Preliminary Cap and Trade Simulation of Florida Joining WCI

Dan Wei and Adam Rose
School of Policy, Planning and Development
University of Southern California

September 12, 2008

This summary presents the preliminary simulation results of Florida joining the cap and trade program of WCI. 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.

The ten WCI partners include seven U.S. states: Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington; and three Canadian provinces: British Columbia, Manitoba, and Quebec. The WCI cap and trade program has a broad sectoral coverage, which includes electric sector, residential/commercial fuel uses, large stationary combustion sources, industrial process, fossil fuel production and processing, and transportation fuels (basically all sectors except agriculture, forestry, and waste management). The WCI 2020 regional reduction target is 15 percent below its 2005 GHG emissions level. According to the findings by the WCI Economic Modeling Team, nearly one third of the WCI total emission reduction requirement could be achieved by the reductions from the non-WCI WECC power sector (under the First Jurisdictional Deliverer (FJD) approach proposed for the WCI cap and trade program, the portion of emission reductions that relate to the imported electricity to WCI should be reflected as the WCI BAU reductions). Therefore, in our analysis we assumed that for each WCI partner, the in-state (or in-province) emission reduction goal would be 10% below 2005 level by year 2020. This regional target is applied to each of the ten WCI partners in our analysis.

We first simulated the cap and trade among the current ten WCI partners (see Table 1). The simulation assumes that the permits are grandfathered. The second column in the table shows 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.

Table 2 presents the simulation results for Florida joining the WCI cap and trade program.

Table 3 presents the 2020 baseline emissions, the emission budget (capped emissions), and reduction target in percentage terms for the WCI partners and Florida in the first three numerical columns. Please note that the 2020 emission budget for Florida is computed by interpolating the state's 2017 goal (to return to 2000 levels) and 2025 goal (to return to 1990 levels). The last column in this table 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 states and provinces included in this study.

Summary of the findings from the preliminary 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 many WCI 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. Before Florida joining WCI, the permit price of the cap and trade program among the 10 WCI partners is $78.18/tCO2e. Washington is the biggest permit buyer in the market, followed by California. New Mexico is the biggest permit seller.

4. Because Florida has a marginal cost curve steeper than the WCI average level, when it joins the WCI, the permit price increases to $102.76/tCO2e. Florida becomes the biggest permit buyer in the market, followed by Washington. New Mexico is still the biggest permit seller, followed by Arizona.

5. In both simulation cases, if we compare the net cost of each state/province after trading with the corresponding element in the column before trading, 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 cost saving amount is shown in the Cost Saving column in the result tables (Table 1 and Table 2). Compared with the pre-trading condition, Florida can save $941 million in 2020 by joining WCI, a cost saving of around 15.01%.

Please note these are the preliminary simulation results. They are subject to change when we get the finalized quantification analysis results from the TWGs.

TABLE 1. EMISSION TRADING SIMULATION AMONG WCI PARTNERS IN YEAR 2020[a,b]

(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	Net Cost		(million tCO_2e)	(million tCO_2e)	(percent from BAU)	(percent from BAU)
AZ	-789	-669	-124	-793	4	-1.59	72.61	46.92	45.89
CA	-17,613	-18,400	669	-17,731	118	8.56	143.40	25.68	27.21
MT	-213	34	-459	-425	212	-5.88	13.61	40.59	23.06
NM	-372	301	-1,068	-767	395	-13.66	37.91	45.96	29.40
OR	635	-164	514	350	285	6.57	15.05	19.19	27.57
UT	-100	104	-227	-123	23	-2.91	32.41	37.56	34.19
WA	1,781	-387	1,111	724	1,056	14.21	20.92	18.36	30.84
BC	-451	-310	-168	-478	27	-2.15	17.85	26.06	22.92
MB	-345	-261	-148	-409	64	-1.89	7.31	42.76	31.69
QC	-4,010	-3,935	-99	-4,034	24	-1.27	20.24	24.41	22.88
Total	-21,479	-23,687	0	-23,687	2,208	29.34[c]	381.30	29.87	29.87

tCO_2e = metric tons of carbon dioxide equivalent; BAU = business as usual.

Permit Price = \$78.18/tCO_2e.

[a] Sector coverage: Electric sector (Consumption-based) + Residential/Commercial fuel use + Large stationary combustion sources + Industrial process + Fossil fuel production and processing + Transportation fuels. AFW (Agriculture, Forestry, and Waste Management) sector is excluded from the sector coverage.

[b] The cap for WCI partners is 15% below 2005 level by year 2020. According to the findings by the WCI Economic Modeling Team, nearly one third of the WCI total emission reduction requirement could be achieved by the reductions from the non-WCI WECC power sector. Therefore, in our analysis we assumed that for each WCI partner, the in-state (or in-province) emission reduction goal would be 10% below 2005 level by year 2020.

[c] Represents number of permits bought or sold.

TABLE 2. EMISSION TRADING SIMULATION AMONG WCI PARTNERS AND FLORIDA IN YEAR 2020[a,b]

(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	Net Cost		(million tCO_2e)	(million tCO_2e)	(percent from BAU)	(percent from BAU)
AZ	-789	26	-955	-928	139	-9.29	80.31	51.89	45.89
CA	-17,613	-17,710	96	-17,614	1	0.93	151.03	27.04	27.21
MT	-213	192	-783	-591	378	-7.62	15.35	45.81	23.06
NM	-372	751	-1,916	-1,165	793	-18.65	42.90	52.01	29.40
OR	635	8	480	488	147	4.67	16.95	21.61	27.57
UT	-100	493	-741	-248	148	-7.21	36.72	42.55	34.19
WA	1,781	-165	1,209	1,044	737	11.76	23.37	20.51	30.84
BC	-451	-127	-429	-556	105	-4.18	19.87	29.02	22.92
MB	-345	-205	-258	-463	119	-2.51	7.93	46.40	31.69
QC	-4,010	-3,860	-215	-4,075	65	-2.09	21.06	25.40	22.88
FL	6,265	1,812	3,513	5,325	941	34.19	131.54	31.22	39.34
Total	-15,213	-18,787	0	-18,787	3,573	51.55[c]	547.03	32.22	32.22

tCO_2e = metric tons of carbon dioxide equivalent; BAU = business as usual.

Permit Price = \$102.76/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/province for a given case. The *average* mitigation cost per unit of CO_2 equivalent in the simulation differs for each state/province. For FL, for example, it is \$13.77/tCO_2e. Please note that the average mitigation cost is related to mitigation level of a state/province, which for this case is 31.22% below the baseline level in 2020 for FL. Multiplying the average mitigation cost by the number of tons of CO_2 mitigated will equal the *total* mitigation cost for each state/province shown in the second numerical column in the table.

[a] Sector coverage: Electric sector (Consumption-based) + Residential/Commercial fuel use + Large stationary combustion sources + Industrial process + Fossil fuel production and processing + Transportation fuels. AFW (Agriculture, Forestry, and Waste Management) sector is excluded from the sector coverage.
[b] The cap for WCI partners is 15% below 2005 level by year 2020. According to the findings by the WCI Economic Modeling Team, nearly one third of the WCI total emission reduction requirement could be achieved by the reductions from the non-WCI WECC power sector. Therefore, in our analysis we assumed that for each WCI partner, the in-state (or in-province) emission reduction goal would be 10% below 2005 level by year 2020.
[c] Represents number of permits bought or sold.

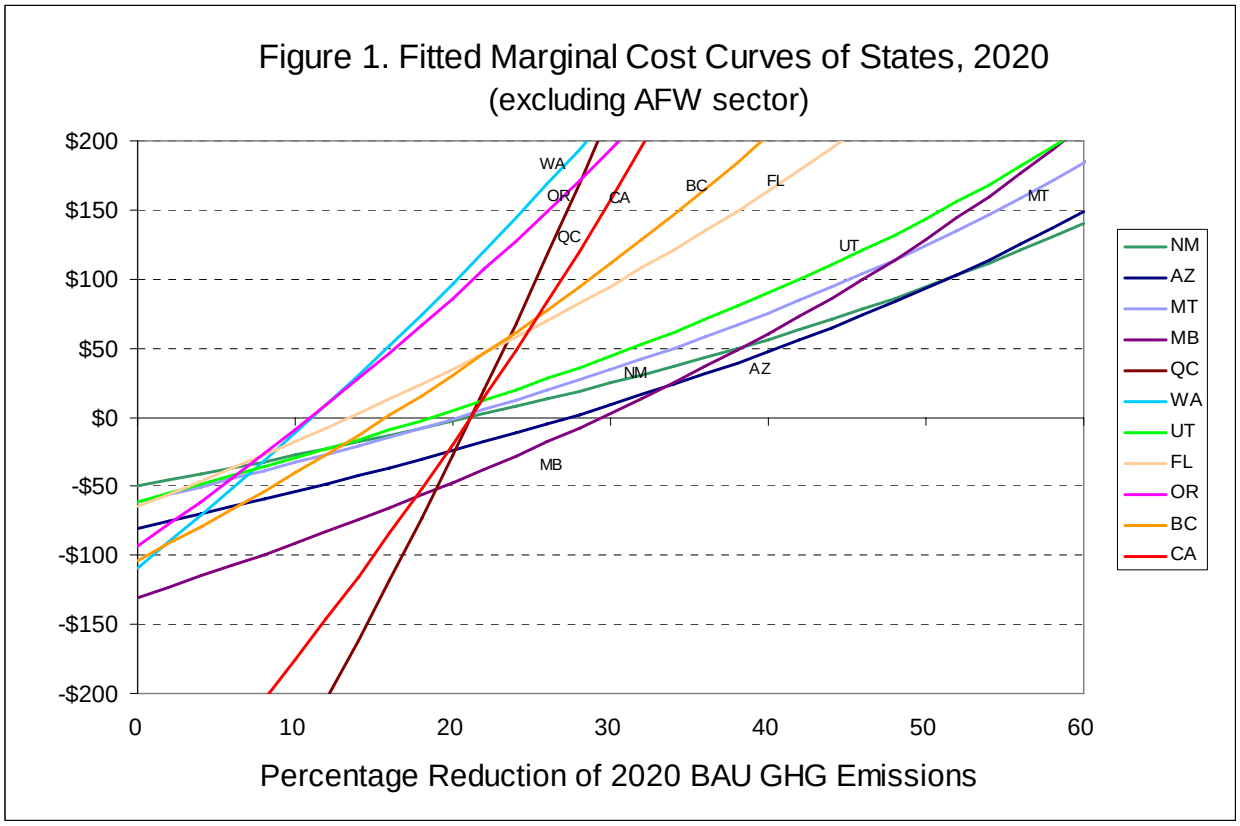
TABLE 3. DATA TABLE

State	2020 BAU Gross Emissions (Consumption-based)[a] ($MMtCO_2e$)	Emissions Cap in 2020[b] ($MMtCO_2e$)	GHG Mitigation Goal in 2020 (relative to BAU emissions)	Autarkic Marginal Mitigation Cost ($/tCO_2e$)
AZ	154.8	83.7	45.89%	73.4
CA	558.5	406.5	27.21%	105.8
MT	33.5	25.8	23.06%	9.0
NM	82.5	58.2	29.40%	22.8
OR	78.4	56.8	27.57%	166.6
UT	86.3	56.8	34.19%	62.7
WA	113.9	78.8	30.84%	231.0
BC	68.5	52.8	22.92%	53.1
MB	17.1	11.7	31.69%	12.1
QC	82.9	63.9	22.88%	40.9
FL	421.3	255.5	39.34%	159.0
Total	1,697.6	1,150.6	32.22%	

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

[a] Sector coverage: Electric sector (Consumption-based) + Residential/Commercial fuel use + Large stationary combustion sources + Industrial process + Fossil fuel production and processing + Transportation fuels. AFW (Agriculture, Forestry, and Waste Management) sector is excluded from the sector coverage.

[b] The cap for WCI partners is 15% below 2005 level by year 2020. According to the findings by the WCI Economic Modeling Team, nearly one third of the WCI total emission reduction requirement could be achieved by the reductions from the non-WCI WECC power sector. Therefore, in our analysis we assumed that for each WCI partner, the in-state (or in-province) emission reduction goal would be 10% below 2005 level by year 2020. 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).



AFW = agriculture, forestry, and waste management; BAU = business as usual; GHG = greenhouse gas.

Notes: 1. Marginal cost curves of AZ, CA, MT, NM, WA, and FL are developed based on mitigation options data of these states (from state final or draft climate action plans).
2. Marginal cost curves of OR, BC, MB, and QC are developed based on WA, WA, MN, and CT 2020 curves, respectively. UT only has mitigation options data available for residential/commercial/industrial sector and the transportation sector. The state emission mitigation potentials and costs for the energy supply sector are approximated from New Mexico 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. Arizona Climate Change Advisory Group. 2006. *Climate Change Action Plan*. http://www.azclimatechange.gov/.
2. California Air Resources Board. 2008. *Climate Change Draft Scoping Plan (June 2008 Discussion Draft)*. http://www.arb.ca.gov/cc/scopingplan/document/draftscopingplan.pdf.
3. Montana Climate Change Advisory Committee. 2007. *Montana Climate Change Action Plan*. http://www.mtclimatechange.us/CCAC.cfm.
4. New Mexico Climate Change Advisory Group. 2006. *NM Climate Change Action Plan.* http://www.nmclimatechange.us/.

5. Washington Climate Advisory Team. 2008. *2008 Climate Change Interim Report—Leading the Way on Climate Change: The Challenge of Our Time*. http://www.ecy.wa.gov/climatechange/interimreport.htm.
6. Geller, H., Baldwin, S., Case P., Emerson, K., Langer, T., and Wright, S. 2007. *Utah Energy Efficiency Strategy: Policy Options*. http://www.swenergy.org/pubs/UT_Energy_Efficiency_Strategy.pdf.
7. Florida Governor's Action Team on Energy and Climate Change. 2008. *ESD Policy Options Document*. http://www.flclimatechange.us/ee.cfm.

Emissions Inventory and Forecast Data:
For WCI Partners: Williams and Roe. 2008. "Task 0 State-Provincial GHG Summaries Tech Memo 1-31-08.doc" and associated Excel workbooks (including data from Western State GHG plans and WRAP database), as updated by Partner feedback through 6-19-08.
For Florida: Draft Florida Inventory and Forecast Analysis by CCS.
http://www.flclimatechange.us/Inventory_Forecast_Report.cfm.

Appendix. Development of the Marginal Cost Curve for Florida

In this study, the Florida marginal cost curve is developed based on the reduction potential and mitigation cost/saving data of individual mitigation options in the sectors that are covered by the cap and trade program. Since the sectoral coverage of the WCI cap and trade program includes basically all sectors except agriculture, forestry, and waste management sectors, we collected the 2020 Florida GHG reduction potential and mitigation cost/saving data of individual options that are quantitatively analyzed by the ESD and TLU TWGs. Table A1 presents the list of these options. Please note these are only preliminary analysis results; they are subject to change with the undergoing concurrent stakeholder process.

Table A1. ESD and TLU Sectors GHG Mitigation Options of Florida

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 BAU Emissions[1]	Cumulative GHG Reduction Potential	Weights (add-up to 100)
ESD-12	Demand-Side Management (DSM)/Energy Efficiency Programs, Funds, or Goals for Electricity	23.59	-$35.78	5.60%	5.60%	19.344
TLU-1a	Develop and Expand Alternative and Renewable Fuels[2]	7.30	-$17.00	1.73%	7.33%	5.981
ESD-9	Power Plant Efficiency Improvements	14.38	-$11.78	3.41%	10.75%	11.791
ESD-14	Improved Building Codes for Energy Efficiency[3]	14.21	$0.19	3.37%	14.12%	11.648
ESD-11	Waste-To-Energy (WTE)	5.60	$1.44	1.33%	15.45%	4.590
ESD-8	Combined Heat and Power (CHP) Systems	2.23	$9.54	0.53%	15.98%	1.832
ESD-13a	Energy Efficiency in Existing Residential Buildings	5.69	$9.99	1.35%	17.33%	4.667
TLU 4	Improving Transportation System Management	4.55	$12.91	1.08%	18.41%	3.731
ESD-6	Nuclear Power	11.84	$28.24	2.81%	21.22%	9.709
TLU-8	Increase Freight Movement Efficiencies	0.63	$48.00	0.15%	21.37%	0.517
ESD-5	Renewable Portfolio Standard (RPS) Option 2: 20% by 2025	30.22	$89.16	7.17%	28.54%	24.780
TLU 2	Add-on Technologies for Existing Vehicles and New Vehicles	1.21	$90.00	0.29%	28.83%	0.992
TLU 5	Increasing Choices in Modes of Transportation	0.51	$256.71	0.12%	28.95%	0.418

[1] 2020 projected consumption-based gross CO2e emission level is 421.27 Million Metric Tons CO2e (excluding AFW sector).
[2] The GHG reduction potential of 2020 is computed as the average of the 2015 and 2025 reduction potentials.
[3] This is a recent action additional to the recommended policy options. We include this option in the list to develop the cost curve since it is not included in the baseline emission forecast.

In Table A1, Column 3 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 Florida 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.

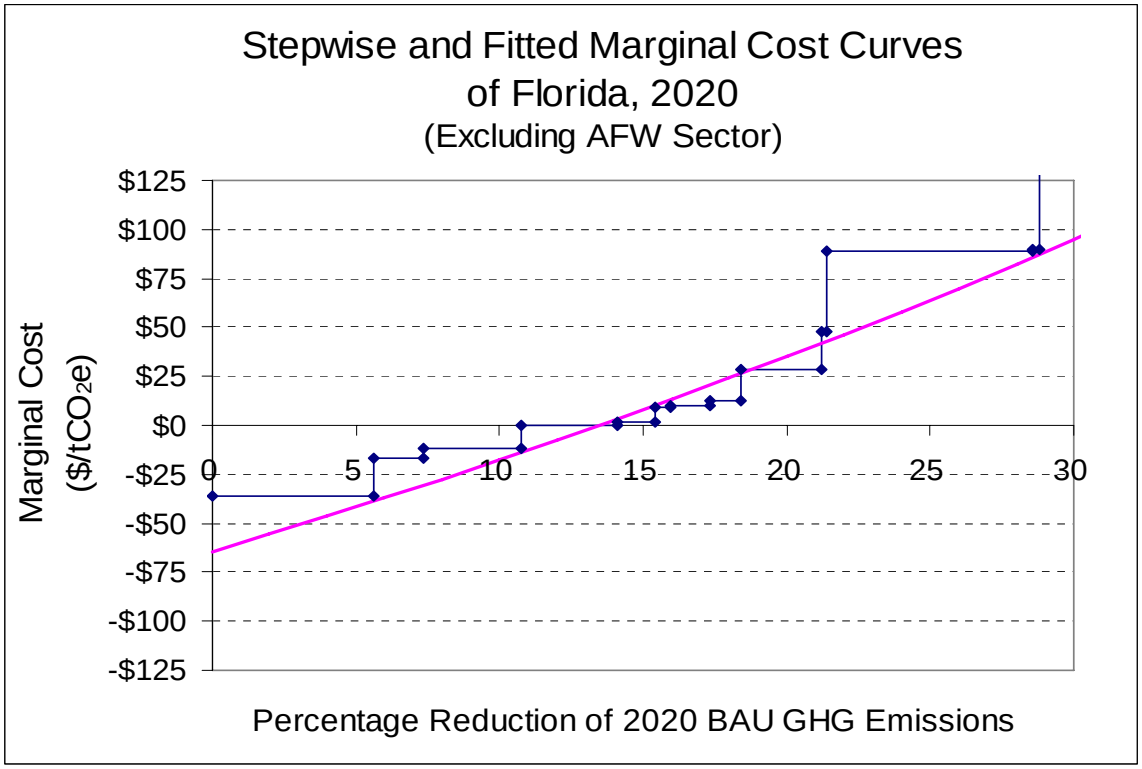


Figure A1. Stepwise and Fitted Marginal Cost Curve of Florida, 2020

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 is then used in our C&T analysis model.

The fitted curve shown in Figure A1 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.

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 Florida has the following specification:

$$MC = -64.79 - 447.61 \times \ln(1 - R)$$

The fitted curve has an intercept with the Y-axis at MC = -$64.79. The curve increases to MC=0 at the emission reduction level of 13.48 which indicates that Florida has cost-saving mitigation potentials up to the level of about 13.48% of the 2020 BAU emissions.