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Climate Change Policy as Economic Stimulus: Evidence and Opportunities from the States

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White Paper
Draft for Discussion

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Climate Policy as Economic Stimulus: Evidence and Opportunities from the States

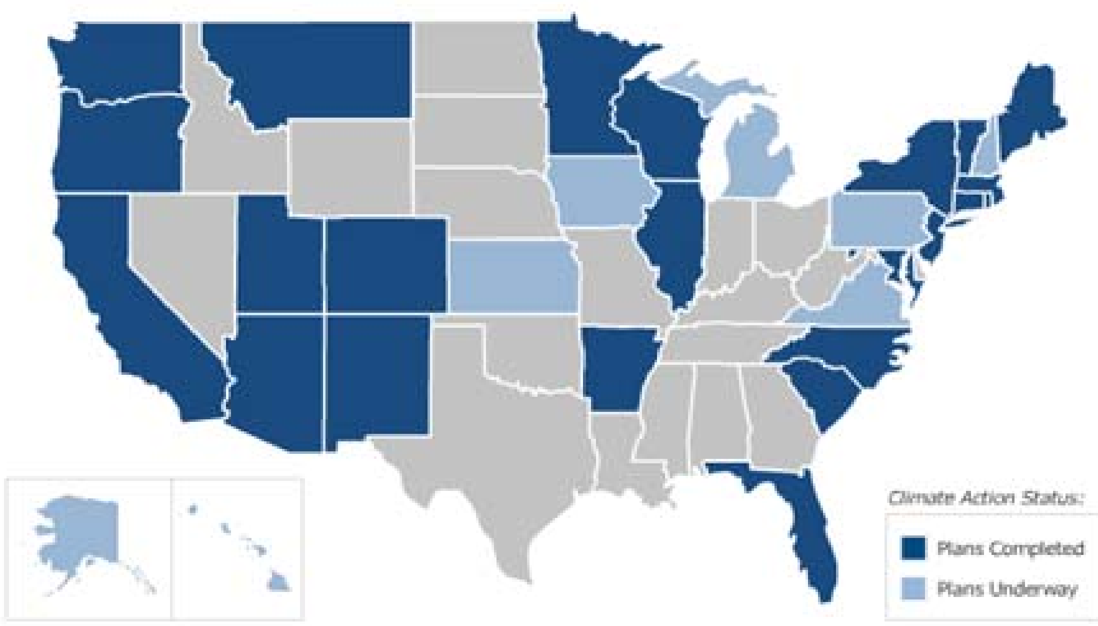
Key Finding

Done properly, sector-based climate change mitigation policies can cut pollution, save money and create jobs. State opportunities can be scaled to the national level.

Abstract

Twenty U.S. states have completed and begun implementation of comprehensive multi-sector greenhouse gas reduction plans with quantified costs and emission reduction benefits that cover over two thirds of the United States economy and population. Results from individual states, economic sectors, and policies vary; but all indicate a consistent pattern for cost effective achievement of near term and mid term greenhouse gas emissions reduction targets at science based levels (1990 levels or below by 2020). Preliminary national projections of this data suggest a net savings of $20.8 billion in 2012 and $85 billion in 2020, and from 2009 to 2020 cumulative savings of $535.5 billion, through implementing a climate plan involving all U.S. states and economic sectors. (For perspective, the federal economic stimulus being discussed for 2009 is between $100-200 billion.) This savings estimate does not include the potential for additional co-benefits such as energy independence, health and environmental protection. Economic benefits would begin accruing as soon as actions are implemented. Macro-economic analysis of a sample of state climate action plans indicates that sector-based climate mitigation actions have the potential to immediately expand employment, income and investment, thus contributing to national economic recovery.

Figure 1. States with Climate Action Plans Completed or Underway



Overview

On October 15th the state of Florida released a recommended plan of action to address global climate change. It was released during a difficult moment—as the greatest financial crisis since the Great Depression was rippling across the globe. The plan contained fifty separate policy recommendations that taken together delivered three critical end results: reduction of greenhouse gas (GHG) emissions 33% below 1990 levels by 2025 (equal to 20% below 1990 levels by 2020); a cut in the consumption of gasoline by 54 billion barrels over the same time period; and a projected net economic savings for the state's economy of $28 billion by 2025.

The Action Team that drafted the plan directly addressed the wisdom of pursuing climate action during the economic crisis with this comment in the first pages of its report to the Governor:

"The Action Team completes its charge during a time of economic uncertainty. While it may be assumed by some readers that the current economic environment would hamper Florida's progress toward a low carbon economy, the Action Team firmly believes that current economic conditions precisely sharpen the "call to action" first issued by Governor Crist in 2007. Now is the time for strategic investment in Florida's low carbon energy infrastructure if we are to be successful in diversifying the state's economy, creating new job opportunities, and positioning Florida's "green tech" sector as an economic engine for growth."

Guided by over 100 Florida stakeholders and technical work group representatives, with support from agency leaders and the Center for Climate Strategies (CCS), and working under an Executive Order issued by Governor Charlie Crist, the Florida Action Team accomplished what many other states and their stakeholders have done with expert information and assistance through completely nonpartisan collaboration since 2001: they have identified economically and politically viable actions in all economic sectors with the potential to cut GHG pollution substantially, save money, and create jobs.

More than 30 states have developed or are in the process of developing climate action plans similar to one Florida released in October.[1] Most are built on a model of open, stepwise, democratic, fact based decision-making that identifies and designs climate policy options as a driver of economic benefit while also stabilizing GHG emissions at levels consistent with science-based stabilization scenarios (typically at or below 1990 emissions levels by 2020).

Potential for Economic Stimulus

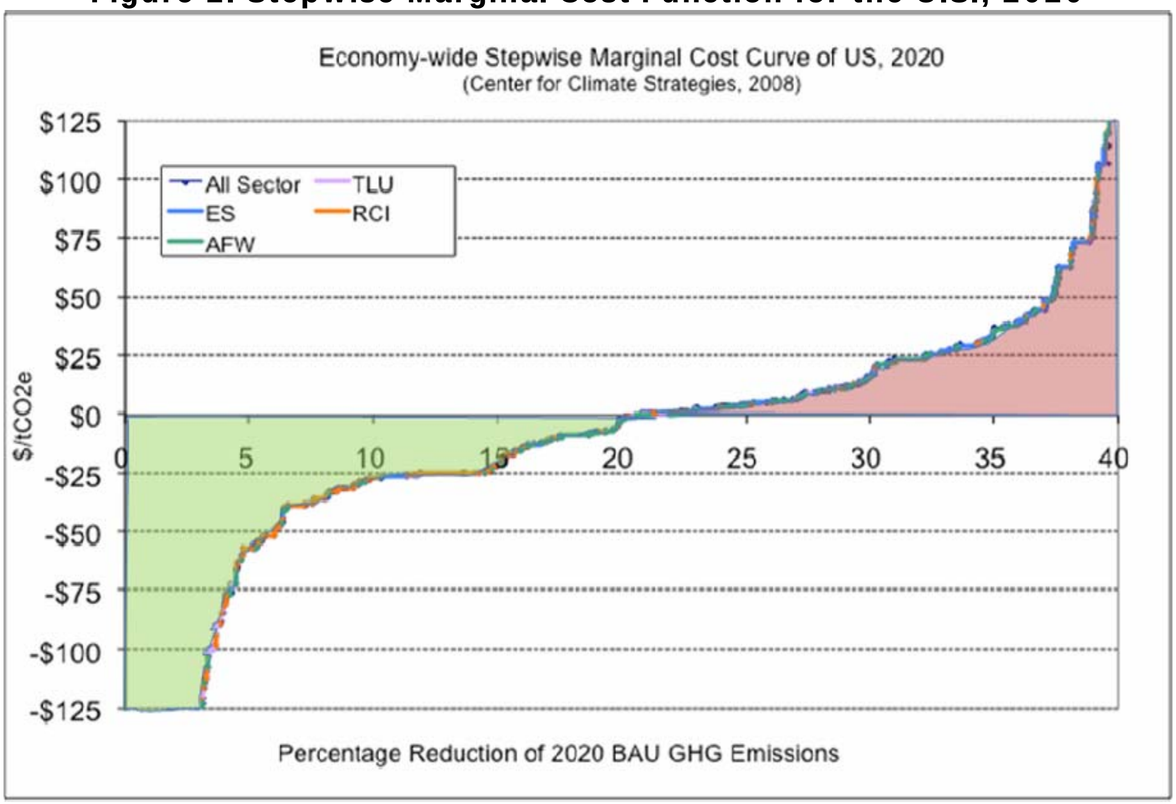
This white paper provides an aggregate snapshot of this ongoing climate policymaking work pioneered by state governments. Relying on the latest data available from 20 states that have completed quantified climate plans and

[1] The state climate plans are written as the endpoint of public and comprehensive planning processes involving all relevant stakeholders. The processes generally take 12-18 months to complete. For more information please see www.climatestrategies.us.

associated policy portfolios, CCS has constructed a model that scales up and projects the win-win-win opportunity to a national level.

The preliminary analysis—summarized here and presented in detail in the appendix —suggests that by adopting a portfolio of climate change mitigation policies touching every sector of the economy, the U.S. can stimulate the economy toward recovery, cut consumption of fossil fuels and reduce GHG emissions simultaneously. The quantified result is graphically represented by the following "marginal cost curve." It suggests that by adoption of a portfolio of policies similar to those developed by individual state governments, the U.S. could reduce GHG emissions to 10% below 1990 levels by 2020 at an estimated net economic savings of $20.8 billion in 2012 and $85 billion in 2020, and from 2009 to 2020 cumulative savings of $535.5 billion, through implementing a climate plan involving all U.S. states and economic sectors. (For perspective, the economic stimulus being discussed for 2009 is between $100-200 billion.). These results do not include additional economic benefits associated with avoidance of climate change damages, improvement, health or air quality, land protection, creation of jobs, local community investment, improved energy independence, or other co-benefits.

Figure 2. Stepwise Marginal Cost Function for the U.S., 2020



AFW=agriculture, forestry and waste management, ES=energy supply, RCI=residential commercial and industrial; TLU=transportation and land use

A complete list of the policy measures included in the cost curve can be found in the detailed analysis in Appendix I. This portfolio of climate policies returns greater savings (area below "0") than it expends in costs (area above "0") and, if fully implemented at an equivalent level in all 50 states, would reduce emissions to below 1990 levels by 2020.[2]

The cost curve has been constructed from a series of line segments joined together. Each line segment that has been plotted refers to a specific recommended policy action (from a state climate plan) defined by two attributes. First, the length of each line segment is determined by the GHG emission reduction potential of the related policy option. The longer the line segment, the greater the emission reduction. And second, the cost curve shows the potential net cost or savings associated with each policy measure. If the policy measure saves money on a net basis, its line segment finds its place below the "0" line. If it costs money or requires investment on a net basis, it finds its place as a line segment above the "0" line.

A growing body of related economic analysis indicates that these climate policies could have a significant and beneficial effect on job creation and overall economic development. Two important forces are at play. First, actions that reduce energy demand and infrastructure expenses save money and, by freeing up scarce capital for other uses, have an expansionary effect on the economy. In many cases they also have an economic stimulus effect by investing in labor-intensive installation of new energy efficient equipment, buildings and facilities. Second, actions that shift energy supply away from conventional fossil fuel sources to renewable and alternative sources typically result in proportionately higher use of labor per unit of energy produced. The higher cost of production for some of these options also results in more highly leveraged investments in job creation. This is even more pronounced when new indigenous energy supplies replace imported energy. The results of state climate action plans show that economic development benefits can result from specific sector-based policies and measures for these reasons, and others.

For instance, in 2008 the North Carolina Climate Action Plan Advisory Group recommended 56 comprehensive, climate mitigation action recommendations in all economic sectors estimated to reduce GHG emissions in North Carolina to within one percent of 1990 levels by 2020; yield a net savings of over $5 billion; create

[2] It is worth noting that the assumptions behind the state climate plans are conservative and have been overtaken by recent events. We are in the process of revising this analysis by inserting into the model higher fuel prices more reflective of current market conditions. It is safe to assume that this would increase the savings side of the cost curve, as the value of energy efficiency gains would be even greater than they already are. We are also revising estimates of projected greenhouse gas emissions levels to take the economic slowdown into account. Since emissions will rise at a slower rate, the impact of reductions as a percentage of the total carbon footprint will likely be more significant. In short, we expect the new analysis to point to the potential for even steeper emissions reductions and even greater net economic benefit. In addition, some important emissions reduction actions in state plans do not provide numerical estimates of costs but were expected to provide net savings or low costs. These actions are not included in the current cost curve and would expand its coverage and reduce its overall costs.

more than 15,000 jobs; and generate $565 million in employee and proprietor income, $302 million in gross state product, $2.2 billion in net additional employee and proprietor income, and more than $1.2 million in net gross state product.[3] Specific North Carolina examples include the following:

Example 1: Residential, Commercial & Industrial Options in North Carolina
Table 1 presents summary results for the residential, commercial and industrial (RCI) mitigation options analyzed in the North Carolina climate action plan. By 2020, these options would result in the net creation of more than 9,100 jobs, $364 million in additional employee and proprietor income, and $42 million in net gross state product. Over the study period, 2007–2020, the options would generate $1.9 billion (NPV) in additional employee and proprietor income and $937 million (NPV) in gross state product. The economic impacts associated with these options are driven primarily by energy bill savings resulting from energy efficiency measures.

Table 1: Summary Results for North Carolina Residential, Commercial and Industrial Climate Mitigation Policy Options

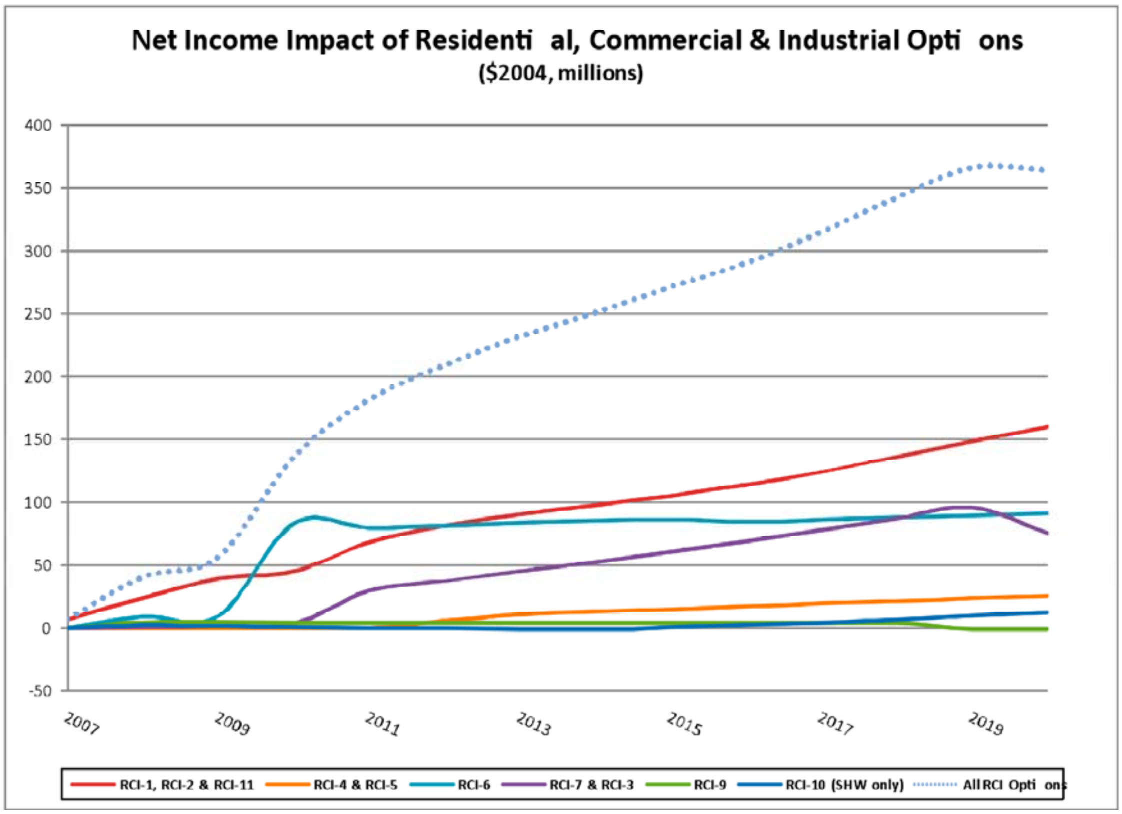
Residential, Commercial and Industrial Options	Net Annual Employment (FTE)			Net Income ($2004, million)				Total Value-Added ($2004, million)			
	2010	2015	2020	2010	2015	2020	2007-2020 NPV	2010	2015	2020	2007-2020 NPV
RCI 1, 2 & 11 (Efficiency Funding & Energy Audits)	1,309	3,121	4,575	45	105	160	789	18	(4)	(55)	36
RCI 4 & 5 (Market Transformation & Appliance Standards)	-	430	771	-	15	26	87	-	1	(11)	(9)
RCI 6 (Energy Codes)	1,964	2,076	2,163	83	86	90	623	96	77	57	571
RCI 7 & 3 (High Performance Buildings)	126	1,239	1,372	3	61	76	388	(5)	46	32	273
RCI 9 (Bulk Purchasing & Green Power)	105	99	12	4	4	(1)	33	5	3	(5)	28
RCI 10 (Solar Water Heating)	13	(4)	218	1	0	13	21	0	1	24	37
All RCI Policies	**3,518**	**6,961**	**9,110**	**136**	**271**	**364**	**1,942**	**114**	**125**	**42**	**937**

Note: Values in parentheses identify loss of jobs, income, or Value-Added to the economy. NPV = net present value. FTE=Full Time Equivalent

[3] "Secondary Economic Analysis of Greenhouse Gas Mitigation Options for North Carolina," prepared for the Center for Climate Strategies, Appalachian State University Energy Center, David Ponder, Jeffery Tiller, Jason Hoyle, August 2008.

The results in Table 1 indicate that actions related to energy efficiency and conservation for buildings, facilities and manufacturing in North Carolina generate net gains in employment, income and investment. These actions also yield some of the highest greenhouse gas reductions in the state plan. This category of actions has a high potential for saving money by saving energy, starting immediately, and to free up scarce capital for investment that has an economic stimulus effect. Figure 3 demonstrates this graphically for income effects. All state climate action plans have found that energy efficiency and conservation measures have a high potential for net economic savings and greenhouse gas reduction. Results from North Carolina suggest that they may have broader economic benefits as well.

Figure 3. Net Income Gains from North Carolina Residential, Commercial and Industrial Climate Mitigation Policy Options

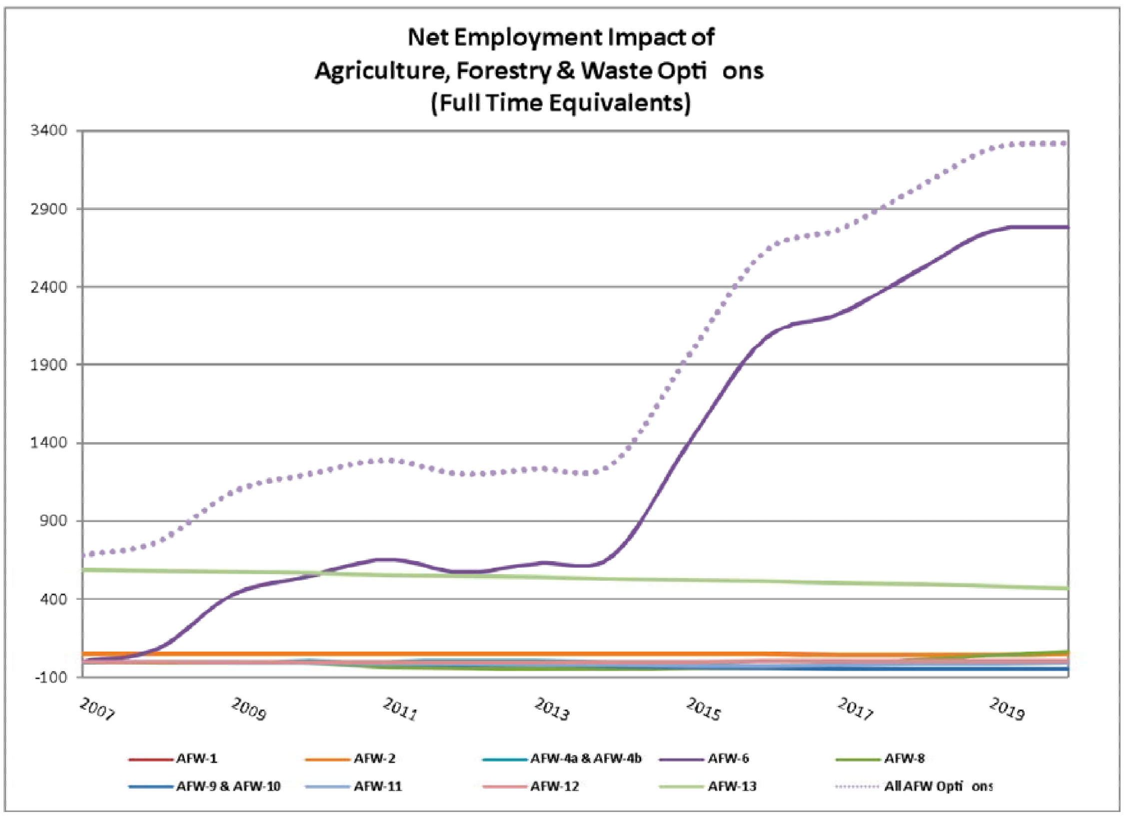


RCI=residential, commercial and industrial (Numbers refer to specific options in this sector from the NC climate plan.)

Example 2: Cellulosic Ethanol Production Subsidy in North Carolina
This option from the North Carolina climate action plan proposes to displace 10% of North Carolina's gasoline consumption with starch and cellulosic derived ethanol by 2010 ramping up to 25% by 2025. The option assumes a state subsidy to support ethanol producers worth $.23 per gallon through 2015, at which time it is assumed technological advances will make cellulosic ethanol production costs more competitive. Since the Agriculture, Forestry and Waste (AFW) technical working

group analysis quantified only the cost of the subsidy and not the value of the capital investments and operating expenses, including feedstocks, required to meet the production targets, this study relied on additional investments research and literature to quantify these values. When all these factors are considered, this mitigation option would result in the creation of more than 2,781 jobs, $163 million in additional annual employee and proprietor income, and more than $298 million in annual gross state product by 2020. For the study period, 2007-2020, the mitigation option would increase employee and proprietor income by $547 million (NPV) and gross state product by more than $1 billion (NPV). Figure 4 below shows the high job creation potential for this climate policy option (the solid purple line) in absolute terms as well as compared to other actions in the agriculture, forestry and waste management sectors. It reinforces the point that energy markets may play a central role in the economic opportunities of these sectors.

Figure 4. Net Employment Gains from Actions to Expand In State Cellulosic Ethanol Supplies in North Carolina



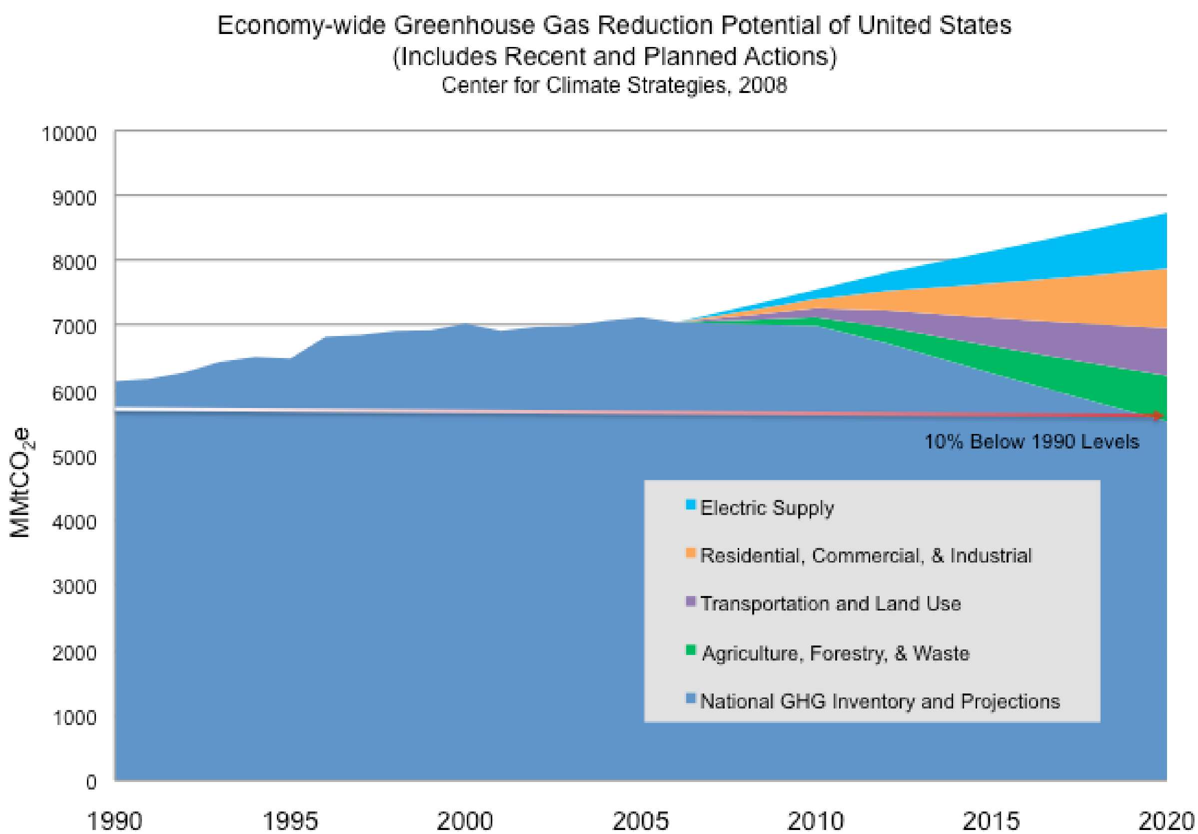
AFW=agriculture, forestry and waste management (Numbers refer to specific options in this sector from the NC climate plan.)

Follow-up studies of the recommendations of the Arizona Climate Change Advisory Group estimated a cumulative net increase in employment associated with new clean and renewable energy supply options of 289,000 jobs by 2020.[4] In addition, policies that have the potential to save money by saving energy and infrastructure expenses are likely to have an expansionary effect on the economy by freeing up scarce capital for other uses. Analysis of the New Mexico Climate Change Advisory Group recommendations shows similar results.

Sector Based Pathways for Action

Data from the states on a sector-by-sector basis, as shown in figure 3, provides the estimated scale and trajectory of actions in each sector.

Figure 5. US GHG Reductions by Sector 2009-2020



$MMtCO_2e$=million metric ton carbon dioxide equivalent

As the “wedge” graph shows, implementation of climate policy options could begin immediately and provide near term economic benefits (jobs, income, investment) as programs expand to full levels in later years. Climate change mitigation options in this analysis are grouped into one of four sector areas:

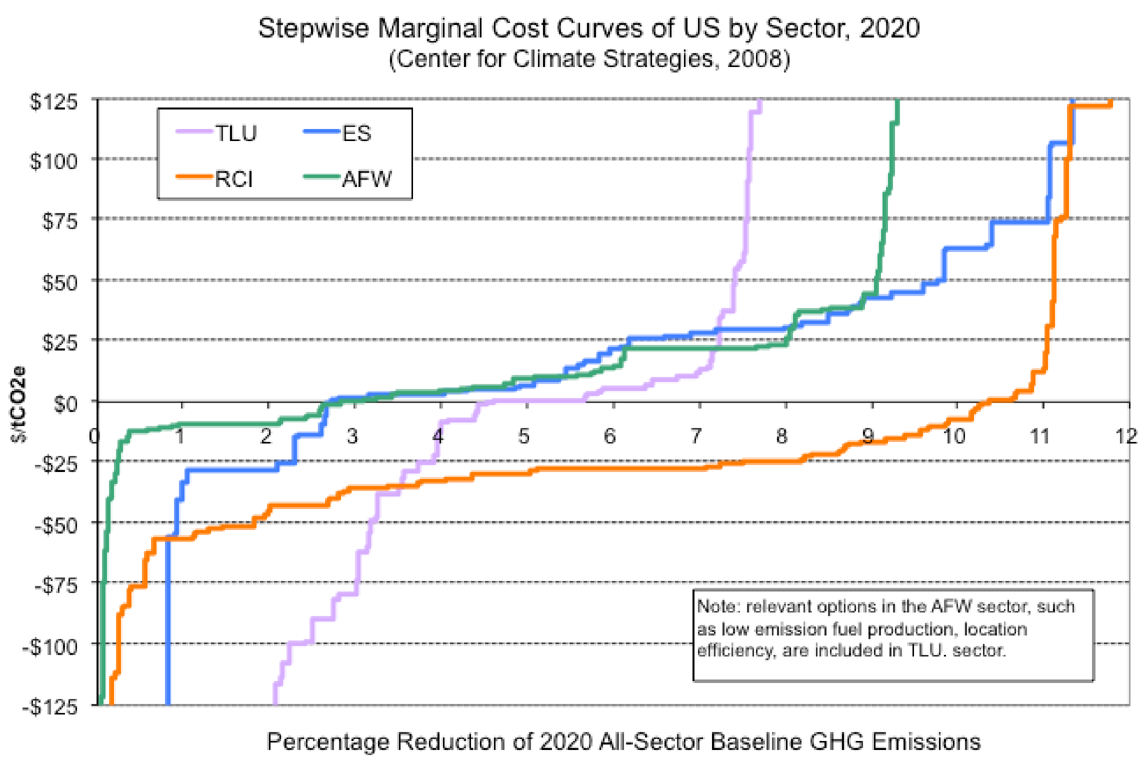
- *Transportation and Land Use* (vehicle efficiency, location efficiency, and lower carbon fuels)

[4] Economic Impacts of Climate Policies in Arizona, 2006-2020, prepared for the Center for Climate Strategies as a supplement to the Arizona Climate Change Advisory Group Report, Adam Rose and Dan Wei, August 2006.

- *Agriculture, Forestry and Waste* (land conservation, improved management practices, waste reduction and recycling)
- *Residential, Commercial and Industrial* (energy efficiency and conservation, and industrial process improvements)
- *Heat and Power* (clean and renewable energy supplies for electricity and direct fuel use)

This sectoral snapshot shows that emission reduction opportunities are available across all economic sectors, and suggests that a comprehensive approach (i.e. all economic sectors, policy instruments, levels of government) is critical to achieving full, cost effective benefits for national goals. The comparison of cost curves across economic sectors and actions within each sector demonstrate that each is unique and must be addressed by appropriate policy instruments. These differences reflect choices made by stakeholders and technical work groups as they developed policy agreements. Through the stepwise process, they work to identify the most appropriate policy implementation mechanisms that simultaneously reduce emissions, reduce costs, address feasibility issues and maximize co-benefits. To do this they try to match the best policy instruments (e.g. codes and standards, funding incentives, market based approaches, negotiated agreements, information and education, reporting and disclosure) with each of the underlying policy actions (e.g. advancing energy efficiency, renewable energy, transportation improvements, resource conservation, etc.) to create optimal policy design.

Figure 6. Stepwise Marginal Cost Function U.S. Economic Sectors U.S., 2020



Mapping Implementation Across Jurisdictions and Policy Instruments

State climate action plans have typically found that the mechanisms required to fully adopt a full range of policy solutions would be difficult to undertake by a single level of governmental jurisdiction (local, state, federal) alone.[5] For example, energy efficiencies that can be captured through improved building codes may best be determined locally, whereas improved appliance efficiency standards may best determined at a regional or national level due to market scale issues for manufacturers and wholesalers. The result has been the development of policies that call for integrated state and national solutions. From a technical perspective, in order to attain the lowest cost approach to national emissions reduction goals, a combination of policies and measures at the state and federal levels and a national market-based system is likely to be needed.

The role of well-designed sector based policies is important in this comprehensive policy structure for four key reasons:

1. Emissions reductions delivered through sector-based policies and measures at the state and federal level reduce emissions and thereby relieve pressure on a cap and trade program to deliver economy-wide emissions reductions entirely on its own.
2. Specific policies and measures, properly designed, can reduce barriers to efficient GHG emissions markets by using “non price” policy instruments where emission prices are not likely to be fully effective at stimulating behavioral response, and by otherwise addressing specific market imperfections and failures (such as split incentives). In so doing, they reduce the cost of national cap and trade or carbon tax programs that must rely on efficiently priced markets and mechanisms.
3. Sector-based policies and measures also can assure the full level of effort needed to reach economy wide emissions reduction targets if a federal cap and trade or carbon tax program does not fully cover all economic sectors.
4. Sector-based policies and measures provide a means to achieving co-benefits (e.g. health, energy security) by selecting policies using a broader set of criteria than ‘cost per ton of GHG emissions reduced’.

These issues highlights the importance of constructing a comprehensive policy portfolio that appropriately matches responsibility for policy implementation with the appropriate jurisdiction level and policy instruments – recognizing that overlap is inevitable and integration is important. The Venn diagram in Figure 5 below suggests a way of conceptualizing the integrated structure of a comprehensive national climate plan.

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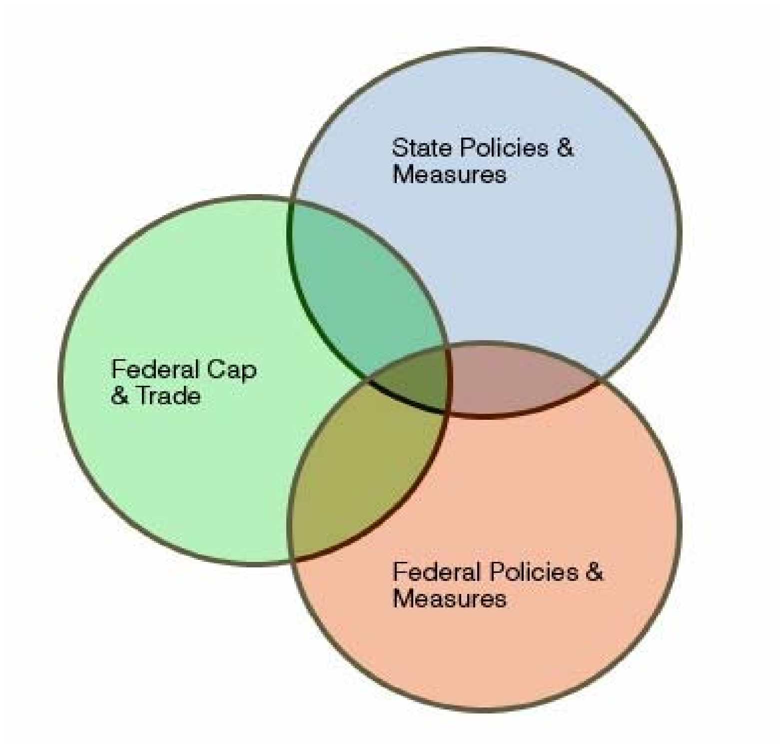
[5] For a broader discussion, see “Developing a Comprehensive Approach to Climate Change Policy in the United States That Fully Integrates Levels of Government and Economic Sectors,” By: Thomas D. Peterson, Robert B. McKinstry, Jr., & John C. Dernbach, 26 VA Envtl L. J. 219 (2008)

Within this policy architecture, the role of the Clean Air Act is critical given its history and the landmark Supreme Court Case of Massachusetts versus EPA.[6] Now in its third generation, and regarded as one of the nation's most successful environmental laws, some experts see a comprehensive application of the current Clean Air Act for GHG controls as the best way forward; others advise targeted modifications; and some favor broadly amending the law for climate change purposes.[7] Based on past experience, the Clean Air Act could serve as a bridge over time from current to new policy mechanisms, and between the federal government, states and localities through existing (or modified) mechanisms that encourage partnership between all levels of government and cost effective actions in all economic sectors.

Figure 7. Comprehensive Climate Policy Integration



Conclusion

State action on climate change, through a wide variety of proven sector-based actions, is well underway and making important contributions to GHG reductions, energy savings, and economic stimulus. State climate action plans demonstrate the

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[6] Final comments to the EPA's Advanced Notice of Proposed Rulemaking are due on November 28, 2008.

[7] See the article *Clean Air Jump-Start* provided in the appendix for a fuller discussion of the subject.

potential benefits of immediate expansion of these actions as a part of a longer-term comprehensive national solution to GHG reduction in the U.S.

Since the success of so many national policy solutions is likely to depend upon state and local as well as federal implementation, federal climate policy is likely to work best when built upon a foundation of effective state-federal partnership. The success of state climate action plans also point to the critical need to integrate a combination of policy instruments in order to achieve the lowest cost and highest value national approach to emissions reduction.

State actions provide a critical head start for national policy that can work economically and in full integration with a national cap and trade program, with other federal policies and measures, and within the framework of the Clean Air Act.

The severe economic downturn is resetting national priorities and suggests that economic recovery is first and most immediate pathway for national climate action. As the Florida Action Team recently determined, and as data from 19 other states suggests, there may be a large opportunity to design and deploy climate change policy as an economic stimulus.

Appendix I

Development of State and National Marginal Cost Curves for GHG Mitigation

The following attachment provides a detailed explanation of how the marginal cost curve on page 3 of this white paper was derived.

Table 1 below provides the list of policy options that were part of the analysis. Also provided is a summary of key assumptions and uncertainties, as well as links to data sources, to permit independent corroboration of the findings presented in this white paper.

DEVELOPMENT OF STATE AND NATIONAL MARGINAL COST CURVES FOR GHG MITIGATION

Dan Wei and Adam Rose

November 14, 2008

1. Developing Marginal Cost Curves for States with Climate Change Action Plans

Thirty states have developed or are developing Climate Change Action Plans. The Action Plans of twenty states (Arkansas, Arizona, California, Colorado, Connecticut, Florida, Iowa, Maine, Maryland, Michigan, Minnesota, Montana, North Carolina, New Mexico, New York, Rhode Island, South Carolina, Utah, Vermont, and Washington) provide information on both the reduction potential and net costs (or savings) of GHG mitigation options. In each state, a list of specific policy actions and agreements has been developed (typically 50 per state) and agreed to by participants of the planning process (an appointed group of stakeholders and technical work group members working with professional facilitation and technical support.) Most of these climate mitigation actions have been quantified through a rigorous, iterative technical consensus building process.

To build a marginal cost curve of climate mitigation actions in all states and sectors, a number of steps are required. First, the following data is developed and summarized for each of the quantified climate mitigation options in the climate action plans for early and mid term target years in each of these twenty states:

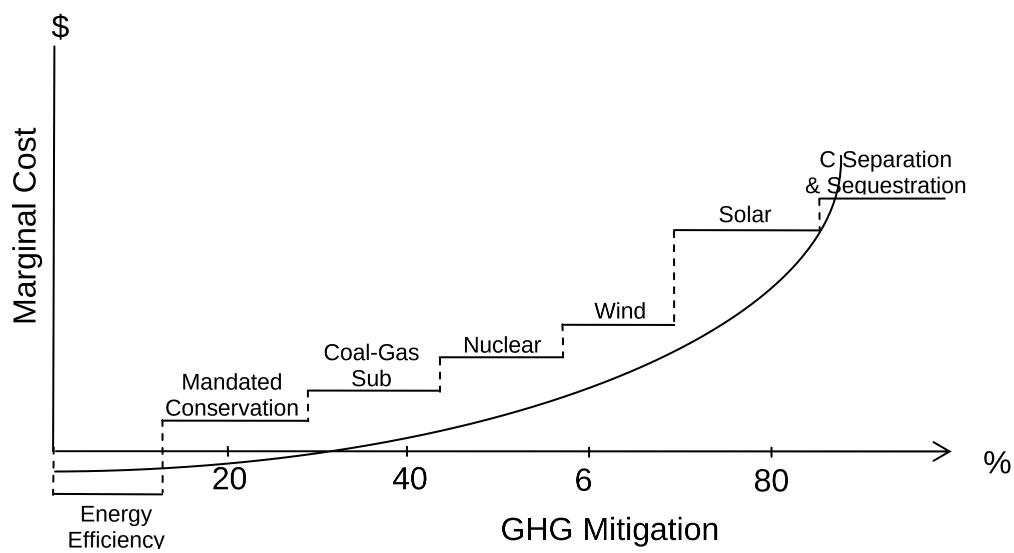
1. The GHG reduction potential of the mitigation option (maximum percentage of total emissions that can be reduced by the option)

2. The cost (or cost-saving) per ton of GHG that can be reduced (specified in terms of cost-effectiveness)

For each state, the full list of climate mitigation policy actions are then ordered from lowest cost to highest cost. A step function is developed based on the mitigation potential and cost per ton of GHG reduction for each policy option. This marginal cost curve of GHG emissions reductions can be used for direct assessments of cost effectiveness of individual or cumulative actions, as done in the state climate action plans. In addition, a stylized step function is presented in Figure 1: a smooth curve is fitted to the step function using regression methods. The fitted curve can be used as the marginal cost curve for formally modeling scenarios of state level policy instrument design, including a variety of policies and measures, cap and trade, carbon tax, or some combination.

Using Florida as an example, Table 1 summarizes 28 climate mitigation options analyzed in a quantitative manner for the state by the Center for Climate Strategies (CCS) through the technical work group process. Column 3 of the table presents the estimated 2025 annual GHG reduction potential for each option, with reduction potentials translated into percentages of the 2025 BAU emissions level in Column 5. The estimated cost or cost saving per ton of GHG removed by each option in 2025 is presented in Column 4. The options are listed in ascending order in terms of cost, beginning with the cheapest option. Column 6 lists the cumulative GHG reduction potentials of the policy options listed in the table. The last column presents the proportion of GHG mitigation contributed by each option.

Apx. I-Figure 1. Stylized Marginal Costs of GHG Mitigation (Curve)



Apx.I-Table 1. GHG Mitigation Options for Florida in 2025

Sector	Climate Mitigation Actions	Estimated 2025 Annual GHG Reduction Potential (MMtCO2e)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2025 Baseline Emissions	Cumulative GHG Reduction Potential	Weights (add-up to 100)
TLU	FL: Develop and Expand Low-GHG Fuels	12.62	-$142.00	2.72%	2.72%	5.83
TLU	FL: Low Rolling Resistance Tires and Other Add-On Technologies	1.84	-$90.00	0.40%	3.12%	0.85
TLU	FL: Improving Transportation System Management (TSM)	6.98	-$80.00	1.51%	4.63%	3.22
AFW	FL: Improved Commercialization of Biomass-to-Energy Conversion and Bio-Products Technologies--C. Bio-Products Technologies and Use	0.3	-$62.00	0.06%	4.69%	0.14

ESD	FL: Demand-Side Management (DSM)/Energy Efficiency Programs, Funds, or Goals for Electricity	21.8	-$43.00	4.71%	9.40%	10.06
ESD	FL: Building Codes for Energy Efficiency (HB 697 and Executive Order 127)	15.4	-$30.00	3.32%	12.72%	7.11
ESD	FL: Promoting Renewable Electricity through Renewable Portfolio Standard (RPS), incentives and barrier removal (20% by 2020)	34.5	-$29.00	7.45%	20.17%	15.93
ESD	FL: Energy Efficiency in Existing Residential Buildings	5.4	-$28.00	1.17%	21.34%	2.49
ESD	FL: Improved Building Codes for Energy Efficiency	4.9	-$27.00	1.06%	22.39%	2.26
AFW	FL: Improved Commercialization of Biomass-to-Energy Conversion and Bio-Products Technologies--A. Manure Digestion/Other Waste Energy Utilization	0.09	-$17.00	0.02%	22.41%	0.04
ESD	FL: Power Plant Efficiency Improvements	8.9	-$14.00	1.92%	24.33%	4.11
AFW	FL: Promotion of Farming Practices That Achieve GHG Benefits--A. Soil Carbon Management	0.9	-$9.00	0.19%	24.53%	0.42
AFW	FL: In-State Liquid/Gaseous Biofuels Production	8.2	-$8.00	1.77%	26.30%	3.79
ESD	FL: Landfill Gas-To-Energy (LFGTE)	8.7	$1.00	1.88%	28.18%	4.02
TLU	FL: Increasing Freight Movement Efficiencies	1.1	$2.00	0.24%	28.41%	0.51
AFW	FL: Afforestation	3.1	$4.90	0.67%	29.08%	1.43
ESD	FL: Combined Heat and Power (CHP) Systems	2.2	$5.00	0.47%	29.56%	1.02
AFW	FL: Reforestation	11.6	$5.30	2.50%	32.06%	5.35
AFW	FL: Promotion of Advanced Municipal Solid Waste (MSW) Management Technologies (Including Bioreactor Technology)	4.4	$9.00	0.95%	33.01%	2.03
AFW	FL: B. Urban Forestry	8.7	$10.00	1.88%	34.89%	4.02
AFW	FL: A. Pine Plantation Management	0.9	$11.00	0.19%	35.08%	0.42
AFW	FL: B. Non-Federal Public Land Management	0.4	$11.00	0.09%	35.17%	0.18
AFW	FL: Expanded Use of Agriculture, Forestry, and Waste Management (AFW) Biomass Feedstocks for Electricity, Heat, and Steam Production	40	$21.00	8.63%	43.80%	18.46
AFW	FL: Forest Retention—Reduced Conversion of Forested to Non-Forested Land Uses	0.6	$26.00	0.13%	43.93%	0.28
AFW	FL: Promotion of Farming Practices That Achieve GHG Benefits--C. Nutrient Management	0.3	$26.00	0.06%	44.00%	0.14

ESD	FL: Nuclear Power	7.3	$36.00	1.58%	45.57%	3.37
AFW	FL: Improved Commercialization of Biomass-to-Energy Conversion and Bio-Products Technologies-- B. WWTP Biosolids Energy Production & Other Biomass Conversion Technologies	5	$44.00	1.08%	46.65%	2.31
AFW	FL: Reduce the Rate of Conversion of Agricultural Land and Open Green Space to Development	0.5	$93.00	0.11%	46.76%	0.23

AFW=agriculture, forestry and waste management; ESD=energy supply and demand; TLU=transportation and land use

[1] Florida 2025 projected consumption-based gross GHG emission level is 463.3 million metric tons of carbon dioxide equivalent (MMtCO2e).

Based on the data presented in Table 1, the stepwise marginal cost function for Florida in 2025 is drawn in Figure 2. 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.

In this example, the step function is color-coded for three different sectors (ESD: Energy Supply and Demand; TLU: Transportation and Land Use; AFW: Agriculture, Forestry, and Waste Management). The figure indicates that, collectively, the reduction potential of the 28 options from all these sectors can avoid about 47% of 2025 baseline emissions in Florida. The ESD sector has the highest reduction potential. On average, options in the AFW sector have the highest costs per ton, while most options in the TLU and ESD sectors would result in cost savings.

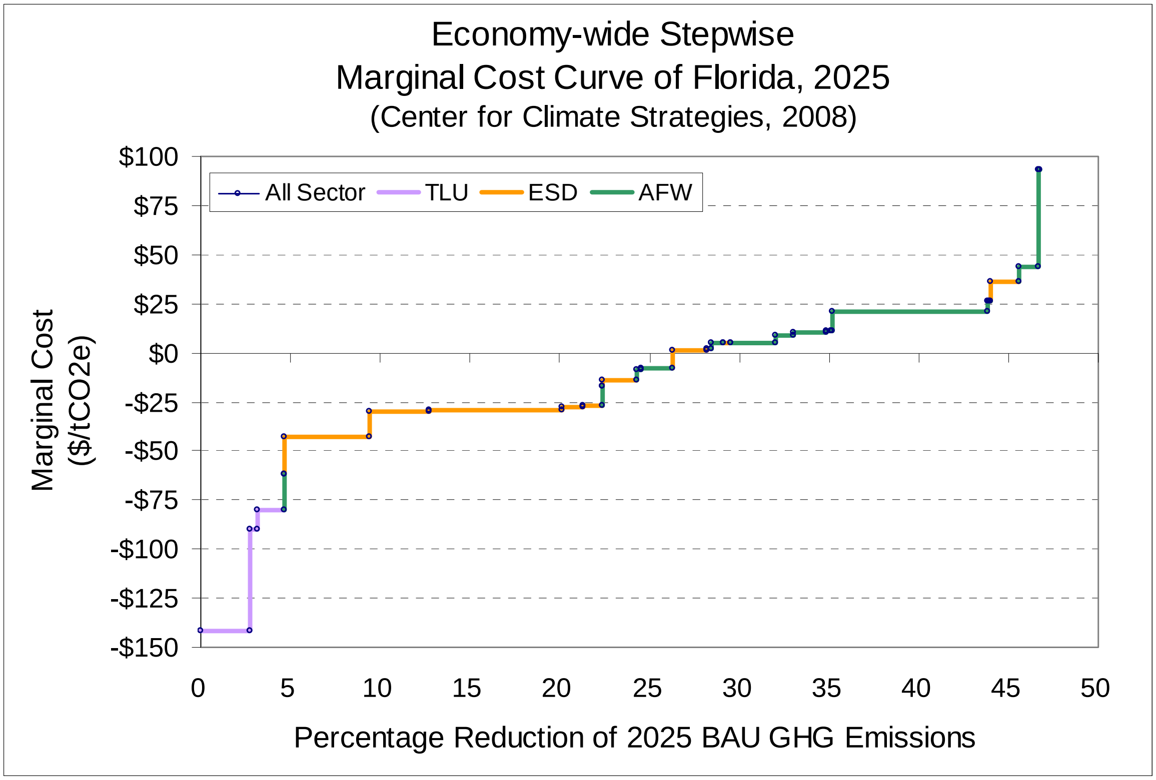
One possible specification of a marginal cost (MC) curve for Florida is the following functional form:

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

where, *MC* is the marginal cost; *R* is the percentage reduction of GHG emissions; *a* and *b* are intercept and slope parameter values, respectively.

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

Apx. I-Figure 2. Stepwise Marginal Cost Function for Florida, 2025



AFW=agriculture, forestry and waste management, ESD=energy supply and demand, TLU=transportation and land use

When we fit the curve, we weight each policy option based on its GHG mitigation potential. This gives relatively greater influence to those options that have the potential for higher levels of application, and thereby should improve the accuracy of the estimation.

The logarithmic marginal cost curve for Florida (the pink curve) depicted in Figure 3 has the following specification:

$$MC = -78.43 - 195.14 \times \ln(1 - R)$$

The curve has a Y-axis intercept at MC = -$78.43. The curve increases to MC=0 at the emission reduction level of 33%, which indicates that Florida has cost-saving mitigation options (such as energy efficiency) up to that level of the 2025 BAU emissions. The regression analysis that estimates the fitted curve has an R-square of 0.7649, indicating a reasonably good fit.

An alternative specification of the step-function is to use a third-order polynomial functional form. This alternative fitted curve is also depicted in Figure 3 (the green curve).

The third order polynomial cost curve for Florida has the following specification:

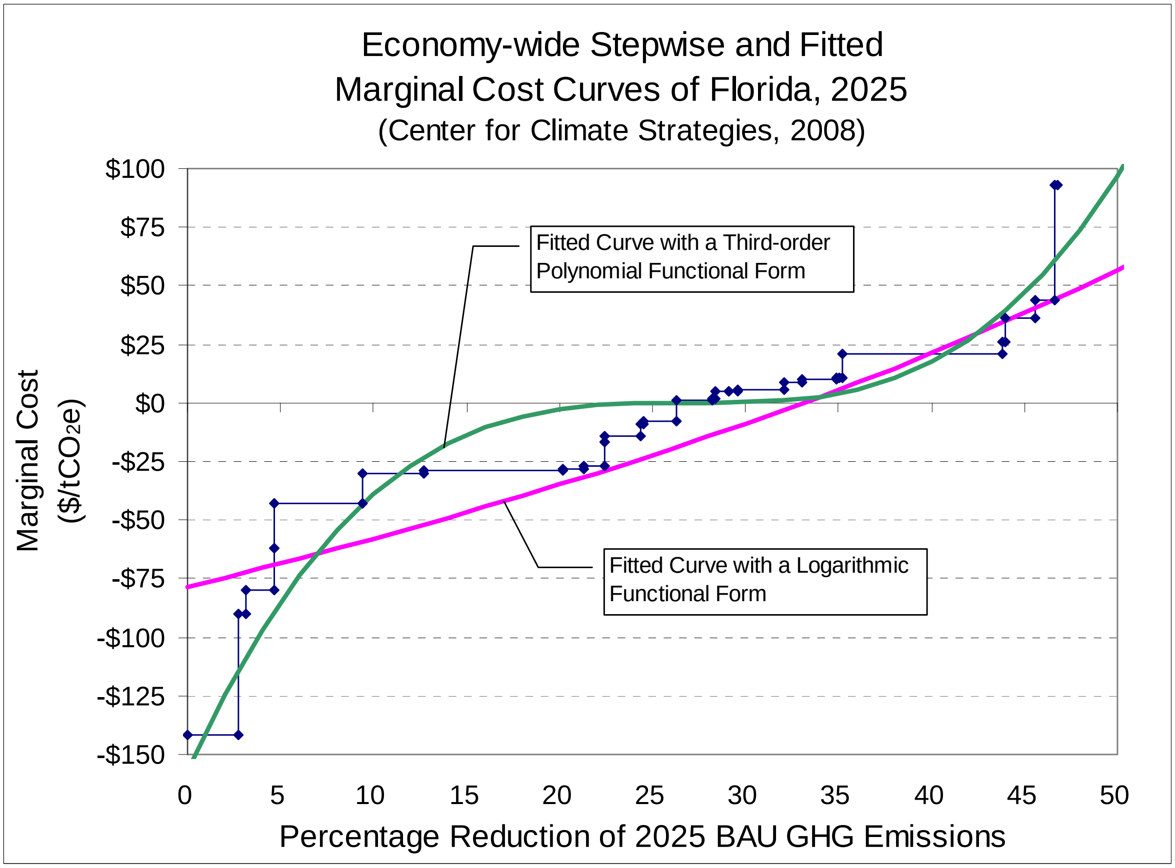
$$MC = 0.00796 \times (R - 27)^3$$

This fitted curve has a Y-axis intercept at MC = -$156.72. The curve increases to MC=0 at the emission reduction level of 27%. The regression analysis that estimates this fitted curve also has a good fit, with an R-square of 0.8639. .

Either fitted MC curve then can be used in our non-linear programming model of policy instrument design, which has been applied to the analysis of cap and trade, carbon tax, and/or regulatory (command and control) responses to the Kyoto Protocol, European Union Trading System, Regional Greenhouse Gas Initiative (RGGI), Midwestern Governors Association (MGA) region, Western Climate Initiative (WCI), Pacific Rim states and countries, and Florida's choice of joining RGGI or WCI (see Rose et al., 1998; Rose and Zhang, 2004; MCCGA, 2008; Rose and Wei, 2008; FL Action Team, 2008).

The stepwise and fitted marginal cost curves developed for Florida for the year 2025 are show in Apx. I - Figure 3 on the next page.

Apx. I-Figure 3. Stepwise and Fitted Marginal Cost Curves for Florida, 2025



BAU=business as usual (no new actions to address climate) $/tCO2e= cost per ton carbon dioxide equivalent

2. Developing National Marginal Cost (MC) Curves

We developed the GHG mitigation marginal cost curve for the US based on the mitigation and cost data of the 20 states as indicated above. The GHG mitigation (sequestration) options for the twenty states are put together and then classified into the four sectors (ES, RCI, TLU, and AFW).

Note that the mitigation options for Arkansas, Florida, Michigan, and Minnesota are analyzed for Year 2025, and the options for Vermont are for Year 2028. The data for the remaining states is for Year 2020. For the national curves, we used Year 2020 as the standard year. In order to approximate 2020 MC curves for the states that have performed quantification analysis for target years other than 2020, we assumed a 2% technical improvement or innovation rate for these states. Our method is to shift the step function of AR, FL, MI, and MN 2% a year upward from 2025 back to 2020, and shift the step function of VT 2% a year upward from 2028 back to 2020.

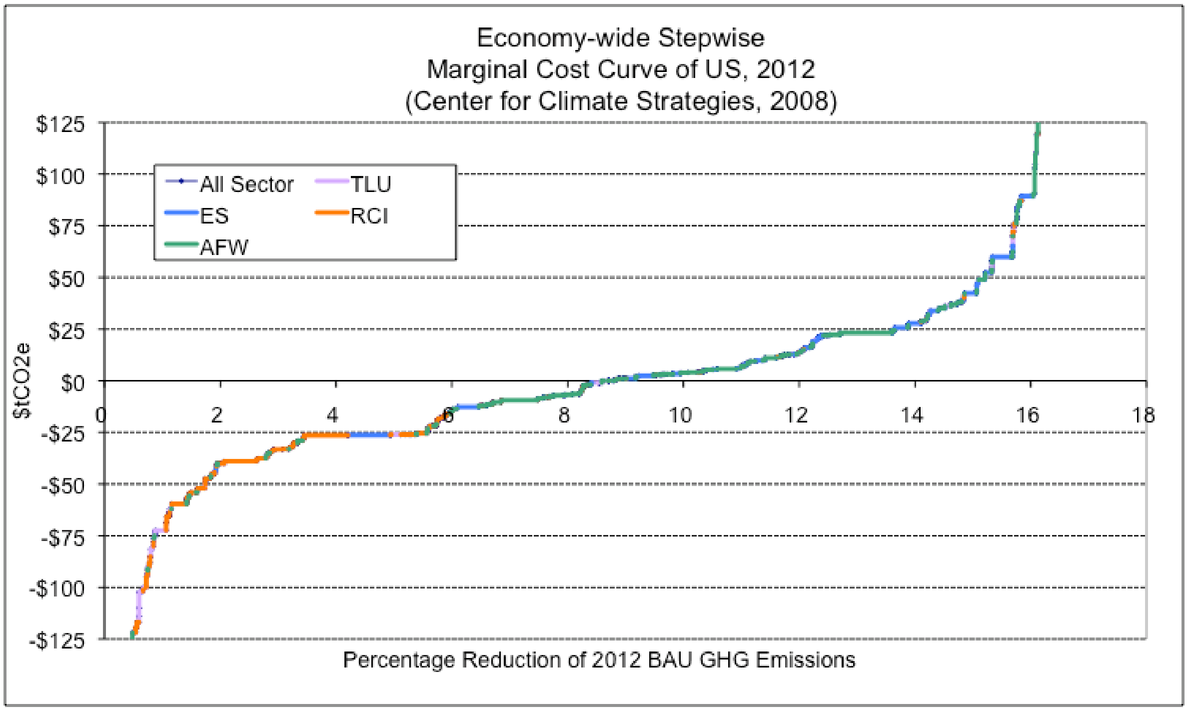
Next, the national MC step function is developed using the same methodology as described in Section 1. Figure 4 shows the stepwise marginal cost curve of the US for year 2020. Each horizontal segment in Figure 4 represents an individual policy option from a state. Although many similar policy options (such as Renewable

Portfolio Standard and Clean Car Standard) are recommended in more than one state Action Plans, since different state would have different implementation cost associated with these policies, we did not combine the same policy options implemented in different states together. The reduction potential of each policy option (as shown along the horizontal axis in Figure 4) is computed with respect to the total emissions of the twenty states in year 2020. Since the national curve is developed from the data collected from the twenty states, it can be viewed as the weighted average curve of these states.

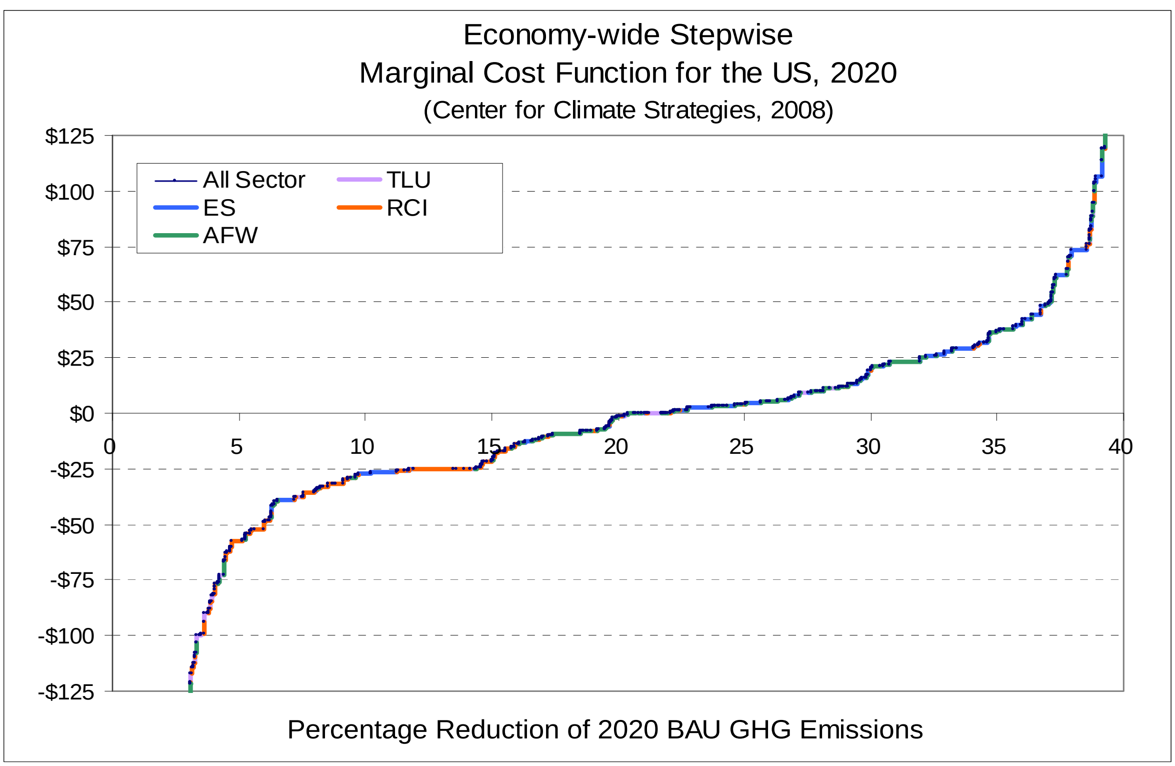
3. Summary of Key Assumptions:

- The state curves for AZ, CA, CO, CT, IA, MD, ME, MT, NC, NM, NY, RI, SC, UT, and WA are for year 2020. The curve for AR, FL, MI, and MN is for 2025, and the curve for VT is for 2028.
- UT only has data for energy efficiency options in RCI and TLU sectors. So the cost curve for UT is partial.
- The standard year we used for national curves is 2020. The mitigation cost data for options of AR, FL, MI, MN, and VT are adjusted to year 2020 based on the assumption of 2% annual technical improvement or innovation rate. In other words, we used the same reduction potential numbers for individual options in year 2020 as in year 2025 (2028), and assumed the cost per ton of CO_2e reduction being about $(1+2\%)^n$ (n=5 for AR, FL, MI, and MN and n=8 for VT) higher in year 2020 than in year 2025 (2028).
- Some policy options are analyzed for different sensitivity cases or the per unit mitigation costs are presented in cost ranges. In such cases, we used average numbers in the cost curve development.
- The stepwise marginal cost weighted cost function for the United States in the year 2020 is shown in Apx. I- Figure 4 on the next page.

Apx. I-Figure 4. Stepwise Marginal Cost Function for the US, 2012



Apx. I-Figure 5. Stepwise Marginal Cost Function for the US, 2020



AFW=agriculture, forestry and waste management, ES=energy supply, RCI=residential commercial and industrial; TLU=transportation and land use

- When we developed the fitted MC curves from the step MC step functions, each policy option is weighted based on its GHG mitigation potential. This gives relatively greater influence to those options that have the potential for higher levels of application and should improve the accuracy of the estimation.
- The marginal cost curves embody direct mitigation costs only and do not include various transactions costs.
- The marginal cost curves do not distinguish between producer vs. consumer allocation of permits.

4. Summary of Key Uncertainties:

- In the state Climate Change Action Plan, some policy options are only analyzed in a qualitative way, i.e., no quantified GHG reductions or mitigation costs/cost savings or both have been evaluated. When we develop the state and national cost curves, we only utilized the list of options that have both the reduction and cost data available. Potentially, this would result in an underestimation of the total mitigation potential of all applicable GHG mitigation options.
- The national economy-wide and sectoral curves are now developed based on the options of the twenty states that have reduction and cost data. This method approximates the national curves as the weighted average ones of the twenty states. We consider these 20 states a fairly good representation of the U.S. in terms of the proportions of GHG emissions contributed by different sectors and the coverage of regions.[8] The accuracy of the national curve can be improved as more state data become available.
- For most states, the step function orders individual options (that have quantified cost/savings) from lowest cost to highest, without taking account of overlaps among options. We are only able to eliminate the overlaps among options for AR, CA, IA, and MI. Without the adjustment of overlaps in the cases of the other states would result in an overestimation of the mitigation potential. Some states have evaluations of aggregated overlaps at the sectoral level. In the next stage, we need to decide how to translate the overlaps at the sectoral level to the level of individual options, and scale back the reduction potentials of these options.

[8] The proportions of the 2020 projected emissions from the ES, RCI, AFW, and TLU sectors of the 20 states are 34.3%, 24.4%, 8.4%, and 32.9%, respectively. Based on the U.S. 2006 emissions inventory, the corresponding proportions are 38.7%, 25.1%, 9.5%, and 26.8%. Therefore, if we assume the emission proportions are the same in 2020 for the U.S. as in 2006, the 20 states only slightly under-represent the emissions from the energy supply sector, and slightly over-represent the emissions from the transportation and land use sector.

5. Data Sources:

Arkansas Governor's Commission on Global Warming. *Final GCGW Report*. Forthcoming, http://www.arclimatechange.us/stakeholder.cfm.

Arizona Climate Change Advisory Group. 2006. *Climate Change Action Plan*. http://www.azclimatechange.gov/.

California Air Resources Board. 2008. *Climate Change Draft Scoping Plan: a Framework for Change*. http://www.arb.ca.gov/cc/scopingplan/document/draftscopingplan.htm.

Colorado Climate Action Panel. 2007. *Colorado Climate Action Panel Final Report*. http://www.coloradoclimate.org/Climate_Action_Panel.cfm.

Connecticut Governor's Steering Committee on Climate Change. 2005. *2005 CT Climate Change Action Plan*. http://www.ctclimatechange.com/StateActionPlan.html.

Florida Governor's Action Team on Energy and Climate Change. 2008. *Florida's Energy and Climate Change Action Plan*. http://www.flclimatechange.us/stakeholder.cfm.

Iowa Climate Change Advisory Council. 2008. *Draft Policy Option Descriptions*. http://www.iaclimatechange.us/capag.cfm.

Maine Department of Environmental Protection. 2004. *Final Maine Climate Action Plan 2004*. http://www.maine.gov/dep/air/greenhouse/.

Maryland Commission on Climate Change. 2008. *Climate Action Plan*. http://www.mde.state.md.us/Air/climatechange/index.asp.

Michigan Climate Action Council. 2008. *Draft Policy Option Descriptions*. http://www.miclimatechange.us/stakeholder.cfm.

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

Montana Climate Change Advisory Committee. 2007. *Montana Climate Change Action Plan*. http://www.mtclimatechange.us/CCAC.cfm.

North Carolina Climate Action Plan Advisory Group. 2008. *Recommended Mitigation Options for Controlling Greenhouse Gas Emissions*. http://www.ncclimatechange.us/capag.cfm.

New Mexico Climate Change Advisory Group. 2006. *NM Climate Change Action Plan*. http://www.nmclimatechange.us/.

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

Rhode Island Greenhouse Gas Process. 2002. *Rhode Island Greenhouse Gas Action Plan*. http://righg.raabassociates.org/.

South Carolina Climate, Energy and Commerce Committee. 2008. *South Carolina CECAC Final Report*. http://www.scclimatechange.us/plenarygroup.cfm.

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

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

Washington Climate Advisory Team. *Leading the Way: A Comprehensive Approach to Reducing Greenhouse Gases in Washington State*. http://www.ecy.wa.gov/climatechange/cat_meetings.htm.

6. References:

Florida Governor's Action Team on Energy and Climate Change. 2008. *Florida's Energy and Climate Change Action Plan*. http://www.flclimatechange.us/stakeholder.cfm.

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

Nordhaus, W.D. 1994. *Managing the Global Commons*. Cambridge, MA: MIT Press.

Rose, A. and Wei, D. 2008. "Greenhouse Gas Emissions Trading among Pacific Rim Countries: An Analysis of Policies to Bring Developing Countries to the Bargaining Table," *Energy Policy* 36(4): 1420-9.

Rose, A. and Zhang, Z.X. 2004. "Interregional Burden-Sharing of Greenhouse Gas Mitigation in the United States," *Mitigation and Adaptation Strategies for Global Change* 9(3): 477-500.

Rose, A., Stevens, B. K., Edmonds, J., and Wise, M. 1998. "International Equity and Differentiation in Global Warming Policy," *Environmental and Resource Economics* 12(1): 25-51.

Appendix II

Selected Climate Change Policy Development References

Federal Climate Change Legislation as If the States Matter, By: Robert B. McKinstry, Jr., John C. Dernbach, & Thomas D. Peterson, 22 Natural Res. & Envt., *No. 3, p. 3 (Winter 2008).*

Developing a Comprehensive Approach to Climate Change Policy in the United States That Fully Integrates Levels of Government and Economic Sectors, By: Thomas D. Peterson, Robert B. McKinstry, Jr., & John C. Dernbach, 26 VA Envtl L.J. 219 (2008)

The Implications of the New "Old" Federalism in Climate-Change Legislation: How to Function in a Global Marketplace When States Take the Lead, By: Robert B. McKinstry, Jr. & Thomas D. Peterson, 20 Pac. McGeorge Global Bus. & Dev. L.J. 61 (2007).

The Evolution of State Climate Change Policy in the United States: Lessons Learned and New Directions, By: Thomas D. Peterson, 14 Widener L. J. 81 (2004)

Reducing Conflicts Between Climate Policy and Energy Policy in the U.S.: The Important Role of the States, By: Thomas D. Peterson and Adam Z. Rose. Center for Integrated Regional Assessment, The Pennsylvania State University, Energy Policy 34 (2006) 619–631.

Integrating State and Federal Action in National Climate Policy: A Case for Partnership, By: CCS President Thomas D. Peterson and Robert B. McKinstry (April 2008)

Governors on the March, By Ken Colburn, Michael Northrop and David Sassoon, in Environmental Finance June 2008

Economic Impacts Of Energy Policies In Arizona 2006-2020, By: Adam Rose and Dan Wei, (November 2008).