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Macroeconomic impacts of the Florida Energy and Climate Change Action Plan

ADAM ROSE*, DAN WEI

School of Policy, Planning, and Development, University of Southern California, 650 Childs Way, Los Angeles, CA 90089, USA

The impacts of the Florida Energy and Climate Change Action Plan on the state's economy are analysed. The plan contains 50 policy recommendations developed through a stakeholder-driven, consensus-based process. The analysis carefully links each greenhouse gas mitigation/sequestration option to the workings of the Florida economy with the use of the Regional Economic Models, Inc. (REMI) Policy Insight model. The results indicate that most of the recommended options individually have positive impacts on the state's economy. When combined, the plan's recommendations would, on a net present value basis, increase the gross state product (GSP) by about $37.9 billion and increase employment by 148,000 full-time equivalent jobs by 2025. The Florida Renewable Portfolio Standard contributes the highest GSP gains, or nearly 50% of the total. The economic gains arise primarily from the ability of mitigation options to both lower the cost of production and increase consumer purchasing power. The results also stem from the stimulus of increased investment in plant and equipment. Sensitivity analyses of key assumptions and parameters indicate that the results are robust.

Keywords: climate action plan; energy efficiency; macroeconomic impacts; renewable portfolio standard

L'impact du plan d'action de la Floride sur l'énergie et le changement climatique sur l'économie nationale est analysé. Le plan contient 50 recommandations élaborées par un processus axé sur les parties prenantes et fondé sur le consensus. L'analyse lie soigneusement chaque option d'atténuation des gaz à effet de serre ou de séquestration par rapport au fonctionnement de l'économie de la Floride par le modèle d'aperçu politique REMI. Les résultats indiquent que la majorité des options recommandées ont individuellement un effet positif sur l'économie de l'État. Dans leur ensemble, les recommandations du Plan causeraient, en terme de valeur actuelle nette, une augmentation du Produit d'Etat Brut (*Gross State Product*, GSP) d'environ $37.9 milliards et une augmentation de 148,000 emplois à temps plein équivalents d'ici 2025. Le système de quotas d'énergies renouvelables de la Floride (*Florida Renewable Portfolio Standard*, FRP) contribue le plus de profit au GSP, soit près de 50% du total. Les gains économiques proviennent essentiellement de la capacité des options d'atténuation à réduire les coûts de production tout en augmentant le pouvoir d'achat des consommateurs. Les résultats proviennent également de l'effet de la relance de l'investissement dans les centrales et leur équipement. Les analyses de sensibilité des hypothèses et paramètres principaux dénotent des résultats robustes.

Mots clés : efficacité énergétique; impacts macroéconomiques; plan d'action sur le climat; quotas d'énergies renouvelables

1. Introduction

The Florida Energy and Climate Change Action Plan (FECCAP), introduced in 2001, addresses a critical issue for citizens of the state by designing policies and measures to mitigate emissions of greenhouse gases (GHGs). The implementation of technical and behavioural mitigation options requires changes both in the way businesses and government operate and in the way households and visitors conduct their daily lives. FECCAP, in part, seeks to reduce potentially negative economic impacts

*Corresponding author. *E-mail*: adamzros@sppd.usc.edu

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caused by climate change and has identified a number of mitigation options that result in net cost savings. For example, many electricity demand-side management (DSM) practices translate into a reduction in the electricity requirements for producing a given outcome (such as running an assembly line or cooling a home), that is, an energy efficiency improvement.

All the cost estimates for mitigation options in FECCAP apply only to the site of their application, and are termed 'local economic impacts'. (It is beyond the scope of FECCAP to evaluate broader economic impacts, often referred to as 'regional macroeconomic impacts'.) The mitigation options include the ripple effects of decreased or increased spending on mitigation, and the interaction of demand and supply in various markets. For example, a reduction in consumer demand for electricity reduces the demand for generation from all sources, including fossil energy and renewables. However, most reductions in coal and natural gas occur in other states. At the same time, businesses and households who have reduced electricity bills have more money to spend on other goods and services. If households purchase more food or clothing, the production of these goods within the state is stimulated, at least in part. Food processing and clothing manufacturers, in turn, purchase more raw materials and hire more employees. More raw material suppliers then purchase more of the inputs they need, and the additional employees in all these firms in the supply chain purchase more goods and services from their wages and salaries. The sum total of these 'indirect' impacts is some multiple of the original, direct, on-site impact. This is often referred to as 'the multiplier effect', a key aspect of macroeconomic impacts. It applies to both increases and decreases in economic activity and can be further stimulated by price decreases and muted by price increases. The extent of both the many types of linkages in the economy and macroeconomic impacts is extensive and cannot be traced by a simple set of calculations. It requires the use of a sophisticated model that reflects the major structural features of an economy, the workings of its markets and the interactions between them.

The purpose of this article is to evaluate the macroeconomic impacts of FECCAP on Florida's economy. In this study, we used the Regional Economic Models, Inc. (REMI) Policy Insight model (REMI, 2007), the most widely used state-level economic modelling software package in the US.[1] The Florida version of the REMI model was applied to the estimation of the macroeconomic impacts of the major GHG mitigation options on output, income, employment and prices in the state for the years 2008–2025. The application involves the most extensive analysis to date of the linkages between individual mitigation options and the workings of the state economy. It is also based on mitigation data carefully estimated by Technical Working Groups (TWGs) through an extensive stakeholder process.[2] This study therefore makes a useful contribution to the evaluation of detailed mitigation options in a macroeconomic context by combining 'top-down' and 'bottom-up' approaches to assessing mitigation costs at the US state level.

Our results indicate that the net macroeconomic impacts on the Florida economy will be significantly positive. Although many mitigation activities incur costs – as when the cost of production is increased by the need to purchase new equipment – these are more than offset by both shifts in spending out of energy savings and the stimulus of business in the state that produces the necessary equipment.

The analysis below is based on the best estimation of the cost and savings of various mitigation options. However, these costs/savings, and some conditions relating to the implementation of these options, are not known with full certainty. Examples include the net cost, or cost savings of the options themselves, and the extent to which investment in new equipment will simply displace investment in other equipment in the state or will attract new capital from elsewhere. Accordingly, a sensitivity analysis was performed to investigate these alternative conditions.

This article is divided into six sections. Section 2 summarizes the workings of the REMI model. Section 3 presents an overview of how we translate technical analysis of mitigation options into

REMI simulation policy variables, as well as how the data are further refined and linked to key structural and policy variables in the model. Section 4 summarizes the set-up and process of policy simulation in REMI, and Section 5 presents the simulation results, including a sensitivity analysis and interpretation of results. Section 6 provides a summary and some policy implications.

2. REMI model analysis

Several modelling approaches can be used to estimate the total regional economic impact of environmental policy, including both direct (i.e. on-site) effects and various types of indirect (i.e. off-site) effects. These approaches include input–output (I–O), computable general equilibrium (CGE), mathematical programming and macroeconometric models. Each has its own strengths and weaknesses.

The choice of which model to use depends on the purpose of the analysis and various options that can be considered as performance criteria (e.g. accuracy, transparency, manageability and costs). After a careful consideration of these criteria, we chose to use a form of econometric model known as the REMI Policy Insight model (REMI, 2007). The REMI model is superior to all the others in terms of its forecasting ability, and is comparable to CGE models in terms of analytical power and accuracy. The availability of this model to the State of Florida made it (together with an I–O model) the least costly. With a careful explanation of the model, its application and its results, it can be made as transparent as any of the others.[3]

The REMI model has evolved over 30 years (e.g. Treyz, 1993). Although it is a 'packaged' programme, it is built with data that are region specific. Government agencies in practically every state in the US have used a REMI model for a variety of purposes, including evaluating the impacts of a change in tax rates, the exit or entry of major businesses, in particular, or economic programmes, in general, and, more recently, the impacts of energy and/or environmental policy actions.

A summary of the major features of the REMI model is provided here (see Appendix A in the supplementary online file for a more detailed discussion). A macroeconometric forecasting model covers the entire economy, typically in a top-down manner, based on macroeconomic aggregate relationships such as consumption and investment. Although the REMI model includes these key relationships, it differs because it is based on a more bottom-up approach. In fact, it makes use of the finely grained sectoring detail of an I–O model; that is, it divides the economy into at least 70 sectors, thereby enabling the capture of important differentials between them. This is particularly important in a context like the FECCAP, where various options are fine-tuned to a given sector or where they directly affect several sectors somewhat differently.

The macroeconomic character of the model enables the analysis of interactions between sectors (e.g. ordinary multiplier effects), but with some refinement for price changes not found in I–O models. In other words, the REMI model incorporates the responses of producers and consumers to price signals in the simulation. In contrast, in a basic I–O model, a change in prices is not readily taken into account. More specifically, a basic I–O model separates the determinants of quantity and prices; that is, price changes will not generate any substitution effects in an I–O analysis. The REMI model is capable of capturing this and other price–quantity interactions.[4] The REMI model also brings into play features of labour and capital markets, as well as trade with other states or countries, including changes in competitiveness.

The econometric feature of the REMI model is based on an inferential statistical estimation of key parameters based on time-series (i.e. historical) data for Florida. (The other candidate models use 'calibration' based on a single year's data.) The REMI model thus is, *prima facie*, better able to predict the future course of the economy than the alternative models.[5] The major limitation of the REMI model when compared with other models is that it is pre-packaged and not readily adjustable to any unique features of the case under consideration. Other models, based as they are on fewer data and a less formal estimation procedure, can more readily accommodate data changes in technology that might be inferred, for example, from engineering data. However, our assessment of the REMI model is that these adjustments were not needed for the present analysis.

3. Input data

3.1. Florida Energy and Climate Change Action Plan

The Florida Governor's Action Team on Energy and Climate Change was established at the Florida Summit, 'Serve to Preserve: A Florida Summit on Global Climate Change', hosted by Governor Charlie Crist on 12–13 July 2007. Phase 1 of the planning process was completed on 1 November 2007, with 30 recommendations proposed to reduce GHG emissions in Florida. Phase 2 began in February 2008. The Center for Climate Strategies (CCS) was asked to facilitate and provide technical support for this stakeholder-based, consensus-building process.[6]

Six TWGs were designated by the Action Team: Energy Supply and Demand (ESD), Agriculture, Forestry and Waste Management (AFW), Transport and Land Use (TLU), Adaptation, Cap-and-Trade, and Government Policy and Coordination. The task for each TWG was to identify and provide, in its relevant sector, a technical analysis of potential GHG mitigation, sequestration and offsetting policy options.[7]

The cost of implementing the policy options is estimated in a Delphi-type process (i.e. expert elicitation) by a group of experts comprising a TWG for each of the four sectoral groupings associated with mitigation. Decisions are based on the relevant literature, key assumptions and data collected from Florida governmental agencies. For example, power plant cost data for Florida are obtained from the Florida Public Service Commission, which compiles data submitted by over 20 utility companies in the state. The costs and potential of DSM programmes are largely based on the data presented in an American Council for an Energy Efficient Economy (ACEEE) report on the potential for energy efficiency and renewable energy in Florida (Elliott et al., 2007). The projections of Florida energy prices, which are used to estimate the values of energy savings, are collected from the US Energy Information Administration (EIA) Supplemental Tables to the 2007 *Annual Energy Outlook*. Savings typically include the dollar value of reduced energy consumptions resulting from implementation of the policy options. Co-benefits, such as values of improved air quality, and health and energy security benefits, however, are not included in the quantification. For each individual policy option, the data sources, key assumptions, quantification methodologies and key uncertainties are comprehensively documented in the Appendices of FECCAP (FCAT, 2008).

At the end of the process, 50 policy actions were recommended, of which 28 recommendations were quantified with emissions reduction potentials and associated net costs/cost savings over the period 2008–2025. Table 1 lists the estimated impacts (i.e. reductions and costs/savings) of implementing each of the 28 quantified policy options. In total, the 28 policy options can generate $33.6 billion net cost savings (2005 Net Present Value (NPV)) and reduce 1.9 billion tonnes of carbon dioxide-equivalent (CO_2e) GHG emissions during the 2008–2025 period.

There have been many criticisms of the application of the expert/engineering/stakeholder approach to estimating the cost and potential energy savings that can be achieved from DSM programmes. Many economists challenge the existence of substantial negative-cost energy saving opportunities. Joskow and Marron (1992) examine the costs of electric utility efficiency programmes and argue that the

TABLE 1 Estimated reductions and costs/savings of mitigation/sequestration options

Policy no.	Option	GHG reductions ($MMt CO_2e$)					NPV	Cost
		2017	% of 2017 BAU level (%)	2025	% of 2025 BAU level (%)	Total 2008–2025	2008–2025 ($million)	effectiveness ($/t CO_2e)
ESD-5	Promoting renewable electricity through RPS, incentives and barrier removal (20% by 2020)	17	4.19	34.5	7.45	319	−9,274	−29
ESD-6	Nuclear power	0	0.00	7.3	1.58	49.4	1,782	36
ESD-8	CHP systems	1.8	0.44	2.2	0.47	26.5	126	5
ESD-9	Power plant efficiency improvements	8.4	2.07	8.9	1.92	111.4	−1,541	−14
ESD-11	Landfill gas-to-energy (LFGTE)	3.7	0.91	8.7	1.88	64.7	79	1
ESD-12	DSM/energy efficiency programmes, funds or goals for electricity	13	3.20	21.8	4.71	201.4	−8,566	−43
ESD-13a	Energy efficiency in existing residential buildings	3.4	0.84	5.4	1.17	50.4	−1,432	−28
ESD-14	Building codes for energy efficiency (HB 697 and executive order 127) and improved building codes for energy efficiency	8	1.97	20.3	4.38	146.4	−4,347	−30
TLU-1	Develop and expand low-GHG fuels	6.2	1.53	12.62	2.72	106.41	−15,161	−142
TLU-2	Low rolling resistance tyres and other add-on technologies	0.8	0.20	1.84	0.40	13.99	−1,259	−90
TLU-4	Improving transportation system management (TSM)	3.94	0.97	6.98	1.51	63.91	−5,106	−80
TLU-8	Increasing freight movement efficiencies	0.59	0.15	1.1	0.24	11.52	21	2
AFW-1	Forest retention – reduced conversion of forested to non-forested land uses	0.5	0.12	0.6	0.13	7.2	186	26
AFW-2	Afforestation and restoration of non-forested lands							
	A1. Afforestation	1.6	0.39	3.1	0.67	28	134	5
	A2. Reforestation	6.1	1.50	11.6	2.50	104	555	5
	B. Urban forestry	4.6	1.13	8.7	1.88	78	759	10
AFW-3	Forest management for carbon sequestration							
	A. Pine plantation management	0.5	0.12	0.9	0.19	7.9	84	11
	B. Non-federal public land management	0.3	0.07	0.4	0.09	3.9	41	11
AFW-4	Expanded use of agriculture, forestry and waste management (AFW) biomass feedstocks for electricity, heat and steam production	21	5.17	40	8.63	361	7,432	21
AFW-5	Promotion of farming practices that achieve GHG benefits							
	A. Soil carbon management	0.5	0.12	0.9	0.19	8	−74	−9
	C. Nutrient management	0.2	0.05	0.3	0.06	2.6	68	26

Continued

TABLE 1 Continued

Policy no.	Option	GHG reductions ($MMt\ CO_2e$)					NPV 2008–2025 ($million)	Cost effectiveness ($/t CO_2e)
		2017	% of 2017 BAU level (%)	2025	% of 2025 BAU level (%)	Total 2008–2025		
AFW-6	Reduce the rate of conversion of agricultural land and open green space to development	0.2	0.05	0.5	0.11	4.2	394	93
AFW-7	In-state liquid/gaseous biofuels production	4	0.98	8.2	1.77	68	−532	−8
AFW-8	Promotion of advanced municipal solid waste (MSW) management technologies (including bioreactor technology)	1.9	0.47	4.4	0.95	34	294	9
AFW-9	Improved commercialization of biomass-to-energy conversion and bioproducts technologies							
	A. Manure digestion/other waste energy utilization	0.04	0.01	0.09	0.02	0.8	−13	−17
	B. WWTP biosolids energy production and other biomass conversion technologies	2.4	0.59	5	1.08	42	1,848	44
	C. Bioproducts technologies and use	0.2	0.05	0.3	0.06	2.6	−161	−62
Total[a]		110.9	27.29	216.63	46.76	1917	−33,633	

[a]Without adjusting for overlaps within sectors and among sectors.

cost of electricity savings calculated, based on the programme costs reported by the utilities, significantly underestimates the actual societal cost of conservation. The authors give three reasons for the over-optimistic estimate of cost-saving potentials. First, the utilities may not be able to report all relevant utility costs and customer participation costs. Second, electricity savings are computed based on engineering estimates rather than on measurements of actual reductions in consumption. Third, most of the studies omit the effects of ‘free riders’ (i.e. those utility customers that would have invested in efficiency even in the absence of the DSM programmes).

The CCS analysis of the Florida DSM programme is based on the ACEEE report on energy efficiency and renewable energy potential in Florida (Elliott et al., 2007). The cost of efficiency presented there includes both the utility administration cost and the customer participation cost of energy efficiency programmes. The electricity savings in GWh in each year are computed based on the energy efficiency targets determined through the stakeholder planning process of Florida. Certain costs, such as the transaction costs of customers, and free rider effects are not considered in the analysis, which may lead to an underestimation of the cost. On the other hand, to be conservative, utility generation costs of avoided electricity (i.e. saved electricity through DSM) are used, rather than electricity sales prices to end-users, to compute the electricity savings in dollar values. In addition, any indirect benefits such as avoided future environmental costs and health benefits are not taken into account; that is, they are not part of the cost savings. In general, assessments by economists of the cost savings of energy efficiency have become more optimistic over time (cf. Sweeney, 2008).

3.2. REMI model input development

The quantification analysis of costs/savings undertaken by the TWGs was limited to the direct effects of implementing the policy options. For example, the direct costs of an energy efficiency option include the ratepayer's payment for the programme and the energy customer's expenditure on energy efficiency equipment and devices. The direct benefits of this policy option include savings on the energy bills of customers.

All the analyses of the TWGs pertain to the direct (microeconomic or partial equilibrium) effects of policy implementation. It is beyond the scope of the TWGs to perform broader economic impacts analyses, which are often referred to as 'macroeconomic' and 'general equilibrium' impacts. To supplement the formal analysis of the Florida Action Team, the REMI model was selected to evaluate the macroeconomic impacts (such as gross state product (GSP), employment and personal income) of various GHG emissions reduction strategies. For this study, the Florida REMI model is based on US and Florida historical data throughout 2006.

Before undertaking any economic simulations, the key quantification results for each policy option conducted by the TWGs are translated to model inputs that can be utilized in the model itself. This step involves the selection of appropriate policy levers in the REMI model to simulate the policy's changes. The input data include sectoral spending and savings over the full time horizon (2008–2025) of the analysis. In Table 2, one example option is chosen, FL CAP Policy #ESD-12, to illustrate how the TWG results are translated into REMI economic variable inputs. The analysis represents a much more extensive linkage of mitigation options and model variables than has been done previously (e.g. EDRG, 2006).

In Table 2, the first two columns show the quantification analysis results of this mitigation option according to their applicability to business (commercial and industrial) and household (residential) sectors as provided by the ESD TWG. The last column of Table 2 presents the corresponding economic variables in the REMI model and their position within it (i.e. in which of the five major blocks, as introduced in Appendix A in the supplementary online file, the policy variables can be found).

DSM refers to programmes implemented by the utilities that are aimed at reducing electricity consumption in the business and household sectors. The annual energy (i.e. electricity) savings resulting from the implementation of the DSM/energy efficiency programmes are distributed among the commercial, industrial and residential sectors based on the baseline electricity consumption of these sectors. For both business and household sectors, the selected REMI policy variables representing energy savings come from the 'wages, prices and costs block'. For the former, the energy savings are simulated as the decrease of 'electricity fuel cost for individual industry'. For the latter, the energy savings are simulated as the 'consumer price' decrease under the 'household operation' category.

The reduction in electricity consumption from this mitigation option would result in a decrease in demand from the electric utility sector. This is simulated by reducing the 'exogenous final demand' from the utilities sector in REMI. This variable can be found in the 'output block'.

The total costs of this policy option are divided into two parts: utility cost (or ratepayer cost) and participant cost. The former is paid by the utilities, but would eventually be passed on to all customers through electricity rate increases. The latter is paid by those customers that participate in particular DSM/energy efficiency programmes. The ratio between ratepayer costs and participant costs is assumed to be 60:40. Both costs are distributed among the commercial, industrial and residential sectors based on the reference case electricity sales to the corresponding sectors. For the business sectors, the ratepayer costs are simulated by increasing the value of the 'electricity fuel cost' variable under the 'wages, prices and costs block'; the participant costs are simulated by increasing the value

TABLE 2 Mapping DSM into REMI inputs

TWGs quantification results		Policy variable selection in the REMI model
Energy savings of customers	Businesses (commercial and industrial sectors)	Wages, prices and costs block → fuel costs → electricity fuel cost (amount) → decrease
	Households (residential sector)	Wages, prices and costs block → prices (housing and consumer) → consumer price (equivalent currency amount) → household operation → decrease
Electricity demand decrease from the utility sector		Output block → industry demand → exogenous final demand (amount) for utilities sector → decrease
Energy customer outlay on energy efficiency (EE) goods	Businesses (commercial and industrial sectors)	Wages, prices and costs block → production cost (amount) → increase
	Households (residential sector)	Output block → consumer spending (amount) → computers and furniture → increase Output block → consumption reallocation (amount) → all consumption sectors → decrease
Paying for the EE programme (ratepayer costs)	Businesses (commercial and industrial sectors)	Wages, prices, and costs block → fuel costs → electricity fuel cost (amount) → increase
	Households (residential sector)	Output block → consumer spending (amount) → household operation → increase Output block → consumption reallocation (amount) → all consumption sectors → decrease
Investment on EE technologies		Output block → industry demand → exogenous final demand (amount) for machinery manufacturing, computer and electronic product manufacturing, and electrical equipment and appliance manufacturing sectors → increase
EE programme budget spending		Output block → industry demand → exogenous final demand (amount) for utilities and professional and technical services sectors → increase

of the ‘production cost’ variable under the ‘wages, prices and costs block’. For the residential sector, the ratepayer costs would result in an increase in consumer spending on household operation (and a decrease in all the other consumptions correspondingly); participant costs are simulated by increasing ‘consumer spending’ on computers and furniture (the household consumption category in REMI that includes energy-efficient appliances) and decreasing consumer spending in all other consumption categories proportionally.

Finally, the DSM programme would increase the demand for goods and services from industries that supply energy-efficienct equipment and appliances. This was simulated in the REMI model by increasing the ‘exogenous final demand’ from machinery manufacturing, computer and electronics manufacturing, and electrical equipment and appliance manufacturing sectors. The budget spending of the DSM programme would also stimulate demand from local energy auditing services and utility administration. These are simulated by increasing the ‘exogenous final demand’ from the professional and technical services and utility sectors.

It is necessary to supplement the basic TWG data with some additional data and assumptions, where costs and some conditions relating to the implementation of the options are not specified or are not known with certainty:

- Capital investment in power generation is split 60:40 between sectors that provide generating equipment and the construction sector for large power plants (such as coal-fired power plants), and 80:20 for smaller installations (mainly renewables).
- For some ESD options, energy consumers' participant costs in energy efficiency programmes are only computed by the TWGs for entire commercial sectors and/or industrial sectors. In REMI model analysis, the costs are distributed among the 70 individual sectors based on the data in the Florida I–O table (MIG, 2008) in relation to the delivery of utility services to individual sectors.
- For option ESD-8, combined heat and power (CHP) systems, the total costs of installing such systems are only computed by the ESD TWG for the commercial and industrial sectors as a whole. Data on the Florida market potential for CHP systems in existing facilities of industrial, commercial and institutional sectors are used to distribute the input costs among individual sectors in the REMI model analysis (Elliott et al., 2007).
- For option AFW-2, afforestation and restoration of non-forested lands, potential future cost savings (revenue) from forest products (e.g. merchantable timber or bioenergy feedstocks) are not taken into account, because they would most likely not be realized during the time frame of this analysis.
- For the forestry options, it is assumed that programme funding comes from the state government budget. It is also assumed that increased government spending in these forestry programmes will be offset by an equivalent decrease in the amount of government spending on other goods and services.
- In all the applicable analyses, a stimulus from only 50% of the capital investment requirements is simulated, based on the assumption that 50% of the investment in new equipment will simply displace other investments in the state.
- In cases of technology substitution, it is assumed that the operation and maintenance (O&M) cost spent on new electricity generation will simply displace the O&M cost for the replaced generation. Thus, in the REMI model, zero net additional O&M cost is simulated.
- For most of the ESD options, utility avoided cost is used as the avoided costs for displaced electricity consumption. For option ESD-8, CHP, avoided costs are based on the retail prices of fuels to the sector (commercial or industrial) that invests on the CHP system.

4. Simulation set-up in REMI

Figure 1 shows how a policy simulation process is undertaken in the REMI model. First, a policy question is formulated. Second, external policy variables that embody the effects of the policy are identified. For example, in a renewable portfolio standard (RPS), relevant policy variables include incremental costs and investment in renewable electricity generation; avoided generation of conventional electricity; and electricity price changes. Third, baseline values for all the policy variables are used to generate the baseline, or 'control', forecast. In the REMI model, the baseline forecast is based on the most recent data available (i.e. 2006 data for Florida), and the external policy variables are set equal to their baseline values. Fourth, an alternative forecast is generated by changing the values of the external policy variables. For example, in our analysis of the RPS option, the costs to the ratepayers, the investments to

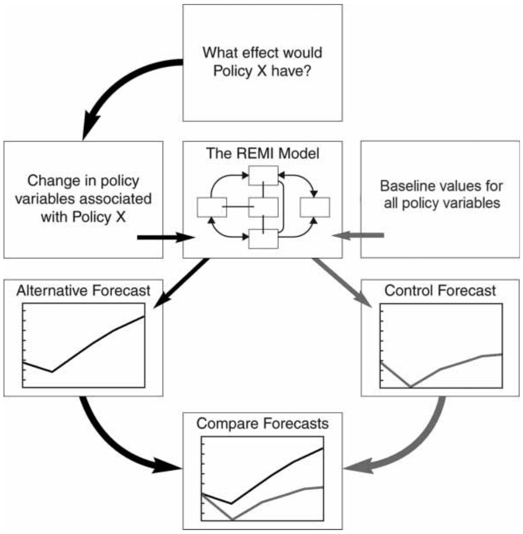

FIGURE 1 Process of policy simulation in REMI

Source: REMI (2007).

renewable electricity generation and the avoided investment to conventional electricity generation are based on the technical assessment of implementing this mitigation option by the ESD TWG. Fifth, the effects of the policy scenario are measured by comparing the baseline forecast and the alternative forecast. Sensitivity analysis is undertaken by running a series of alternative forecasts with different assumptions of the values of the policy variables.

In this study, the REMI model is run for each of the 28 recommended Florida mitigation policy options *individually* in a comparative static manner, that is, one at a time, holding everything else constant. Next, a *simultaneous* simulation is run in which it is assumed that all the policy options are implemented together. A simple summation of the effects of individual options is then compared with the simultaneous simulation results to determine whether the 'whole' is different from the 'sum' of the parts.

Differences can arise from non-linearities and/or synergies. The latter stem from complex functional relationships in the REMI model.

Before performing simulations in REMI, overlaps between policy options are eliminated as much as possible. This process is conducted by applying 'overlap factors' identified by the TWGs to both the costs and savings of the relevant policy options.

5. Presentation of the results

5.1. Basic results

A summary of the basic results of the application of the REMI model to determine the statewide macroeconomic impacts of individual FECCAP mitigation options is presented in Tables 3 and 4. Table 3 includes the GSP impacts for each option for four selected years, as well as an NPV calculation for the entire period 2008–2025. Table 4 presents analogous results for employment impacts statewide, although (for reasons noted below) an NPV calculation of employment impacts is not appropriate.

TABLE 3 GSP impacts of the Florida FECCAP ($billions, constant 2000)

Option	2010	2015	2020	2025	NPV
ESD 5	0.17	0.79	2.62	4.50	16.22
ESD 6	0.00	0.00	−0.60	−1.00	−2.48
ESD 8	−0.06	−0.29	−0.60	−0.99	−4.21
ESD 9	0.00	0.10	0.30	0.41	1.70
ESD 11	0.00	0.00	0.01	0.01	0.04
ESD 12	0.00	0.12	0.38	0.70	2.40
ESD 13a	0.00	0.15	0.49	0.92	3.08
ESD 14	0.00	−0.01	0.03	0.43	0.46
Subtotal – ESD	0.12	0.88	2.62	4.97	17.21
AFW 1	0.00	0.00	0.00	0.00	0.00
AFW 2	0.08	0.56	1.25	2.04	8.04
AFW 3	0.00	0.00	0.00	0.00	−0.01
AFW 4	0.00	−0.05	−0.12	−0.17	−0.71
AFW 5	0.00	0.00	0.01	0.01	0.05
AFW 6	0.00	0.01	0.04	0.08	0.26
AFW 7	0.00	0.88	0.77	0.43	4.07
AFW 8	0.00	0.01	0.04	0.07	0.23
AFW 9	0.01	0.08	0.19	0.32	1.22
Subtotal – AFW	0.26	1.50	2.18	2.78	13.17
TLU 1	0.07	0.26	0.55	0.86	3.83
TLU 2	0.00	0.01	0.03	0.03	0.16
TLU 4	−0.01	−0.12	−0.28	−0.53	−1.87
TLU 8	0.04	0.04	0.09	0.25	0.81
Subtotal – TLU	0.10	0.19	0.39	0.63	2.93
Summation total	0.31	2.57	5.19	8.38	33.31
Simultaneous total	0.31	2.73	5.95	11.06	37.90

The NPV of the total GSP impact for the period 2008–2025 is about $33.3 billion (constant 2000), with the impacts increasing steadily over the years to an annual high of $8.4 billion in 2025. In that year, the impacts represent an increase of 0.66% in GSP in the state.

Table 3 contains several important points:

- The macroeconomic impacts of 15 of the 20 options[8] are positive.[9]
- Option ESD-5, RPS, yields the highest positive impacts to the economy, an NPV of $16.2 billion. Option ESD-8, CHP, results in the highest negative impacts to the economy, an NPV of −$4.2 billion.
- Mitigation options from the energy supply and demand sector yield the highest positive impacts to the economy, followed by options from the agriculture, forestry and waste management sector.

Most of the options that generate positive impacts do so because they result in cost savings, and thus lower production costs in their own operation and that of their customers. This raises business profits and the purchasing power of consumers in Florida, thus stimulating the economy. The cost savings emanate either from direct reductions in fuel and electricity costs (by simply using existing resources more prudently) or through payback on initial investment in greener technologies. The options that result in negative macroeconomic impacts do so because, although they do reduce GHGs, the payback on investment from a purely economic perspective is negative; that is, they do not pay for

TABLE 4 Employment impacts of the Florida FECCAP (thousands)

Option	2010	2015	2020	2025
ESD 5	2.054	8.335	23.370	36.710
ESD 6	0.000	0.000	−3.554	−7.130
ESD 8	−0.681	−3.779	−7.616	−11.590
ESD 9	0.000	1.129	2.980	3.569
ESD 11	0.000	0.077	0.163	0.240
ESD 12	0.158	3.023	6.097	8.666
ESD 13a	0.000	2.554	6.722	10.920
ESD 14	0.298	−0.202	−1.326	−0.301
Subtotal – ESD	1.829	11.137	26.836	41.084
AFW 1	0.075	0.283	0.305	0.308
AFW 2	6.760	18.300	29.450	40.000
AFW 3	0.030	0.113	0.204	0.279
AFW 4	0.000	2.957	9.600	20.470
AFW 5	−0.023	0.034	0.090	0.142
AFW 6	0.428	1.520	3.283	5.153
AFW 7	0.000	17.290	15.460	7.447
AFW 8	0.008	0.072	0.422	0.645
AFW 9	0.273	1.996	4.079	6.440
Subtotal – AFW	7.551	42.566	62.893	80.883
TLU 1	1.112	3.951	7.712	11.290
TLU 2	0.000	0.126	0.265	0.370
TLU 4	−0.140	−1.982	−3.981	−6.701
TLU 8	0.985	0.509	0.945	2.283
Subtotal – TLU	1.958	2.604	4.941	7.242
Summation total	11.338	56.307	94.670	129.210
Simultaneous total	11.380	57.720	100.400	148.300

themselves in a narrow economic sense. This also raises the cost for production inputs or consumer goods to which they are related.[10]

The employment impacts are summarized in Table 4 and are qualitatively similar to those in Table 3. In this case, 16 of 20 options yield positive employment impacts. By the year 2025, these new jobs accumulate to the level of about 129,000 full-time equivalent jobs generated directly and indirectly in the Florida economy by FECCAP, which represents an increase of 0.99% over baseline projections. The employment impacts in the REMI model are presented in terms of annual differences from the baseline scenario and, as such, cannot be summed across years to obtain cumulative results. For example, a new business opens in 2009 and creates 100 new jobs. As long as the business is open, the area will have 100 more jobs than it would have had without the business. In other words, it will have 100 more jobs in 2009, 2010, 2011, and so on. The total number of jobs created is obviously not 100 + 100 + 100 + … Every year it is the *same* 100 jobs that persist over time, not an *additional* 100 jobs. In contrast to the impacts to GSP, the simulation results indicate that mitigation and sequestration options in the AFW sector will create more jobs than mitigation options in the ESD sector. The reason for this is that the AFW options will affect sectors that are relatively more labour-intensive than the ESD options.

The last row of Tables 3 and 4 presents the simulation results of the GSP and employment impacts for the simultaneous run, in which it is assumed that all the policy options are implemented concurrently. When we implement the simultaneous run in the REMI model, we ‘shock’ the model by including all the variable changes in the individual runs together. The simultaneous simulation indicates a GSP impact in NPV terms of $37.9 billion for the period 2008–2025, with the impacts increasing steadily over the period to an annual high of $11.1 billion in 2025. This increase represents 0.87% of GSP in the state in that year. The cumulative new job creation in 2025 is about 148,000 full-time equivalent jobs, an increase of about 1.13% from the baseline level. A comparison between the simultaneous simulation and the summation of simulations of the individual options shows that the former yields higher positive impacts to the economy: the GSP NPV is 13.8% higher and the job increase in 2025 is 14.7% higher. The difference between the simultaneous simulation and the ordinary sum is explained by the non-linearity in the REMI model and synergies in the economic actions it captures. In other words, the relationship between the model inputs and the results of REMI is non-linear. Because the simulation results are magnitude-dependent and are not calculated through fixed multipliers, when all the mitigation options are modelled together, the increased magnitude of the total stimulus to the economy causes wage, price, cost and population adjustments to occur differently than if each option is run on its own.[11]

Appendix B (in the supplementary online file) presents the impacts on GSP and employment of each individual economic sector for the simultaneous simulation. The impacts of the various mitigation options vary significantly by sector of the Florida economy. It is expected that producers of wind and solar equipment will benefit from increased demand for their products, as will most consumer goods and trade sectors because of increased demand stemming from increased purchasing power. The top five positively impacted sectors in terms of the NPV of GSP are, in descending order, real estate, retail trade, professional and technical services, wholesale trade and agriculture. The first and last of this set expand primarily because of the TLU and AFW options.

One expects electric utilities related to fossil fuels, including gas pipelines, to witness a decline. In fact, the utilities sector is expected to have the largest negative impact by far: −$9.8 billion. Other negatively affected sectors in descending order of impacts are passenger transit, apparel manufacturing, petroleum refining and leather goods manufacturing. However, none of these sectors is expected to have a decline of more than $1 billion. The passenger transit impact is surprising, but probably represents one of the limitations of the model in that it does not incorporate all the technological changes associated with the policy options.

5.2. Sensitivity tests

Because option ESD-5, RPS, yields the highest positive impacts to the economy, sensitivity analyses for both the entire RPS option and the solar component were performed separately. The sensitivity analyses were undertaken with respect to two key variables, capital investment cost and value of replaced electricity.

- *Capital investment cost*. Cases are considered in which capital investment is 50% higher than the base case and 50% lower than the base case. In the REMI model, capital investment is attributed to the construction and equipment sectors with a ratio of 2:8. The higher (or lower) capital investment translates into higher (or lower) final demand increase in these two sectors. As in the base case, we simulate a stimulus from only 50% of the investment requirement, based on the assumption that 50% of the investment will displace existing investment in the state.
- *Value of replaced electricity*. Cases are considered in which the value of replaced electricity is 50% higher and 50% lower than in the base case. In the REMI model, the replacement of conventional electricity with renewable electricity was simulated by changing the source of generation from imports to in-state, based on the assumption that all the renewable electricity would be generated

within Florida. Therefore, if the replaced electricity has a higher (or lower) value, it will result in a higher (or lower) stimulus to the state economy.

The results of the first sensitivity analysis are presented in Table 5 for the entire RPS option. The sensitivity analysis for change in investment affects the results only slightly; for example, a 50% change in the input value will only yield a 2–3% change in the impact on GSP and employment from each of these two options. In contrast, a sensitivity analysis for a change in the value of replaced electricity results in considerable changes in the results; for example, a 50% change in the input value will result in an over 40% change in the impacts on GSP and employment from each of the two options.

The base case results for the solar and RPS options are thus highly robust for the first sensitivity variable, that of investment costs. However, they are less robust (i.e. the results vary significantly) for the second variable, the value of replaced electricity. However, to place this in a broader context, the base case results project employment gains of 148,000 new jobs from FECCAP by 2025. The maximum decrease in the base case result stemming from the worst-case sensitivity outcome of RPS (a combination of the sensitivity case of 50% lower investment and the case of 50% lower value of electricity replaced) is, however, only 15,500 jobs, a lowering of the base case by only 10.4%. Thus, the overall results for the entirety of FECCAP are robust to any sensitivities in the RPS option. Also, because the solar option is subsumed by the RPS option, variations in the value of key variables of the solar option will result in an even smaller impact on the overall base case results.

Fischer and Newell (2008) find that RPS is among the relatively least attractive of various renewable energy options, primarily because of its price-distorting nature. However, the attractiveness of this option is highly influenced by its location. In coal- and gas-producing states, dampening macro-impacts will stem from a decline in fossil fuel demand and associated multiplier effects. In Florida, because coal and most natural gas are not produced there but rather imported, such offsetting forces are not in effect.

In addition to the sensitivity analyses for RPS options, sensitivity tests on two parameters of the analysis for some of the other options were also performed. For example, for ESD-8, CHP, the parameters are fuel prices and costs. In the simulations, the following was assumed:

- The fuel prices are 50% lower or 50% higher than the levels used in the base case analysis, which affects the fuel cost savings (to all the commercial and industrial sectors; the product of the physical amount of displaced fuel use and the price of fuels). Meanwhile, a change of fuel prices also affects the gross fuel costs for CHP systems (which are part of the increased production cost to the commercial and industrial sectors). Moreover, these also affect the 'exogenous final demand' for the outputs of the oil/gas extraction sector and forestry sector (in value terms).

TABLE 5 Sensitivity analyses of RPS

	GSP (2008–2025 NPV) ($billions, fixed 2000)	Employment (by 2025) (thousands)
RPS base case	16.2	36.7
50% higher investment	16.7	37.8
50% lower investment	15.9	36.0
50% higher value of replaced electricity	23.1	51.9
50% lower value of replaced electricity	9.4	21.9

- The costs of the CHP systems are 50% lower or 50% higher than the levels used in the current analysis and can be divided into three parts: annualized capital costs, fuel costs and O&M costs. The sensitivity of fuel costs is analysed in the previous paragraph. In the REMI analysis, it was assumed that the O&M costs for the new CHP systems would be equal to the O&M costs for the production of energy in conventional ways. Thus, we confine the sensitivity analysis to the capital cost, which translates into the demand for production for construction, electrical equipment and appliance manufacturing sectors. Note also that this sensitivity test implicitly refers to whether the investment funds come from within the state (and thus displace other investment) or whether they flow into the state from the outside (and thus do not have a displacement effect).

We combined these two sensitivities into two cases:

- The *upper-bound case*: the two variations that result in the highest estimate.
- The *lower-bound case*: the two variations that result in the lowest estimate.

The upper-bound case involves fuel costs that are 50% higher (thus yielding higher savings) plus CHP investment costs that are 50% lower. The lower-bound case includes the opposite combination. The sensitivity tests indicate that the results are relatively robust, that is, varying the parameters does not change the results in a major way.

Our final sensitivity test relates to the 5% discount rate used in the base case analysis. When a 2% discount rate is used in the simultaneous run, the base case NPV increase in GSP climbs from $37.9 billion to $55.5 billion. When a 7% discount rate is used, the base case estimate drops to an increase of $29.8 billion. Changes in the discount rate do not affect the employment estimates.

Our results are similar to, although more positive than, those of other recent studies. In a recent study of the impacts of RPS standards and energy efficiency improvements for the California economy (similar to those in the Florida case), Roland-Holst (2009) also projected a net increase of half a million jobs by 2050. If adjustments are made for the relative sizes of the two state economies, the results for the renewables and energy efficiency options are very similar in percentage terms. Kammen (2007) estimates the creation of a large number of new jobs stemming from climate change legislation.

There are debates in the literature regarding estimates and implications of job creation through investment in energy efficiency and clean energy. For example, employment gains resulting from investment in a clean energy economy are reported in many recent studies (Global Insight, 2008; Bezdek, 2007; Pollin et al., 2009a). Morriss et al. (2009) challenge the findings in the ‘green job’ studies by identifying seven myths embedded in the definition, assumptions and modelling approach used in these studies. A similar debate is also found in the exchange between the Heritage Foundation and the Political Economy Research Institute of University of Massachusetts, Amherst (e.g. Campbell, 2009a, 2009b; Pollin et al., 2009a, 2009b).

Most of the debates focus on the following four issues: (i) whether the dampening effects on fossil fuel industries are properly accounted for when the net effects of investment in clean energy and efficiency are computed; (ii) whether the increase in ‘green jobs’ will reduce the labour productivity of the economy given that many of the renewable energy industries are labour-intensive; (iii) whether an I–O analysis is an appropriate modelling tool to evaluate the economic impacts of the clean energy and energy efficiency investment; and (iv) whether directing the investment to a clean energy economy means switching from free markets to more government mandates.

Many studies report findings that clean energy investment creates more jobs than investment of the same amount on fossil fuel industries in the US. The results in the present study regarding Florida show similar outcomes. One major reason is that the spending on clean and renewable energy has more local content. For example, nearly all coal used in coal-fired electricity generation in Florida is imported from outside the state. By developing renewable electricity, most renewable feedstock of biomass electricity generation (which accounts for nearly 50% of the planned renewable electricity generation mix in Florida) will come from local sources.

In this study, both the stimulus effects on energy efficiency equipment manufacturing and engine and turbine manufacturing sectors and the dampening effects on fossil fuel sectors were carefully modelled. Table 2 (Section 3.2) presents details of both the stimulus and dampening effects simulated in the REMI model to evaluate the comprehensive impacts of the DSM programme on the state economy. In addition, to be conservative, the stimulus effects of only 50% of the capital investment were simulated based on the assumption that 50% of the investment in new equipment will simply displace other investment in the state.

The choice of the REMI model is based on various considerations, as elaborated in Section 2. First, the REMI model overcomes the static, linear and non-price-responsive features of the I–O models that have been used in many similar studies in the literature. Second, compared with other competitive modelling approaches, the REMI model has superior forecasting ability. Third, compared with CGE models, the REMI model provides comparable analytical capability and modelling accuracy, but with more desirable manageability and costs for our study.

Several analysts have noted that top-down and bottom-up economic models yield different results, largely due to their inherent biases. We have tried to minimize this by combining features of top-down and bottom-up modelling. For example, CGE models typically yield relatively more pessimistic impacts than other models because of their assumption of optimizing behaviour, which neglects the possibility of market failures that would provide openings for many energy efficiency improvements. Likewise, Knopf and Edenhofer (2009) note that the relatively low cost of attainment of the climate stabilization targets of one of the five models used in the EU ADAM Project is attributed to its Keynesian nature, with emphasis on the fact that the model does not assume full employment and hence there is no investment displacement of consumption. The REMI model also does not assume full employment, but we believe that this is a realistic assumption. Of course, there is another reason for an expansionary outcome in the Florida analysis that is not possible in the ADAM Project analysis at the global level: the prospect of attracting some investment in clean and more efficient technologies from outside the region.

Finally, the measures and programmes recommended in FECCAP include a comprehensive suite of policy instruments that include not only government regulations, standards and codes, but also various market-based incentives. In fact, Florida is among the few states that has established a separate cap-and-trade TWG to evaluate the feasibility and impacts of Florida joining one of the existing regional cap-and-trade programmes (FCAT, 2008, Chapter 4).

6. Conclusions

The analysis of impacts of FECCAP on the state's economy has been summarized. A state-of-the-art macroeconometric model was used to perform this analysis, based on data supplied from six Florida TWGs that had been vetted by means of an in-depth, consensus-based technical assessment and stakeholder process. The results indicate that most of the GHG mitigation and sequestration options individually have positive impacts on the state's economy. The combination of options has an NPV of increasing GSP by about $37.9 billion and increasing employment by 148,000 full-time equivalent jobs by 2025. The Florida Renewable Portfolio Standard contributes the highest GSP gains, or nearly

50% of the total. Afforestation and Restoration of Non-Forested Lands and the Renewable Portfolio Standard contribute the highest employment gains, which combine to account for nearly 60% of total job creation.

The economic gains stem primarily from the ability of mitigation options to improve energy efficiency and thus lower production costs and raise consumer purchasing power. The economic gains also stem from the stimulus of increased investment in plant and equipment.

Several tests were performed to determine the sensitivity of the results to major changes in key variables such as capital costs, fuel prices and avoided costs of electricity generation. The tests indicate that the results are robust, that is, the overall results do not change much even when these variables are changed by $\pm 50\%$. The estimates of economic benefits to Florida represent a lower bound from a broader perspective. They do not include the avoidance of damage from climate change that continued baseline GHG emissions would induce, the reduction in damage from the associated decrease in ordinary pollutants, reduction in the use of natural resources, reduction in traffic congestion, and so on. Overall, FECCAP is a win–win policy.

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Notes

1. The REMI model is used extensively to measure the economic impacts of proposed legislative and other programmes and policies across the private and public sectors by government agencies in nearly every state of the US. In Florida, it is used by the Florida Joint Legislative Management Committee, Division of Economic & Demographic Research, the Florida Department of Labor (Agency for Workforce Innovation), and other state and local government agencies. In addition, it is the chosen tool to measure these impacts by a number of university researchers and private research groups that evaluate economic impacts across states and the nation.
2. Data used for the REMI model inputs were provided by the Florida Governor's Climate Action Team Electricity Supply and Demand (ESD), Agriculture, Forestry and Waste (AFW), and Transportation and Land Use (TLU) CAT TWGs, September 2008.
3. There is a debate about the size of the multipliers used in different regional policy analysis models. Rickman and Schwer (1995) compare the default multipliers in three of these models: IMpact analysis for PLANning (IMPLAN), REMI and Regional Input-Output Modeling System (RIMS II). They show that the default multipliers have significant differences. Comparatively speaking, IMPLAN estimates the largest multipliers, whereas the REMI model estimates the smallest multipliers. The differences stem from three major factors. First, different closure rules are used. Second, different techniques to regionalize the national technical coefficients are adopted. Finally, data from different sources are used to develop the model. Therefore, it is hard to say which model provides the more accurate multipliers of the regional economy. However, the REMI model has special features that are important to the present policy analysis. First, both IMPLAN and RIMS II are static I–O models, whereas the REMI model is dynamic. Thus, the REMI model has the capability of analysing

the time path of impacts of the simulated policy change and is superior to the other two models in terms of its forecasting ability. In fact, the implicit multipliers of the REMI model vary from year to year. Second, the REMI model is non-linear. Therefore, in contrast to the other two models, the REMI model simulation results are not dependent on fixed multipliers or a linear relationship with the input data. In the REMI model analysis, changes in the magnitude of the inputs lead to an appropriate variation in the model's multipliers. Moreover, because the REMI model multipliers are generally smaller than the multipliers of the other two models, the impacts are on the more conservative side; that is, positive economic impacts are more likely to be understated than overstated.

4. The production cost change of sector *i* in the REMI model first affects the price of the goods produced by this sector. Then the price change generates successive impacts on the downstream customer sectors that use the product of sector *i* as an intermediate input. The only exception is that the REMI model does not fully and automatically pass the production cost change of the energy supply sector (particularly the electricity generation sector) to the downstream commercial and industrial customer sectors. This must be done by manual insertions of changes in the model.
5. One of the reviewers raised the concern of using a model like the REMI model for simulations between 2008 and 2025, which is well outside the forecasting horizon adopted by macroforecasters at the IMF, Federal Reserve, and so on. We acknowledge that the REMI model obtains its short-term economic forecast from the Research Seminar in Quantitative Economics (RSQE) of the University of Michigan and uses these data in the short-term baseline projection in the model. The long-term projection is from the model's internal calculations. However, in simulating the economic impacts of climate policy options, the interesting results are the relative changes with respect to the baseline level. In other words, one is more interested in results measured as percentage changes from the baseline level. These percentage changes are not very sensitive to the choice of baseline forecasts within a reasonable range. Given its grounding in the RSQE, it is not unwarranted to conclude that the REMI model forecasts fall within this reasonable range.
6. The CCS works directly in partnership with state leaders and their stakeholders to identify, design and implement policies that address climate, energy and economic needs and opportunities. Through its projects, CCS addresses key GHG emissions issues across a wide range of sectors by working closely with government officials, institutional experts and members of the stakeholder community. CCS provides the technical assessments, start-up planning, independent facilitation, policy design and analysis, and capacity building needed for successful consensus building and climate mitigation policy development. The CCS stakeholder process has been successfully used in over 20 state climate change planning efforts and has to date included a combined total of over 1,000 stakeholders and TWG experts across all geographic regions and economic sectors. The process combines the traditional facilitated conflict resolution model with expert technical assistance and analysis. The development and analysis of policy options occurs at two levels: (i) the gubernatorial 'commission' composed of governor-appointed representatives of groups, interests and parties that have a direct stake in the effects of climate change or efforts to mitigate them; and (ii) a set of TWGs or subcommittees made up of members of the commission plus other individuals with particular expertise in the topic area of focus.
7. An analysis of inventory and forecast (I&F) of GHG emissions in Florida was first conducted. The aim of the I&F analysis is to provide TWGs with an understanding of historical, current and possible future business-as-usual GHG emissions in Florida. The baseline projections are based on various existing projections of population growth, electricity generation expansion, fuel use changes, trends in vehicle miles travelled and other GHG-emitting activities in Florida (Strait et al., 2008). The baseline emission forecasts are then used as a point of reference.
8. In the original 28 quantified options in FECCAP, many are sub-options that belong to the same categories. In the REMI model analysis, the sub-options that came from the same category were bundled as one policy option in the simulation. One example is that FL Policy #AFW-2 includes three sub-options: afforestation, reforestation and urban forestry.
9. Note that while an option that exhibits cost savings usually results in positive macro-impacts, this is not always the case. Likewise, a positive cost option may result in a positive impact if the investment stimulus is especially strong (e.g. FL Policy #ESD-11, landfill gas). Note also that the REMI model includes many interactive effects and is non-linear.
10. The results for FL Policy #ESD-8 (co-generation), for example, can be decomposed into negative and positive stimuli, with the net effects being negative. The negative economic stimuli of this option include the increased

cost (including annualized capital costs, operating and maintenance costs, and fuel costs) to the commercial and industrial sectors due to the installation of CHP systems and reduced final demand from conventional electricity generation (which equals the sum of electricity output from the CHP plus avoided electricity use in boilers/space heaters/water heaters). The positive stimuli include various fuel cost savings (e.g. electricity, natural gas, oil and other) to the commercial and industrial sectors from displaced heating fuels for all kinds of CHP systems, an increase in final demand to the construction and electrical equipment and appliance manufacturing sectors, and an increase in final demand in forestry (biomass) and oil and gas extraction (NG and oil) sectors due to an increased demand of fuels and feedstocks to supply the CHP facilities.

11. The FECCAP options have the ability to lower the Florida Price Index by 0.29% from baseline by the year 2025. This price decrease, of course, has a positive stimulus on GSP and employment.

References

Bezdek, R., 2007, *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*, Report for American Solar Energy Society, Boulder, CO [available at www.greenforall.org/resources/renewable-energy-and-energy-efficiency-economic].

Campbell, K., 2009a, 'The PERI Report on Clean Energy: The Wrong Question and a Misleading Result', *Backgrounder* No. 2303 (July) [available at www.heritage.org/Research/Reports/2009/07/The-PERI-Report-on-Clean-Energy-The-Wrong-Question-and-a-Misleading-Result].

Campbell, K., 2009b, PERI Study: Ill-Conceived Analysis of Non-Existent Legislation, 16 July, the Heritage Foundation, Washington, DC [available at http://blog.heritage.org/2009/07/16/peri-study-ill-conceived-analysis-of-non-existent-legislation/].

EDRG, 2006, *Economic Impacts of Proposed Northeast Regional Greenhouse Gas Initiative*, prepared for the Staff Working Group of the Northeast Regional Greenhouse Gas Initiative, Economic Development Research Group, Inc., Boston, MA.

Elliott, R.N., Eldridge, M., Shipley, A.M., Laitner, J., Nadel, S., Fairey, P., Vieira, R., Sonne, J., Silverstein, A., Hedman, B., Darrow, K., 2007, *Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands*, Report No. E072, American Council for an Energy Efficient Economy (ACEEE), Washington, DC [available at www.aceee.org/research-report/e072].

FCAT, 2008, *Florida's Energy and Climate Change Action Plan*, Florida Climate Action Team [available at www.flclimatechange.us/documents.cfm].

Fischer, C., Newell, R.G., 2008, 'Environmental and technology policies for climate mitigation', *Journal of Environmental Economics and Management* 55(2), 142–162.

Global Insight, 2008, *U.S. Metro Economies: Current and Potential Green Jobs in the U.S. Economy*, Prepared for The United States Conference of Mayors and the Mayors Climate Protection Center, Lexington, MA [available at www.usmayors.org/pressreleases/uploads/greenjobsreport.pdf].

Joskow, P.L., Marron, D.B., 1992, 'What does a negawatt really cost? Evidence from utility conservation programs', *The Energy Journal* 13(4), 41–74.

Kammen, D., 2007, Testimony for the *2007 Hearing on 'Green Jobs by Global Warming Initiatives'*, US Senate Committee on Environment and Public Works, September 25 [available at http://rael.berkeley.edu/node/735].

Knopf, B., Edenhofer, O., 2009, 'The economics of low stabilisation: implications for technological change and policy', in: M. Hulme, H. Neufeldt (eds), *Making Climate Change Work for Us*, Cambridge University Press, Cambridge, 291–318.

MIG, 2008, *Florida Input–Output Table*, Minnesota IMPLAN Group, Stillwater, MN.

Morriss, A.P., Bogart, W.T., Dorchak, A., Meiners, R.E., 2009, 'Green jobs myths', *Missouri Environmental Law and Policy Review* 16(2), 326–473.

Pollin, R., Heintz, J., Garrett-Peltier, H., 2009a, *The Economic Benefits of Investing in Clean Energy*, report by Department of Economics and Political Economy Research Institute (PERI), University of Massachusetts-Amherst [available at www.peri.umass.edu/economic_benefits/].

Pollin, R., Heintz, J., Garrett-Peltier, H., 2009b, *Clean Energy Investments, Jobs, and U.S. Economic Well-being: A Third Response to Heritage Foundation Critics*, Report by Political Economy Research Institute (PERI) and Department of

Economics, University of Massachusetts-Amherst, Amherst, MA [available at www.peri.umass.edu/fileadmin/pdf/other_ publication_types/green_economics/Response_to_Heritage_Foundation_August4.pdf].
REMI, 2007, *REMI Policy Insight 9.5 User Guide*, Regional Economic Models, Inc., Amherst, MA.
Rickman, D.S., Schwer, R.K., 1995, 'A comparison of the multipliers of IMPLAN, REMI, and RIMS II: benchmarking ready-made models for comparison', *The Annals of Regional Science* 29(4), 363–374.
Roland-Holst, D., 2009, *Energy Pathways for the California Economy*, Department of Agricultural and Resource Economics, University of California, Berkeley, CA.
Strait, R., Mullen, M., Dougherty, B., Bollman, A., Anderson, R., Lindquist, H., Williams, L., Salhotra, M., Schreiber, J., 2008, *Final Florida Greenhouse Gas Inventory and Reference Case Projections 1990–2025*, Center for Climate Strategies, Washington, DC [available at www.flclimatechange.us/ewebeditpro/items/O12F20490.pdf].
Sweeney, J., 2008, 'A cost-effectiveness analysis of AB 32 measures', presented at the California Air Resources Board (CARB) Economic Analysis Technical Stakeholder Working Group Meeting on Cost-Effectiveness of AB 32 Implementation, Precourt Center, Stanford University, Stanford, CA.
Treyz, G.I., 1993, *Regional Economic Modeling: A Systematic Approach to Economic Forecasting and Policy Analysis*, Kluwer Academic Publishers, Boston, MA.