The Projected Economic Impacts of Emissions Regulation

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Executive Summary

- In recent years, there has been growing interest in the use of government intervention (cap-and-trade systems, carbon taxes, renewable portfolio standards, etc) to reduce emissions of greenhouse gases (GHGs). Deliberations have now reached the point where federal, regional and state-level governments in various parts of the United States have firm proposals for the imposition of emission-reducing mechanisms.

- Much of the recent policy debate has focused on the potential economic impacts of lowering GHG emissions. As a result there have been numerous studies detailing the economic implications of proposed policy.

- The primary objective of this paper is to examine the reasonableness and validity of examples of the most prominent studies of the economic impacts of GHG-reduction measures, and to provide a consensus view of the likely sign and magnitude of any economic impacts.

- On the surface, the results of the research that investigates the economic impact in this area are perplexing. Some studies predict the introduction of environmental regulation for GHGs will create a "win-win" scenario—a positive economic impact on the economy, coupled with improved environmental outcomes. At the other end of the spectrum, studies warn that the introduction of environmental regulation will cause significant reductions in economic activity with little or no environmental benefit.

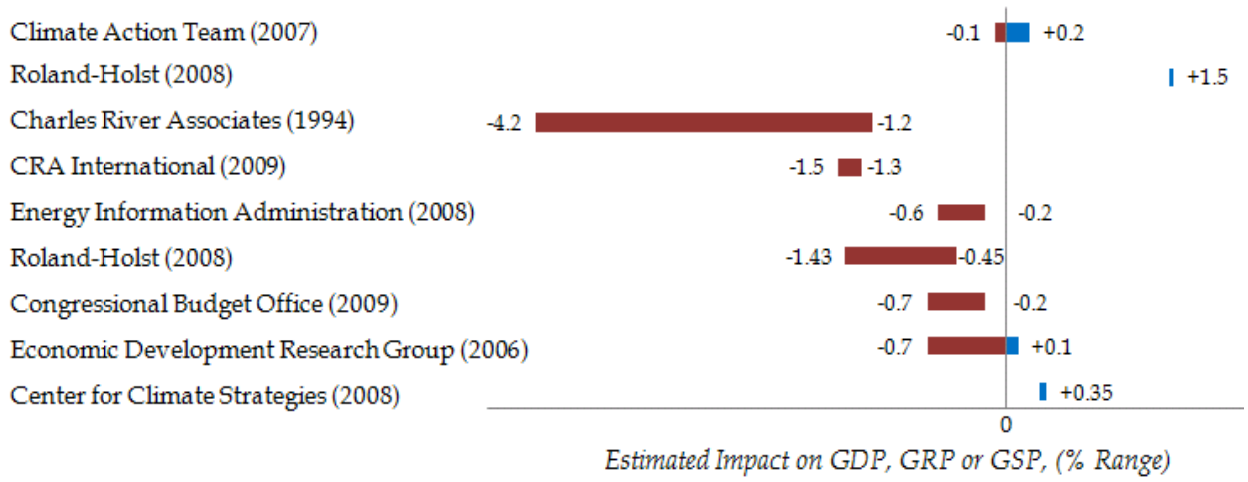
- Some of the research predicts large positive economic impacts which are driven by substantial new technology cost savings. This conclusion is dubious because if the private financial impact of technological change in this area were indeed positive, we would expect the market process to lead electricity suppliers toward these new, less intensive carbon-emitting technologies naturally and without the need for any government intervention.

- Some studies are problematic simply because of the method that underlies them. For instance, in many cases, the social benefits or costs of a policy measure are estimated simply by tabulating the benefits or costs for an individual, and then adding them together for every individual in society. This approach is incorrect because often times, the benefits to individuals exist because society incurs a cost, or vice versa. Thus, the method can result in significant over- or under-estimations of the social benefits or costs of a policy measure.

- We examine 11 recent studies, each of which assesses the economic impacts of one or more emissions-reducing programs. The 11 studies were chosen for varying reasons. In their entirety, the 11 studies examine the majority of potential mechanisms that could be adopted to reduce GHG emissions. The 11 studies are the most prominent currently being cited by proponents and detractors of emission-reducing legislation. T 11 studies examined also encompass a range of effect estimates which is typical of the literature as a whole.

- The methods, assumptions and results vary widely and in some cases, the presentation of results leaves considerable latitude for interpretation. The following chart illustrates the variation in findings among several of the studies we evaluate.[1,2]

Variation in Results from Studies of the Economic Impacts of Climate Change Policy



[1] The omitted studies did not provide estimates of policy impacts on GDP, GSP or GRP.
[2] The results presented here correspond to the macroeconomic effect of interest (i.e. change in GDP, GSP, or GRP) for the time horizon examined in each study. Some results were presented in cumulative terms for the entire study period, whereas others reflect the estimated impact for a single year. Some studies presented a range of results, whereas others presented only one point estimate.

- We evaluate each study using a standard set of criteria. We find that many of them share some common failings, including:
    - incompleteness in the assessment;
    - inappropriateness of the time horizon modeled;
    - invalid assumptions;
    - unreasonable base case;
    - unsuitable forecasting model;
    - opaque analysis;
    - non-existent or insufficient sensitivity analysis.

Overall Study Conclusions

- Ultimately, closer examination of the literature reveals some important insights. The studies examined have various failings which ultimately affect the accuracy, validity and sensibility of their results.

- Studies that suggest that environmental outcomes can be improved in conjunction with increased economic activity rely on some highly dubious premises and in many cases violate basic economic principles. This is especially true with regard to assumptions concerning the costs associated with renewable energy and gains from energy efficiency.

- The remaining studies suggest that there is a trade-off between economic activity and environmental improvements. The magnitude of the negative economic impact associated with reducing carbon emissions reported within the studies examined is highly dependent upon the assumptions made. In particular:

    - the shorter the time horizon, the higher the financial costs associated with reducing emissions;
    - the higher the carbon tax or emission permit price paid by emitters, the higher the resulting energy prices and the lower the amount of proceeds recycled back

into the economy, the higher the annual economic costs associated with reducing carbon emissions.

- Ultimately, further research that identifies and examines a wide range of possibilities and eventualities over a sufficiently long time horizon will be required to improve the robustness of results to give a better indication of the potential magnitude of the negative economic impact associated with reducing carbon emissions.

- Whilst further research will improve the estimates surrounding the magnitude of the economic impact of reducing carbon emissions it is highly unlikely, if undertaken correctly, that it will alter its direction.

- Simply put, whatever the ultimate path the United States decides to take with regards to carbon emissions, if it decides to reduce its carbon emission levels it will cause a moderate *reduction* in economic activity. The observed reduction in economic activity will be determined by the required reduction in GHG emissions, the time frame for these reductions, the financial costs associated with reducing GHG emissions and how the government allocates any revenues received.

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1. Introduction

In recent years, there has been growing interest in the use of government intervention (cap-and-trade systems, carbon taxes, renewable portfolio standards, etc) to reduce emissions of greenhouse gases (GHGs). Deliberations have now reached a point at which federal, regional (multiple states combined) and state-level governments in the United States have firm proposals for the imposition of GHG emission-reducing mechanisms.

Interfering with the free market will inevitably have consequences. As fossil fuel use becomes more expensive, as a result of government-imposed restrictions and mechanisms, the economy in general will necessarily react. There have been a number of studies that have attempted to assess the likely *economic impact* of GHG regulation at the state, region or country level. The results of research in this area are perplexing. Some studies predict the introduction of environmental regulation for greenhouse gases will create a "win-win" scenario—a positive impact on the economy, coupled with improved environmental outcomes. At the other end of the spectrum, studies warn that the introduction of environmental regulations will cause significant harm to economic activity with little or no environmental benefit—a "lose-lose" scenario.

The primary objective of this paper is to examine the reasonableness and validity of examples of the most prominent GHG-reduction economic impact studies, with particular emphasis on papers that predict "win-win" outcomes,[3] to provide a consensus view of the likely sign and magnitude of any economic impacts.

We examine 11 prominent papers concerned with the economic impact of various government intervention mechanisms. Making sense of these studies can be difficult. The methods, assumptions and results vary widely and in some cases, the presentation of results can leave considerable latitude for interpretation. Below are excerpts from each of the studies we examine, illustrating the variation in results and conclusions among them.

[3] A "win-win" outcome in this context occurs when a climate policy initiative leads to both environmental benefits (typically lower CO_2 levels) and higher levels of economic activity.

"Overall, the *Florida Energy and Climate Change Action Plan* is a win-win policy in terms of aggregate economic performance and emissions reductions." p. 20.

-The Centre for Climate Strategies (2009) *"The Economic Impact of the Florida Energy and Climate Change Action Plan on the State's Economy"*

"Despite higher electric prices, consumers paying for an energy efficiency program and their buying efficient goods, the combined effects of generating technology investments (traditional, renewable and energy efficient) and bill savings eventually [outweigh] the effect of higher electric prices." p. 25.

-Economic Development Research Group Inc (2006) *"Economic Impacts of the Proposed Northeastern Regional Greenhouse Gas Initiative"*

"Our analysis makes clear that S. 2191 promises extraordinary perils for the American economy. Arbitrary restrictions predicated on multiple, untested, and undeveloped technologies will lead to severe restrictions on energy use and large increases in energy costs. ... [T]hese higher energy costs will spread through the economy and inject unnecessary inefficiencies at virtually every stage of production and consumption ... ." p.1.

-William W. Beach et al. (2008) "*The Economic Cost of the Lieberman-Warner Climate Change Legislation," Heritage Foundation Center for Data Analysis Report No. 08-02"*

"S. 2191 increases the cost of using energy, which reduces real economic output, reduces purchasing power, and lowers aggregate demand for goods and services. …[P]rojected real GDP generally falls… . Adverse economic impacts generally increase over time as higher cost emissions abatement options are required as emissions caps become more stringent while population and economic activity levels continue to grow." p. xi.

-Energy Information Administration (2008) *"Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007"*

"The higher cost of energy would hurt profit margins, causing firms to reduce investment in [WCI] member states." p.17.

-The Beacon Hill Institute at Suffolk University (2009) *"The Economic Analysis of the Western Climate Initiative's Regional Cap-and-Trade Program"*

"The studies reviewed by the CBO yielded a wide range of estimates of losses in GDP from climate policies, but all of them concluded that, all else being equal, higher prices for emission allowances would impose greater losses in GDP." p.12.

-Congressional Budget Office (2009) *"The Economic Impact of Legislation to Reduce Greenhouse-Gas Emissions"*

"It is not possible to avoid these costs through any free distribution of carbon allowances. Although the wise use of revenues from an auction or carbon tax can ameliorate impacts to some segments of the economy, the cost of bringing emissions down to levels required by the caps cannot be avoided." p. 2

-Montgomery et. al. (2009) *"Impact on the Economy of the American Clean Energy and Security Act of 2009"*

"…[T]he competitiveness impacts from a unilateral U.S. climate policy on domestic manufacturers as a whole, and even differentiated by energy intensity, are small for a $15 per ton C02 price. The bulk of the effect on domestic manufacturing comes from a shift in domestic consumption—a desirable effect from the perspective of seeking a cost-effective policy and one that has nothing to do with the presence or absence of foreign regulation." p. 27

-Aldy, J. and Pizer, W. (2009) *"The Competitiveness Impacts of Climate Change Mitigation Policies. Pew Center for Global Climate Change"*

"Higher energy prices lead consumers to make do with less energy and transportation services in order to keep some income available for spending on other goods and services that now appear relatively less costly and worthwhile." P. 4-7.

-Charles River Associates Inc. (2004) "*Economic Impacts of Carbon Taxes: An Overview*"

" ... [T]he risks of excessive energy dependence include long-term economic growth. A lower carbon future for California is a more prosperous and sustainable future." P.8.

-David Roland-Holst (2008) "*Energy Efficiency, Innovation, and Job Creation in California,*"

> "... the results are consistent with the expectation that there is value in implementing policies that promote emission reductions as broadly as possible throughout the economy." P. 40.
>
> -Economics Subgroup, California Climate Action Team (2007) "*Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report: Final Report*"

In Section 4, we outline the criteria that we use to assess the reasonableness and validity of each study's conclusions. In Section 5, we present a general discussion of what we see as moot arguments[4] that are common to many of the papers examined. In Section 7, we apply our broad criteria to each paper. Section 8 presents our conclusions.

2. Overview of Emission-Reduction Mechanisms

2.1. Renewable Portfolio Standards

Renewable Portfolio Standards (RPS) adjust, by means of government imposition, the electricity generation mix in favor of higher levels of renewable generation than would otherwise be adopted by electricity utilities in a least cost planning regime.[5] Typically, an RPS requires that over time, an increasing percentage of electricity sales are met via renewable generation resources such as wind, solar, geothermal and biomass. This (increasing) renewable requirement reduces the amount of carbon emissions by encouraging, through a command approach, a reduction in fossil fuel electricity generation.[6]

Because it is a *renewable* portfolio standard, it biases generation towards renewable resources and away from carbon-emitting technologies and other non-renewable forms of non-carbon emitting generation (particularly nuclear). If a utility decides to replace carbon-emitting

[4] 'Moot' in the legal sense of having been already determined.
[5] If this were untrue, a RPS would be unnecessary.
[6] Many states (as well as the current proposals at the Federal level) allow energy efficiency to count towards RPS compliance although Arizona is currently not one of them.

generation plants with a nuclear plant, even though the amount of carbon emitted is reduced, this decision typically does not receive any credit under an RPS.[7]

2.2. Cap-and-Trade (C&T)

A cap-and-trade program works by creating a limit on the total amount of carbon emissions allowed in a given period.[8] Once the cap is determined,[9] emissions certificates (or permits) are allocated via some mechanism (either freely distributed, auctioned off or some combination of the two).[10] If an entity wants to emit *x* tons of carbon, it is required to have at least that amount of emissions permits in its possession. The entities that reduce their carbon emissions through time are able to sell the permits that they no longer require.[11]

Cap-and-trade programs offer a choice to covered entities: they can either continue emitting carbon but purchase a permit, switch to non-carbon emitting technologies, or shut down production. This program flexibility typically provides an incentive for the most efficient converters[12] to be the first to adopt non-carbon emitting technologies.

Since acquiring the permits may well be costly,[13] it raises the relative cost of using intensive carbon-emitting technologies versus non-intensive carbon-emitting technologies. Carbon emissions are reduced in two ways. First, if the permit price is sufficiently high, such that it causes the cost of carbon-emitting technologies to exceed non-carbon-emitting technologies, then there would be a (cost) incentive to switch to non-carbon emitting technologies. Secondly, after the introduction of a cap-and-trade program, even if carbon-emitting technologies remain as the least-cost alternative, there would still be a reduction in emissions.

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[7] Some legislative proposals subtract new nuclear generation from the calculation of retail sales, which does afford partial credit (indirectly) to nuclear by lowering the overall RPS requirement.
[8] Carbon emissions are customarily measured in metric tons.
[9] Typically the cap is reduced through time.
[10] There is an on-going debate about which distribution mechanism is desirable.
[11] Thus cap-and-trade creates a revenue incentive for an entity to reduce their carbon emissions.
[12] The firms that can reduce their carbon emissions levels at the lowest cost.
[13] Even if initially the permits are given away, because not enough permits will be allocated some entities will have to purchase permits off other entities to ensure compliance with the program.

The cap-and-trade program will cause an increase in the costs of goods and services that use carbon-emitting technologies as inputs. As a result, the final prices of these goods and services will increase. Consumers, reacting to these higher prices, will then reduce their consumption of goods and services that are produced using carbon-emitting technologies and switch to less-carbon intensive products if they are available.[14] If the permits are auctioned, a stream of revenue will flow to the government. This stream of revenue (net of administrative costs) could be re-distributed in various ways back into the economy.

2.3. Carbon Taxes

A carbon tax generally works differently to a cap-and-trade program (but under certain assumptions the final effects can be the same). Cap-and-trade programs determine the *quantity* of emissions and allow the market mechanism to determine the *price* of the permits (for instance, per ton of carbon emissions). By contrast, a carbon tax determines the *price* of emissions and allows the market to determine the *quantity* of emissions. By internalizing the cost of emissions (emitters have to pay to emit carbon), carbon taxes raise the relative price of using carbon-emitting technologies and the final price of goods and services that use carbon-emitting production techniques.

Thus, carbon taxes provide a monetary incentive for both producers and consumers to alter their behavior and move away from carbon-intensive technologies and products. Carbon taxes also generate revenue for the government which can be allocated to various uses.[15]

2.4. Offsets

Some policy measures have special provisions to allow offsets. An offset is an instrument that represents investment in an activity that reduces the amount of CO_2 in the atmosphere.[16] When

[14] Even if substitutes are not available as long as demand is not perfectly inelastic then consumers will still reduce their consumption of goods and services that are produced using carbon-emitting technologies.
[15] It is an on-going debate regarding what the "best use" of carbon tax revenue is.
[16] For example regulated entities could pay farmers to reduce the frequency at which they till their soil (this is known as soil sequestration).

offsets are allowed, regulated entities may purchase them in lieu of reducing their own emissions.

Offsets affect the *distribution* of the reductions across regulated and non-regulated sectors or entities. If no offsets are allowed, all of the required reductions must come from the sectors that are being regulated. If offsets are allowed, some or potentially all of the reductions may come from sectors that are not required by legislation to reduce their emission levels.

Regulated entities are likely to use offsets if they are more cost-effective than reducing carbon emissions.[17] Thus offsets are an alternative option for regulated entities that face high direct costs associated with their "carbon decision-making."[18,19]

2.5. Energy Efficiencies

If there is an improvement in energy efficiency (improvements in miles per gallons (mpg) of gasoline is a standard example), the total amount of GHG emissions may be reduced for the same level of economic activity. Energy efficiency enables an economy to become less energy-intensive (which reduces the amount of carbon emitted), even if the underlying economic activity remains the same.[20] However, given that less energy is required to perform a particular task, individuals may respond by increasing the number of tasks or activities they undertake. For example, improvements in fuel efficiency may induce individuals to drive more miles.[21]

[17] As it will be shown when examining the studies below much of the literature assumes offsets are a cost effective alternative. If they were not there would be no financial incentive for a regulated entity to utilize them.
[18] These decisions may include the costs associated with implementing carbon reducing measures, paying a carbon tax or purchasing an emissions permit.
[19] Offsets mean that the regulated entity does not directly have to reduce their actual emission levels but instead reduces them indirectly by enabling the regulated entity to claim credit for emission-reducing activities performed by non-regulated entities. This means that the entity can avoid adopting emission reducing options, paying carbon taxes or purchase emissions permits.
[20] Here we are focusing on how energy efficiency can reduce the amount of energy *per dollar* of economic activity and not any potential changes in economic activity that might occur if energy efficiency measures are adopted.
[21] The improvement in fuel efficiency lowers the marginal cost of driving each mile. Increases in the total amount of an activity undertaken due to an improvement in the efficiency associated with that activity (which lowers the cost) is known as the rebound effect.

2.6. Command and Control

Command and Control (CAC) regimes aim to restrict pollution levels by government mandate. A typical CAC regime includes standards that restrict the levels of certain types of emissions and/or the amount of pollutants present in the ambient environment. Further, polluting firms may be required to use certain technologies or practices.

Command and control mechanisms are different to say, a cap-and-trade mechanism, in that it allows less flexibility in how total emissions are reduced by often treating all carbon-emitting entities in the same manner. For instance, all carbon-emitting entities may have to comply with the same amount of pollutants present in the ambient environment irrespective of the entities ability to reduce emission levels. Thus command and control mechanisms do not allow the most efficient (low cost) converters to offset some of the emissions produced by high cost converters that a cap-and-trade program would allow. Therefore due to the lack of flexibility surrounding who and where emissions reductions can occur command and control programs tend to not lead to the least cost method of reducing emission levels being adopted relative to other mechanisms available. In theory, a CAC regime allows the regulating entity to determine (and control) efficient pollution levels. In practice, identifying and enforcing standards that yield efficient outcomes is difficult.

Ambient standards regulate an outcome for a specific area, so they allow some latitude for firms (or the entities that regulate them) to choose the means by which to achieve regulated levels. Penalties can be imposed for non-compliance, but ambient standards themselves cannot be directly enforced. *Emissions standards* apply to specific industries, firms or activities, but they allow regulated entities to choose the best—or the most cost-effective—technologies or practices with which to comply. Emissions standards can be enforced but they cannot guarantee the desired level of ambient pollution. *Technological standards* also apply to specific industries, firms or activities, but they may leave little (or no) choice as to the most cost-effective means by which to comply. Like emissions standards, technological standards can be enforced but they cannot guarantee the desired outcome.

2.7. Interactions among Programs

Programs or legislation that attempt to reduce carbon emissions, are often introduced in combination (i.e. multiple policy mechanisms may be adopted simultaneously, each with different, but related goals). For instance, the most recent federal legislation currently being discussed (H.R. 2454, American Clean Energy and Security Act of 2009) has an RPS component and it includes energy efficiency recommendations. It also allows offsets. Together, each of these components will interact with the center-piece of the legislation, a cap-and-trade program. Thus, when modeling the economic impact of a particular emission reducing program, it is important to understand the interactions among the various programs.

An often debated point is the interaction of allowing offsets and a cap-and-trade program.[22] Suppose offsets are not allowed. In all likelihood, some of the regulated entities (which are often grouped together and called the "covered" sector) would be required to invest in emissions-reducing technologies sometime in the future in order to meet the emissions cap requirement. Within a cap-and-trade framework, the emissions permit price will ultimately be determined by the marginal abatement costs associated with adopting carbon-reducing technologies. Marginal abatement costs are typically increasing with respect to the *cumulative level* of carbon emissions avoided. That is, it becomes increasingly expensive for the covered sector to continue to reduce its carbon emission levels.[23] As the cap is lowered, marginal abatement costs will increase (because the cumulative level of carbon emissions avoided will increase) which will in turn cause the price of emission permits to increase through time.[24]

If offsets are allowed and they are utilized by the covered sector, the cumulative amount of carbon emissions avoided in the covered sector would be lower than if offsets are not allowed. Importantly the *total amount* of carbon emissions avoided would be the same with or without offsets. However, the *distribution* of carbon emissions avoided would vary across the covered

[22] See Energy Information Administration (2009) *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009* and Congressional Budget Office (2009) *The Use of Offsets to Reduce Greenhouse Gases* for a recent discussion.
[23] This would be especially true for sectors, such as the utility sector, that is estimated to face increased demand for energy for the foreseeable future.
[24] This assumes no new technological changes that alter the marginal abatement costs.

and uncovered sectors in the two cases (assuming offsets are a cost effective method of reducing carbon emissions).[25]

When offsets are allowed, marginal abatement costs would be lower in the covered sector and therefore emissions permit prices would be lower as a result.[26] Thus, the economic impact of a cap-and-trade program that allows offsets could have significantly different economic results from one that does not allow offsets but with the same environmental outcome.[27]

3. Economic Impact Assessments

What must be included in an assessment of the economic impact of GHG reduction measures? To answer this question, we must first consider the fundamental relationships among the different groups in an economy. Just for illustration we consider an abstract economy where there are just four groups:

- consumers – consuming *all* the goods and services produced;
- government;
- energy providers;
- industry – divided into intensive and non-intensive energy users.

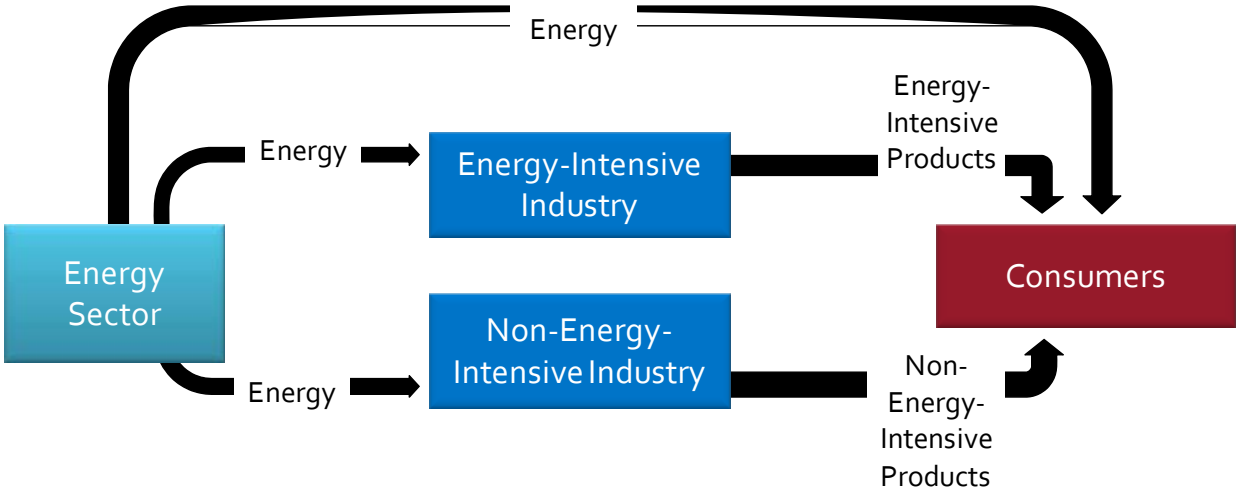
The relationships among these different groups are described (in very abstract form) in the flow chart below.

[25] In the case of no offsets, then all of the avoided emissions would have to occur in the covered sector. With offsets, assuming they are cost effective, a percentage of the avoided emissions will occur in the uncovered sector.

[26] This will affect the rate at which energy prices increase due to the introduction of a cap-and-trade program.

[27] There are numerous components left out in this example. For instance, the different effects of domestic offsets versus international offsets are ignored. Also, if offsets offer a cost-effective alternative method of reducing carbon emissions (they would not be utilized if they were not cost-effective), and a policy goal is to reduce overall carbon emissions at the lowest possible cost, the sector that contains the source of the offset should be regulated, at least in theory (of course this may not be feasible for international sources of offsets). All of these components and their implications are outside of the scope of this paper.

Figure 1: The Economy without Emissions-Reducing Policy



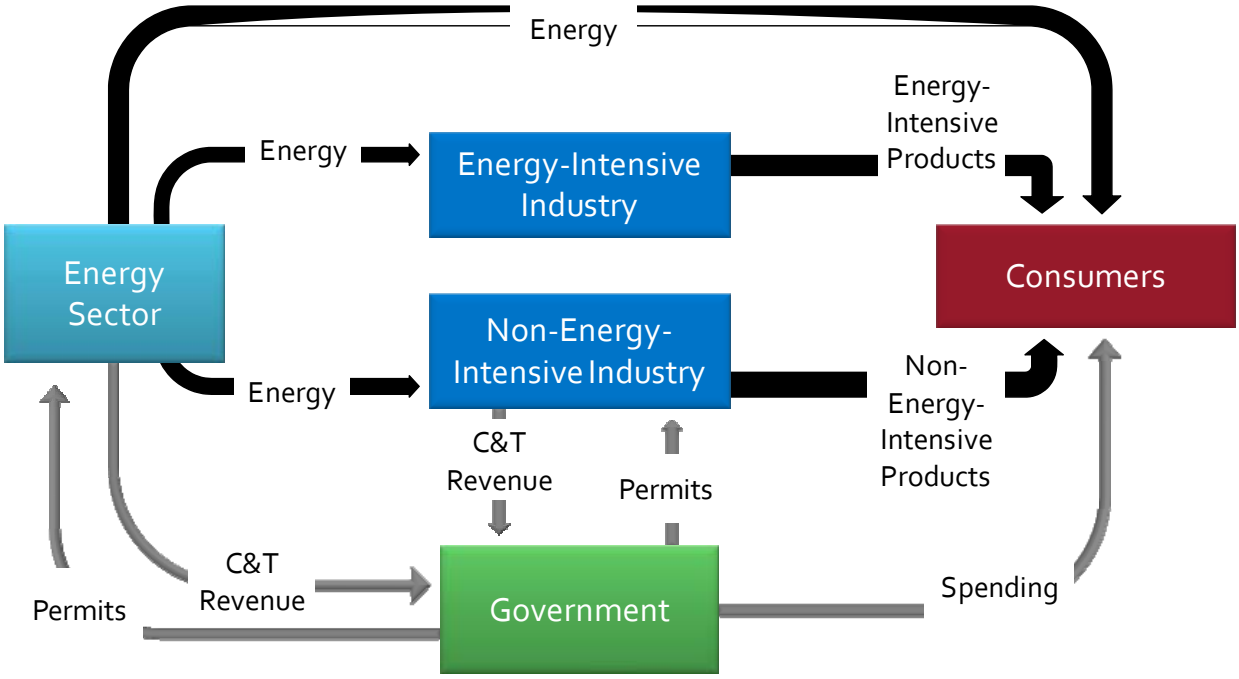
In a steady-state competitive free market, absent any form of government intervention, we expect energy providers to provide at lowest cost to both consumers and industry.[28] In turn, we expect industry to provide desirable goods and services at lowest cost to consumers. We also expect consumers to enjoy the benefits of the unfettered market system by allocating their expenditures to best fit their needs, given the current prices of energy and products.

One means of assessing the economic well-being of this economy is to measure the total value of all the goods and services consumed by consumers. The hypothetical economic system we have described works at maximum efficiency, given the price of energy (and other production inputs) and the available technology.

Now suppose we introduce a government sector which intervenes in the free market process because of a negative externality (specifically, the emission of GHGs). Intervention can take many forms (see section 2). Let's take the case of the introduction of a cap-and-trade system for emissions. This is represented in the figure below.

[28] It is important to note that many utility providers are in fact regulated monopolies.

Figure 2: The Economy with a Cap-and-Trade Program



We can trace through the effects of the introduction of a C&T system step by step:

1. The energy sector is affected in two principal ways. First, assuming (at least some of) the permits are auctioned, energy providers experience *directly* higher costs. Secondly, the energy sector is likely to move away from GHG-intensive methods of energy provision towards less intensive methods. To comply with the required GHG reduction, much of the currently deployed infrastructure may have to be replaced before the end of its useful life.[29] The latter results in *indirectly* higher costs.

Economic effect: higher energy prices.

2. Industry must also purchase permits to continue operation. This entails *direct* higher costs if production involves the emission of GHGs. The cost of energy provided by the energy sector to

[29] Thus the required GHG reduction and the *timeframe* for these reductions are important parameters when determining the overall economic impact of GHG reduction. The shorter the timeframe and the more stringent the reductions the higher the potential amount of assets retired before the end of their useful life.

industry also rises, resulting further *direct* higher costs. We expect industry to adapt by moving towards less energy intensive production methods, but this too entails *indirect* higher costs. A further effect on industry is a differential impact on energy-intensive as opposed to non-energy-intensive producers. The relative price of energy-intensive products rises.

Economic effects: higher prices for goods and services, differential impact on energy intensive versus non-energy intensive industry.

3. Government gathers revenue from both the energy sector and industry from the auctioning of permits. This revenue can be spent in a number of different ways but we assume here (for illustrative purposes only) that it is ultimately distributed to consumers.

Economic effect: additional funds available to consumers.

4. Consumers experience a number of different effects. First, the price of energy they consume increases. This reduces the amount of money that they have available to spend on products from industry. Secondly, the prices of products from industry increase as a result of industry's rising cost of production. Generally, this means consumers receive fewer goods and services for the same expenditure. However, there is also a tendency for consumers to purchase more non-energy intensive products because, in relative terms, their prices have fallen. Finally, consumers receive a transfer from government. The transfer allows them to increase the amount they spend on products from industry. However, the total transfer value is affected by transaction costs of administering the program and receiving the revenues.

Economic effects: less funds available to consumers due to energy price increases, additional funds available to consumers due to government transfer, generally more expensive products, energy intensive products become relatively more expensive.

There are of course several other possible market interventions that either federal or state governments will likely adopt in the foreseeable future. The point of our example is to illustrate the complex nature of the effects associated with any form of market intervention and to

provide a concrete example from which to construct criteria that can be used to evaluate pre-existing economic impact assessments.

4. Evaluation Criteria

4.1. Completeness of the Assessment

Even from the abstract example presented above, it is clear that there are several countervailing influences upon the economy, emanating from any government intervention. It is important that *all* of these influences are accounted for in any assessment of economic impact. Thus the first criterion by which all economic impact assessments must be judged is the degree to which they have included all relevant influences.

4.2. Appropriateness of the Time Horizon Evaluated

We would not expect the economy described in the example above to adjust instantaneously to the government intervention. We expect a period of years, possibly even decades between the intervention and the achievement of a new, steady state of the economy. During the period of adjustment, it is likely that the effect of the intervention would have differential impacts upon the flows and the affected parties through time. For instance, there may well be an initial boost in terms of investment in the energy sector, funded through borrowing, which is repaid over an extended period.

If an assessment of the economic impact were performed for a restricted time period which did not encompass all the effects, the assessment would likely either over- or understate the true magnitude. Thus a second criterion that should be applied to the evaluation of any economic impact assessment must be that it allows sufficiently lengthy time period to include the movement from one steady-state (*without* the government policy intervention) to the new one (*with* the government policy intervention).

4.3. Assumption Validity

We consider the key determinants to each of the input variables and evaluate the reasonableness of the assumptions that underlie the inputs. Amongst the several studies in our review, there is considerable variation in some of the input values. Reasonableness as a concept is not easy to operationalize but we take the term to mean "in line with common belief or practice."

4.4. Reasonableness of the Base Case

To measure the effects of a policy change, each study must first assume a base case (or counterfactual) for the analysis. The predicted economic outcomes for the base case scenario are then compared to the results of a scenario (or multiple scenarios) in which the adoption of at least one emissions-reduction measure is assumed. The estimated effects of a policy change are based on the difference between the results in the base case and those from the alternative policy scenarios. In order to obtain meaningful results, the base case must be reasonable.

4.4. Model Suitability

There are some widely-accepted models that are commonly used for the purpose of measuring the economic effects of a policy change.

The REMI model is perhaps the best-known and most-respected model, as it is recognized by the business and academic community as a leading commercial tool. REMI contains detailed industry data files that are specific to the subject geography and it accounts for the interrelationships among industries. Accordingly, REMI is well-suited to measure the effects of the policy changes considered in the papers that are the focus of this study.

Another well-known model is IMPLAN, an input-output model that estimates predictive multipliers for economic activities within a specific region. Like REMI, IMPLAN uses detailed industry data files that are location-specific. An important difference between REMI and

IMPLAN is that REMI will measure effects over time, whereas IMPLAN will only estimate them at a point in time.

In addition to or as an alternative to the models described above, a number of researchers employ their own proprietary models. It can be difficult to assess the suitability of a proprietary model.

Regardless of which model is selected, its validity is dependent upon the quality of the data used. Both REMI and IMPLAN contain data files for each applicable geography. The files must be updated periodically and updates are typically made available annually.

4.5. Transparency of Analysis

In general, we gauge the transparency of each study on the basis of how easily the work might be replicated. In order to replicate the results of a study, one would need the input data, the underlying assumptions, and the model used. Here we examine whether the data sources have been appropriately disclosed, whether the underlying assumptions are clearly explained, and whether the model is accessible. Where proprietary models have been used, the basis for our assessment of transparency is whether the study could be replicated if we had access to the model.

4.6. Assessment of Sensitivity of Results

The results of every study are dependent on the quality of input data and assumptions. Where inputs are based on forecast values (e.g. the price of natural gas in 2020), it is preferable that the researcher present a range of possible values, reflecting the possibility of variance in the model inputs. In applying this criterion, we examine whether the researcher has performed adequate analysis to test the sensitivity of the conclusions to the inputs.

5. Moot Issues[30]

One of the curious aspects of much of the research which examines the effect of government-imposed mechanisms to encourage the use of lower GHG-emitting technology in the realm of power generation is the often-predicted large positive economic impact. This conclusion is curious because if the private financial impact of technological change in this area were indeed positive, we would expect the market process to lead electricity suppliers toward new, less intensive carbon-emitting technologies *naturally*, without the need for any government intervention.

There is little or no evidence that, without some form of government intervention, electricity suppliers, or other carbon emitting industries are moving toward increased usage of renewable generation methods because there is incontrovertible evidence that it would afford them no financial gain. Thus, from the perspective of the private sector, the financial case for new rules does not currently exist without government intervention. Positive economic impacts generally flow directly from private financial gain.

Consider the following example. If a new generating technology becomes available at a lower cost, there is a private financial incentive to introduce the technology and allow power to become cheaper for consumers. The adoption of the new technology then logically leads to a reduction in expenditures on electricity by power consumers. That reduction has subsequent ripple effects, both reducing production costs and increasing consumer expenditures in other areas. The fact that suppliers must currently be cajoled or forced into using renewable technologies arises from the fact that these technologies are generally more expensive in a private sense and lead to higher prices for consumers.

The conclusion is that government intervention is likely to have negative general economic impacts rather than positive ones. Effectively, if a government-imposed mechanism to reduce carbon emissions were to have a positive economic impact, electricity suppliers would be racing to renewable technologies without the need for the mechanism in the first place. Of course, in

[30] 'Moot' in the legal sense of having been already determined.

this discussion, we ignore the critically important environmental benefits that less intensive carbon-emitting technologies allow. Given the current cost-competitiveness of alternative renewable technologies, the case for the latter should be made on the basis of the environmental benefits rather than questionable economic benefits.

Another potential area of concern occurs during the aggregation of benefits and costs at society's level. If a single consumer reduces his/her vehicle miles travelled (perhaps by purchasing a fuel-efficient vehicle), the resulting *private* benefit is the total amount of money saved due to reduced gasoline consumption. This would include, amongst other things, money spent on fuel and reduced costs associated with maintaining the vehicle. However, the gain to *society* overall may not be as large. Part of the private savings may actually be a cost to society; the individual's cost saving also results in lower gas tax collection for society.[31] Thus if private benefits or costs are simply aggregated, the effect on society may be misrepresented.[32]

6. Overview of Studies Examined

Below is a brief outline of each of the 11 studies we examined. The studies are grouped according to the principal emissions-reducing program examined.[33] It should be noted that whilst the studies below measure the economic impacts of reducing GHGs, they may examine different proposed pieces of legislation, they are conducted at various points in time with different baselines and study periods examined, they investigate different geographies and they may report results across a range of various macroeconomic variables.

We have applied the evaluation criteria described in Section 4 to each of the papers we have examined. A brief summary of our evaluation is presented at the end of each outline below. The Appendix presents a more robust discussion of our evaluations.

[31] For instance 18.4 cents per gallon of gas is collected in the form of federal gas taxes. State gas taxes vary across states.
[32] See Stavins et al for an example of when mistakes like this may occur. One common mistake is to ignore rebound effects. See footnote 16 for more details.
[33] If more than one program is examined then the mechanism that has the largest economic impact is used to determine which group it is placed in.

6.1. Renewable Portfolio Standard Studies

6.1.2 Centre for Climate Strategies (2009)

> "Overall, the *Florida Energy and Climate Change Action Plan* is a win-win policy in terms of aggregate economic performance and emissions reductions." p. 20.

The Centre for Climate Strategies study examines the economic impact of the Florida energy and climate change action plan on the Florida economy. Overall there are 50 policy recommendations in the action plan. 28 policy recommendations are quantified in terms of their costs and affect on GHG emissions. It is estimated that the 28 policy recommendations combined would lead to total net cost savings of $33.6 billion (2005$) and a total reduction in GHG emissions of approximately 1,917 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) over the period 2009-2025.[34]

The action plan reports that the introduction of an RPS of 20 percent of retail sales by 2020 will lead to a net present value saving of $9,274 million (2005$) and reduce total GHG emissions of approximately 319 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) over the period 2009-2025.

Using REMI, the authors estimate that the adoption of measures quantified in the Florida action plan would cause Gross State Product (GSP) to increase by $37.9 billion (2000$) in cumulative terms by 2025 relative to the base case (business-as-usual (BAU)). Also, by 2025 employment would be higher by approximately 148,000. Of this, the RPS will contribute approximately $16 billion (2000$) towards the cumulative increase in GSP and create 36,700 jobs by 2025. Overall the report concludes that an overwhelming win-win outcome is possible in Florida.

6.1.2.1 Evaluation

[34] See Table 1, Centre for Climate Strategies, 2009**.** Note: These figures are not adjusted for overlaps within and among sectors caused by the various policy measures.

- **Completeness of the Assessment:** The assessment is substantially complete. However, it does not capture any change in O&M costs, which would be likely to result from the projected increase in renewable generation.
- **Appropriateness of the Time Horizon Evaluated:** The timeframe is appropriate in that it covers the legal duration of the policy recommendations, but it may be insufficient to capture the long-run economic effects of the programs.
- **Assumption Validity:** Some of the critical input assumptions are questionable. For instance, the levelized cost of PV is assumed to fall substantially by 2025 while conventional generation is expected to become significantly more expensive. These assumptions violate basic economic principle (if they were true, it would be unnecessary to adopt the policy measures).
- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** The authors use REMI, which is suitable for this purpose of the analysis.
- **Transparency of the Analysis:** The analysis is sufficiently transparent.
- **Assessment of Sensitivity of Results:** Some sensitivity analysis was performed, but we would have expected it to be more robust.
- **Conclusion:** The study violates basic economic principles and is therefore unreasonable.

6.2. Cap-and-Trade Studies

6.2.1 Economic Development Research Group (2006)

> "Despite higher electric prices, consumers paying for an energy efficiency program and their buying efficient goods, the combined effects of generating technology investments (traditional, renewable and energy efficient) and bill savings eventually [outweigh] the effect of higher electric prices." p. 25.

The Economic Development Research Group (EDRG) presents an analysis of the economic impacts of proposed climate change policies of the northeast Regional Greenhouse Gas

Initiative (RGGI), a mandatory regional cap-and-trade program in which participating states restrict GHG emissions, create CO_2 allowances, and set rules for participation in CO_2 allowance auctions. At the time of the study, nine states were participants in the planned RGGI: New Hampshire, Vermont, Maine, Rhode Island, Massachusetts, Connecticut, New York, New Jersey and Delaware.[35] The study examines the proposed policies in conjunction with energy efficiency provisions, as well as in combination with proposed federal and Canadian policy measures, for the period from 2008 through 2035.

The authors present the following three assumption scenarios:[36]

- "RGGI Package": Assumes a carbon-cap target of 35 percent, resulting in 2020 emissions levels 10 percent below 1990 levels. Allows offsets and assumes energy efficiency measures will be adopted.
- "RGGI Package + Canadian ("CN") – Federal Policies": Combines the assumptions of the RGGI Package with the adoption of a national Canadian policy, which assumes emissions stabilize at projected 2008 levels, beginning in 2008; and a federal policy that assumes stabilization at 2015 levels, beginning in 2015.
- "RGGI Package + 2 x Efficiency": Based on the RGGI Package, but replacing the energy efficiency assumption with twice as much adoption of energy efficiency measures.

For comparison, two reference scenarios are constructed. In the "Default Reference," existing state air quality regulations are assumed to be in place, as well as federal RPS and "3P" regulations. The "High-Emissions Reference" assumes coal builds are permitted in the RGGI region.

In each scenario, the ICF Consulting IPM Model is used to predict wholesale prices for electricity, natural gas, and oil; the investment mix for traditional and renewable energy generation technologies; and investment in energy efficiency measures and the resulting energy

[35] In addition to the nine states listed here, Maryland is also now a participant in the RGGI, which took effect in July 2008 (Point Carbon News, 2008).
[36] p. 14.

savings. Results from the IPM Model are then mapped to a 12-region REMI model, which is used to forecast the macroeconomic effects of the policy changes over time.

The results of the RGGI Package and RGGI Package + CN – Federal Policies scenarios are each presented alongside both reference scenarios, for comparison. The RGGI Package + 2 x Efficiency scenario is compared only to the Default Reference.

By comparison to the Default Reference, all three scenarios affect an increase in cumulative investment in pollution control and new plants over the policy horizon. Retail electricity prices generally increase in both the RGGI Package and the RGGI Package + CN – Federal Policies scenarios, but decrease in the RGGI Package + 2 x Efficiency scenario. The authors explain that the price increases would be "…mitigated when a two-fold energy efficiency program helps avert load growth further…." (p. 19).

By comparison to the High-Emissions Reference, both scenarios result in a cumulative decrease in investment in pollution control and new plants. With the Canadian and federal policies in place, however, cumulative investment is estimated to decrease only $416[37] million over the policy horizon, or roughly one percent of cumulative investment in the High-Emissions Reference scenario.

The proposed energy efficiency program is estimated to cost $9,228.6[38] million over the life of the program, in addition to $1,476.6 million in cumulative consumer outlays for energy-efficient goods. However, in both the RGGI Package and the RGGI Package + CN – Federal Policies scenarios, the resulting averted load growth is shown to create substantial savings in the residential, commercial, and industrial sectors, for a net cumulative benefit of at least $9 billion.

6.2.1.1 Evaluation

[37] In 2003 dollars.
[38] In 2003 dollars.

- **Completeness of the Assessment:** The study is incomplete as it appears to overlook some key economic effects. For instance, it is unclear whether emissions permits are auctioned, and if so, what happens with the proceeds.
- **Appropriateness of the Time Horizon Evaluated:** The study period extends through the legal life of the proposed policy, but that horizon is insufficient to capture the long-run economic effects of the program.
- **Assumption Validity:** Some of the critical assumptions in the base case are aggressive, with the net result of minimizing the negative economic effects and maximizing the positive effects of the proposed program.
- **Reasonableness of the Base Case:** The base case is unreasonable, as it assumes that a federal RPS is in effect in 2015.
- **Forecasting Model Suitability:** The authors used REMI and a proprietary model, which are suitable for the purpose of the analysis.
- **Transparency of the Analysis:** The study is not sufficiently transparent. It would be difficult to replicate the study with the information presented.
- **Assessment of Sensitivity of Results:** No sensitivity analysis was performed.
- **Conclusion:** The results of the study are unreliable. The methodology is incomplete and the conclusions are in violation of basic economic principles.

6.2.2 Beach, Kreutzer, Lieberman and Loris (2008)

> "Our analysis makes clear that S. 2191 promises extraordinary perils for the American economy. Arbitrary restrictions predicated on multiple, untested, and undeveloped technologies will lead to severe restrictions on energy use and large increases in energy costs. ... [T]hese higher energy costs will spread through the economy and inject unnecessary inefficiencies at virtually every stage of production and consumption ... ." p.1.

Beach et al. provide analysis of the Climate Security Act of 2007 (S. 2191), spearheaded by Senators Lieberman and Warner, to 2030. The proposed S. 2191 would impose strict upper

limits on emissions of six greenhouse gases, particularly carbon dioxide (CO_2). The mechanism proposed to limit emissions in the legislation is a federally-created cap-and-trade system.

Beach et al. offer two assumption scenarios:

- "Generous" -- all currently enacted federal, state and local legislation will be overcome and carbon capture and sequestration technology *will* be commercially available within 10 years.
- "Reasonable" -- carbon capture and sequestration technology *will not* be commercially available within the 20 year timeframe.

With their "generous" scenario in place, the authors show the results of S. 2191, relative to a base case of no enactment of the legislation and the economy maintaining the long-term trend growth of the November 2007 Global Insight forecast, to be a cumulative GDP reduction of $1.438 trillion (2000$) and 3.37 million jobs[39] lost between 2010 and 2030. With their "reasonable" scenario, a cumulative GDP reduction of $4.57 trillion (2000$) occurs with 9.94 million jobs[40] lost between 2010 and 2030.

6.2.2.1 Evaluation

- **Completeness of the Assessment:** It is difficult to determine whether the analysis is complete because it is not transparent. For instance, there is no clear explanation of how the proceeds of the cap-and-trade program are recycled back into the economic system.
- **Appropriateness of the Time Horizon Evaluated:** The study period extends through the legal life of the proposed policy, but that horizon is insufficient to capture the long-run economic effects of the program.
- **Assumption Validity:** Some of the assumptions are questionable, as they are inconsistent with reputable sources. For instance, estimates of the costs of conventional generation are relatively conservative, which could bias the study to predict unreasonably severe economic effects.

[39] In person years.
[40] In person years.

- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** The authors used Global Insight's U.S. macro model, which is suitable for this purpose.
- **Transparency of the Analysis:** The study is not sufficiently transparent. It is unclear whether or how all the relevant economic effects have been captured. Thus, it would be difficult to replicate the study.
- **Assessment of Sensitivity of Results:** Although two alternative scenarios were presented, we would have expected a more robust analysis.
- **Conclusion:** The results of the study may be considered unreasonable because the study is not transparent. Also, the predicted economic effects may be unreasonably severe because of a bias in the input assumptions.

6.2.3 Energy Information Administration (2008)

> "S. 2191 increases the cost of using energy, which reduces real economic output, reduces purchasing power, and lowers aggregate demand for goods and services. …[P]rojected real GDP generally falls … . Adverse economic impacts generally increase over time as higher cost emissions abatement options are required as emissions caps become more stringent while population and economic activity levels continue to grow." p. xi.

The EIA presents an analysis of Title I of S. 2191, through 2030.

The study presents the following five assumption scenarios:[41]

- "Core": Assumes key low-emissions technologies are developed and deployed, commensurate with the decreasing emissions requirements of S.2191, without any major obstacles. Also, domestic and international offsets may be used without significant costs or regulatory restrictions.

[41] p. 8.

- "No International Offsets": Replicates the key assumptions of the Core scenario, but the use of international offsets is assumed to be significantly limited.
- "High Cost": Replicates the key assumptions of the Core scenario, but with the assumption that the costs of nuclear, coal with carbon capture and sequestration (CCS), and biomass generating technologies are 50 percent higher than in the Core scenario.
- "Limited Alternatives": Assumes key low-emissions technologies are not developed or deployed on the scale necessary to meet the declining emissions caps in S.2191. Rather, the deployment of these technologies is held to the levels in the reference case.
- "Limited/No International": Adds the assumptions of the No International Offsets scenario to those in the Limited Alternatives scenario.

The scenarios offer high- and low-end values for the effects of the legislation, treating major inputs as discrete categories. Either technological innovation occurs at pace with decreasing emissions caps, as in the Core scenario, or it does not, as in the Limited Alternatives scenario.

The results of each scenario are presented alongside a reference case which assumes S. 2191 is not adopted but current policy measures remain in place.[42] Assumptions concerning emissions levels for five of the six targeted GHGs are based on scenarios in a separate study from the Environmental Protection Agency, which assumes the implementation of certain climate change policy measures and the voluntary adoption of certain low-emissions technologies.

Although S. 2191 would remain in effect through 2050, the analysis applies only to the period through 2030. To model the costs of compliance with progressively lower emissions caps after 2030, the authors assume a positive balance of banked allowances at the end of 2030. In all cases, the balance is assumed to be 5 billion tons.

In all cases, the cumulative economic effects of S. 2191 over the study period are shown to be negative. In the Core scenario, in which the assumptions are most optimistic, the Act results in

[42] The Energy Independence and Security Act of 2007 was enacted on December 19, 2007 and is included in the reference case.

cumulative decreases of $444 billion[43] in GDP, $558 billion in consumption, and $1,348 billion in industrial shipments. In the High Cost scenario, where the assumptions are least optimistic, cumulative GDP falls $1,306 billion, cumulative consumption falls $1,422 billion, and cumulative industrial shipments decrease by $3,684 million. In percentage terms, the effects on cumulative GDP are small, ranging from 0.2 percent in the Core scenario to 0.6 percent in the Limited Alternatives/No International scenario.

6.2.3.1 Evaluation

- **Completeness of the Assessment:** The study is complete in that it accounts for all the relevant economic effects.
- **Appropriateness of the Time Horizon Evaluated:** The study essentially spans the legal life of the proposed legislation, but that horizon may be insufficient to capture the long-run economic effects of an evolving program.
- **Assumption Validity:** The assumptions are assumed to be reasonable, as the EIA and the EPA are highly-regarded sources for the kinds of information examined.
- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** The EIA's National Energy Modeling System (NEMS) is suitable for this purpose.
- **Transparency of the Analysis:** The study is sufficiently transparent, as the results could be replicated (assuming access to NEMS).
- **Assessment of Sensitivity of Results:** Although there are five alternative scenarios for the time period through 2030, no sensitivity analysis is performed around the simplifying assumptions that account for the following 20 years.
- **Conclusion:** The study is reasonable.

6.2.4 Beacon Hill Institute (2009)

[43] In 2000 dollars. All cumulative figures are quoted as present value at the time of the study, assuming a discount rate of 4 percent.

> "The higher cost of energy would hurt profit margins, causing firms to reduce investment in [WCI] member states." p.17.

The focus of the Beacon Hill Institute study is to examine the economic impact of a cap-and-trade program which is part of the Western Climate Initiative (WCI). The study examines the economic impact of the estimated changes in energy prices[44] (electricity, natural gas, oil and gasoline) that are associated with introducing a cap-and-trade program for the seven U.S. States that are part of the WCI.[45]

Using a proprietary computable general equilibrium model (CGE) the study estimates the percentage change in economic variables such as employment and personal income that will occur if energy prices change by the amounts forecast in 2020 as a result of the introduction of a cap-and-trade program.[46] These percentages forecasted with the CGE model are applied to forecasts for these same variables in 2020 for the various WCI states.[47]

The authors find that net employment would be *lower* by approximately between 20,412 and 109,433 in 2020 if 100 percent of the permits are auctioned. If 25 percent of the permits are auctioned, net employment would be *lower* by between 35,531 and 145,687 in 2020. This result is primarily driven by the fact that it is assumed that auction revenues are used to increase public sector employment. In the private sector, employment in the 100 percent case would be *lower* by between 103,931 and 251,674 in 2020. In the 25 percent case private sector employment would be *lower* by approximately between 35,177 and 165,397 in 2020.

In Arizona, net employment is estimated to be lower by between 4,801 and 18,440 and per capita disposable income[48] would decrease by between $48 and $139 in 2020 in the 100 percent auction case. If 25 percent of the permits were auctioned net employment was estimated to be

[44] Western Climate Initiative, *Design Recommendations*,2009: Table B-16.
[45] Arizona, California, Montana, New Mexico, Oregon, Utah, Washington.
[46] The authors calculate the average percentage change in economic variables from numerous CGE state models (with only one being a WCI state –which may be a potential issue) in 2020.
[47] They report that the average fall in private employment is 0.9 percent for the broad with no-offsets case.
[48] The authors calculate everything in real terms (as they adjust nominal growth in economic variables by a forecast of inflation). However, they do not report the base year.

between 4,876 and 20,496 lower and per capital disposable income would decrease by between $50 and $225 in 2020.

6.2.4.1 Evaluation

- **Completeness of the Assessment:** The study is complete insofar is it accounts for all of the relevant economic effects – although only for a single year.
- **Appropriateness of the Time Horizon Evaluated:** The time horizon is inappropriate as the study examines the economic effects in only one year.
- **Assumption Validity:** Some of the assumptions are questionable. For instance, some inputs are taken from the WCI's study, which the authors themselves discredit.
- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** The State Tax Analysis Modeling Program (STAMP) is not suitable for evaluating this type of policy change, as the STAMP can simulate changes in economic variables for no more than five years.
- **Transparency of the Analysis:** The study is sufficiently transparent, as the results could be replicated if one had access to STAMP.
- **Assessment of Sensitivity of Results:** Limited sensitivity analysis was performed and only average results were reported for each state, rather than a range of results. Thus the analysis is not sufficiently robust.
- **Conclusion:** The study is a somewhat inaccurate but reasonable attempt to examine the macroeconomic impact of carbon pricing for a single year. However, it does not provide a full and accurate assessment of the impact of carbon pricing.

6.2.5 Congressional Budget Office (CBO) (2009)

> "The studies reviewed by the CBO yielded a wide range of estimates of losses in GDP from climate policies, but all of them concluded that, all else being equal, higher prices for emission allowances would impose greater losses in GDP." p.12.

The focus of the CBO study is to examine the economic impact of introducing H.R. 2454, "American Clean Energy and Security Act of 2009" on the U.S. economy.[49] The main focus of the study is the modeling of the economic impacts associated with the introduction of a carbon cap-and-trade program on the whole U.S. economy. The Act calls for a restriction of greenhouse gases from covered entities[50] to 17 percent below 2005 levels by 2020 and 83 percent below 2005 levels by 2050.

The CBO estimates that the price of emissions permits would be $15 (2007$) in 2012.[51] Thereafter, the CBO estimates that the price per permit will increase by an annual real amount of 5.6 percent. Therefore, by 2050 the emissions permits would be $118 (2007$).[52]

In order to quantify the economic impacts associated with these permit prices, the authors rely upon a survey of previous studies of cap-and-trade programs and their impacts on real GDP. Based upon this survey, the CBO assumes GDP will decrease by 0.01-0.03 percent *per dollar* of allowance price.[53] Applying these percentages to their permit price forecast, the authors estimate that in 2020 real GDP would be between 0.2 and 0.7 percent below its baseline. By 2050, real GDP is estimated to be between 1.1 and 3.4 percent below its baseline.

Examining the distribution of impacts across different income levels, the CBO estimates that in 2020 individuals in the lowest quintile[54] that have an average income equal to approximately $17,900 would benefit under the cap-and-trade program by approximately 0.7 percent ($125 2010$). All of the remaining quintiles would have reduced purchasing power in 2020. In percentage terms the middle quintile (average income of approximately $51,700 (2010$)) faces the largest reduction in purchasing power (0.6 percent).[55] The middle quintile suffers the

[49] This is often referred to as the "Waxman-Markey Act".
[50] Covered entities would be phased into the program between 2012 and 2016.
[51] The first year the program would be in place.
[52] The CBO acknowledges that there are numerous different factors that determine the price for emissions permits. For instance, the offset provisions in the Act reduce the allowance price by 70 percent. Also banking of permits and regulations and subsidizes also assist with lowering the price.
[53] These estimates were taken from the studies examined.
[54] The quintiles have an equal number of individuals.
[55] In absolute dollar terms the highest quintile faces the largest reduction in income – $1,235 (2010$).

largest percentage decline because of the assumed distribution of the proceeds. Some of the funds will be allocated to limit the impact of higher energy prices low-income households, whilst some of the funds will be passed onto shareholders (which benefits the highest quintile).

By 2050, the lowest quintile would benefit under the cap-and-trade program by approximately 2.1 percent ($355 (2010$)). The remaining quintiles would suffer larger percentage losses in 2050 than in 2020 with the middle quintile having reduced purchasing power of approximately 1.1 percent ($590 (2010$).

6.2.5.1 Evaluation

- **Completeness of the Assessment:** Completeness is problematic. At the disaggregated income level, some economic effects appear to have been omitted.
- **Appropriateness of the Time Horizon Evaluated:** The study spans the legal life of the proposed legislation.
- **Assumption Validity:** Assumptions are valid, as they are representative of those used by several other others who have examined the same legislation.
- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** This criterion is inapplicable, as no formal model was used.
- **Transparency of the Analysis:** The study is sufficiently transparent, as the results can easily be replicated.
- **Assessment of Sensitivity of Results:** No sensitivity analysis is performed.
- **Conclusion:** The study is a reasonable as it uses conclusions from a wide range of other studies to reach its aggregate conclusions. However, the disaggregated results must be handled with care. They are sensitive to the assumptions made with regards to the allocation of permits, which are as yet unassigned.

6.2.6 Montgomery et. al. (2009)

> "It is not possible to avoid these costs through any free distribution of carbon allowances. Although the wise use of revenues from an auction or carbon tax can ameliorate impacts to some segments of the economy, the cost of bringing emissions down to levels required by the caps cannot be avoided." p. 2

Montgomery et. al. presents an analysis of the policy provisions in the proposed H.R. 2454 which requires a 17 percent reduction in emissions by 2020 and 83 percent by 2050. The baseline for these targets is 2005.. The authors examine the economic impacts of H.R. 2454 on the U.S. over the period from 2010 through 2050.

Two assumption scenarios are constructed:[56]

- "Low Cost": Assumes high elasticity of demand for electricity; zero- and low-carbon alternative fuels are reduced to cost parity with motor gasoline; capital costs for new generating technologies are based on AEO Early 2009 release; CCS capacity limits are assumed to reach 270 GW by 2050; and wealth transfers out of U.S. from international offset purchases priced at marginal cost of international offsets.
- "High Cost": Assumes low demand elasticity; no zero-carbon fuels; capital costs for new generating technologies are flat through the forecast horizon; CCS capacity reaches 180 GW by 2050; no expansion of existing nuclear capacity; and international offsets are purchased at CO_2 allowance price.

The two scenarios are considered against a reference case, with forecasts based on standard EIA estimates, modest growth in CCS capacity (equal to high-cost case assumption), and international offsets priced equal to the low-cost case.

Using three proprietary models, the authors estimate the cumulative macroeconomic effects of H.R. 2454 over study period. Employment is reduced by 2.3 million to 2.7 million jobs, net of

[56] p. 25.

any new "green" jobs, in each year. GDP decreases to $170 billion[57] (1 percent) below the reference level in 2015, $350 billion (1.3 percent) below the reference level in 2030, and $730 billion (1.5 percent) below the reference level in 2050.

6.2.6.1 Evaluation

- **Completeness of the Assessment:** The assessment is complete insofar as it accounts for all of the relevant economic effects.
- **Appropriateness of the Time Horizon Evaluated:** The time horizon is appropriate in that the study spans the legal life of the proposed legislation. However, as with any evolving program, long-run economic effects may persist after legislation expires.
- **Assumption Validity:** Assumptions are valid, as they are taken from highly-regarded EIA estimates.
- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** Three proprietary models are used, so it is difficult to assess their suitability for this purpose.
- **Transparency of the Analysis:** The study is sufficiently transparent. It appears as though the results could be replicated if one had access to the models.
- **Assessment of Sensitivity of Results:** Two scenarios are compared to a reference case to establish a range of carbon prices that may result.
- **Conclusion:** The results of the study appear to be reasonable, assuming the forecasting models were reasonable suitable for this purpose.

6.2.7 Aldy & Pizer (2009)

> "…[T]he competitiveness impacts from a unilateral U.S. climate policy on domestic manufacturers as a whole, and even differentiated by energy intensity, are small for a $15 per ton $C0_2$ price. The bulk of the effect on domestic manufacturing comes from a shift in domestic consumption—a desirable effect

[57] In each case (2015, 2030, 2050), GDP is expressed in 2008 dollars.

from the perspective of seeking a cost-effective policy and one that has nothing to do with the presence or absence of foreign regulation." p. 27

In a study prepared for the Pew Center on Global Climate Change, the authors present an analysis of the impacts of a domestic cap-and-trade system on the international competitiveness of U.S. manufacturing industries.

Using data from over 400 U.S. manufacturing industries, the authors perform a statistical analysis to estimate the historical relationships between energy prices and shipments, trade, and employment in those industries over the period from 1986 to 1994. Using the resulting model, the authors then simulate the effect of introducing a carbon allowance price of $15 per ton in 2012.[58] The authors assume there is no similar regulation adopted in other countries.

Aldy and Pizer find that higher energy prices would lead to a 1.3 percent decline in production, on average, across the U.S. manufacturing industries considered. Consumption would decrease 0.6 percent, on average, which the authors interpret to mean that only 0.7 percent of production would actually migrate overseas in response to the cap-and-trade program.

For energy-intensive industries,[59] the effects are more severe. At $15 per ton of CO_2, the value of total shipments would decrease by about 4 percent and consumption would decrease between 2 and 3 percent.

For the least energy-intensive industries, the study shows no significant effects on employment. In the most energy-intensive industries, employment would decrease less than 3 percent.

The authors conclude that consumers of energy-intensive manufactured goods generally do not respond to higher prices by consuming more imports, but rather, by decreasing their use of those goods or by substituting with less energy-intensive materials.

[58] At this price, the EIA estimates that electricity prices would increase approximately 8 percent.
[59] Energy-intensive industries are those for which energy costs exceed 10 percent of shipment value.

6.2.7.1 Evaluation

- **Completeness of the Assessment:** The assessment is complete insofar as it accounts for all of the relevant economic effects.
- **Appropriateness of the Time Horizon Evaluated:** The time horizon is inappropriate. Although the proposed policy change is long-term, the study examines only one year, when the economic effects could be less severe.
- **Assumption Validity:** The assumptions appear to be reasonable..
- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** The model is not well-suited for this purpose because it captures only short-run economic effects.
- **Transparency of the Analysis:** The study is sufficiently transparent, as the results could be replicated if one had access to the data.
- **Assessment of Sensitivity of Results:** No sensitivity analysis was performed around the assumed carbon price. This is a substantial shortcoming, as all forthcoming economic effects hinge on that assumption.
- **Conclusion:** The study should be regarded with some skepticism. The short-run results appear to be reasonable, but the authors' conclusion that the effects are "small" is not substantiated by the analysis.

6.3. Carbon Tax Studies

6.3.1 Charles River Associates (1994)

> "Higher energy prices lead consumers to make do with less energy and transportation services in order to keep some income available for spending on other goods and services that now appear relatively less costly and worthwhile." P. 4-7.

The Charles River Associates study examines the economic impact, at various degrees of sector disaggregation, associated with the introduction of a carbon tax on the U.S. economy. Using a proprietary input-output model (DRI input-output model) three scenarios were examined, a carbon tax set at $50, $100 and $200 (1992$) per metric ton of carbon which is phased in by 2000.[60] It was assumed that all revenue generated would be recycled back into the economy in the form of reduced taxation elsewhere.[61]

The paper reports that by 2010 real GDP would fall below its baseline level by approximately 1.2 ($50 carbon tax) – 4.2 ($200 carbon tax) percent.[62] Also, they found that regions that were reliant on coal-based electricity generation and/or were dominated by energy intensive sectors would face the largest declines in economic activity.

6.3.1.1 Evaluation

- **Completeness of the Assessment:** The assessment is substantially complete insofar as it appears to account for most of the relevant economic effects of a carbon tax.
- **Appropriateness of the Time Horizon Evaluated:** The time horizon is inappropriate, as it is only 15 years (which has the effect of raising the economic costs of emissions reductions).
- **Assumption Validity:** The assumptions appear to exaggerate the economic impacts of a carbon tax. For example the report assumes carbon tax revenue is lump-sum rebated to consumers. This, therefore, does not alter the incentive to work at the margin.[63] Also, this assumption does not offset any of the inflationary impacts associated with a carbon tax.[64] Also the authors assume that a carbon tax has no effect on the before-tax prices of fossil fuel. All these assumptions are biased to raising the economic costs associated with carbon taxes

[60] The authors suggest that a tax between $100 - $200 would be needed to hold carbon emissions in 2010 at its 1990 level.
[61] Specifically, reductions (lump-sum) in federal personal income taxes.
[62] For the $100 carbon tax real GDP would be 2.3 percent below its baseline level.
[63] Specifically they leave marginal tax rates unchanged.
[64] This is important because the authors then assume that interest rates increase (which further depresses economic activity) due to inflationary concerns.

- **Reasonableness of the Base Case:** The base case is reasonable, as it reflects "business as usual," without any new policy measures in place.
- **Forecasting Model Suitability:** The model is an input-output model, which appears to be appropriate for this purpose.
- **Transparency of the Analysis:** The study is sufficiently transparent, as the results could be replicated if one had access to the model.
- **Assessment of Sensitivity of Results:** Three alternative scenarios are presented. However, we would have expected to see a more robust sensitivity analysis.
- **Conclusion:** The study should be regarded as an example of the "worse-case scenario" in terms of reduced economic activity associated with carbon taxes.

6.4. Energy Efficiency Studies

6.4.1 Roland-Holst (2008)

> " ... the risks of excessive energy dependence include long-term economic growth. A lower carbon future for California is a more prosperous and sustainable future." p. 8.

Roland-Holst's California-centered study provides both an historical assessment of the economic impact of the reduction in per capita energy usage between 1972 and 2007 to approximately 40 percent below the 2007 national average level and a forecast of the economic impact of instituting the California Air Resources Board (CARB) Draft Scoping Plan.

The CARB Draft Scoping Plan, which also contains a cap and trade component, includes a series of interrelated energy reduction oriented measures with the aim of meeting California's target of 427 $MMtCO_2e$ overall emissions in 2020 including the imposition of:

- a C&T system (without offsets) with 100 percent of permits auctioned;
- various transportation emission standards;
- various changes to building and appliance energy efficiency standards and conservation measures;

- renewable energy programs;[65]
- other high global warming potential reduction measures.

Roland-Holst estimates the cost of the measures, apart from the C&T system, to be $10.8 billion.

The reduction in per capita energy usage between 1972 and 2007

The historical part of the Roland-Holst study uses a 'forensic' input-output approach, piecing together the changes in the structure of the California economy over the period caused by the per capita reduction in energy usage (amongst other causes). Against a counterfactual of per-capita energy usage growing from 1972 at national levels, it determines that the effects of the energy use reduction to approximately 40 percent below national levels by 2007 was the creation of 1.463 million jobs and a $44.6 billion (2000$) increase in Household Incomes.

The California Air Resources Board (CARB) Draft Scoping Plan

The forward-looking part of the Roland-Holst study uses the BEAR computable model and assess, against a counterfactual of California "business as usual" (BAU), finds cumulative effects to 2020 of a 1.5 percent rise in Gross State Product (amounting to $76 billion), a 1.2 percent rise in Household Income and 403,00 new jobs created.

6.4.1.1 Evaluation

- **Completeness of the Assessment:** The assessment is incomplete as it fails to accounts for the costs of adopting energy-efficient technologies.
- **Appropriateness of the Time Horizon Evaluated:** This criterion is inapplicable, as the assessment is a historical one.
- **Assumption Validity:** Some of the assumptions are egregious. For instance, historical changes in energy consumption are assumed to have been the direct result of policy changes only.

[65] Including an RPS of 33%.

- **Reasonableness of the Base Case:** The national energy trend appears to be a reasonable counterfactual.
- **Forecasting Model Suitability:** The model may not be accurately representative of California, as some portions appear to have been imputed from national models.
- **Transparency of the Analysis:** The study would be difficult to replicate.
- **Assessment of Sensitivity of Results:** No sensitivity analysis was performed.
- **Conclusion:** The study should be regarded with skepticism because of the heroic assumptions about adoption costs.

6.4.2 Climate Action Team (2007)

> "... the results are consistent with the expectation that there is value in implementing policies that promote emission reductions as broadly as possible throughout the economy." p. 40.

The Climate Action Team (2007) study provides an update to the 2006 Climate Action Team (CAT) Report with revised cost, savings and technical estimates and the inclusion of the effects of a California-wide cap-and-trade system. The analysis includes 40 climate strategies designed to reduce California emissions to 1990 levels by 2020 including an economy-wide C&T system with no offsets, instituting transportation emissions standards, improving building and appliance energy efficiency and conservation, and the promotion of renewable energy programs.[66]

Using two CGE models (Environmental Dynamic Revenue Analysis Model (E-DRAM) and Berkeley Energy and Resources Model (BEAR)), CAT find Gross State Output will change by +0.2% or -0.1% and Total Employment will rise by 0.3% and 0.2% relative to the reference case in 2020 as a result of initiating the strategies.

[66] Including an RPS.

6.4.2.1 Evaluation

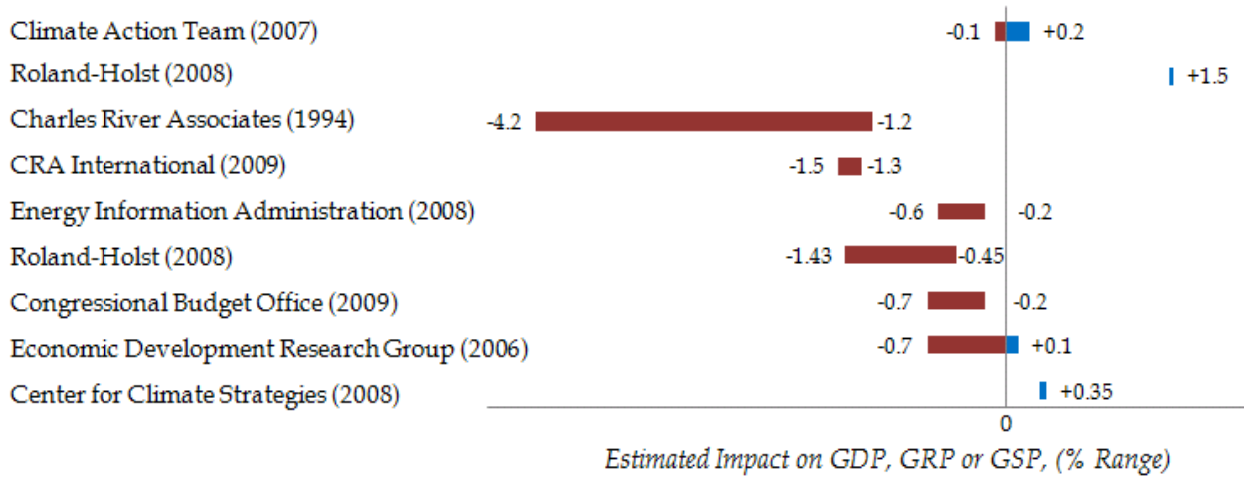
- **Completeness of the Assessment:** The assessment is complete insofar as it appears to have accounted for all of the relevant economic effects.
- **Appropriateness of the Time Horizon Evaluated:** The time horizon is inappropriate.
- **Assumption Validity:** Some assumptions are questionable. For instance, the energy prices for conventional fuels are assumed to be relatively low. This can have the effect of distorting the base case and biasing the results.
- **Reasonableness of the Base Case:** The base case is not clearly explained.
- **Forecasting Model Suitability:** The authors used two reputable CGE models, which are well-suited for this purpose.
- **Transparency of the Analysis:** The study is not sufficiently transparent, as it would be difficult to replicate the results and disentangle the effects of one policy change from another.
- **Assessment of Sensitivity of Results:** The study does not include a formal sensitivity analysis but rather the use of the same set of assumptions in two different model frameworks.
- **Conclusion:** The results must be treated with skepticism because of the unrealistic and inappropriate assumptions employed.

6.5 General Evaluation

Among the 11 studies, there is considerable variation in the methodologies, assumptions and results. Also in some cases, the presentation of results is such that they can be easily misinterpreted. The figure below presents a general illustration of the variation in results among several of the studies.[67,68]

[67] Studies are not shown if the authors did not provide estimates of policy impacts on GDP, GSP or GRP.
[68] The results presented here correspond to the macroeconomic effect of interest (i.e. change in GDP, GSP, or GRP) for the time horizon examined in each study. Some results were presented in cumulative terms for the entire study period, whereas others reflect the estimated impact for a single year. Some studies presented a range of results, whereas others presented only one point estimate.

Figure 3: Variation in Results from Studies of the Economic Impacts of Climate Change Policy



8. Conclusions

At first glance it appears that there is a significant amount of disagreement in the literature with regards to the cost of reduced emission levels. Some studies, such as the Center for Climate Strategies, and Roland-Holst report a win-win situation for Florida and California respectively. Other studies, such as Charles River & Associates, report significant reductions in economic activity for the United States for little or no environmental benefit. Whilst the majority of studies examined report moderate reductions in economic activity as a result of improved environmental benefits.

Closer examination of the literature reveals some important in-sights. The studies examined have varying degrees of failings which ultimately affects the accuracy, validity and sensibility of their results.

Studies that suggest that environmental outcomes can be improved along with increased economic activity rely on some highly dubious assumptions, and in many cases violate basic economic principles. Examples include assumptions concerning the costs associated with renewable energy and gains from energy efficiency.

The remaining studies suggest that there is a trade-off between economic activity and environmental improvements. The magnitude of the negative economic impact associated with reducing carbon emissions reported within the studies examined is highly dependent upon the assumptions made. Assumptions surrounding the time horizon examined, the financial costs associated with reducing emissions, the size of the carbon tax or emission price that prevails for those entities that continue to emit carbon, how much energy prices will increase, and how, and how much, of any proceeds from emission-reducing programs are recycled back into the economy ultimately determine the size of the negative economic impact.

The shorter the time horizon, the higher the financial costs associated with reducing emissions, the higher the carbon tax or emission permit price paid by emitters, the higher the resulting

energy prices and the lower the amount of proceeds recycled the higher the overall economic costs associated with reducing carbon emissions.

Ultimately, further research that identifies and examines a wide range of possibilities and eventualities over a sufficiently long time horizon will be required to improve the accuracy of results to give a better indication of the potential magnitude of the negative economic impact associated with reducing carbon emissions.

However, whilst further research will improve the estimates surrounding the magnitude of the economic impact of reducing carbon emissions it is highly unlikely that it will change its direction. Simply put, whatever the ultimate path the United States decides to take with regards to carbon emissions, if it decides to reduce its carbon emission levels it will cause a reduction in economic activity.

Appendix: Detailed Evaluation of Studies Examined

Summary	*Author*	*Programs Modeled*	*Study Period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*	
	Economic Development Research Group, Inc.	Regional cap-and-trade program administered by participating sites	2008-2035	Northeast Region	IPM Model (proprietary), REMI	Not specified	
Results		*Projected Change in GRP (Range from High-Emissions to Default Case)*			*Projected Change in Jobs (Range from High-Emissions to Default Scenario)*		
	Scenario	2009	2015	2021	2009	2015	2021
	RGGI Package	-$280M (-0.01%) - +$170M (0.01%)	-$1.1B (-0.05%) - +$250M (0.01%)	-$1.77B (-0.07%) - +$210M (0.01%)	'-2,340 to +2,590	-8,260 to +4,180	-10,720 to +4,290
	Package + CN - FED Policies	-$560M (-0.03%) to -$780M (-0.04%)	+$1.31B (0.05%) to +$1.64B (0.07%)	+$2.76B (0.1%) to +$2.28B (0.1%)	-5,390 to -8520	+18,760 to +22,310	+26,240 to +22390
	Package w/ 2x Efficiency (Compared only to Default)	+$850M (0.04%)	+$1.26B (0.05%)	+$1.58B	+10610	+15000	+18020
Evaluation Criteria	*Completeness of the Assessment*	Assessment is incomplete: There is no explanation of how emissions allowances are modeled (or how the proceeds from allowance auctions are recycled back into the economic system). Further, investment on energy efficiency technologies appears to account only for new demand, with no offset for the less-efficient technologies that are no longer assumed to be purchased.					
	Appropriateness of the Time Horizon evaluated	The study period extends through 2035, as do the requirements of the proposed policy measures. An evolving cap-and-trade program would be expected to have long-run economic effects that would not be captured in this horizon.					
	Assumption Validity	Assumptions are questionable. In the reference scenario, natural gas prices are expected to grow 7.5 percent each year, on average, over the period from 2010 to 2024. The source of this assumption is not identified, but the EIA has forecasted much more modest growth over the same period, suggesting that the 7.5 percent growth assumption is aggressive. This will have the effect of minimizing the economic impact of the policy scenarios, relative to the reference scenario. Energy efficiency measures are assumed to avert one-third of projected load growth over the forecast horizon. This appears to be an aggressive assumption as well, which would again have the effect of minimizing the economic impacts in the policy scenarios.					

	Reasonableness of the Base Case	The base case is unreasonable. The "Default Reference" scenario assumes that a federal RPS is adopted and in effect in 2015. At the time of this paper (and at the time of the study) no such policy was in effect or under any serious consideration. This assumption will reduce the observed changes in electricity prices, as well as any of the macroeconomic effects.
	Forecasting Model Suitability	The models are acceptable but not ideal. The IPM Model is proprietary and we cannot access it to fully assess its suitability. However, ICF is a well-regarded consulting firm with a breadth of experience performing research and analysis of energy markets, so their model is likely to be credible. Generally, REMI is well-suited to the measurement of the economic impacts of policy changes. However, the model used here is a regional model that comprises 12 states, of which only nine were RGGI participants. This approach may overlook leakages from RGGI participant states to non-participants that are nevertheless included in the regional model.
	Transparency of the Analysis	It would be difficult to replicate this analysis, mainly because it is not clear how emissions allowances were treated.
	Assessment of the Sensitivity of the Results	Multiple scenarios are presented against two references. Together, this approach is sufficient to establish a range of outcomes for the policies under consideration. A useful sensitivity analysis -- which was omitted -- would have been to examine the effects of variations in the carbon-cap targets (e.g. from 35 percent to 30 percent).

Summary	*Author*	*Programs Modeled*	*Study period*	*Study area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Centre for Climate Strategies	28 policy recommendations, including RPS, Demand-Side Management, and Energy Efficiency Progams	2008 - 2025	Florida	REMI	
Results	*Projected Change in GSP (Relative to Base Case)*		*Projected Change in Jobs*			
	$37.9 billion cumulative increase (2000$)		By 2025 employment would be higher by 148,300.			
Evaluation Criteria	*Completeness of the Assessment*	Appears that the majority of the analysis attempts to incorporate the various effects each policy has on the economy. Although it is assumed that O&M costs associated with electricity generation remains unchanged which appears unlikely given the amount of renewable generation assumed.				
	Appropriateness of the Time Horizon evaluated	Time frame is of an appropriate length.				
	Assumption Validity	Questionable inputs. 1. Assumes that the levelized cost of PV will fall to $50 (2006$) per megawatt hour (MWh) in 2025. 2. Assigns a higher avoided cost to all PV output equal to $134 per MWh (an assumed peak power price). 3. 1 and 2 combined suggest that if the RPS is required to create these cost savings then this is a violation of basic economic least-cost production principles. Utility companies would adopt PV generation if the assumed cost conditions were in fact true. Therefore there would be no need for a RPS to force utilities to acquire renewable generation. Questionable inputs. 1. Assumes that the levelized cost of PV will fall to $50 (2006$) per megawatt hour (MWh) in 2025. 2. Assigns a higher avoided cost to all PV output equal to $134 per MWh (an assumed peak power price). 3. 1 and 2 combined suggest that if the RPS is required to create these cost savings then this is a violation of basic economic least-cost production principles. Utility companies would adopt PV generation if the assumed cost conditions were in fact true. Therefore there would be no need for a RPS to force utilities to acquire renewable generation.				
	Reasonableness of the Base Case	Standard base case in REMI – business as usual.				
	Forecasting Model Suitability	REMI is a dynamic economic impact model that is able to model changes in the economic environment through time.				
	Transparency of the Analysis	Possible to disentangle the effects of the bundled measures. For instance the RPS is reported to contribute the single largest increase in GSP ($16.22 billion (200$) in cumulative terms of the study period.				
	Assessment of the Sensitivity of the Results	Some sensitivity analysis is performed. If the assumed avoid cost of electricity is 50 percent lower (higher) the effect of the RPS would be $9.44 billion ($23.13 billion) - 2000$				

Summary	*Author*	*Programs Modeled*	*Study period*	*Study area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Beacon Hill Institute (2009)	Regional cap-and-trade program	2020	Seven WCI Member States	REMI	Auction Proceeds are used to increase State government employment

Results	*Region*	*Net Change in Employment*	*Change in GRP/GSP*
	All States	-20,412 to -109,433	Not Examined
	Arizona	-4,801 to -20,496	Not Examined

Evaluation Criteria	*Completeness of the Assessment*	Authors include energy price changes across all affected sectors as well as allocation of potential government revenue from selling permits. However authors do not apply these changes to WCI state-specific models. Instead they rely on non-WCI specific models to assess the impact of a cap-and-trade program.
	Appropriateness of the Time Horizon evaluated	Only looks at one year (2020). Therefore, the evaluation of the total economic impact of the cap-and-trade program is not possible.
	Assumption Validity	Questionable which may affect the accuracy of results. 1. Take price assumptions from the WCI. However, authors spend the first part of the paper discrediting the assumed complementary programs that feed into determining energy price changes used to generate their findings. For instance the authors note that no explanation in the WCI report is given to why purported gains in energy efficiency and reductions in VMTs that produce annual savings would not be captured by economic agents without government intervention. Therefore if they question the accuracy of the input results they should attempt to adjust the inputs when modeling the economic outcome to improve accuracy. 2. In the broad with no offsets case residential and commercial electricity prices are below the reference case. No explanation in the paper or source document is provided. 3. Apply the average percentage change in economic variables from CGE models that are non-WCI (except one for Washington). Therefore the reported macroeconomic results (employment etc) are based upon deviations in a base case which is not state specific.
	Reasonableness of the Base Case	Business as usual case.
	Forecasting Model Suitability	Used CGE: State Tax Analysis Modeling Program (STAMP) model to estimate percentage changes in economic variables in 2020. However, the CGE model is only able to simulate changes in economic variables for 5 years. Effects of price changes may take more than 5 years to calculate full impact.
	Transparency of the Analysis	Possible to re-produce results if access to CGE models was possible.
	Assessment of the Sensitivity of the Results	Limited sensitivity analysis was performed: 3 WCI cases and 25 percent versus 100 percent auctions were examined. Authors only use the average results from the various state specific CGE modeling for each case examined rather than reporting a range.

Summary	*Author*	*Programs Modeled*	*Study period*	*Study area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Congressional Budget Office (2009)	Cap-and-trade portion of H.R. 2454, "American Clean Energy and Security Act of 2009"	2020 - 2050	U.S.	Meta analysis of past studies' results	Distributed back into the economy according to the legislation provisions. With some going to consumers and some going to firms.
Results	*Base Case*	*Change in Real GDP (Range)*				
	"Business as usual"	*2020*			*2050*	
		-0.2% to -0.7%			-1.1% to -3.4%	
Evaluation Criteria	*Completeness of the Assessment*	At the aggregate level it appears that many of the elements within the act are incorporated into the analysis. At the disaggregated income level some of the impacts are not assigned due to incomplete information on allocations.				
	Appropriateness of the Time Horizon evaluated	Time frame is of an appropriate length.				
	Assumption Validity	The average economic impact per dollar of allowance price is taken from a survey of recent studies. The majority of these previous studies examined the same Act.				
	Reasonableness of the Base Case	Standard business as usual base case is assumed.				
	Forecasting Model Suitability	No formal model was used. Instead the study relies on a range of estimates for the economic impact per dollar of allowance price from previous studies.				
	Transparency of the Analysis	Easy to replicate results. Some transparency issues around how they derive their forecast for permit prices.				
	Assessment of the Sensitivity of the Results	No sensitivity analysis surrounding economic impacts is performed. Even though the CBO acknowledges that elements within the Act will affect the permit price which, given their framework, will affect the economic impact of the Act.				

Summary	*Author*	*Programs Modeled*	*Study Period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Beach, Kreutzer, Lieberman and Loris (2008)	Climate Security Act of 2007 (S. 2191), a federal cap-and-trade system	2008 - 2030	U.S.	Global Insight's U.S. Macro Model	Not explained

Results	*Scenario*	*Net Change in Employment*	*Change in GDP*
	Generous	-3.37M (-0.11%)	-$1,438B (-0.45%)
	Reasonable	-9.9926M (-0.32%)	-$4,570N (-1.43%)

Evaluation Criteria	*Completeness of the Assessment*	It is difficult to determine whether the analysis is complete because of the lack of transparency. There is some suspicion that some beneficial elements may have been omitted.
	Appropriateness of the Time Horizon evaluated	Timeframe in an evolving cap-and-trade framework will not fully capture all of the economic effects.
	Assumption Validity	1. Study does not explicitly explain how the proceeds of the cap-and-trade system would be recycled back into the economic system. 2. Many of the estimates of the cost of conventional energy appear to be low compared to current forecast of their likely evolution over the period. 3. Little scope is allowed for the inevitable innovation that would occur around such a policy which would lead to more cost-effective methods of reducing GHG emissions.
	Reasonableness of the Base Case	Global Insight forecasts are a well-regarded and reasonable counterfactual.
	Forecasting Model Suitability	No explicit reference is made as to how Global Insight's U.S. macro model was employed.
	Transparency of the Analysis	Many important assumptions are explicitly stated but those concerning the GHG emissions reduction capabilities of technology are not and the model employed is not detailed.
	Assessment of the Sensitivity of the Results	Offers two scenarios to bracket potential effects but there is no detailed sensitivity analysis.

Summary	*Author*	*Programs Modeled*	*Study period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Energy Information Administration (2008)	S. 2191	2008 - 2050	U.S.	EIA's National Energy Modeling System (NEMS)	10% distributed to load-serving entities to curb rising energy costs
Results	*Scenario*	*Cumulative Change in GDP (2000 $)*				
	Core	-$444B (-0.2%)				
	High Cost	-$729B (-0.3%)				
	Limited Alternatives	$912B (-0.4%)				
	No International Offsets	-$546B (-0.2%)				
	Limited Alternatives/No International Offsets	-$1,306B (-0.6%)				
Evaluation Criteria	*Completeness of the Assessment*	All relevant economic effects are accounted for.				
	Appropriateness of the Time Horizon evaluated	The study horizon is appropriate insofar as it covers the period from 2008 to 2030, which would have been the duration of the proposed provisions in S. 2191. However, it should be noted that a policy measure of this sort may have long-run economic effects that could outlive the regulatory framework.				
	Assumption Validity	Assumptions are reasonable. All estimates and assumptions were based on actual provisions in S. 2191 or on figures provided by the EPA or the EIA -- two highly-regarded sources for this information. A number of other studies use data from these same sources.				
	Reasonableness of the Base Case	Base case is a reasonable representation of "business as usual."				
	Forecasting Model Suitability	The forecasting model is appropriate. The authors used the EIA's NEMS and forecasts from Global Insight.				
	Transparency of the Analysis	With access to NEMS and all data, the analysis could be replicated. As such, it is sufficiently transparent.				
	Assessment of the Sensitivity of the Results	Sophisticated modeling is done for the period from 2008 to 2030, after which point the authors assume that a positive balance of allowances has accumulated in order to satisfy the caps for the remaning 20 years of the study period. Although there are 5 scenarios modeled, no sensitivity analysis was done around the assumed bank of allowances (e.g. + 6B tons versus +5B tons).				

Summary	*Author*	*Programs Modeled*	*Study Period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	CRA International Montgomery, Baron, Bernstein, Bloomberg, Ditzel, Lane, Smith, Tuladhar, and Yuan (2009)	H.R. 2454	2012 - 2050	U.S.	Three proprietary CRA models: Multi-Sector, Multi-Region Trade (MS-MRT), Multi-Region National (MRN), and North American Electricity and Environment Model (NEEM)	All funds are directed to a state-led R&D program for renewable generation technologies and energy efficiency programs.

Results	*Net Change in Employment*	*Change in GDP Relative to Baseline Forecast*		
		2015	2030	2050
	-2.3M to -2.7M jobs each year through 2030	-$170B (-1.0%)	-$350B (-1.3%)	-$730B (-1.5%)

Evaluation Criteria	*Completeness of the Assessment*	All relevant economic effects are accounted for.
	Appropriateness of the Time Horizon evaluated	The time horizon is appropriate. The study period extends through 2050, as do the policy provisions under consideration.
	Assumption Validity	Assumptions are based on the EIA's Annual Energy Outlook, and appear to be reasonable.
	Reasonableness of the Base Case	Base case is a reasonable representation of "business as usual," with no cap-and-trade or RPS programs in place.
	Forecasting Model Suitability	Three proprietary models were used. We do not have access to these models and cannot speak to their suitability for this purpose. However, based on the authors' descriptions, it appears that the models account for the relevant economic effects over a relevant time horizon, so it is reasonable to infer that they are suitable.
	Transparency of the Analysis	It appears that the results could be replicated if one had access to the proprietary models. As such, the analysis is sufficiently transparent.
	Assessment of the Sensitivity of the Results	Two alternative scenarios were run to estimate upper and lower bounds for carbon prices. No additional sensitivity analysis was performed.

Summary	*Author*	*Programs Modeled*	*Study period*	*Study area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Aldy and Pizer (2009)	Federally-created cap-and-trade system or carbon tax	2012 (short-run analysis)	U.S.	multiple regression analysis	not applicable

Results		*Change in Employment*	*Change in Production*	*Change in Consumption*
	Least energy-intensive industries	less than 1% decrease	less than 2% decrease	less than 1% decrease
	Most energy-intensive industries	less than 3% decrease	less than 4% decrease	less than 3% decrease

Evaluation Criteria	*Completeness of the Assessment*	The assessment is incomplete. The authors examined only the short-run effects of a carbon tax (or cap-and-trade system), which ignores the dynamic and iterative process that would occur over time as producers and consumers continuously respond to the policy change and to one-another. Also, the authors do not discuss how the assumed carbon tax revenues are spent (that is, how the funds are recycled through the economy).
	Appropriateness of the Time Horizon evaluated	The time horizon is inappropriate. A policy measure of this sort should be evaluated over a much longer horizon.
	Assumption Validity	All input data is reasonable, as it was based on historical observations of prices. The carbon tax is assumed to be $15 per metric ton. This is the critical assumption in the study and it is a conservative estimate by comparison to other studies.
	Reasonableness of the Base Case	Implicitly, the base case is "business-as-usual," which is reasonable.
	Forecasting Model Suitability	The methodology is not suitable for the purpose of this assessment. As mentioned above, this short-run approach is inappropriate as a means of evaluating the macroeconomic effects of a proposed policy change.
	Transparency of the Analysis	The study is reasonably transparent. Given access to the same data sets, the results could probably be replicated.
	Assessment of the Sensitivity of the Results	No sensitivity analysis is performed to examine the effect of variations in the carbon price. This is the central assumption to the study and the failure to perform sensitivity analysis is a major flaw.

Summary	*Author*	*Programs Modeled*	*Study Period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Charles River Associates, (1994)	3 carbon tax prices: $50, $100 and $200 per metric ton (1992 $)	1995 - 2010	U.S.	Proprietary input-output model	Revenues are lump-sum returned back to consumers
Results	*Scenario*	*Change in Real GDP by 2010 (Relative to Base Case)*				
	$50 carbon tax	*-1.2%*				
	$200 carbon tax	-4.2%				
Evaluation Criteria	*Completeness of the Assessment*	Appears that many of the elements of a carbon tax are modeled.				
	Appropriateness of the Time Horizon evaluated	Time frame is limited to only 15 years. This short timeframe causes the economic costs of reducing emissions to be higher.				
	Assumption Validity	Assumptions made will tend to cause an over-estimate of economic impact associated with carbon tax. 1. Assumes carbon tax revenue is lump-sum rebated to consumers. This, therefore, does not alter the incentive to work at the margin. Also, this assumption does not offset any of the inflationary impacts associated with a carbon tax. 2. Assumes all of the carbon tax is passed onto the consumer in the form of higher prices. 3. Assumes that carbon tax has no effect on the before-tax prices of fossil fuel.				
	Reasonableness of the Base Case	Business as usual.				
	Forecasting Model Suitability	Model appears to be a detailed input-output model that is well suited to examining the impact of carbon taxes on the energy sector and the overall macroeconomic model.				
	Transparency of the Analysis	Possible to replicate results if access to proprietary model was available.				
	Assessment of the Sensitivity of the Results	No additional sensitivity analysis is performed outside of the 3 scenarios examined.				

Summary	*Author*	*Programs Modeled*	*Study Period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*
	Roland-Holst (2008)	Historical analysis of the reduction of California per-capita energy usage over period to approximately 40% below 2007 national average.	1972 - 2007	California	Proprietary input-output model	Not applicable
Results	*Change in Household Income*			*Change in Jobs*		
	+$44.6B			+1.163M jobs		
Evaluation Criteria	*Completeness of the Assessment*	The fact that no allowance is made for adoption costs in moving from a less efficient set of technologies to a more efficient set is a major flaw.				
	Appropriateness of the Time Horizon evaluated	This is a historical assessment.				
	Assumption Validity	There are some major assumptions made to allow the ultimate conclusion. 1. changes in energy consumption in California were due solely to policy changes and would otherwise have followed the national trend; 2. the cost of the energy usage changes was just 23,520 jobs; 3. The lack of an accounting for adoption costs overstates the amount of household spending diverted due to energy efficiency thus boosting its effect against all other factors affecting the growth of the economy during the period.				
	Reasonableness of the Base Case	Seems a reasonable national energy trend counterfactual.				
	Forecasting Model Suitability	Some of the Input-output tables for California appear to be imputed from national input-output tables and may not truly reflect changing structure of California economy.				
	Transparency of the Analysis	It is not possible to trace through the effects of the energy usage reductions directly to mutations in the structure of the California economy. The study infers this which is a detraction.				
	Assessment of the Sensitivity of the Results	There is no sensitivity analysis reported.				

	Author	*Programs Modeled*	*Study Period*	*Study Area*	*Model(s) Used*	*Treatment of Auction Proceeds*
Summary	**Roland-Holst (2008)**	California Air Resources Board (CARB) Draft Scoping Plan including: 1. Cap and trade without offsets 2. Transportation emission standards 3. Building and appliance energy efficiency and conservation 4. Renewable energy programs 5. High GWP measures	2008 - 2020	California	BEAR, a CGE model	Not applicable

	Change in GSP	*Change in Household Income*	Change in Jobs
Results	+$76B (+1.5%)	+1.2%	+403,000

Evaluation Criteria	*Completeness of the Assessment*	The fact that no allowance is made for adoption costs in moving from a less efficient set of technologies to a more efficient set is a major flaw.
	Appropriateness of the Time Horizon evaluated	Time frame is of an appropriate length.
	Assumption Validity	1. No adoption costs are included in the analysis 2. Assumes measures will promote innovation and technical change providing further energy efficiency gains of 1% per annum, on average, above current trend 3. The assumption that innovation will generate further 1% per annum reductions in energy usage in the future on top of the historical trend appears heroic. 4. The major cost saving occurs through the adoption of GHG emission standards for new passenger vehicles (Pavley standards). The estimated savings violate two moot points. First, if there are (significant) cost savings to be made why are the standards required? Consumers would demand cars that meet these standards without government intervention if the (significant) estimated financial saving was indeed true. Also, the social savings estimated are simply an aggregation of private savings (that uses the retail price of gasoline in its calculation) and therefore overestimates the true financial savings to society. 5. The fuel savings are highly sensitive to the gas price assumed. For instance, originally a gas price of $2.07 (2005$) in 2020 was assumed, whilst in the study this has been updated to $3.673 (2007$).
	Reasonableness of the Base Case	The base case in this study is BAU for California but this is not fully outlined.
	Forecasting Model Suitability	The BEAR is a computable general equilibrium (CGE) model. CGE models are perfectly reputable research tools but it is not possible to determine the validity of this particular CGE model because of its limited availability and description in the study.
	Transparency of the Analysis	The results are reported as a whole and it is largely-speaking not possible to trace through and disentangle the effects of individual policies in the CARB bundle. However, the study does disentangle its forecasts for the direct effects of the policy bundle and the induced innovation effects.

	Assessment of the Sensitivity of the Results	No analysis is reported.

	Author	*Programs Modeled*	*Study period*	*Study area*	*Model(s) Used*
Summary	**Climate Action Team (2007)**	Emissions reduced to 1990 levels by 2020 through variety of measures including: 1. Cap and trade without offsets 2. Transportation emission standards 3. Building and appliance energy efficiency and conservation 4. Renewable energy programs 5. High GWP measures	2007 - 2020	California	BEAR and E-DRAM (both CGE models)

	Model	*Net Change in Employment*	*Change in GDP*
Results	E-DRAM	+0.3%	+0.2%
	BEAR	+0.2%	-0.1%

Evaluation Criteria	*Completeness of the Assessment*	The study appears to have taken full account of the effects of the 40 strategies encompassed.
	Appropriateness of the Time Horizon evaluated	Time frame is of an appropriate length.
	Assumption Validity	1. Energy price assumptions low for conventional fuels. 2. Net costs associated with the 40 strategies include a value for "Avoided Criteria Pollutant Emissions" - this is not a financial cost or saving.
	Reasonableness of the Base Case	The base case in this study is a reference case with all 40 strategies turned off. The reference case is not outlined.
	Forecasting Model Suitability	BEAR and E-DRAM are computable general equilibrium (CGE) models. CGE models are perfectly reputable research tools.
	Transparency of the Analysis	The results are reported as a whole and it is largely-speaking not possible to trace through and disentangle the effects of the 40 strategies. The study also only reports the effects for the one year of 2020. The cumulative effects should also be reported along with the annual effects.
	Assessment of the Sensitivity of the Results	Comparison of the results from the BEAR and E-DRAM model as shows wide disparities in the estimates. Scenarios examined within each model also show wide variations. This suggests the results are not very robust.

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