.24	4.93	20.04
WA	1.32	7.81	-8.71	-0.90	2.22	-1.61	4.93	35.13
!!								
Total	43.79	-331.30	0.00	-331.30	375.08	20.93	88.32	32.65

^a Permit Price = \$5.40/tonCO₂e. This is the price of the last permit sold, which is also equal to the price of the last ton of CO₂e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO₂e equivalent in this simulation differs for each state. For CA, for example, it is \$1.67/tonCO₂e. Please note that the average mitigation cost is related to mitigation level of a state, which for this case is 38.12% below the baseline level in 2020 for CA. Multiplying the average mitigation cost by the number of tons of CO₂e mitigated will equal the *total* mitigation cost for each state.

^b Represents number of permits bought or sold.

TABLE IWBP. POWER SECTOR EMISSION TRADING SIMULATION AMONG FIVE WESTERN STATES
AND MINNESOTA IN YEAR 2020
(million dollars or otherwise specified)

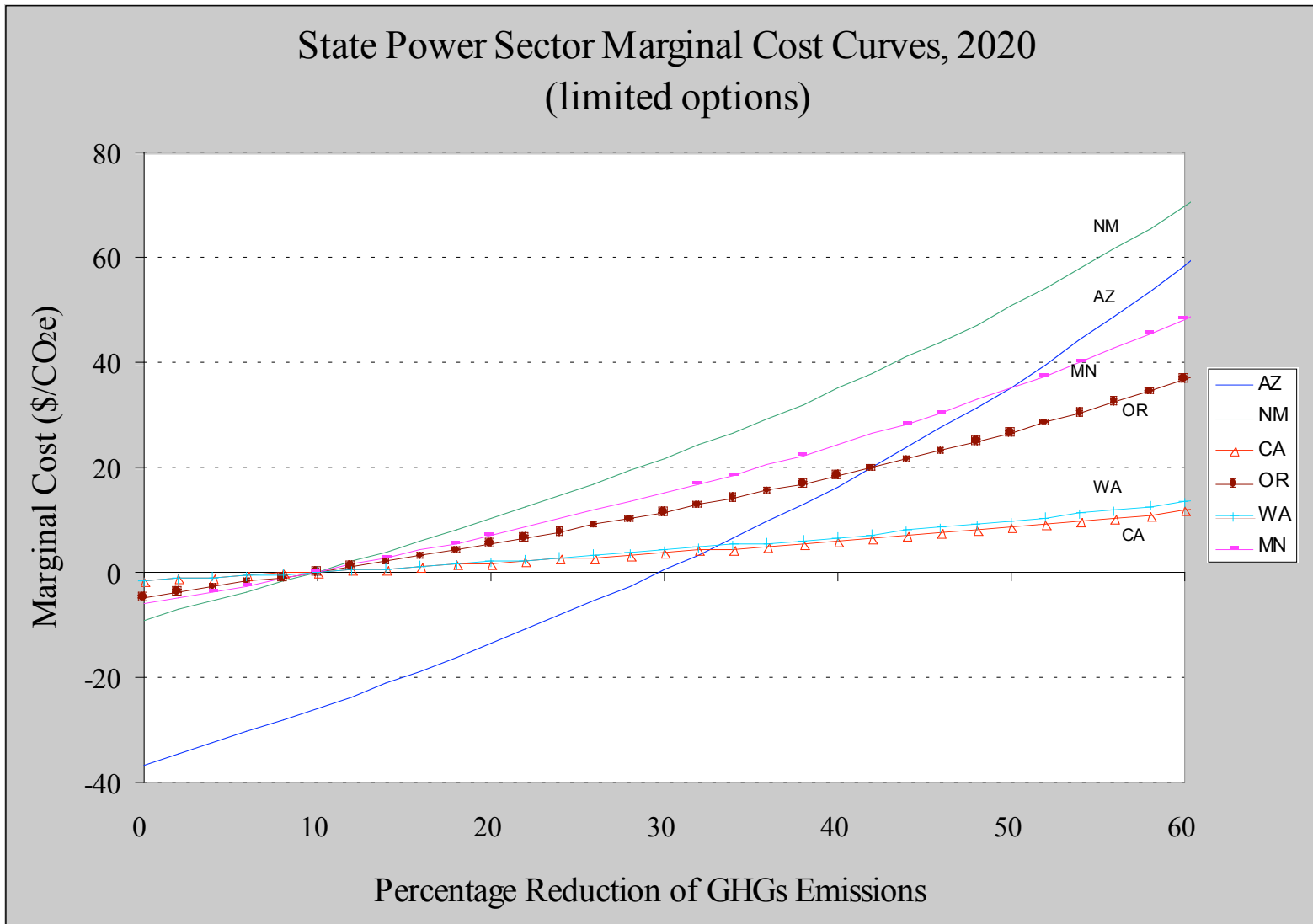
State	Before Trading	After Trading ^a			Cost Saving	Permits Traded	Emission Reduction	Emission Reduction
	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost		(million tCO ₂ e)	(million tCO ₂ e)	(percent from baseline)
AZ	-56.01	-410.53	98.95	-311.58	255.57	14.40	24.75	34.28
CA	13.02	131.93	-178.43	-46.50	59.53	-25.96	57.87	44.14
NM	89.71	-6.28	37.46	31.18	58.53	5.45	4.81	16.84
OR	-4.26	4.54	-12.82	-8.28	4.02	-1.87	5.56	22.59
WA	1.32	12.57	-16.42	-3.85	5.17	-2.39	5.71	40.67
MN	136.77	1.04	71.26	72.31	64.46	10.37	13.11	19.74
!!								
Total!	180.55	-266.72	0.00	-266.72	447.28	30.22	111.79	33.19

^a Permit Price = \$6.87/tonCO₂e. This is the price of the last permit sold, which is also equal to the price of the last ton of CO₂e mitigated (its *marginal* mitigation cost). It is the same for each state for a given case. The *average* mitigation cost per unit of CO₂e equivalent in this simulation differs for each state. For MN, for example, it is \$0.08/tonCO₂e. Please note that the average mitigation cost is related to mitigation level of a state, which for this case is 19.74% below the baseline level in 2020 for MN. Multiplying the average mitigation cost by the number of tons of CO₂ mitigated will equal the *total* mitigation cost for each state.

^b Represents number of permits bought or sold.

DATA TABLE
(for Power Sector)

State	Cap: 15% Below 2005 Emissions in 2020 (million tCO ₂ e)	Baseline 2020 Gross Emissions (Consumption-based) (million tCO ₂ e)	GHG Mitigation Goal in 2020 (relative to baseline emissions)	Autarkic Marginal Mitigation Cost (dollars per tCO ₂ e)	Gross Product in 2020 (million 2000 dollars)
AZ	33.05	72.20	54.22%	44.65	6,219
CA	99.21	131.11	24.33%	2.51	43,086
NM	18.28	28.54	35.94%	29.33	1,568
OR	20.90	24.59	15.01%	2.63	2,564
WA	10.71	14.03	23.64%	2.72	4,030
MN	42.93	66.40	35.35%	19.77	5,267
Total	225.08	336.87			62,734



Note: These marginal cost curves are presented for a range of mitigation levels, including those much higher than required to meet the cap in year 2020. 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.

Including more options for power sector

Arizona Emission Reduction Potentials and Cost/Cost-savings for Each Policy Option — Power Sector Only

Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Estimated 2020 Annual GHG Reduction Potential Attributable to Power Sector (MMtCO ₂ e)	GHG Reduction Potential as Percentage of 2020 Baseline Emissions	Cumulative GHG Reduction Potential
**Appliance Standards	1	-\$66.00	0.7	0.93%	0.93%
Electricity Pricing Strategies	1.5	-\$63.00	1.5	2.08%	3.01%
***Demand-Side Efficiency Goals, Funds, Incentives, and Programs	15.1	-\$36.00	7.6	10.46%	13.46%
*Distributed Generation Renewable Energy Applications	2.1	-\$25.00	2.1	2.91%	16.37%
*Distributed Generation Combined Heat and Power	2.7	-\$25.00	2.7	3.74%	20.11%
Reduce Barriers to Renewables and Clean Distributed Generation	2.7	-\$25.00	2.7	3.74%	23.85%
*Improve Forest Ecosystem Management - Residential Lands	0.5	-\$21.00	0.5	0.69%	24.54%
*Improve Forest Ecosystem Management - Other Lands	0.2	-\$21.00	0.2	0.28%	24.82%
**Building Standards/Codes for Smart Growth	3.1	-\$17.00	2.1	2.88%	27.70%
***"Beyond Code" Building Design Incentives and Programs for Smart Growth	3.1	-\$17.00	2.1	2.88%	30.57%
Use Biomass Feedstocks for Electricity or Steam Production	0.1	-\$8.00	0.1	0.14%	30.71%
Integrated Resource Planning	5.4	-\$2.00	5.4	7.48%	38.19%
Environmental Portfolio Standard/Renewable Energy Standard and Tariff	16.4	\$6.00	16.4	22.71%	60.91%
Decrease the Conversion of Forestland to Developed Uses	0.3	\$17.00	0.3	0.42%	61.32%
Direct Renewable Energy Support (including Tax Credits and Incentives, R&D, and siting/zoning)	2.1	\$31.00	2.1	2.91%	64.23%
Increase Reforestation and Restoration of Forestland	0.1	\$44.00	0.1	0.14%	64.37%
**Carbon Intensity Targets	14	\$44.00	9.4	12.99%	77.36%
Reduce Conversion of Farm and Rangelands to Developed Uses	0.2	\$65.00	0.2	0.28%	77.64%

Notes:

1. Green overlaid options are proposed for electricity supply sector; yellow overlaid options are for residential, commercial, and industrial sector; pink overlaid options are for agriculture and forestry sector.
2. For green options, 100% emission reductions are credited to power sector.
3. For pink options (carbon sequestration), 100% emission reductions are credited to power sector.
4. For yellow options, the ones start with a "**", have 100% emission reductions attributed to power sector; for the ones start with "***", the options apply to emission reductions with respect to both natural gas and electricity consumption reductions. We assume 67% emission reductions are credited to power sector; for the ones start with "****", the options apply to emission reductions with respect to natural gas, fuel oil, and electricity consumption reductions. We assume 50% emission reductions are credited to power sector.

New Mexico Emission Reduction Potentials and Cost/Cost-savings for Each Policy Option — Power Sector Only

Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential (MMtCO ₂ e)	Estimated Cost or Cost Savings per ton GHG Removed	Estimated 2020 Annual GHG Reduction Potential (MMtCO ₂ e)	GHG Reduction Potential as Percentage of 2020 Baseline Emissions	Cumulative GHG Reduction Potential
Improve Forest Ecosystem Management - Residential Lands	0.2	-\$46.00	0.2	0.70%	0.70%
**State Appliance Standards	0.3	-\$46.00	0.2	0.70%	1.41%
*Rate Design (Including Time of Use Rates, Increasing Block Rates, and Seasonal Use Rates)	0.3	-\$40.00	0.3	1.05%	2.46%
*Regional Market Transformation Alliance	0.5	-\$27.00	0.5	1.75%	4.21%
***Government Agency Requirements and Goals (including procurement) -- Focus on operations	0.2	-\$20.00	0.1	0.35%	4.56%
*Demand Side Management (DSM) Programs, Energy Efficiency Funds, and/or Energy Efficiency Requirements for Electricity	1	-\$18.00	1.0	3.50%	8.06%
Improve Forest Ecosystem Management - Other Lands	0.5	-\$15.00	0.5	1.75%	9.81%
**Improved Building Codes	2.4	-\$12.00	1.6	5.63%	15.45%
***Building Energy Performance Promotion and Incentives for Energy Performance Enhancements (Attaining “Reach Codes”) in Non-Government Buildings (Including Existing Buildings)	1.3	-\$2.00	0.7	2.28%	17.73%
***Building Energy Performance Requirements for State-funded and Other Government Buildings (“Reach Codes”)	0.04	\$1.00	0.0	0.07%	17.80%
Incentives and Promotion for Renewable Energy and Clean Combined Heat and Power	0.9	\$4.00	0.9	3.15%	20.95%
Mandate(s) for Renewable Energy (RPS, etc.): 10% in 2011, 1% increase/year to 2021	2.6	\$6.00	2.6	9.11%	30.06%
Convert Agricultural Land to Grassland or Forest to Increase Carbon Sequestration	0.4	\$7.00	0.4	1.40%	31.46%
*Green Power Purchasing	0.1	\$7.00	0.1	0.35%	31.81%
RPS with Financial Incentives for Centralized Renewables: 10% in 2011, 2% increase/year to 2021	4.2	\$8.00	4.2	14.72%	46.53%
Conservation Tillage/No Till	0.1	\$15.00	0.1	0.35%	46.88%
Generation Performance Standard	3.8	\$21.00	3.8	13.31%	60.19%
Decrease the Conversion of Forestland to Developed Uses	0.1	\$22.00	0.1	0.35%	60.54%
Advanced Coal/Fossil Technologies (e.g., IGCC with carbon capture)	4.3	\$29.00	4.3	15.07%	75.61%
Financial Incentives for Distributed Renewables	0.4	\$105.00	0.4	1.40%	77.01%

Notes:

1. Green overlaid options are proposed for electricity supply sector; yellow overlaid options are for residential, commercial, and industrial sector; pink overlaid options are for agriculture and forestry sector.
2. For green options, 100% emission reductions are credited to power sector.
3. For pink options (carbon sequestration), 100% emission reductions are credited to power sector.
4. For yellow options, the ones start with a “*”, have 100% emission reductions attributed to power sector; for the ones start with “**”, the options apply to emission reductions with respect to both natural gas and electricity consumption reductions. We assume 67% emission reductions are credited to power sector; for the ones start with “***”, the options apply to emission reductions with respect to natural gas, fuel oil, and electricity consumption reductions. We assume 50% emission reductions are credited to power sector.