Analysis of Cap-and-Trade among Power Sectors of RGGI States and Florida in 2020

The Non-linear Programming (NLP) Model we used in the study is capable of analyzing various environmental policy instruments, including cap-and-trade, carbon taxes, and regulations, under a variety of conditions. For cap-and-trade, for example, the latter includes: free granting vs. auctioning, upper limits on permit prices, offsets, banking, etc.

We first simulated a free granting allowance allocation cap-and-trade (C&T) system for RGGI states plus Florida. Because of the extensive availability of low-cost mitigation options, the supply of allowances would exceed the demand at all positive allowance prices. Supply and demand would only be equal at a negative price, which would never prevail in a real world situation; hence allowance trading would not take place.

In usual C&T cases, where the equilibrium point corresponds to a positive allowance price, auction and free granting would reach the same cost-effectiveness level, i.e., the auction price would be at the same level as the equilibrium price in the allowance trading market, and the individual and total CO2 reductions achieved by the partner states in these two allocation cases would be the same, with the overall emission reduction target of the region being met. The only difference between these two allocation cases would be that the auction can generate revenues to the state government, which in turn can be recycled to fund R&D in clean energy technologies, end-use energy efficiencies, etc., and thus lower the impacts to the electricity ratepayers.

Similar to the free granting case, in a 100% auction-based C&T program, the total mitigation undertaken by the 10 RGGI states plus Florida would exceed the overall cap at all positive allowance prices.

Therefore, in this report we analyze two scenarios with hypothetical positive allowance price levels and evaluate the mitigation and allowance purchase choices of the states in a 100% auction-based C&T.

According to the initial RGGI allowance allocation, MD, ME, NH, VT, and RI do not have any GHG mitigation obligations, since the allocated allowances to these states (see Column 3 of Table 1) exceed their 2020 BAU emission levels (see Column 2 of Table 1). For the remaining 5 RGGI states and Florida, which have binding mitigation goals, the reduction target (%) is computed in Column 4 of Table 1. Please note that the 2020 cap for Florida is computed by interpolating the state's 2017 goal (to return to 2000 levels) and 2025 goal (to return to 1990 levels).

In the auction case, we assume the 2020 emission caps for CT, DE, NJ, NY, MA, and FL are the same as shown in Table 1. For MD, ME, NH, VT, and RI, which have excess allowances in the free granting case, we assume their caps in the auction case would equal the state BAU 2020 emission levels (i.e., there is no reason to purchase any excess allowances at auction). Table 2 shows the revised Table 1 for the auction case.

Table 1. RGGI States and Florida 2020 Emission Projections and Caps

	2020 BAU Emissions (MMtCO2)	Cap/Budget (MMtCO2)	Reduction Target (%)	Allowance beyond BAU (MMtCO2)	Reduction Target (MMtCO2)
CT	13.26	9.09	31.45%	0.00	4.17
DE	11.07	6.43	41.94%	0.00	4.65
MD	31.79	31.88	0.00%	0.09	-0.09
ME	1.90	5.06	0.00%	3.15	-3.15
NH	4.93	7.33	0.00%	2.40	-2.40
NJ	23.40	19.46	16.86%	0.00	3.95
NY	56.11	54.66	2.58%	0.00	1.45
VT	0.03	1.04	0.00%	1.01	-1.01
MA	24.97	22.66	9.26%	0.00	2.31
RI	1.78	2.26	0.00%	0.48	-0.48
FL	168.71	109.97	34.82%	0.00	58.75
Total	337.97	269.83	20.16%	7.13	68.14

* The shaded states, MD, ME, NH, VT, and RI, have allocated allowances higher than their projected 2020 BAU emission levels according to the RGGI States allowances allocation table.

Sources: 1. RGGI States GHG Caps by Year from 2009 to 2018 are provided by Jeff Wennberg from CCS. Numbers for year 2019 and year 2020 are estimated by extrapolating 2014 to 2018 numbers.
2. RGGI states 2020 BAU emission projections are obtained from RGGI website http://www.rggi.org/documents.htm, the Reference Case projections. The 2020 values are computed by interpolating 2018 and 2021 projections.
3. The 2020 cap of Florida is computed by interpolating the state's 2017 goal (to return to 2000 levels) and 2025 goal (to return to 1990 levels). The 2020 BAU emission from the power sector (production-based) is from the draft Florida Inventory and Forecast report by CCS.

Table 2. RGGI States and Florida 2020 Emission Projections and Caps (in Auction Case)

	2020 BAU Emissions (MMtCO2)	Cap/Budget (MMtCO2)	Reduction Target (%)	Allowance beyond BAU (MMtCO2)	Reduction Target (MMtCO2)
CT	13.26	9.09	31.45%	0.00	4.17
DE	11.07	6.43	41.94%	0.00	4.65
MD	31.79	31.79	0.00%	0.00	0.00
ME	1.90	1.90	0.00%	0.00	0.00
NH	4.93	4.93	0.00%	0.00	0.00
NJ	23.40	19.46	16.86%	0.00	3.95
NY	56.11	54.66	2.58%	0.00	1.45
VT	0.03	0.03	0.00%	0.00	0.00
MA	24.97	22.66	9.26%	0.00	2.31
RI	1.78	1.78	0.00%	0.00	0.00
FL	168.71	109.97	34.82%	0.00	58.75
Total	337.97	262.70	22.27%	0.00	75.27

In the auction case, there would be no trading among states. According to the basic rationale for permit trading, in equilibrium, each state would choose to mitigate emissions as long as its marginal abatement cost is lower than or equal to the price of allowances, and purchase any remaining allowance (the difference between the state's BAU level and the amount mitigated by autarkic actions) from the auctioneer.

Next, we analyze a 100% auction-based C&T case with a hypothetical allowance price at $7/tCO2e. Table 3 (Column 4) presents the amount of emissions that can be reduced by each state's autarkic (own) mitigation actions associated with a marginal cost of $7/tCO2e (these are computed based on the states' marginal abatement cost curves shown in Figure 1). Please note that because of the lack of direct data for Florida, for now the marginal cost curve for the state is estimated based on the mitigation options data of South Carolina. We will re-develop the Florida cost curve when data are available. The simulation results of the auction case with an allowance price equal to $7/tCO2e are presented in Table 4. A second simulation with the auction price assumed to be at $1/tCO2e is presented in Table 5.

In the auction case, each state would utilize all its mitigation potential with marginal cost less than $7/tCO2e before purchasing allowances from the auctioneer, because it would be cheaper for them to reduce emissions than to buy allowances from the auctioneer at $7. As a result, the total emission reductions achieved by the 11 states in this case are 100.39 MMtCO2. As indicated before, the sum of the mitigations undertaken by the states would exceed the mitigation needed to achieve the cap of the 11 states as a whole at all positive allowance prices. The total cap of the 11 states is 262.70 MMtCO2e in 2020, or 22.27% below the BAU emissions of 337.97 MMtCO2e. The total emission reductions in the $7/tCO2e case are 29.70% below BAU, 7.43% more than the cap requires. Comparing the numbers in the second column and the fourth column of Table 3, we can see that Connecticut, New Jersey, and Florida will reduce less emissions than the state emissions budget requires. The other eight states would mitigate more than their budgets require. Cumulatively, the 11 states would mitigate emissions 25.12 MMtCO2e more than the total cap indicates. The basic rationale is that it is cheaper to mitigate than to buy an auctioned permit for a broad range of emission levels.

As shown in Table 4, because of the availability of large cost saving mitigation potentials, mitigation cost for all the 11 states are negative. The auction cost is computed by multiplying the amount of allowances the state buys from the auctioneer by the allowance price. The total net cost of a state is the sum of its mitigation cost and the auction cost. Most states have negative total net cost, which indicates overall cost savings from joining the auction-based C&T program. The total cost savings for Florida in the $7/tCO2e auction price case are $731.62 million.

Comparing the two auction cases with auction prices at $7 and $1, the amount the states choose to reduce by mitigation options (100.39 MMtCO2 vs. 93.83 MMtCO2, respectively) and the amount to be bought from the auctioneer (237.58 MMtCO2 vs. 244.14 MMtCO2, respectively) differ slightly. However, the results show that when the allowance price is lower, the states would choose to reduce less emissions on their own and purchase more allowances from the auctioneer. The biggest difference between these two cases is the total auction cost. This is due primarily to the difference of the two auction price levels. In addition, Delaware shift to the list

states that mitigate less than their budget requires. Cumulatively, the 11 states would mitigate emissions 5.49%, or 18.56 MMtCO2e more than the total cap indicates.

The recycling of the auction revenues by the government is not evaluated in this study.

Table 3. Mitigation Potential Associated with MC=$7/tCO2e

	Reduction Target (MMtCO2)	In-state Reduction Potential with MC<= $7 (%)	In-state Reduction Potential with MC<= $7 (MMtCO2)
CT	4.17	5.78%	0.77
DE	4.65	44.17%	4.89
MD	0.00	53.34%	16.96
ME	0.00	39.92%	0.76
NH	0.00	6.78%	0.33
NJ	3.95	8.49%	1.99
NY	1.45	5.44%	3.05
VT	0.00	100.00%	0.03
MA	2.31	47.72%	11.92
RI	0.00	62.95%	1.12
FL	58.75	34.72%	58.58
Total	75.27	29.70%	100.39

Table 4. Simulation Results of an Auction Case among RGGI States and Florida (with assumed auction price at $7/tCO2)

State	Total BAU Emissions in 2020 (million tCO2)	2020 Emissions Cap/Budget (million tCO2)	Emission Reduction Undertaken by the State[a]		Mitigation Cost (million dollars)	Emission Allowances Bought from Auctioneer (million tCO2)	Auction Cost (million dollars)[b]	Net Cost (million dollars)[c]
			(percent from BAU)	(million tCO_2)				
CT	13.26	9.09	5.78	0.77	-49.64	12.50	87.47	37.83
DE	11.07	6.43	44.17	4.89	-164.01	6.18	43.28	-120.73
MD	31.79	31.79	53.34	16.96	-617.74	14.83	103.83	-513.91
ME	1.90	1.90	39.92	0.76	-41.36	1.14	8.00	-33.36
NH	4.93	4.93	6.78	0.33	-25.67	4.59	32.16	6.48
NJ	23.40	19.46	8.49	1.99	-313.93	21.42	149.92	-164.01
NY	56.11	54.66	5.44	3.05	-573.12	53.06	371.43	-201.69
VT	0.03	0.03	100.00	0.03	-2.34	0.00	0.00	-2.34
MA	24.97	22.66	47.72	11.92	-692.28	13.06	91.40	-600.88
RI	1.78	1.78	62.95	1.12	-61.32	0.66	4.61	-56.71
FL	168.71	109.97	34.72	58.58	-1,502.57	110.14	770.95	-731.62
Total	337.97	262.70	29.70	100.39	-4,043.99	237.58	1,663.04	-2,380.95

[a] In equilibrium, each state will choose to mitigate to the level at which its marginal abatement cost equals the auction price.
[b] We assume the auction price is $7/tCO2 in this case.
[c] Sum of Mitigation Cost and Auction Cost.

Table 5. Simulation Results of an Auction Case among RGGI States and Florida (with assumed auction price at $1/tCO2)

State	Total BAU Emissions in 2020 (million tCO2)	2020 Emissions Cap/Budget (million tCO2)	Emission Reduction Undertaken by the State[a]		Mitigation Cost (million dollars)	Emission Allowances Bought from Auctioneer (million tCO2)	Auction Cost (million dollars)[b]	Net Cost (million dollars)[c]
			(percent from BAU)	(million tCO_2)				
CT	13.26	9.09	5.54	0.73	-49.77	12.53	12.53	-37.24
DE	11.07	6.43	41.46	4.59	-165.20	6.48	6.48	-158.72
MD	31.79	31.79	50.49	16.05	-621.34	15.74	15.74	-605.60
ME	1.90	1.90	38.28	0.73	-41.49	1.17	1.17	-40.31
NH	4.93	4.93	6.54	0.32	-25.72	4.61	4.61	-21.11
NJ	23.40	19.46	8.34	1.95	-314.07	21.45	21.45	-292.62
NY	56.11	54.66	5.35	3.00	-573.31	53.11	53.11	-520.20
VT	0.03	0.03	100.00	0.03	-2.34	0.00	0.00	-2.34
MA	24.97	22.66	45.96	11.48	-694.03	13.50	13.50	-680.54
RI	1.78	1.78	60.81	1.08	-61.47	0.70	0.70	-60.78
FL	168.71	109.97	31.92	53.86	-1,521.35	114.86	114.86	-1,406.49
Total	337.97	262.70	27.76	93.83	-4,070.08	244.14	244.14	-3,825.95

[a] In equilibrium, each state will choose to mitigate to the level at which its marginal abatement cost equals the auction price.
[b] We assume the auction price is $1/tCO2 in this case.
[c] Sum of Mitigation Cost and Auction Cost.

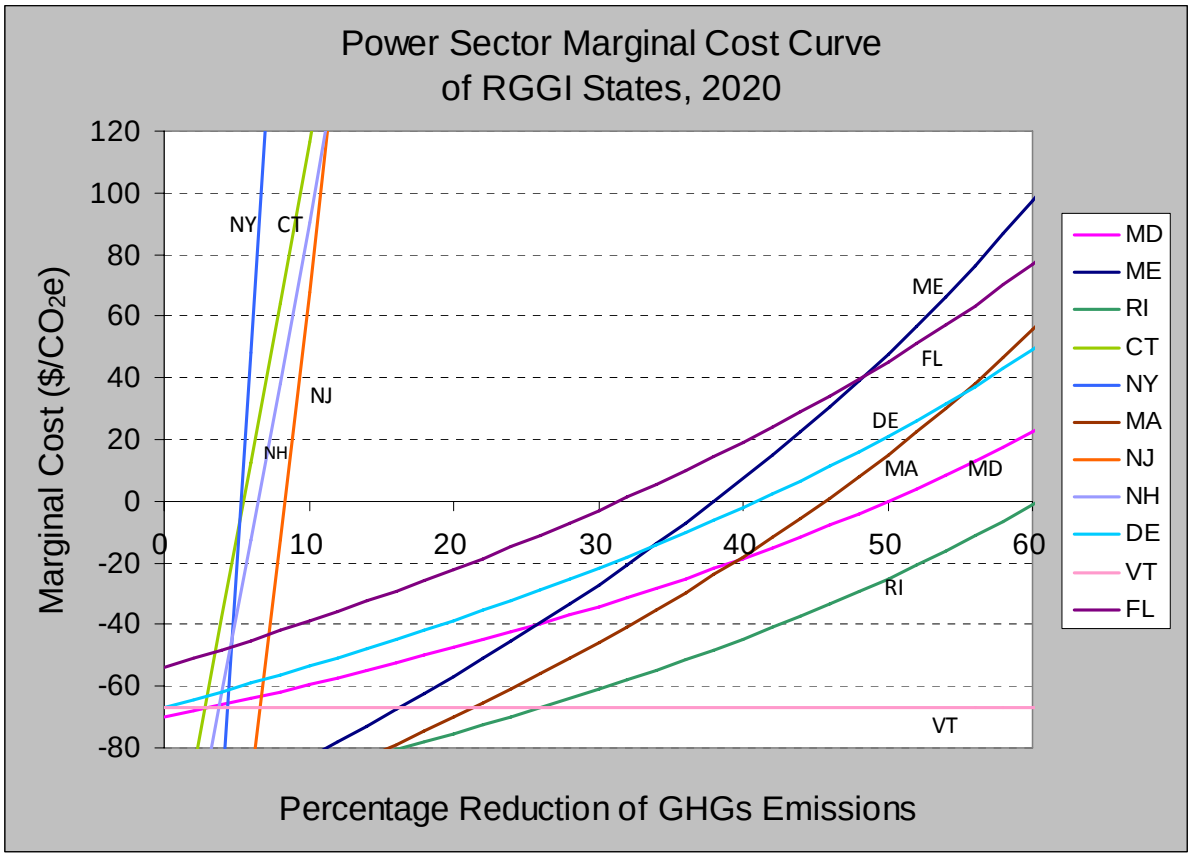

Figure 1. State Marginal Cost Curves of Power Sector, 2020

Notes: 1. Similar methods as elaborated above for Maryland are adopted to develop marginal cost curves of CT, ME, NY, RI, and VT. Data sources are listed below.

2. There are no direct data for MA, NJ, NH, and DE and the direct options data for Florida is not ready to use. Marginal cost curves for these five states are developed based on cost curves of four reference states RI, NY, CT, MD, and SC respectively. For each of the five states that lack the direct data, mitigation cost/saving data for the reference state is adopted. Emission reduction potential data of the reference state is adjusted by the weights of emissions from the ES and R, C, I sectors of the state under estimation.

Sources: 1. Connecticut Governor's Steering Committee on Climate Change. 2005. *2005 CT Climate Change Action Plan*. http://www.ctclimatechange.com/StateActionPlan.html.
2. Maryland Commission on Climate Change. 2008. *Maryland Climate Change Action Plan*. http://www.mdclimatechange.us/index.cfm.
3. Maine Department of Environmental Protection. 2004. *Final Maine Climate Action Plan 2004*. http://www.maine.gov/dep/air/greenhouse/.
4. Center for Clean Air Policy and New York GHG Task Force. 2003. *Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions*. http://www.ccap.org/pdf/04-2003_NYGHG_Recommendations.pdf
5. Rhode Island Greenhouse Gas Process. 2002. *Rhode Island Greenhouse Gas Action Plan*. http://righg.raabassociates.org/.
6. Vermont Governor's Commission on Climate Change. 2007. *Final Report and Recommendations of the Governor's Commission on Climate Change*. http://www.anr.state.vt.us/air/Planning/htm/ClimateChange.htm.
7. South Carolina Climate, Energy & Commerce Advisory Committee. 2008. Draft South Carolina *Climate Change Action Plan*. http://www.scclimatechange.us/plenarygroup.cfm.

In the above analysis, we have assumed the Florida 2020 cap is equal to its state goal (interpolation of the state 2017 and 2025 goals). Next, we would look at the scenario in which Florida has the same 2020 cap as the RGGI states as whole, which is 10% below 2005 levels. Table 6 is very similar to Table 2, except for the Florida and Total rows. The RGGI goal of 10% below 2005 levels translates to 121.51 MMtCO2e emissions budget to Florida (compared with the 109.97 MMtCO2e budget in the Florida state goal scenario).

Table 6. RGGI States and Florida 2020 Emission Projections and Caps (in Auction Case, with Florida following RGGI goal)

	2020 BAU Emissions (MMtCO2)	Cap/Budget (MMtCO2)	Reduction Target (%)	Allowance beyond BAU (MMtCO2)	Reduction Target (MMtCO2)
CT	13.26	9.09	31.45%	0.00	4.17
DE	11.07	6.43	41.94%	0.00	4.65
MD	31.79	31.79	0.00%	0.00	0.00
ME	1.90	1.90	0.00%	0.00	0.00
NH	4.93	4.93	0.00%	0.00	0.00
NJ	23.40	19.46	16.86%	0.00	3.95
NY	56.11	54.66	2.58%	0.00	1.45
VT	0.03	0.03	0.00%	0.00	0.00
MA	24.97	22.66	9.26%	0.00	2.31
RI	1.78	1.78	0.00%	0.00	0.00
FL	168.71	121.51	27.98%	0.00	47.20
Total	337.97	274.25	18.86%	0.00	63.72

With the same hypothetical allowance price levels ($7/tCO2e and $1/tCO2e) as in the previous scenario (Florida state goal scenario), the amount of emissions the state chooses to mitigate and the amount of allowances it purchases from the auctioneer are the same as before. Therefore, the simulation results of the scenario in which Florida follows the RGGI goal are same as the results shown in Tables 4 and 5 (except for the third column in Tables 4 and 5 which shows the 2020 emissions cap/budget). The percentages of emissions Florida chooses to mitigate are 34.72% (or 58.58 MMtCO2e) in the $7 case and 31.92% (or 53.86 MMtCO2e) in the $1 case, respectively. These are same in the two scenarios. However, since Florida has less stringent mitigation target in the RGGI goal scenario than in the state goal scenario (27.98% vs. 34.82%, or 47.20 MMtCO2e vs. 58.75 MMtCO2e below 2020 BAU), the only difference in these two scenarios is that Florida would reduce more emissions than required by its emissions budget in the RGGI goal scenario (11.38 MMtCO2e more in the $7/tCO2e case, and 6.66 MMtCO2e more in the $1/tCO2e case). Recall that in the Florida state goal scenario, Florida is in the list of states that mitigate less than their budget requires.