Analysis of a Carbon Fee or Tax as a Mechanism to Reduce GHG Emissions in Massachusetts

Prepared for the Massachusetts Department of Energy Resources

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Principal Findings

British Columbia (BC) precedent: BC provides a precedent for Massachusetts, having instituted a revenue-neutral carbon tax in 2008 that is now $30/ton. Since 2008, BC cut its GHG emissions substantially compared to the rest of Canada, while experiencing economic growth slightly higher than the rest of its nation.

Economy-wide coverage of the fee/tax: it would be administratively feasible and effective for the state to impose a fee/tax on our major sources of carbon dioxide emissions: direct combustion of fossil fuels and electricity consumption. However, the small emission cuts from including the electric sector argue for considering exempting it from the fee/tax.

Fee/tax rates modeled: we modeled three scenarios. In all three, the fee/tax begins at $10/ton and rises to $30/ton in year five (replicating British Columbia). In following years through 2040, rates rise gradually to either $50, $75, or $100/ton. At $30/ton, residential natural gas prices would rise by about 12%.

Feasible system for returning all funds to the public: it is feasible to return all of the revenue to households, businesses, and institutions through tax cuts or rebates. The revenues could be divided into two parts: (1) funds obtained from households, which would be returned to this sector as a whole, and (2) funds obtained from businesses and institutions, which again would be returned to these sectors.

Positive impacts on economic indicators: impacts from the fee/tax would be small in relation to the overall size of the state economy. However, economic indicators such as disposable personal income, personal income per capita, and the labor share of state income would rise due to the fee/tax.

Positive impacts on employment: employment is forecasted to grow by 4,000 to 10,000 jobs by 2030 due to the tax/fee, primarily because the state would be spending less on importing fuels and energy. Households at the lowest income levels would see the greatest job gains.

Carbon dioxide emissions would fall substantially: the greater the fee/tax rate, the greater the drop in pollution, with carbon dioxide emissions falling by 5% to 10%, larger than almost any of the state's other greenhouse gas reduction policies are projected to achieve.

Most households can be fully compensated for rising prices: fossil fuel cost increases will be relatively small, especially in the early years of a fee/tax. Under a system that gave equal rebates either per person or per household, or a mixture of these designs, on average low- and moderate-income households would have a net gain or come out about even. We find that a per-person rebate, or a mixed system, would be more equitable than a per household rebate.

Businesses and institutions can be compensated: a system that gives all businesses, non-profit institutions, and governments rebates in proportion to their shares of either 1) total state employment or 2) total state payroll, would leave most entities with small gains from the fee and rebate combined, while for most others the fee would exceed the rebate by only a small amount in relation to their overall operating costs.

Executive Summary

I. Overview and Policy Context

Massachusetts is a national leader in energy and environmental policy. From energy efficiency and clean energy policies to environmental planning and protection efforts, Governor Deval Patrick's Administration has made combating and preparing for climate change a major component of his tenure.

This study was commissioned by the Massachusetts Department of Energy Resources (DOER) to analyze how a possible revenue-neutral carbon tax (or fee) could be implemented in the Commonwealth. The study was the outcome of discussions between several stakeholders and public officials including former Massachusetts Energy and Environmental Affairs Secretary Rick Sullivan; Massachusetts Energy and Environmental Affairs Secretary Maeve Vallely Bartlett; , Senator Marc Pacheco - Chair, Senate Committee on Global Warming and Climate Change; Senator Michael Barrett; Representative Frank Smizik - Chair, House Committee on Global Warming and Climate Change, and; Representative Thomas Conroy.

A carbon fee/tax is a simple and transparent way to create a price for emitting carbon dioxide (and possibly other greenhouse gases) to the atmosphere. Such a fee/tax would support the state's other policies that contribute to meeting the mandates of the Global Warming Solutions Act (GWSA) of 2008 and the roadmap set by the Massachusetts Clean Energy and Climate Plan for 2020. These documents require the state to reduce its greenhouse gas (GHG) emissions to 25% below the 1990 level by 2020 and to at least 80% below 1990 by 2050.

DOER requested the tax to be revenue-neutral, so that the residents, companies, and other institutions of the Commonwealth would receive back via tax cuts or rebates as much money as they are paying in carbon taxes. Our modeling is designed on this basis, and estimates the net impacts from the combination of a fee/tax along with returning all the funds to the public. There was broad support during the public stakeholder process for a system designed in this way; although some stakeholders felt that a portion of the funds should be used for government programs that help to reduce GHG emissions, such as providing incentives for energy efficiency and renewable energy.

British Columbia and Other Examples of Carbon Taxes

The full study and its appendices discuss in depth many of the existing examples of carbon taxes throughout the world. One jurisdiction with similarities to Massachusetts is British Columbia (BC), which instituted a revenue-neutral carbon tax in 2008. Since passage of the tax, BC has cut its GHG emissions substantially compared to the rest of Canada, while experiencing economic growth slightly higher than the rest of its nation.

In the United States, besides Massachusetts, legislative efforts surrounding carbon taxes are currently underway in the states of Washington, Oregon, and Vermont.

II. Design Issues in Imposition of the Tax

We were guided by the following key principles in designing the tax and methods of returning the revenue to the public:

- **High potential to reduce GHG emissions** – to be worth the effort of implementing it, a carbon tax should make a major contribution to achieving the state's GHG reduction mandate for 2050.
- **Economy-wide -** cover all major sources of greenhouse gas (GHG) emissions; beginning with fossil fuels and the electricity generated by such fuels.
- **Revenue-neutral** – the DOER specified that this study should assume that all revenues from the tax would be returned to the public.
- **Gradual phase-in -** the tax should be phased-in over time so that households and businesses would have time to consider their options for reducing their costs and for adjusting their energy (carbon) use.
- **Social equity** - both costs and other impacts may be distributed unevenly across geographic locations, income groups, and economic sectors. The study focuses on a tax design that corrects such inequities, including through how the tax revenues are returned to the public.
- **Protect business -** mitigate any economic dislocation that could be caused by competition from firms in untaxed jurisdictions

We modeled three price trajectories for the tax. In all three, the price begins at $10/ton and rises $5/year to reach $30 in the fifth year. After that, we model low, medium, and high annual rate increases that result in the tax reaching $50, $75, or $100 per ton in 2040, the last year of the modeling. In choosing the rates of price escalation we were guided by the first principle above, that the tax should make a major contribution toward reaching the state's legal requirement to reduce GHG emissions to at least 80% below the 1990 level by 2050.

Metric versus short tons: note that throughout this study all GHG emission impacts will be counted in metric tonnes, the accepted international unit. When the word "ton" appears, it should be understood to refer to metric tonnes.

Where and on what Entities Should the Carbon Tax be Levied?

For purposes of the study, we have assumed that the tax would be imposed only on the major sources of fossil fuel combustion (oil, natural gas, gasoline, and coal) and on emissions from electricity generation. Due to the small contribution that electricity makes to reducing CO_2 emissions when the carbon tax is applied, exclusion of it from the fee/tax system should be considered. Optimally, the tax should also cover other greenhouse gases besides CO_2, but we have not addressed them here. For each fossil fuel, we propose to institute the tax in a manner that is least costly to administer. This differs somewhat for each fuel, but in general the preference is to place the tax at the point of first sale in Massachusetts, or on out-of-state suppliers where appropriate – as the full report discusses in detail.

Electricity Generation and Interactions with the Regional Greenhouse Gas Initiative (RGGI)

We examined several approaches for setting a price on carbon in the electricity sector. Implementing the tax on this sector involves complications due both to RGGI and to the regional nature of electricity supply. In recent years Massachusetts has imported on the order of one-third of its electricity, and existing tracking systems do not identify the sources of this electricity in a way compatible with a carbon tax.[1] Without such tracking, the Commonwealth cannot impose carbon-specific taxes on imports.

Given these difficulties, we have concluded that the most appropriate method of handling the electricity sector at present would be to apply the tax directly on household, business, and institutional consumers at the retail level, based on average emissions in the New England region. This would create less of an incentive to move toward lower-emission generation sources, but would be simple to implement and would give consumers an incentive to improve energy efficiency and to implement distributed generation of renewable power.

III. Designing a System for Rebating the Carbon Tax Revenues

The study also examines the impacts of instituting a carbon tax while then returning all the revenues to the public through cutting other taxes or providing rebates to households and businesses. We then estimate the net impacts on households at different income levels and businesses and institutions of different types.

The analysis in this section does not assume any changes in energy production and consumption as a result of the tax. But Section IV below will use other models to estimate changes in fossil fuel consumption due to the tax, which in turn will cause changes throughout the economy. These changes increase the benefits from a carbon tax in terms of employment and other economic indicators, relative to those documented in Section III.

Formulas for returning revenues to households

We assume that the household sector as a whole receives as much money back as it pays in for the carbon tax. Households are "ranked" by their income levels, and divided into 5ths, with the lowest-income 5th called Quintile 1 and the highest income Quintile 5.

Reducing tax rates inequitable: First, we have determined that reducing the rates of any of the major state and local taxes paid by households – income, sales, or

[1] Calculating imported power involves some complexities in the use of statistics from the U.S. Energy Information Administration, and the most recent EIA data currently available is for 2012.

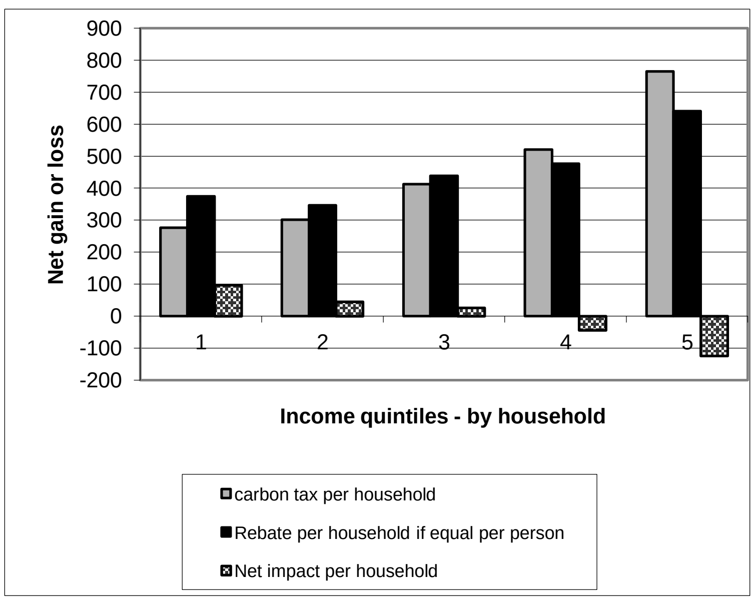
local property taxes – will not sufficiently protect lower-income households because on average they will pay more in carbon taxes than they would get back from the tax cuts; while higher-income households will get back more from tax cuts than they pay in.

Provide rebates instead: two scenarios are analyzed for how funds will be distributed:

1) equal rebate payments per household
2) equal rebate payments per resident of the state

Low and moderate income households gain or come out about even: Under either rebate scenario, because energy use rises with income, the bottom two quintiles will have a net gain from the combination of tax and rebate, while quintile three will come out about even, quintile 4 will have a small loss, and quintile 5 (those households with the highest incomes) will come out behind by about $100 to $300.

Figure ES-1: $30/ton tax, equal rebates per person



Impacts by household size: Equal rebates per household favor smaller households, while equal rebates per person favor larger households. The data shows that among the lowest-income quintile, equal rebates per household would mean that households with one to three members see a net benefit, while households with four or more members come out behind. In comparison, with equal rebates per person, the net benefit grows with the number of people in the household. We conclude that the fairer system is to provide equal rebates per person; or a "mixed" system, such as equal rebates for the first member of a household and half as large a rebate for each additional member.

How to distribute rebates to households

Three factors influence the choice of method to distribute rebates: (1) minimizing administrative cost, (2) maximizing visibility of the rebate, and (3) timing – providing rebates early or throughout the year so that they are available to pay higher energy costs. Possible methods include:

1) **Increase personal exemption on income tax** – to yield an average $460 rebate per household, the exemption would need to rise by $8,850 (since the tax rate is 5.2%), which would be a large increase compared to the current exemptions.[2]
2) **Create a carbon tax credit on state income taxes** – on a per person or per household basis.
3) **Rebate outside the tax system** – the state could treat the carbon price as a "fee," and send rebates to households independently of the existing income tax system.
4) **Households that do not file state income taxes** – about 9% of the state's residents are in households that do not file state income tax returns. In order to reach such households, we recommend that legislation instruct DOR and state agencies that administer programs serving low-income households to share their databases; so that as close to 100% of such households are identified as possible, with rebates sent by one of the state agencies involved.

Formulas for Returning Funds to Businesses and Institutions

First, we have determined that the state's corporate excise tax is not a good mechanism for returning funds. One reason is that many of the state's largest economic sectors, which will pay large amounts of carbon taxes, are not for-profits, and would not gain from cuts to the corporate excise tax – such as most hospitals, almost all universities and colleges, and all municipal governments as well as the state government itself.

Return funds according to employment or payroll: instead of giving a corporate tax cut, we recommend returning funds to all companies and institutions in proportion to their shares of either overall state employment or value of payroll. Our calculations indicate that the net impact of the carbon tax combined with such rebates would be quite small impacts on most sectors of the economy, with the state's dominant sectors having small gains. A few sectors, such as construction and several manufacturing industries, would have net losses ranging from 0.1% to 0.9% of their total annual operating costs.[3]

As discussed in Section III.D.4, another possibility that would be more complex, but would have some advantages, is "benchmarking" within an industry. In such a system each industry as a whole would receive rebates equal to the money it pays in carbon taxes, but particular

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[2] If the carbon price is termed a "fee" an evaluation will be necessary to see whether returning the funds to the public through tax cuts is appropriate.
[3] The 0.9% figure is for chemical manufacturing, and the federal government data used here are much larger than data reported to MassDEP, so the true number may not be this high.

companies within an industry would receive different levels of rebates based on their emissions performance relative to other companies in the same industry.

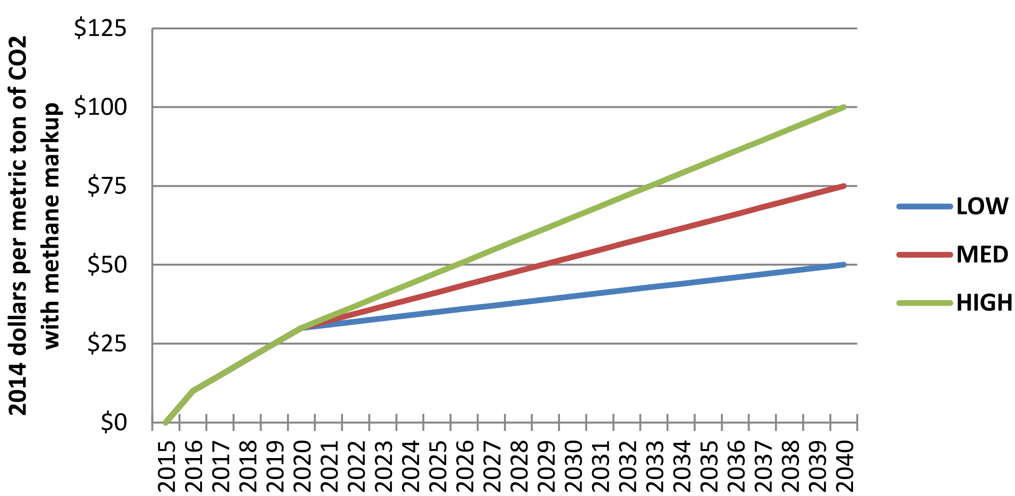
Public transit: We recommend that the state's regional mass transit authorities either be exempted from the carbon tax or be fully rebated for their increased costs.

Energy-intensive manufacturing: The standard rebates related to employment or payroll will yield reasonable net impacts on most manufacturing industries. However, we recommend that the state investigate this area in more depth, and consider targeted rebates for particular manufacturing industries that have substantially higher than average carbon tax costs and face tight competition from firms in other states and nations.

IV. Macroeconomic Impacts

The early years of the carbon tax are modeled to replicate the same tax rates as British Columbia, starting at $10/ton and rising $5 a year to reach $30 in the 5th year. By the 5th year (2020), the tax would bring in around $1.75 billion in revenue to be redistributed to the public. This is equivalent to about 7% of Fiscal Year 2015 state tax revenues[4] and 5% of expenditures (the other funds come from the federal government share of state program costs).[5] For the following years through 2040 we modeled three scenarios: gradual increases in the tax rate of $1.00 per year, $2.25 per year, or $3.50 per year.

Figure ES-2: Carbon Tax Rate 2016 Through 2040



All the funds collected would be divided into two buckets: revenues paid by households and individuals return to that sector, and funds paid by businesses, nonprofits, institutions, and governments return to that broad sector of the economy. We tested options and cases for each.

4 Massachusetts FY 2015 Budget Summary, http://www.mass.gov/bb/gaa/fy2015/index.html
5 Massachusetts Tax Revenue Forecasts for FY 2014 and FY 2015, The Beacon Hill Institute at Suffolk University, 12/11/13, http://www.beaconhill.org/RevenueForecastsBHI/BHI-MAForecastFY14FY15-for-2013-12-11-FINAL.pdf

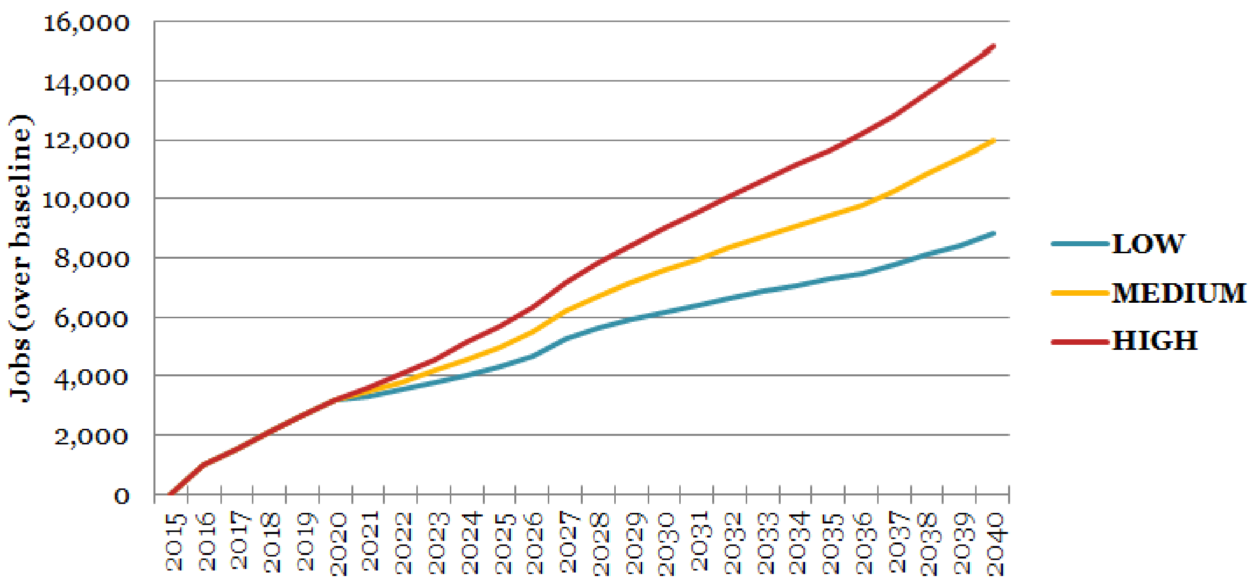
Two options were run for returning revenue to households: either equal rebates per household or equal rebates per individual person. Two options were also tested for returning revenues to businesses, non-profit organizations, and governments: payments based on either a firm/organization/government's share of total state payrolls or total state employment. While the revenue recycling mechanism does have relevance for the distribution of the impacts, it has only a small influence on the macroeconomic impact.

Overall, the carbon fee/tax has small but positive impacts on the Massachusetts economy. These include:

- **Jobs:** 2,000 to 4,000 additional jobs by 2020 and 6,000 to 15,000 by 2040; additional jobs and output would be concentrated in the service and technology sectors that already form the backbone of the Massachusetts state economy
- **Personal income:** greater real personal income in most of the scenarios tested, even adjusting for a higher cost of living

Figure ES-3: Total Employment Change versus Baseline

With three scenarios for the rate of increase in the carbon tax after year five, as shown in the previous graph: the low scenario reaches $50/ton in 2040, the medium scenario $75/ton, and the high scenario $100/ton. All three scenarios provide equal rebates per household and give rebates to businesses and other institutions in proportion to their number of employees.



There are two main reasons Massachusetts performs well with a carbon fee and rebate. Foremost, Massachusetts imports nearly all of its fossil energy resources. Gasoline imports alone cost the state around $8 billion every year, which equals 1.75% of the state economy. Total energy imports are closer to 5% or 6% of the state economy. With the state having no oil and gas extraction and no petroleum refining, much of the negative impact on the fossil energy industry from the carbon tax "exports" itself to other parts of North America and the rest of the world.

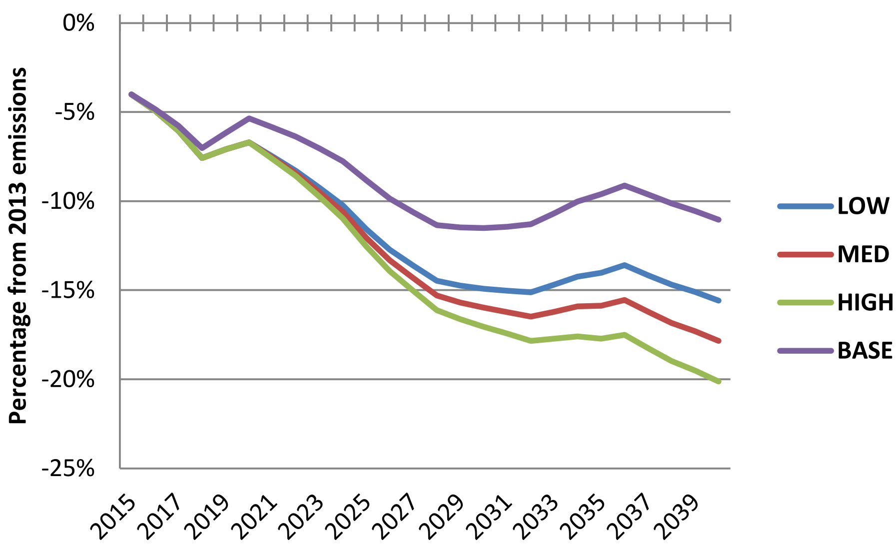
Those dollars then stay in the Massachusetts economy and lead to increased spending on other industries where much more of the money pays for in-state labor, services, and other costs.

Second, the service and information sectors that dominate the Massachusetts economy tend to generate more jobs per dollar of output than do the capital-intensive industries related to energy production and distribution, which helps lead to additional jobs relative to the baseline.
While these incremental jobs are a positive effect, they would be a small impact relative to a state economy of over $450 billion and with 4.3 million jobs at present.

V. Carbon Dioxide Emissions Impact

The effects on carbon dioxide emissions are greater than those on the state economy. The price incentive provided by the carbon tax would reduce state GHG emissions to a larger degree than most other Massachusetts programs that currently operate for this purpose. Emissions would fall by up to six million metric tons per year, or 5% to 10% of current levels. Most of the pollution reductions would come from cuts in consumption of transportation fuels

Figure ES-4: Carbon Dioxide Emissions (percentage change from 2013)



Factors explaining the degree of emissions reduction

There are several reasons why the drop in carbon dioxide emissions relative to the baseline is moderate in size, but not as dramatic as some advocates of a carbon fee/tax would hope:

- **Relatively small price increases for fossil fuels** – For example, at $30/ton, the tax raises gasoline prices by 27 cents per gallon, a 7.7% increase if the current price is $3.50 per gallon. Average annual natural gas prices for heating would rise by about 12%.

- **Inelastic demand for energy** – energy is an essential product, and as such demand is somewhat resistant to price changes. For example, a 10% increase in gasoline prices is estimated to cause about a 6.7% drop in sales by the end of 10 years. For residential sales of natural gas, a 10% price increase is estimated to yield a 3.8% drop in sales.
- **Combining relatively small price increases with inelastic demand results in moderate drops in carbon dioxide emissions** - for natural gas, multiplying the 12% increase in its price by a demand elasticity of -0.38 yields an expected drop in demand of 4.6% after ten years. Even a $100 per metric ton tax in 2040 raises residential natural gas prices by 29.3%, which yields an expected drop in total demand for the fuel of around 10%.

In addition, Massachusetts is already a relatively low-carbon state, with the economy dominated by service and information industries that are not energy-intensive. In addition, unlike many states, natural gas (which has lower CO2 emissions than oil or coal when burned for electricity) has been gaining market share in Massachusetts for many years, and is leading to the elimination of coal-fired electricity generation in the state.

Significance of emissions reduction

Nevertheless, the reductions of carbon dioxide emissions by 5% to 10% in 2040 are larger than almost any of the state's other greenhouse gas reduction policies are projected to achieve, and so would be an important contribution to climate change mitigation in Massachusetts.

The carbon tax has most of its impact in reducing the demand for vehicle fuels, which existing state climate policies have not addressed to a great degree, even though gasoline and diesel fuel make up half of projected carbon tax revenues and 62% of expected CO_2 reductions by 2020. Since 1998, emissions from power generation in the state have fallen by a dramatic 46% while emissions from vehicular fuels have risen slightly by 0.3%. **Thus, an economy-wide carbon tax would greatly increase the state's efforts to address emissions from transportation, which is now the state's largest source of CO_2 emissions.**

Is the carbon charge a tax or a fee?

We have conducted only a preliminary review of this question. However, several sources, including the Massachusetts legislative drafting manual, the Washington State Department of Revenue, and two private think-tanks, provide criteria for deciding the question. The criteria given appear to support terming a revenue-neutral carbon charge a fee rather than a tax.

I. Overview and Policy Context

A. Purpose of study; the stakeholder process

In June of 2014, the DOER commissioned a study to design, analyze and evaluate a revenue neutral carbon tax that will support the state's other policies that contribute to meeting the mandates of the GWSA. Regional Economic Models Inc. (REMI), along with Synapse Energy Economics and Hamel Environmental Consulting, were awarded the contract after an RFP process. The study was designed to analyze a carbon tax as a market mechanism to internalize the external cost of carbon dioxide emissions and reduce overall GHG emissions in the Commonwealth.

The GWSA is Massachusetts' main initiative aimed at reducing the pollution that causes climate change and assisting in the transition to a clean energy economy. Specifically, the GWSA, and the state's roadmap for reaching these mandates, the Clean Energy and Climate Plan for 2020, require the state to reduce overall greenhouse gas emissions in the Commonwealth to 25% below the 1990 level by 2020 (six years from the date of this study) and to 80% below 1990 by 2050 (in 36 years). Reaching these goals will require innovative new tools and programs to be put in place over time and a carbon tax is being studied as one of the tools to get there.

DOER chose to study a carbon tax for the Commonwealth because existing examples of this type of tax have been successful in creating jobs, boosting the economy, and lowering carbon emissions. The theory is that a price on carbon will lower GHG emissions and spur innovation in low-GHG technology, and, therefore, a carbon tax will make many other, less-efficient energy and environmental regulations unnecessary. Further, in addition to helping reduce emissions, it is hypothesized that a carbon tax will lead to lower taxes on productive activities, such as work by employees and capital investment which current tax levels tend to discourage.

Fundamentally, a carbon tax is a simple and transparent way to create a price for emitting carbon dioxide (and possibly other greenhouse gases) to the atmosphere. Said another way, it establishes a price for what economists call an "externality" – a cost to society that is not paid for by either the producers or the direct consumers of a commodity. A carbon tax requires emitters of carbon dioxide to pay for their externality costs in the same way that we currently have dumping fees for solid waste. Many believe that this fundamental change would yield greater gains than virtually any other policy in reaching the ambitious goals of the GWSA, in part because it would be economy-wide. This "polluter pays" approach has been useful in reducing other types of pollution, and the basic motivation of a carbon tax, and thus this study, is the same.

In principal, the carbon tax should apply to all major sources of carbon dioxide and other greenhouse gases in the state, however, due to the effort of setting up the system it may make sense for the state to limit its regulation initially only to the major fossil fuels used for the principal end-uses. However, it will be important for the tax to eventually be comprehensive. MassDEP's most recent GHG inventory says that about 8% of total emissions in 2011 were from non-energy related emissions: industrial processes, agriculture, and waste. In addition, 2.2% is listed as coming from "natural gas and oil systems," which appears to be primarily methane leaks from the natural gas system.[6]

The goals of this study are to:

- Develop a framework to help Massachusetts evaluate and implement a revenue neutral carbon tax
- Consider the carbon tax base -- what sources of GHG emissions should the tax cover?
- Consider how the tax should be collected, by sector of the economy
- Consider how to offset the tax with revenue reductions in other parts of the tax system or by returning funds to the public through other methods such as rebates
- Model the potential impacts of such a price signal across the economy as a whole
- Solicit stakeholders for input on scenarios and assumptions and to inform the study generally

This study offers ways to consider and design a carbon tax for the Commonwealth and then analyzes how each approach would likely impact the citizens, households and business sectors of the state, and its merits in reducing emissions.

Especially important, in this case, is that the state requested the tax to be revenue-neutral, so that the residents and companies of the Commonwealth would receive back via tax cuts or rebates as much money as they are paying in carbon taxes. This is a noteworthy part of the study that looks at where the revenues could be offset through a real-time reduction of other taxes (for example income, sales, excise, or property taxes) or other methods of returning funds to the public. This issue of offsetting the revenue is not a trivial one. Much of this study will look at the important distributional issues that arise in returning the tax in ways that are the most fair, simple and transparent. Finally, the study will show the overall impact to the economy and the environment, using a series of three sophisticated economy-wide models that will forecast indicators such as future job creation, personal income, economic growth, the cost of living, and business competitiveness. Through this analysis, we seek to provide recommendations for policies that will serve as both a benefit to the environment and the economy of Massachusetts.

At the direction of DOER, the consultant team created a stakeholder process to solicit feedback from potentially affected stakeholders and to get their advice and input on study design and policy questions.

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[6] Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990-2011, with Partial 2012 Data, Mass. Dept. of Environmental Protection, July 2014, downloaded from http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/greenhouse-gas-ghg-emissions-in-massachusetts.html, 10/18/14

Part of the goal of the stakeholder process, in addition to getting feedback, was to ensure that the consulting team presented our analysis of which variables and parameters have the most influence on the costs, benefits, and overall impacts of the program. Stakeholders would have the opportunity to assess the modeling results with us and identify key issues and tradeoffs.

To solicit stakeholder input on scenarios and assumptions and to inform the study generally, Pat Field from the Consensus Building Institute worked with Hamel Consulting and the consulting team to facilitate three roundtables. More than 50 invited organizations attended at least one of the three meetings and two webinars over the 12-week period of the study. Stakeholders were convened under the following guidelines:

- The role of Roundtable members was to provide constructive advice, ideas, and data to help the consulting team produce the best possible study
- The final product would be the sole responsibility of the consulting team and no participant would be asked to sign on or formally endorse the work
- To encourage constructive and specific comments on the different options offered concerning the proposed policy options, including means of collecting and redistributing the tax.
- To ensure that the report was as technically robust as possible *and* would take into account a range of stakeholder interests and views, we asked stakeholders to offer any data sources and studies that they thought might be helpful.

The first meeting was held when the team was beginning to prepare the model and was determining basic parameters to study, the second where the team presented its initial results for discussion, and the third when the Stakeholders were able to see more detailed modeling. Two webinars were also held to encourage participation and present detailed modeling results. The Stakeholders were able to refine their comments and offer ideas for additional analysis and development of the implementation approach. The participants were invited to comment in person, at meetings, separately in phone calls to the study team or DOER, and in writing. We are grateful to have received comments, which have enhanced the quality of the report and its analysis.

B. Massachusetts' leadership in energy, climate and air quality policies and programs; leadership going forward

Massachusetts' approach to climate change reflects a long tradition of leadership in addressing environmental problems generally. For more than 30 years, Massachusetts' policies to encourage renewable energy generation and improve energy efficiency have made major contributions to reducing GHG emissions. In part due to this, Massachusetts per capita emissions are the third lowest of any state. Over the last twenty years, the Commonwealth has taken significant steps to directly address GHG emissions and has incorporated climate considerations in state policies across many of its sectors.

The Commonwealth has a long history of nation-leading climate efforts, including coordinating the New England Governors and Eastern Canadian Premiers Regional Climate Agreement in 2001, Massachusetts' first Climate Plan in 2004, the creation of the Massachusetts Renewable Portfolio Standard (RPS) in 1997, helping to design and shape RGGI, and leading the fight in the Supreme Court (Massachusetts V. EPA) to require EPA to treat carbon dioxide as a pollutant. In addition, the Green Communities Act of 2008 required electric and gas utilities to pursue all cost-effective energy efficiency in preference to new energy supplies, and increased the RPS requirement so that renewable energy will be 15% of the state's overall electricity supply in 2020.

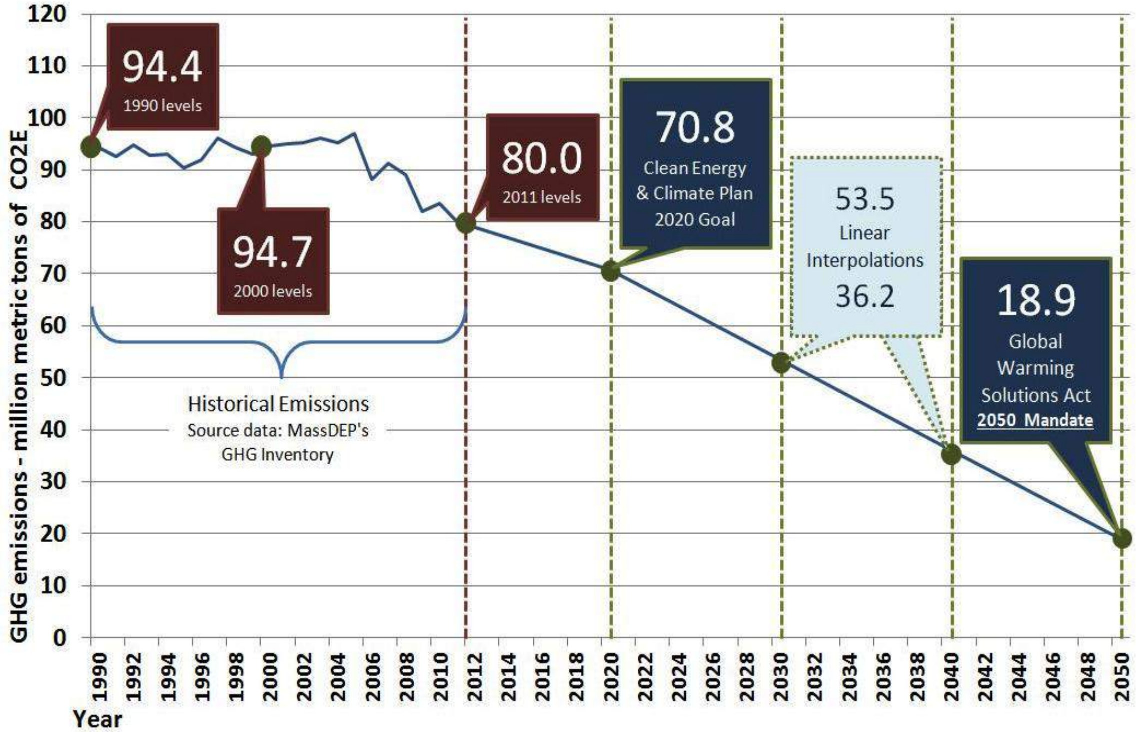
Based on Massachusetts' continued commitment to energy efficiency, the Commonwealth earned the No. 1 ranking in the American Council for an Energy Efficient Economy's (ACEEE) State Energy Efficiency Scorecard in 2011, 2012, 2013 and 2014. In this broad assessment of policies and programs, the state has been evaluated in six policy areas: utility and "public benefits" programs and policies; transportation polices; building energy codes and compliance; combined heat and power policies; appliance and equipment standards; and state government-led initiatives around energy efficiency.

The GWSA, enacted in 2008, established a comprehensive plan for addressing the threat of climate change to the Commonwealth. The law requires reductions in greenhouse gas emissions in accordance with sound science, providing a powerful catalyst for innovative approaches to meet the state's GHG reduction mandates and to build a clean energy economy, creating new jobs and saving consumers money. The GWSA is one of the most robust climate change laws in the nation and also serves as a model for federal action. The law:

- Requires GHG emissions to be reduced between 10% and 25% below the 1990 level by 2020 (with the subsequent Clean Energy and Climate Plan setting the requirement at 25%);
- Mandates that GHG emissions be reduced at least 80% below the 1990 level by 2050;
- Requires interim emissions reduction targets to be set for 2030 and 2040;
- Calls for the development of meaningful plans to achieve these mandates;
- Calls for consideration of policies to adapt to climate change impacts;
- Establishes requirements to measure, track, and report GHG emissions;
- Requires climate change impacts to be considered in decisions by state agencies, boards, commissions, and authorities, including permitting and licensing decisions.

The Patrick Administration has made significant strides on climate change, and yet there remains a great deal to do in order to reach the 2020 reduction requirement and the more challenging 80% reduction mandate for 2050.It is in this context that a carbon tax is being considered as an important tool and opportunity.

Figure I-1: Massachusetts' GHG Reduction Requirements and Interim Targets (MMTCO₂e)



C. Current emissions profile for Massachusetts

According to the Massachusetts Department of Environmental Protection (DEP), as of 2011 (the latest year for which full data was available) the transportation, electricity generation, and buildings sectors produced about 90% of the state's GHG pollution. This largest single sector is transportation: the gasoline and diesel fuel burned to provide road, rail, air, and marine transportation released 39% of the Commonwealth's GHG pollution. The fuel used directly to heat commercial buildings and homes and for industrial processes released 30%.

The coal, natural gas, and oil used to generate electricity in the state emitted 21% (this percentage has fallen significantly since 2011 due to greater use of natural gas and less use of coal for generation),[7] and the remaining 10% came from sources including agriculture, waste, wastewater, landfill gas, and highly warming chemicals for refrigeration, semiconductor manufacturing, and industrial processes.[8]

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[7] DEP's "partial" data for 2012 shows emissions due to electricity consumption falling from 16.5 to 14.1 million metric tons of CO2 from 2011 to 2012. These figures, however, do not include the most up-to-date research on "fugitive" emissions of methane from the lifecycle of natural gas.

[8] Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990-2011, with Partial 2012 Data, Mass. Dept. of Environmental Protection, July 2014, downloaded from http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/greenhouse-gas-ghg-emissions-in-massachusetts.html, 10/18/14

As of the latest U.S. Energy Information Administration (EIA) report, in 2013 Massachusetts used more natural gas than any other fuel on a BTU basis. Natural gas was used to generate 63% of the state's electricity with only 12% being produced from coal combustion. In 2012 the average household spent $3,960 on energy of all types, according the EIA Residential Energy Consumption Survey (RECS). This places Massachusetts 38th out of the 50 states and the District of Columbia in terms of energy spending.

- In 2013, 9.3% of Massachusetts' net electricity generation came from renewable energy resources, primarily from biomass and hydroelectricity.

- Massachusetts is the site of the first federally approved proposed offshore wind project, Cape Wind, and is working to open more offshore areas for wind.

- Compared to the U.S. average, a much greater proportion of Massachusetts residents (31%) use fuel oil as their main space heating fuel and a much smaller proportion of residents (10%) use electricity, according to EIA's RECS.

- According to the EIA, there is less reliance on electricity for heating in the Commonwealth compared to the U.S. as a whole, and the relatively cool summers means that average household electricity consumption in the state was low relative to other parts of the U.S. However, spending on electricity is closer to the national average due to higher prices in New England.

Figure I-2

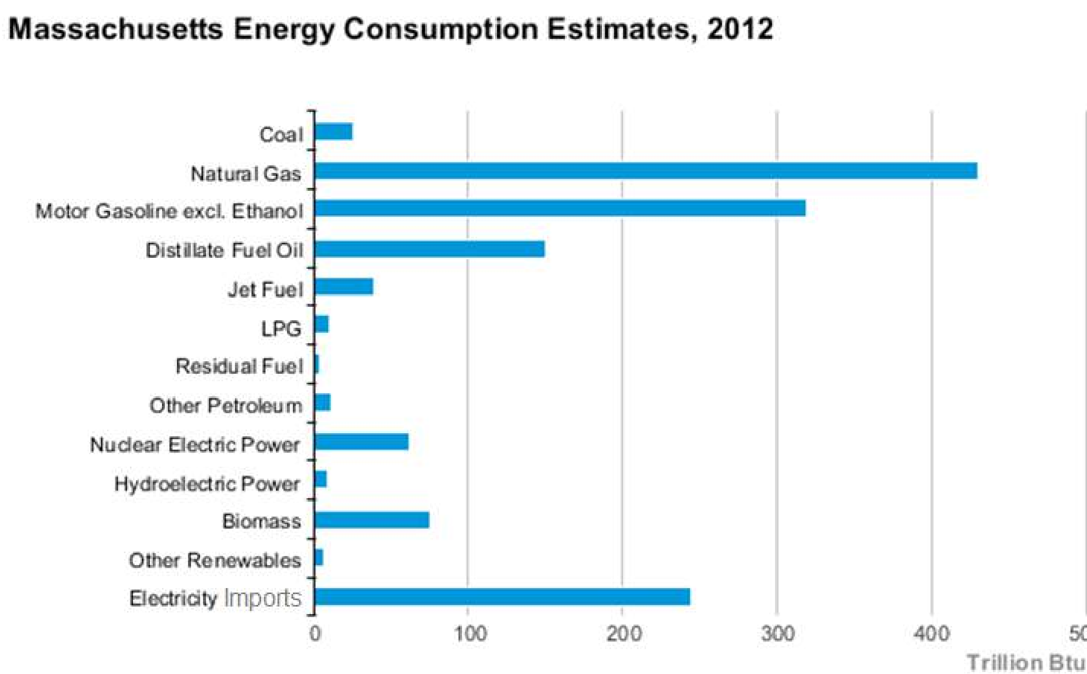


Figure I-3: Percentage of Total GHG Emissions in 2011 by Sector

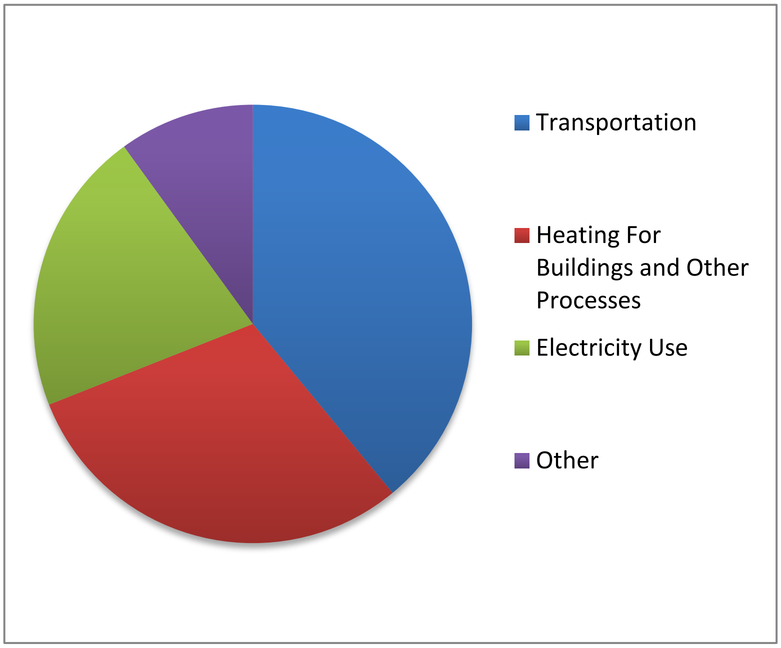
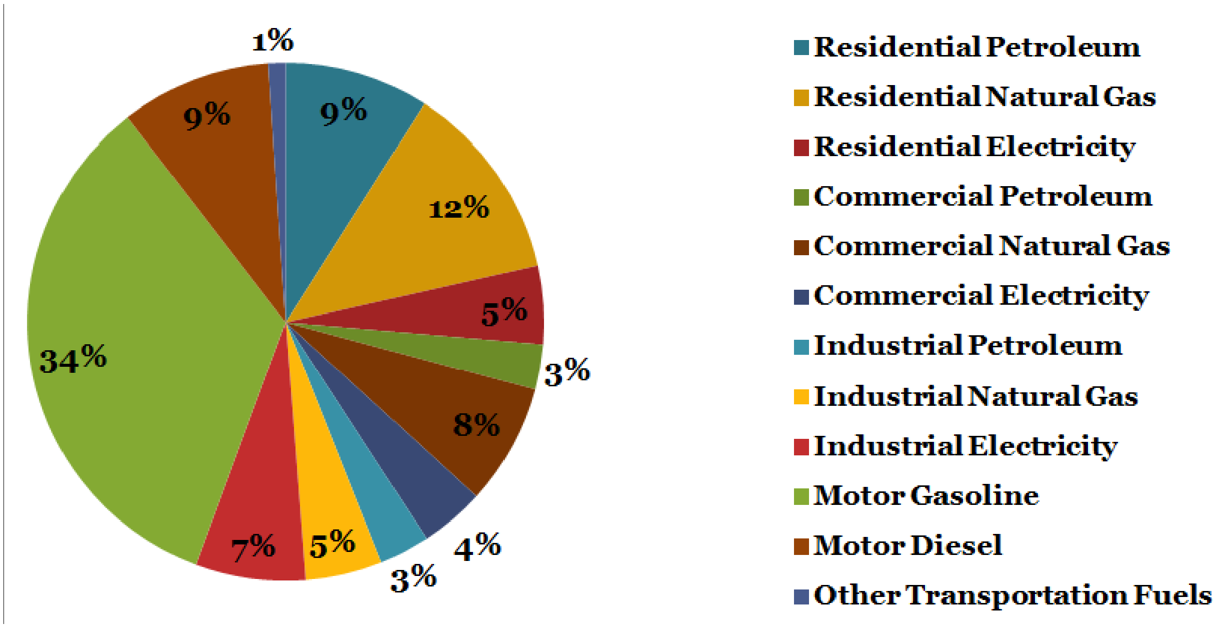


Figure I-4: Percentage of Total GHG Emissions in 2011 by Fuel Source and Sector



D. Literature Review – Existing Carbon Taxes and Analytical Research

All fossil fuels (gasoline, natural gas, propane, coal, heating oil) emit carbon dioxide when burned, the pollutant that is the major cause of climate change. Although Massachusetts has a number of important laws that help to reduce GHG emissions, there is no comprehensive policy that serves as a deterrent to emissions by companies and households.

A carbon tax would be such a deterrent, giving a price "signal" to both companies that make products which use fossil fuels, and to consumers to consider products which use less energy (such as cars, heating and cooling systems for buildings, and appliances) and will save them money. Producers of non-polluting energy sources such as wind and solar power can be sure that the carbon benefits of their cleaner energy will be valued (since non-fossil forms of energy will not pay the carbon tax) and ways to conserve our use of fossil fuels will also be favored.

Programs that stimulate the demand for clean energy, boost supply through pilot projects and incentives, offer support for research and early stage development, and end subsidies to polluting energy will remain necessary, whether or not the Commonwealth enacts a carbon tax. But regulatory policy levers will work better to encourage action by both businesses and households when solid and predictable price signals are also present.

A revenue-neutral carbon tax raises the price of fossil fuels and discourages their use, while ensuring that we aren't harming people's standard of living or making it harder for businesses to operate.

We conducted a literature review of relevant academic articles, reports, websites, and other sources on issues related to setting a carbon tax, especially where such a tax is revenue-neutral. Of special interest were the studies of other places where a carbon tax has been tried. Those evaluations were especially helpful in testing assumptions and seeing what had worked and what had failed in the experience of others.

At present, 14 countries and one province (British Colombia) have carbon taxes, the oldest of which were implemented in the early 1990s.[9] The literature reports that a carbon tax is an effective mechanism to reduce the rate of emissions being added to the atmosphere and to send a price signal that reflects the damage caused by release of global warming gases to the atmosphere.

Most of the places that have imposed a carbon tax have used the revenues to fund their general government budgets (Sweden, Norway) or for special programs (Costa Rica, Japan). The uses of the revenues from carbon taxes fall into the following categories: a) use as a general revenue

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[9] http://www.worldbank.org/content/dam/Worldbank/document/SDN/background-note_carbon-tax.pdf

source, b) investment in research and development, c) investment in energy efficiency and d) dividends (returning the revenue to citizens in a lump sum payment) and e) tax swaps (eliminating other taxes in exchange for implementing a carbon tax). In just a few cases, the funds are being returned to taxpayers.

One advantage of a carbon tax is that it generates a predictable price signal that could be known even a number of years in advance. This allows people and companies to make choices with certainty about their tax liability and the relative benefits of energy efficiency investment in clean energy supplies and energy efficiency in order to reduce their future tax liability.

The countries involved in carbon taxes vary from Iceland, which has a tax only on liquid fossil fuels that is paid directly to the treasury as a part of overall revenue (their electricity and much of building heat comes from carbon-free renewable energy), to Sweden, which has a price of $168 per ton of carbon dioxide (CO2), the highest carbon price in the world. In Sweden, the full tax is paid on transportation fuels, space heating, and non-combined heat and power generation. However, there are many exemptions, resulting in oil accounting for 96% of the revenues from the tax, although it produces less than 75% of the nation's CO_2 that results from fuel combustion. A number of industries and agriculture are partially exempt from the tax, however, limiting its effect.

Figure I-5: Comparing Carbon Taxes in Other Jurisdictions

Place	Price (USD/ tCO_{2e})	Revenue Distribution	Notes
Boulder, Colorado, USA[10]	$0.41 - $6.68	Energy-efficiency and renewable-energy programs, including rebates, credits and "energy audits" for homeowners and businesses.[11] Started in 2007.	Currently applies only to electricity production.
British Columbia, Canada	$27.94	Returned to taxpayers through targeted tax cuts included a personal income tax rate cut, a low-income 'climate action tax credit,' a small business rate cut, a general corporate tax rate cut, and industrial and farm property tax cuts. In addition, BC distributed a one-time check for C$100 to residents in June 2008.	Increased from $23.29US ($30CDN) in 2012.[12]
Costa Rica	n/a	Pays property owners for sustainable development and forest conservation	3.5% tax on fossil fuels since 1997[14]

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[10] Rates paid as a surcharge per kWh depending on type of consumer, from https://bouldercolorado.gov/climate. Converted to $/$tCO_{2e}$ using emissions rates for 2011 of the Public Service Company of Colorado (Xcel Energy), from http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/.

[11] http://www.dailycamera.com/ci_21941854/boulder-issue-2a-carbon-tax-appears-likely-be

[12] http://www.fin.gov.bc.ca/tbs/tp/climate/A4.htm

Place	Price (USD/ tCO_{2e})	Revenue Distribution	Notes
		activities. Fund used for conservation, reforestation, and research[13]	
Denmark	$31	Environmental subsidies (40% of total) and returned to industry (60% of total)	Started in 1992
Finland	$47.30	Government budget with no earmarks; Also independent cuts in income taxes	Started in 1990
France	$9.45	Finance "energy transition."[15]	$19.60 in 2015, $29.75 in 2016
Iceland	$10	Carbon tax on liquid fuels to the treasury	
Ireland	$27.01	Funds national budget; some subsidies for low-income residents.	Started in 2010
Japan	$2	Fund green initiatives.[16]	
Mexico	$0.77 - $3.86		Depending on fuel type
Norway	$4 - $69	Government budget. Used partially to fund special pension fund for all Norwegians.	Depending on fuel type and usage
Quebec, Canada	$3.20	"Green fund," supporting programs for GHG reductions and improved public transit.	Quebec is also in CA cap-and-trade
Sweden	$168	General government budget uses	Started in 1991
Switzerland	$68	1/3 of revenue for programs to reduce emissions from buildings; 2/3 redistributed to the population and economy.[17]	Started in 2008
United Kingdom	$15.75	Reductions in other taxes, including a 0.3% cut in National Insurance Contributions to make carbon tax revenue neutral	Started in 2001

Note: Monetary conversion rates from July 18, 2014.

British Columbia: Revenue-neutrality

In 2007, British Columbia, a province of Canada, established a Climate Action Plan that included not only a carbon tax, but also a commitment to carbon neutrality for all public institutions and participation in the Western Climate Initiative (an effort of several western

14 http://assets.opencrs.com/rpts/R40593_20100222.pdf
13 http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=10166
15 http://www.reuters.com/article/2013/09/21/france-energy-idUSL5N0HH04K20130921
16 http://www.reuters.com/article/2012/10/10/us-energy-japan-tax-idUSBRE8990G520121010
17 http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=de&msg-id=49576

states and Canadian provinces). The plan set ambitious targets for BC's GHG emissions reductions— to reduce them by 33% from a 2007 baseline level by 2020, and 80% by 2050.

On July 1st, 2008, British Columbia implemented a revenue-neutral carbon tax, applied to all fossil fuels purchased and combusted within BC's borders, with the exception of ship and aircraft fuel. Having revenue neutrality "allow(ed) BC to maintain low taxes on what we want (income, productivity) and tax what we don't (GHG emissions)." [18]

Because British Columbia gets more than 86% of its power from hydroelectricity that produces no carbon dioxide emissions (and much of the rest comes from biomass (where the carbon has recently been taken up),[19] its GHG emissions are already relatively low, accounting for 9% of Canada's emissions. Transportation accounts for the largest share of the province's emissions, followed by the rapidly growing oil and gas industry. The tax began at a rate of $10 (U.S. $10.13) per ton of CO2e. It rose by $5 per ton per year, reaching $30 per ton in July, 2014. It covers all fossil fuels burned in the province, accounting for an estimated 77% percent of British Columbia's domestic GHG emissions, according to the government.

The BC Carbon Tax is considered one of the best-designed environmental policies in the world.[20] The tax is coupled with targeted rebates to low-income and "remote" households, alleviating concerns over differential harm to certain parts of society. Revenue from the tax is also used to reduce rates of corporate and personal income taxation, a design that is aimed at getting a "double dividend" from reducing GHG emissions as well as an increase in economic output. The tax applies an identical rate to all emitters, ensuring that greenhouse gases are reduced at the lowest social cost.

The tax rate started at $10 per ton of carbon dioxide equivalent emitted (CO2e) in July 2008 and increased by $5 per ton every year reaching $30/Ton CO2e by July 2012.[11] At $10/ton, the tax represented an increase of 2.7¢/litre of diesel; at $30/ton this increases to 7.7¢/litre.

The BC carbon tax is revenue neutral, and has generated an estimated $CDN 960 million per year (2011-2012). Proceeds from the tax have been used to provide:

1) Personal tax cuts

- Low-income refundable tax credit
- Reduced bottom 2 bracket rates by 2% (2008), 5% (in 2009 and subsequent years)
- Benefit of $200 annually for residents of the northern part of the province and for rural homeowners
- Additional personal income tax rate cuts

[18] Interview with Tim Lesiuk, Acting Head of the Climate Action Secretariat, Ministry of Environment
[19] http://www.empr.gov.bc.ca/EPD/Electricity/supply/Pages/default.aspx
[20] Rivers, N. and Schaufele, B., The Effect of British Columbia's Carbon Tax on Agricultural Trade, Pacific Institute for Climate Solutions, 2014

Through these various provisions, a full or partial credit is being given to about one million citizens of British Columbia. The credit provides an annual maximum of $115.50 CAD for each adult and $34.50 for each child ($115.50 for the first child in a single-parent household).[21]

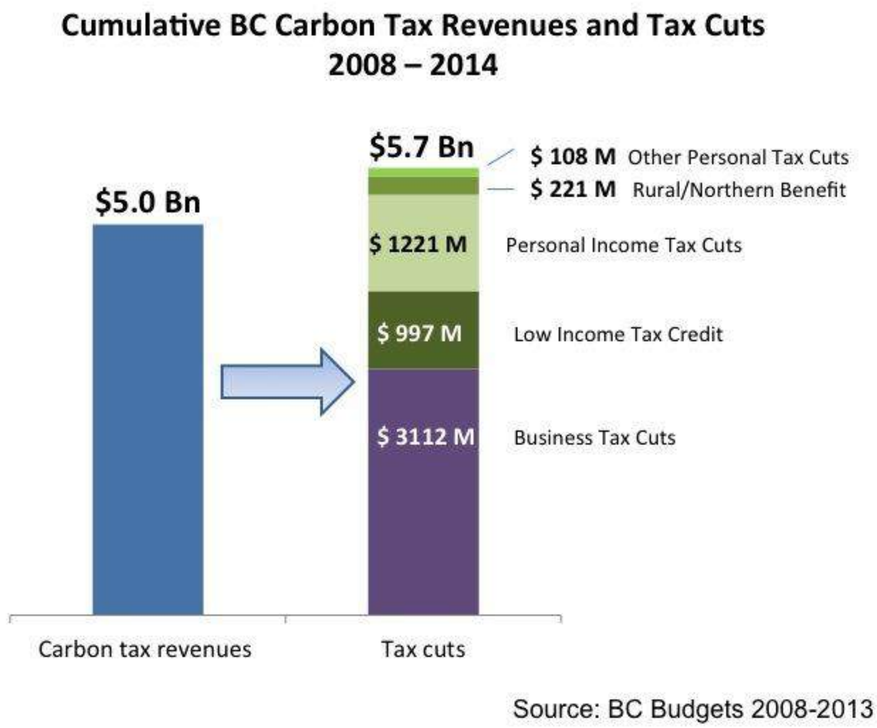
2) Business tax cuts

- Cut the corporate tax rate from 12% to 11% (2008), 10.5% (2010), and 10% (2011)
- Cut the small business corporate income tax from 4.5% to 3.5% (2008) and 2.5% (2010).
- Industrial property tax credit of 50% of school property taxes payable by light and major industrial properties starting in the 2009 taxation year, with the credit rising to 60% in 2011.
- Property taxes reduced 50% for land classified as “farm” starting in 2011.
- A special tax credit for greenhouses (some types are energy intensive) was added in 2013 after a study of the effects of the tax. Since then other analyses have shown that this was likely not needed, but it is still in place today.
- Additional corporate income tax rate cuts.

Combining all their uses of the revenue, British Columbia uses 72% of the funds to cut other taxes, 21% for dividends/rebates, and 7% for general revenue. Based on data provided by the BC Department of Finance, it appears that over the six year period BC returned more in tax cuts than it took in from the carbon tax.

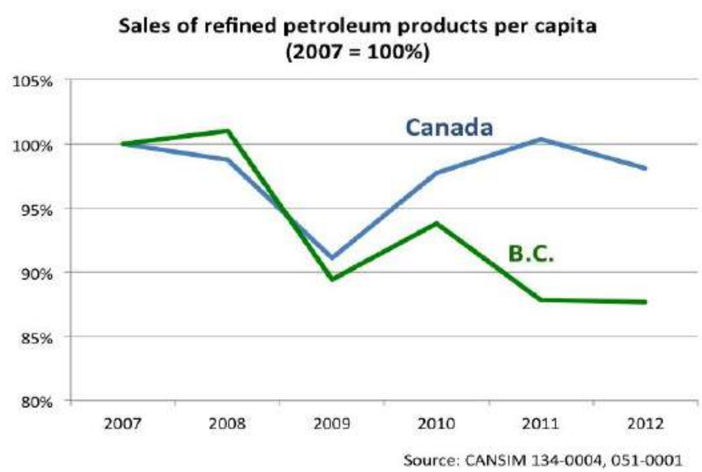
[21] Source: Navius Research, 2013

Figure I-6



Sightline Institute; used with permission; from their web site blog: http://daily.sightline.org/2014/03/11/all-you-need-to-know-about-bcs-carbon-tax-shift-in-five-charts/

Figure I-7[22]



22 Sightline Institute; used with permission; from their web site blog: http://daily.sightline.org/2014/03/11/all-you-need-to-know-about-bcs-carbon-tax-shift-in-five-charts/

Other Carbon Taxes under Consideration

Other states are considering carbon taxes, in particular Vermont, Washington and Oregon. It has been instructive to look at what these states are considering in crafting this study.

Vermont

Vermont has shown interest in both a state and regional approach to reduce greenhouse gas emissions, including a potential tax on carbon fuels.

The Department of Public Service has released a "Total Energy Study" with policy options to move the state closer to its comprehensive goal to meet 90 percent of Vermont's overall energy needs from renewable sources by 2050. The most prominent scenario is a tax on carbon, in addition to the RGGI program. The revenue from the tax would be applied toward renewable energy and emission-reduction goals, according to the report. In other discussions, the economy-wide carbon tax being considered is close to revenue neutral and is one part of a tax reform package that would align price signals with the cost of the carbon abatement used by some energy efficiency programs administrators across new England, including Vermont ($100/short ton).

Oregon

In 2013, the Oregon state legislature passed a study bill on "the feasibility of imposing [a fee or tax on greenhouse gas emissions] as a new revenue option that would augment or replace portions of existing revenues." The study is being conducted by the Northwest Economic Research Center (NERC) and will be completed in November 2014. They are currently looking at levels of taxation that, like the BC carbon tax, starts at $10 per ton of CO_2. But rather than ending at $30 a ton as British Columbia does, the Oregon tax would rise to $60 a ton over the next 20 years (by 2035). They are considering including the electric sector, including out of state generation, and are currently working on a way to implement this approach. Like Massachusetts, Oregon imports a substantial part of its fossil-fuel-fired electricity from outside of the state. In their case, accounting for so-called "carbon by wire" more than doubles the carbon footprint associated with electricity use in state. In early reporting, the NERC estimates that a BC-style carbon tax of $30 per ton of CO2 would generate about $1.2 billion a year, or about 8% of the state's annual General Fund revenue. They are studying both a revenue neutral approach and also one where 50 % of the revenue would be dedicated to corporate income tax cuts, 25% to personal income tax cuts, and 25% to targeted investments in home energy efficiency, industrial energy efficiency, and transportation infrastructure.

Washington State

On April 29, 2014 Governor Jay Inslee issued Executive Order 14-04, Washington Carbon Pollution Reduction and Clean Energy Leadership. The Executive Order created the Carbon Emissions Reduction Taskforce (CERT), charged with providing recommendations on how Washington State can meet its greenhouse gas emission limits through market mechanisms, such as trading, taxes, and incentives, in an effective and efficient manner. Starting in June of 2014, Washington began its own study, similar to this one, and including the use of the REMI model for their state economy. The Governor is seeking advice on market policy options and related economic analysis, with the intent of designing a program that will maximize the benefits and minimize the costs of implementation, while considering the state's specific emissions and energy sources, businesses and jobs, and community sectors. The process will look at different types of economy-wide, multi-sector carbon markets and is to include work on a tax but also an evaluation of regional and state cap and trade markets.

The Taskforce is comprised of senior leaders from business, labor, utilities and public interests, and representatives of federal, tribal and local governments. The Taskforce's advice and recommendations will inform legislation to be requested by the Governor by March 2015 for consideration during the 2015 legislative session.

Most Recent Action in the US Congress

Rep. Jim McDermott (D-Wash.) introduced a carbon tax in Congress in May called the Managed Carbon Price Act. The tax starts at $15 per ton of carbon dioxide, and rises to more than $100 over 10 years. It covers all natural gas, oil and coal burned in the United States with a goal of cutting U.S. carbon emissions by 30% over 10 years.

A bill introduced in July by Rep. Chris Van Hollen (D-MD) called the Healthy Climate and Family Security Act of 2014 would (i) create a permit system covering CO2 emissions for all fossil fuels extracted or brought into the U.S., (ii) auction off permits equaling U.S. emissions in 2005, (iii) ratchet down the number of permits by 80% by 2050, and (iv) distribute all of the proceeds "to the American people as equal dividends for every woman, man and child," according to an op-ed, titled The Carbon Dividend.

II. Design issues in imposition of the tax

A. Criteria for policy design and tax program implementation

In this work, we propose an approach to the tax consistent with the fundamental objectives for any tax: cost-effectiveness, fairness, and simplicity of implementation. In considering the design of the proposed tax and methods for returning revenues to the public we were guided by the following key principles:

- **High potential to reduce GHG emissions** – to be worth the effort of implementing it, a carbon tax should make a major contribution to achieving the state's GHG reduction mandates for 2020 and 2050.

- **Economy-wide -** cover all major fuels and products of GHG emissions. One complication here is how the tax could be applied to the electricity sector, which already has a carbon price through the Regional Greenhouse Gas Initiative (RGGI).

- **Revenue-neutral** – the Department of Energy Resources specified that this study should assume that all revenues from the tax would be returned to the public

- **Gradual phase-in -** the tax should be phased-in over time so that households and businesses have time to consider options for reducing their costs and adjusting their energy (carbon) use, including implementing energy efficiency and renewable energy measures and reducing their purchases of motor fuels.

- **Social equity** - both costs and other impacts may be distributed unevenly across geographic locations, income groups, and economic sectors. The study focuses on a tax design that corrects such inequities, including through how the tax revenues are returned to the public

- **Protect business -** mitigate any economic dislocation that could be caused by competition from firms in untaxed jurisdictions

In addition, several other goals entered into our analysis and design choices:

- To the degree feasible, provide supplementary protection for those low- and moderate-income households who currently have exceptionally high-energy use, such as households who must drive substantially more than average due to where they live or work, and households with high-carbon or expensive heating fuels (electricity, fuel oil, propane) who need to be protected at least over a transitional period. Such protection should phase out gradually over time, so that people have an incentive to modify their driving habits and fuel sources – but we can't expect them to purchase a new car, change where they live or work, or buy a new heating system in a short time period.

- Provide benefits to the state's economy – through reducing the multi-billion annual spending in Massachusetts for out-of-state fuels and electricity, keep more funds within the state's economy and thereby create jobs and increase demand for all industries in the state.

- Promote investment in low-GHG technologies and fuels, along with energy efficiency, along with advancing the state's broader environmental goals.

- Minimize public sector costs – the tax itself will have costs for implementation, administration and enforcement support from government agencies. We sought program designs that would be as simple as possible, using existing systems, while meeting the goals of the effort. We also considered the institutional capacity of the Commonwealth to implement the program in making recommendations.

- Provide a long-term incentive to reduce emissions in all decisions and to innovate over time, calling forward new technologies and approaches.

B. Carbon tax rates

1. Summary of experience elsewhere and analysis in the literature

There is tremendous variation in carbon tax rates throughout the world, ranging from $3 in Japan to $168/ton in Sweden. Given this variation and the several rationales for the tax levels, it is difficult to recommend a "correct" price for Massachusetts to use. The tax needs to be high enough so that it will cause GHG reductions large enough to make a substantial contribution to Massachusetts' legal mandates to reduce emissions 25% by 2020 and 80% by 2050 below 1990 levels. This will require energy suppliers, producers of energy-using machinery, construction companies, and energy consumers of all types to make major changes to their current practices.

There were generally three ways that other nations set their carbon tax rates:

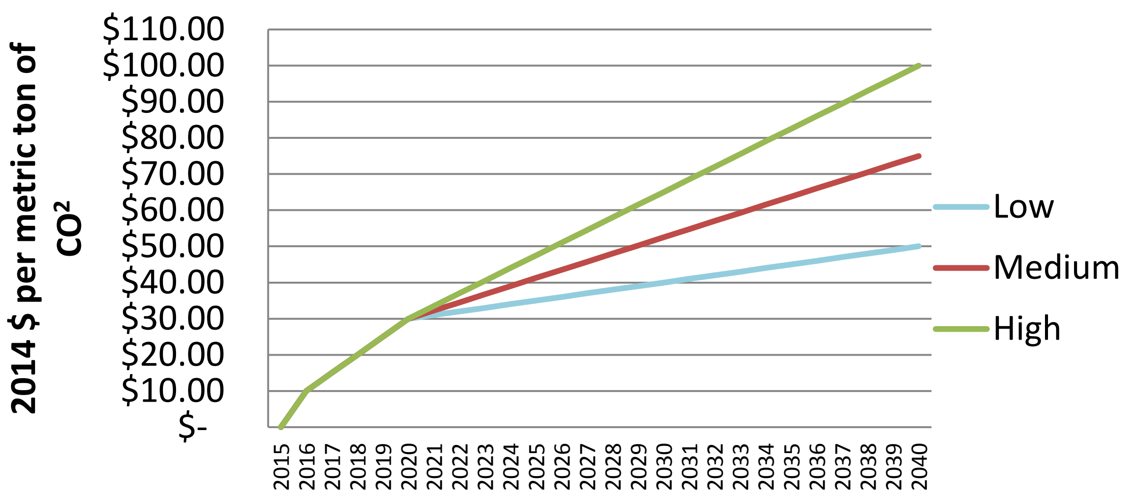
1) For many, they set the rate at a level that would achieve a specific amount of funding that was needed to fill a revenue shortfall in their overall budgets.
2) Others set their rate at a price that would represent the real "social cost of carbon" emissions (although this has been a shifting number). This approach tries to establish a financial value for the various damages that the state would face and to place a number on it.
3) Finally, another approach is to set a variable price to meet a specific carbon level for the economy as a whole.

2. Carbon tax price trajectories modeled in this study

In Section IV on the macroeconomic and GHG reduction impacts of the carbon tax, three price trajectories for the tax are modeled – high, medium, and low. In all three scenarios, the tax rate begins at $10 per metric ton (shown in the figure as beginning in 2016), and then rises by $5 per year, reaching $30 per ton in year five – the same trajectory used in British Colombia, which has similarities to Massachusetts, such as overall population size, an economy dominated by one metropolitan area, and a high standard of living. After the fifth year, there are three different rates of increase, with the high rate reaching a level of $100 per ton in 2040, the medium rate $75, and the low rate $50 per ton. These rates were chosen in large part because the carbon fee/tax needs to be high enough to make a major contribution toward reaching the state's legal requirement to cut GHG emissions 80% below the 1990 level by 2050. In addition, both the Intergovernmental Panel on Climate Change (IPCC) and the European Union (EU) have used $100 per ton as their base (middle) case for modeling of GHG mitigation.[23]

It should be noted that these trajectories, particularly early in the time period, are all relatively modest compared to what many analysts have recommended for the social cost of GHG emissions. For example, DOER has recommended to the state Department of Public Utilities, in DPU proceeding 14-86, that a $52/ton "price" of carbon dioxide should be used in evaluating the benefits of energy efficiency programs as of 2020, rising to $59 in 2030. This is not actually a price that would be charged to energy consumers, but rather would be used in deciding what efficiency measures or programs show greater benefits than costs.[24]

Figure II-1



[23] See http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar//////wg3/364.htm, GRID Arendal: A Centre Collaborating with UNEP, reprinting text from IPCC Third Assessment Report, Climate Change 2001.

[24] Testimony of Elizabeth Stanton of Synapse Energy Economics on behalf of Mass. DOER, in DPU Proceeding 14-86, in her "Summary of conclusions and recommendations."

C. Where and on what entities should the carbon tax be levied?

A frequently asked question is where and on whom would a carbon tax be imposed. The answer depends on the type of fossil fuel and on who the end-user is. The point of taxation would depend on both these factors, and on the industry structure for each fuel.

Natural gas - federal data appears to show that virtually all the supply coming into Massachusetts goes either through gas local distribution companies (LDC's, both private companies and municipally-owned utilities) or to electric power plants. Gas supply that goes directly to end-users, if any, constitutes less than 2% of incoming supply, and comes via three interstate transmission companies.[25] The LDC's are regulated by the Massachusetts Department of Public Utilities (DPU) and the interstate pipelines are regulated by the Federal Energy Resources Commission (FERC). As a result, tracking the supplier volumes and assessing the carbon tax on these entities should not present a problem. The tax would be imposed on gas LDC's and pipelines for household and business end-user gas sales, but not for electric utility sales, See Section (D) below for our discussion of how emissions from electricity consumption should be handled.

Liquid motor fuels – both gasoline (technically RBOB, or "Reformulated Blendstock for Oxygenate Blending", in Massachusetts) and diesel motor fuel (along with other "special fuels") are brought into the state by what the federal EIA calls "prime suppliers," whose distribution to each state is tracked by EIA. At present, the Massachusetts Department of Revenue (DOR) tracks these supplies and assesses excise taxes on them. According to DOR there are approximately 175 companies that supply gasoline and about 1,200 suppliers of special fuels that import fuel into Massachusetts.[26]

For several years, the northeast states have been developing plans for regulating and reducing the greenhouse gas emissions due to motor fuels, called the Clean Fuel Standard (CFS) (modeled after the Low Carbon Fuel Standard, a California fuel regulation). Draft plans for this system proposed regulating emissions at the prime supplier level, rather than further down in the fuel distribution network, and Massachusetts officials indicate that this remains the preferred option. At present, DEP is developing a fuel tracking mechanism, which would be the first step in creating a CFS. Based on the state DOR's ability to collect taxes from these suppliers, assessing a carbon tax on them appears feasible and would minimize the administrative burden compared to imposing the tax at the retail level.[27]

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[25] Natural Gas Annual Respondent Query System (EIA-176 Data through 2012), downloaded 10/16/14. Link provided by Joanne McBrien of Mass. Department of Energy Resources.
[26] Janette Sydney, Mass. Department of Revenue, by phone, 10/16/14.
[27] Nancy Seidman and Christine Kirby, MassDEP, via e-mail, 10/16/14. Prime suppliers from U.S. Energy Information Administration-782C, Companies Reporting Sales. EIA 782C lists only 35 prime suppliers of petroleum fuels, as opposed to the much larger number that the DOR reports.

Heating oil – of all the fuel sources, heating oil presents the greatest difficulty in imposing regulation and a carbon tax. At present heating oil is not taxed in Massachusetts, and thus DOR does not have records on the suppliers. There are a large number of dealers who deliver fuel to homes and commercial buildings, and neither DOR nor MassDEP keeps track of them. On the other hand, there are less than a dozen in-state wholesale distributors who sell to the retail suppliers, and DEP does regulate them for sulfur content in the oil.[28] It appears feasible for DOR to impose the carbon tax on such distributors. However, there may be a few wholesale suppliers in neighboring states who sell to retailers, who then deliver to homes and businesses in Massachusetts. DEP does not have records on such suppliers. In addition, even when located, it is not clear to what degree these out-of-state wholesalers know to what state fuel will be delivered when they sell it to retail dealers.[29] The California Air Resources Board (CARB), which is administering a cap-and-trade system that faces similar issues, says that if a wholesale terminal is in a neighboring state, trucks coming across the state border are required to report the quantity of oil they are carrying to the California state government.[30]

One way in which all retail oil dealers in the state are regulated is for the accuracy and sealing of their metering system that records fuel received by customers. The state's Division of Standards is required to handle such regulation for all towns with a population under 5,000, about 102 in total; while those municipalities with a population over 5,000 are responsible for doing it themselves. In addition, at present 69 of the towns with a population under 5,000 contract with the Division of Standards to handle the regulation themselves. Between the Division and cities and towns, it should be possible to compile a contact list for all oil dealers in the state. With that, a carbon tax could be imposed on them directly, or they could be required to provide information on which wholesale distributors they use, particularly if these are out of state. Then the tax could be imposed on both the in-state and out-of-state wholesalers.[31]

Thus, although it is slightly complicated, it appears that a few new procedures will resolve practical and administrative issues in taxing heating oil.

D. Electricity Generation and Interactions with the Regional Greenhouse Gas Initiative (RGGI)

We have given particular scrutiny to the electricity sector, examining a diversity of issues before making recommendations concerning its role in an economy-wide carbon tax. The issues we considered include: the absence of an advanced electricity tracking system, the reduction in the sector's share of the state's total CO_2 emissions from 33% to below 20% in recent years, the existing regulatory structure for the electric sector in Massachusetts (which includes both clean

[28] Glenn Keith, Mass. Department of Environmental Protection, 10/21/14.
[29] Based in part on discussion with Joanne McBrien of Mass. DOER, by phone, 10/16/14.
[30] Michael Gibbs, Assistant Executive Officer of the California Air Resources Board, by phone, 10/23/14.
[31] Charles Carroll, Massachusetts Division of Standards, by phone, 10/28/14. See also, MA Dept. of Consumer Affairs and Business Regulation, Division of Standards, 2014 Annual Report, page 7, which lists 368 oil trucks and 177 propane trucks as having been inspected in 2013.

renewable energy requirements and RGGI), and the ways that electricity is dispatched and used throughout the Northeast region.

We conclude that there are strong reasons both to include and exclude electricity from the carbon fee/tax at this time, given current conditions in Massachusetts. If the sector is included, we recommend that the fee/tax be imposed at the end-use consumer level, not at the generator level. And we suggest that the fee/tax on consumers should be reduced by the amount that generators have already paid to purchase emission allowances under RGGI, so that electricity faces the same carbon price as other sectors. The sub-sections below explain how we reached these conclusions.

1. Should electricity be included in the carbon fee/tax system?

We find that there are pluses and minuses to including the electricity sector in the carbon fee/tax. On the plus side is our general presumption that a uniform economy-wide carbon price is the most effective and economically efficient means of reducing emissions, giving energy suppliers and consumers an unbiased method of choosing how to meet energy needs. In addition, although electricity has become a smaller share of emissions in Massachusetts in recent years, scenarios for the long-term future of our energy system out to 2050, when we are legally required to reduce emissions by 80% or more, tend to focus on greatly expanding the role of electricity.

The last chapter of the state's Clean Energy and Climate Plan for 2020 offers two scenarios for how to reach the 2050 requirement. In both, clean, renewable electricity is seen as becoming the dominant energy source, replacing direct use of natural gas and petroleum in both operating motor vehicles and in heating buildings.[32] The electricity would need to be provided almost entirely from low-carbon sources. If Massachusetts (and the nation) were to move in this direction, having the appropriate price incentives in the electricity sector would become of much greater importance.

On the other hand, at present electricity supply has dropped from 33% to less than 20% of total emissions in Massachusetts, due in large part to the replacement of coal-fired with natural-gas fired generation in the state and elsewhere in the northeast, caused by falling natural gas prices. In addition, electric sector emissions will be affected by the carbon fee/tax to a smaller degree than other sectors, because:

- Electricity demand is somewhat more resistant to price increases (lower demand elasticity) than are other uses of energy.

- For a given carbon tax rate, the percentage increase in electricity rates will be less than that for other fuel sources, for two reasons. First, for electricity a greater share of its costs

[32] *Clean Energy and Climate Plan for 2020*, Massachusetts Executive Office of Energy and Environmental Affairs, December 2010, pages 95 through 106.

come from non-fuel expenses, including construction of power plants and transmission and distribution lines, than is the case for petroleum and natural gas. Second, much of the electricity supply in the Northeast comes from relatively low-carbon forms of generation, including hydropower, nuclear power, wind, and solar energy.

- As a result, while price changes cause the impacts to vary greatly from one year to the next, as of the most recent data available a $30/ton fee/tax would cause electricity rates to rise by about 5%, gasoline by 8%, and natural gas by 11%.

- Electricity already has more extensive policies addressing its emissions than do use of fuel in the transportation sector and heating of buildings. These include the state's Renewable Portfolio Standard, its intensive energy efficiency programs, strict building codes, and the Regional Greenhouse Gas Initiative.

As a result of all these factors, the modeling discussed in Section V of this study finds that **only about 3% of the drop in CO2 emissions across all energy use would come from placing a carbon tax on electricity generation**. This small impact on emissions argues for not including it in the carbon tax at this time. Massachusetts does need to continue reducing electric-sector emissions, but other pending policies may accomplish this without a carbon fee/tax: EPA's proposed regulations to cut power plant emissions under Section 111(d) of the Clean Air Act, the potential for large-scale imports of hydropower and wind power from other states and Canada, and MassDEP's proposal, currently in formation, to institute a "Clean Energy Standard" for electricity consumption in the state.

However, it should also be noted that the low contribution of electricity to the overall reduction in emissions is partially due to using the federal EIA's projection of future demand for electricity out to 2040. This projection does **not** include an expectation that Massachusetts or the nation will convert much of its motor vehicle fleet and building heating to electricity by that time, which would substantially raise consumption of electricity, and therefore its potential contribution to reducing GHG emissions. In fact, EIA has use of electricity for heating falling, and electricity remaining below 1% of total vehicle fuel use.[33]

2. RGGI and Implementation of a Carbon Tax

In deciding whether to impose the carbon fee/tax on the electricity sector another important consideration is its interaction with the Regional Greenhouse Gas Initiative (RGGI), the first market-based regulatory program in the United States designed to reduce GHG emissions. A cooperative effort among nine northeast states, RGGI is designed to cap and reduce CO_2 emissions from the power sector. States sell nearly all emission allowances through auctions and invest proceeds in energy efficiency, renewable energy, and other consumer benefit programs.

[33] Data provided by Scott Nystrom of REMI, 11/11/14.

While RGGI is a cap-and-trade program rather than a fee/tax program, it does put a price on CO_2 emissions – although this price is currently much lower than the carbon prices considered in this study, and so has less impact. Allowances sold for $4.88 at the last auction[34] – far lower than the prices modeled in this study, which would begin at $10, rise to $30 in the 5th year, and continue rising more gradually after that. If the fee/tax were imposed on either electricity suppliers or consumers, the current RGGI allowance price should be subtracted from the tax rate, so that electricity does not pay a higher penalty for its emissions than do other energy sources.

There is widespread agreement that for electricity, especially, a regional program is preferable to a program operating in only one state. One reason is that emissions reductions can come from choosing among electricity supplies in the entire region, yielding CO_2 reductions at lower cost. Also, there is no incentive for generators to sell to those states that don't have a carbon price in preference to those that do have such a price.

If the fee/tax were imposed only on generators in Massachusetts, it would provide a strong incentive to import lower cost electricity from other states without the tax, as a result of Massachusetts being a part of the tightly integrated New England Independent System Operator-New England (ISO-NE). In recent years the Commonwealth has imported on the order of one-third of its electricity.[35] While the tax could also be imposed on imports, at present electricity is distributed throughout the New England grid without its origin from specific power plants or renewable energy sources being tracked by ISO-NE. It is possible that over time such a tracking system could be developed, along the lines of the tracking system used for renewable energy certificates (RECs), but without one at present Massachusetts cannot assign CO_2 emissions rates that are specific to the power plants actually providing our imports.

California uses an approach that allows generators to become "specified sources" so that power from hydro, wind or solar can come into California with a label, and therefore not be charged the allowance price that fossil fuel generators must pay. Otherwise, importers of power pay based on an "unspecified import" rate corresponding to the average marginal power plant, typically a gas plant. Historically unspecified imports have represented about 50% of California's annual imports.[36] California is different in many respects from Massachusetts. Most of California is an ISO by itself. The parts of California that are not in the ISO are well-integrated with it, so that tracking imports to the state is a relatively simple matter. Massachusetts is entirely embedded within and co-mingled with ISO-New England, so that tracking the specific sources of imported power is more complex.

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34 RGGI Press Release, Sept. 5th 2014. http://rggi.org/docs/Auctions/25/PR090514_Auction25.pdf

35 There are some complexities in calculating a precise figure through use of U.S. Energy Information Administration (EIA) data. By one calculation method, imports in 2012 (the most recent year for which complete data is available) were approximately 35% of electricity consumption in Massachusetts. See Marc Breslow Excel file "MA electric generation, sales 2012 EIA.xls".

36 Nyberg, Michael. 2014. "Thermal Efficiency of Gas-Fired Generation in California: 2014 Update". CEC Staff Paper. Available at: http://www.energy.ca.gov/2014publications/CEC-200-2014-005/CEC-200-2014-005.pdf

Incentives to Import Higher-Carbon Power

Massachusetts could impose a tax on imported power equal to the average carbon content of all electricity generated in New England. This would significantly reduce the price advantage of imports over in-state power sources. However, the average carbon content of ISO-NE power is lower than that from Massachusetts' generators, because it contains a larger fraction of nuclear and hydropower. As a result, imports would face a lower carbon tax, and therefore would still tend to displace in-state generation. This could happen even if the "extra," or incremental, power being generated to displace Massachusetts generation actually came from less-efficient, higher-emission gas plants than lower-emission sources in the Commonwealth. Such changes are termed "leakage," and could cause regional emissions to rise even if Massachusetts' accounting system shows emissions from our own electricity consumption falling. RGGI already faces such a leakage problem, and it would be heightened if, as we have modeled, a Massachusetts carbon tax resulted in carbon prices several times higher than those under RGGI. The problem extends beyond New England, as there is potential for large-scale imports from New York.

One possibility for obtaining low-emission out of state power that is tracked would be for Massachusetts electric utilities (local distribution companies) to sign contracts to buy power from specific low carbon sources. In such cases, the Commonwealth could impose a tax based on the specific carbon emissions of those sources. However, even such a scenario poses difficulties. Out-of-state companies that own several generating facilities could choose to send their higher-emission power to other states and their lower-emission power to Massachusetts, in a process called "shuffling." Doing so would make it appear that emissions are falling in Massachusetts, even though the actual effect of our tax is to make them rise in a larger geographic region. Welton et al. (2013) proposed a solution to this in a white paper on regulating imports into RGGI, whereby bilateral contracts would only be permitted if they were signed before the policy began, purchasing power from a new resource, or purchasing incremental power at an existing resource.[37] This approach is also worth considering for Massachusetts.

CO2 emissions rate to use for setting the carbon fee/tax

We have identified two possibilities for setting an emissions rate for electricity, given that Massachusetts' power comes from all the New England states, New York, and beyond. One possibility is the ISO-NE rate, which is a weighted average rate for all electricity generation in New England. A second possibility is the "Massachusetts emissions factor" used by MassDEP in its inventory of the state's GHG emissions. As required by the Global Warming Solutions Act (GWSA) DEP uses a "consumption" approach to counting the state's electricity-related emissions: our emissions include all those resulting from in-state power generation, plus the emissions that occur in other states and Canada from which we import power.

[37] Welton et al, 2013. "Regulating Electricity Imports into RGGI: Toward a Legal, Workable Solution". Columbia Law School. Available at: https://web.law.columbia.edu/sites/default/files/microsites/climate-change/files/Publications/Fellows/RGGI%20paper_addendum%20Sept.pdf

Due to the integrated nature of the New England grid, Massachusetts does not know the precise sources of its imported power. To address this, DEP assigns a portion of the Commonwealth's imports to exporting states and Canada through a formula that adjusts for the balance between generation and load in each state. Emissions are assigned to MWh based on the mix of generation sources in each state.

DEP's approach appears reasonable, and preferable to simply using the ISO-NE average emissions rate to measure emissions from Massachusetts power imports. Input from the Department of Public Utilities (DPU) supports this conclusion, in part because of a belief that the Commonwealth's strong policies in the electric sector will cause DEP's "MA emissions factor" to fall substantially below the ISO-NE average emissions rate, and would more accurately reflect the emissions contained in imported power. [38] However, the most recent MA emissions factor available from DEP is for 2011 and grid rates have been changing substantially each year. For that reason, we have used the ISO-NE rate for our modeling here; but recommend using the DEP MA emissions factor when an up-to-date calculation is available.

Scenarios Analyzed for the Electric Sector

We identified a number of potential policy designs for Massachusetts, but narrowed these choices—for reasons of technical feasibility—to four approaches that were then subjected to review by the consulting team, state staff and stakeholders. The four approaches are summarized in the table below. Quantitative modeling was performed on three of the options, while only qualitative analysis was performed for option (2).

Figure II-2: Carbon Tax Policy Options Considered for the Electric Sector

Carbon Tax Policies Considered for the Electric Sector	Qualitative Analysis	Modeling Analysis
1. Tax in-state generators, and for imports charge the electric distribution utilities, for the carbon content of the electricity sold	Yes	Yes
2. Tax in-state generators, and utilities for imported power, but provide generators and utilities rebates based on RGGI allowances purchased to cover their emissions	Yes	No
3. Place the tax at the consumer level with the Load Serving Entity collecting the tax	Yes	Yes
4. Waive a carbon tax on electric sector altogether	Yes	Yes

Our analysis and modeling yielded the following results:

Policy Case 1: This carbon tax design would require electricity suppliers (in-state generators and utilities purchasing electricity imports) to pay for carbon emitted during the generation of

[38] Justin Brandt, Massachusetts DPU, personal conversation, 11/10/14.

each megawatt-hour (MWh) produced, at a rate consistent with what the generator was emitting. We modeled such a mechanism by adding the tax incrementally to the obligation on in-state generators to purchase RGGI allowances, and the Massachusetts local distribution companies were taxed on their out-of-state imports based on average emission rates from the New England-ISO region. Synapse Energy Economics, part of the study team, conducted modeling of this scenario. Synapse found that emissions would fall substantially in New England, by about 10 million short tons of CO2 by the mid-2020's. But emissions in New York would rise by just as much as a result of their generators sending power to Massachusetts. The overall result would be that U.S. emissions would rise slightly until the 2030's, when they might fall slightly.[39]

Policy Case 2: In a variation of Case 1, suggested by various stakeholders, the tax was added incrementally to the obligation on in-state generators to purchase RGGI allowances, and the Massachusetts local distribution companies were taxed on their out-of-state imports based on average emission rates from the New England-ISO region. But the generators were then given a rebate equal to the amount of money spent to purchase RGGI allowances sufficient to meet their emissions levels.

Policy Case 3: Given the difficulties and counter-productive results of applying the tax to generators in the absence of being able to specifically track generation sources, we applied the tax directly on household, business, and institutional consumers at the retail level, based on average emissions in the ISO-NE region. In this case, no carbon price beyond the RGGI allowance price would be imposed on generators, and there would be no incentive to favor imported over in-state power. However, there would also be much less incentive for generators to move toward lower-emission power sources. The tax on consumers would be an incentive to improve end-use electric energy efficiency, reduce their use of power, and implement distributed generation of renewable energy, such as rooftop and ground-mounted solar facilities.

Policy Case 4: In this case, we excluded the electric sector from the carbon fee/tax, and instead levied the tax only on the carbon-based fuels burned directly in the state that are not covered under the RGGI program.

Exploration of different policy options for the carbon tax in the electricity sector resulted in the following findings: (1) Creating a tax at the generator level isn't a successful approach to reducing emissions if the carbon tax is imposed only for one state, as the price increment shifts purchases out of state or out of region ("leakage"), so that on a national basis emissions do not fall; (2) Establishing the tax at the generator level and rebating funds to the generators may not actually help consumers, as the generators may be able to retain these rebates as profits; (3) Placing the tax at the consumer level creates an incentive for energy efficiency and distributed

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[39] "Summary of input assumptions and initial results of a state-specific carbon tax on electricity generation in Massachusetts," memorandum from Patrick Luckow of Synapse Energy Economics to Scott Nystrom of REMI, 9/17/2004, pages 8-9 and Figure 7.

renewables, without having the same technical issues as the generation based approach creates; (4) Placing no tax on the electric sector leaves a significant portion of the economy untaxed. While doing so would have little impact on emissions given current circumstances, over the long run (to 2050) it will likely be important to have a price on CO2 emissions that result from electricity generation.

Conclusion

In view of the difficulties with appropriately taxing out-of-state power, we conclude that if the carbon fee/tax is to be imposed on the electric sector, setting the tax at the consumer level is most appropriate at present. In addition, Massachusetts could work with other states in the region to establish a more robust system for tracking electricity from its upstream sources to final consumers. Establishment of such a system would enable the Commonwealth to consider amending a carbon tax law, assuming that a tax was implemented first, to include charges on imported generation that are specific to their carbon content.

E. Is the carbon price a tax or a fee?

Is the carbon price that we consider in this study more appropriately termed a fee or a tax? We have conducted only a preliminary review of this question. However, several sources provide documentation that appears to support terming a revenue-neutral carbon price a fee rather than a tax. According to a U.S. Supreme Court case, the Washington State Department of Revenue, the Massachusetts legislative drafting manual, and two private think-tanks, reasons for terming a governmental charge a fee include:

1) The primary purpose is not to raise revenue
2) The charge is collected from particular entities in order to defray the cost of benefits received by those entities
3) The charge is a penalty, imposed to punish behavior
4) The revenue will not be used for general public purposes, but rather to regulate the behavior of those paying the fees

In regard to (1), a revenue-neutral charge for emitting CO2 into the atmosphere would not have the primary purpose of raising revenue. For criterion (2), if use of the atmosphere is considered a "benefit" to particular entities, for which they are being charged, this also indicates that the charge is a fee. A CO2 price would appear to be a penalty for emitting pollution, as in (3) above, although it may not be intended as a punishment.

Finally, regarding (4), if the revenue is returned to households and businesses, arguments could be made for why this is or is not a "general public purpose." If it is a "general public purpose, this would be a reason to call the charge a tax, although the other reasons listed above might still outweigh this last criterion.

However, it may also be the case that a carbon price is neither a tax, a fee, nor a penalty, as these terms have traditionally been used. Instead, a revenue-neutral carbon dioxide emissions charge may deserve to be in its own unique category.

Sources for this analysis:

- https://malegislature.gov/Legislation/DraftingManual; F. Money Bills: "Non-tax revenue, such as fees or fines. *Opinion of the Justices*, 337 Mass. 800, 809 (1958), quoting *United States v. Norton*, 91 U.S. 566, 569 (1876) (limitation "confined to bills to levy taxes in the strict sense of the words")."
- "How Is the Money Used? Federal and State Cases Distinguishing Taxes and Fees," Joseph Henchman, Background Paper No. 63, March 2013, *Tax Foundation*, pages 2 and 4.
- "Is it a tax or a fee", Jason Mercier, May 5, 2011, Washington (state) Policy Center.

III. DISTRIBUTIONAL IMPACTS AND DESIGN OF THE REVENUE-RETURN MECHANISM:
What Are the Options for How to Distribute Rebates?
What will be the net impacts on households, businesses, and other institutions?

All households, businesses, and other institutions will pay the carbon tax through higher prices for fossil fuels, and possibly for electricity (to the degree that fossil fuels are used to generate power).

However, the present study assumes that the carbon tax is "revenue neutral" in relation to the state government revenues. This means that none of the revenue is used to fund other state programs, but rather all of the revenue is returned to the public. The formulas for returning these funds will have a critical impact on what the net effect of the tax is on different households, businesses, and other institutions such as municipal governments and non-profit organizations, as well as influencing the overall impacts on the economy.

A. Initial impacts of the carbon tax versus improvements to the economy that it will yield over time

In this section of the study we analyze the economy in a "static" fashion, meaning that neither consumers nor producers are assumed to make changes in their buying behavior or the types of goods that they produce as a result of the carbon tax. The purpose of imposing a carbon tax is, of course, to induce such changes in behavior so that emissions of greenhouse gases will be reduced. Neither does this portion of the analysis include the "dynamic" adjustments to the economy studied in the macroeconomic section, such as household or firm relocations between different states because of job creation or the cost of doing business.

However, businesses and consumers will react only gradually to higher prices on fossil fuels. Initially, they will continue to purchase close to the same amount of fuels and electricity as before, simply paying more for them.

The tax revenues collected by the state government will be used to rebate funds to households, businesses, and other institutions. In combination, the taxes and rebates will yield a net impact on every consumer of fossil-fuel based energy. That impact may be positive or negative, depending on how rebates are distributed and on the purchasing patterns of each consumer.

This section of the study examines the net impacts on costs for all consumers, prior to any changes in the supply and demand for fossil-fuel based energy. However, in Section IV the REMI model examines how economic actors react to the higher prices, and what results this yields for the overall economy. As households and businesses adjust to the higher prices, the performance of the economy will improve, with economic gains such as increases in employment and in the disposable income of households.

Therefore Section III addresses how a tax-and-rebate system will affect consumers and producers **initially**, but it should be recognized that these impacts will improve over time due to changes in the overall economy. In particular, the reduction in fossil fuel use will mean that Massachusetts sends billions of dollars less each year to other states and nations to purchase gasoline, diesel fuel, natural gas, heating oil, and electricity. This means that billions more will be spent on industries that contribute more to employment and the standard of living in Massachusetts, such as health care, education, professional services, construction, and retail trade. As a result, **over time the net impacts on households' cost of living and on businesses' cost of operation will be better than those described in the "distributional" analysis of this section.**

B. Formulas for Returning Revenues to Households

In this study we use several basic principles for returning the revenues to the public. These include:

- All funds are returned to the public.[40]
- In rough terms, households as a sector will receive back what they put in due to the tax. Businesses and other institutions as a whole will also receive back what they put in.
- For both households and businesses, the money returned will only equal the carbon tax payments on an aggregate basis, not for each household, business, or institution. Doing the latter would defeat the purpose of the tax, as it would eliminate any incentive for energy consumers to reduce their use of fossil fuels.
- Low income (bottom 20% of households) and moderate income (20% to 60% of households ranked by income per household or by person) should, on average, be fully compensated for their increased costs.[41]
- Households with incomes in the top 40% will see compensation for a smaller fraction of their increased costs; to the degree feasible given the other principles for returning the revenue.
- Business and institutional energy consumers will be compensated through particular formulas, as discussed below.

[40] Except for funds that state agencies receive as rebates for their carbon tax payments, according to the same formula used for all other institutions that pay the tax through higher energy costs.

[41] Fully compensating low- and moderate-income households "on average" by no means guarantees that all such households will come out even or better, since households vary widely in their use of fossil fuel-based energy. To ensure that a high percentage of such households do not face significant losses, the compensation "on average" should put these households well above the break-even mark. In addition or alternatively, households that are in circumstances likely to result in high carbon taxes (such as oil as their home heating source or residence in a location likely to require high driving mileage) could be specifically addressed (as is discussed below).

Based on these principles, we conducted preliminary modeling of several options, as shown in the table below.

Preliminary scenarios for returning carbon tax funds to the public

Scenario	Households	Institutions (businesses, non-profits, cities and towns)
All scenarios	Households as a sector get back the share of total revenues that they put in.	Businesses and institutions as a sector get back their share of total carbon tax
Scenario 1	Funds returned via equal rebate amount per person	Funds returned according to each entity's share of total state employment
Scenario 2	Equal amount rebated per household	Funds returned according to each entity's share of total state employee payroll
Scenario 3	60% of household sector's funds used to increase personal exemption on state income tax; 20% to increase state's version of Earned Income Tax Credit (which is refundable); 20% to increase LIHEAP (fuel assistance) to low income households, concentrated on households who have oil or propane heat.	Could be either Scenario 1 or Scenario 2 for businesses and institutions
Scenario 4	Refundable "carbon tax" credit created in state personal income tax system, 80% of funds used for this credit. Each tax filer receives an equal credit. To assist households who do not file state income tax returns, remaining 20% of funds used to increase LIHEAP assistance	Could be either Scenario 1 or Scenario 2 for businesses and institutions
Scenario 5	Same as scenario 4, but a portion of funds are used to assist low- and moderate-income households who drive substantially more than average	Could be either Scenario 1 or Scenario 2 for businesses and institutions

The remainder of this section of the report discusses the characteristics of these different scenarios, and presents the results of modeling that we have conducted for the subset of scenarios that we concluded were most in-line with the principles discussed above. Our modeling shows impacts from the combination of carbon tax and revenue-return mechanism on:

- Households at different income levels, with different numbers of household members, and with special circumstances that lead them to have higher-than-average usage of fossil fuels
- Businesses and other institutions that have different degrees of energy-intensity, labor-intensity, and wage levels.

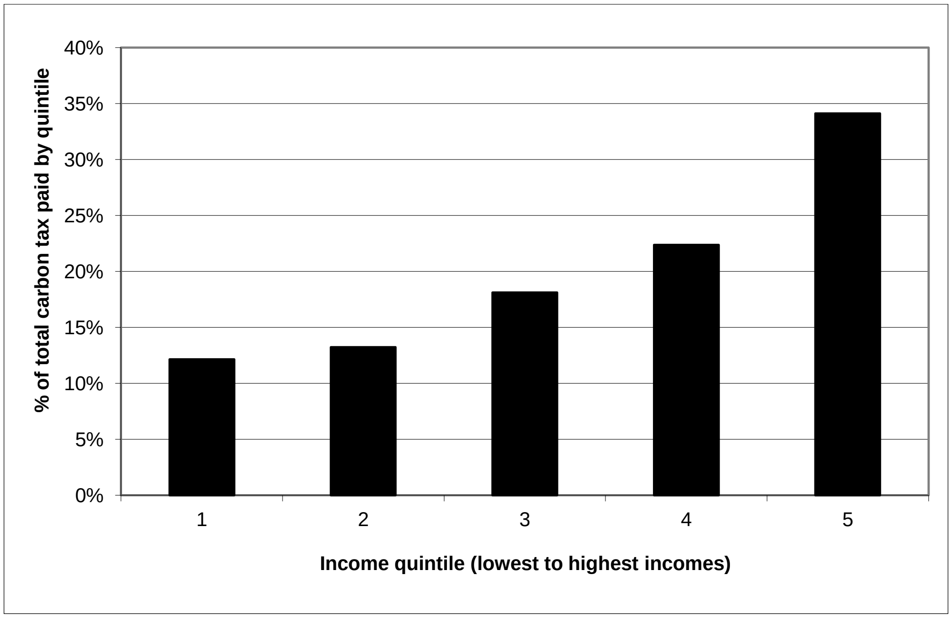
1. Households ranked into quintiles by income per household

One obvious means for returning carbon tax revenues to the public is through reducing other, existing taxes. However, it is important to compensate households fairly at different income levels, particularly at the lower end of the income spectrum. Typically, at low income levels households pay only small fractions of their incomes in taxes. In contrast, all households, including those with small incomes, spend large amounts of money on energy, because it is a basic necessity – for heating their homes and hot water, operating lights and electrical equipment and appliances, and for driving vehicles. As a result, a tax on carbon will be "regressive," meaning that the lower a household's income, the higher the percentage of that income will be spent on a carbon tax.[42]

By examining patterns of energy expenditures of different types by households in each fifth (quintile) of income, we estimate that households in the lowest 20% of income group will pay about 12% of the total carbon tax, those in the middle quintile will pay about 18%, and those in top fifth by income will pay about 34% of the total carbon tax. Note that in this case we are ranking households by income per household.

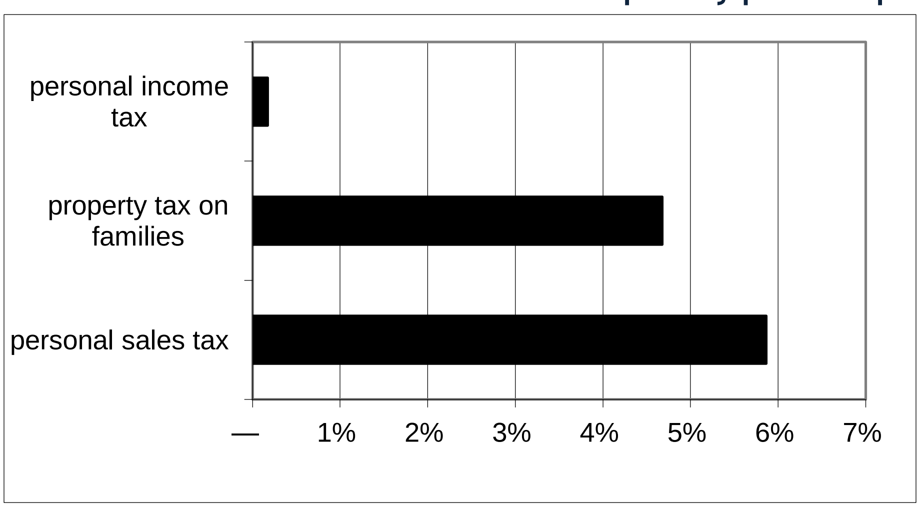
[42] For the random sample of Massachusetts households questioned in the Consumer Expenditure Survey by the U.S. Bureau of Labor Statistics in 2013, income before taxes averaged approximately: $1,700 for quintile one, $20,000 quintile two, $47,000 quintile three, $85,000 quintile four, and $192,000 quintile five. Source data extracted from public microdata available on BLS website by Wei Kang of REMI, June 4, 2014.

Figure III.1: % of total carbon tax paid by each income quintile (Households ranked by income per household)



In order for an income quintile to be "held harmless" – receive as much money back as it pays in – the quintile must pay as large a share of the tax reduced as it pays in the carbon tax. However, it turns out that this is not the case for the major state taxes paid by households in Massachusetts – the personal income, sales, and property taxes. The lowest income quintile (ranked by income per household) pays approximately 6% of total sales taxes, 5% of property taxes paid by families, and only 0.2% of total personal income taxes, as shown in Figure 2 below.[43]

Figure III.2: % of total revenue from each tax paid by poorest quintile



43 "Massachusetts State & Local Taxes," Inst. On Taxation And Econ. Policy, 2013, as cited in Report of the Tax Fairness Commission, Commonwealth of Massachusetts, March 1, 2014, page 10.

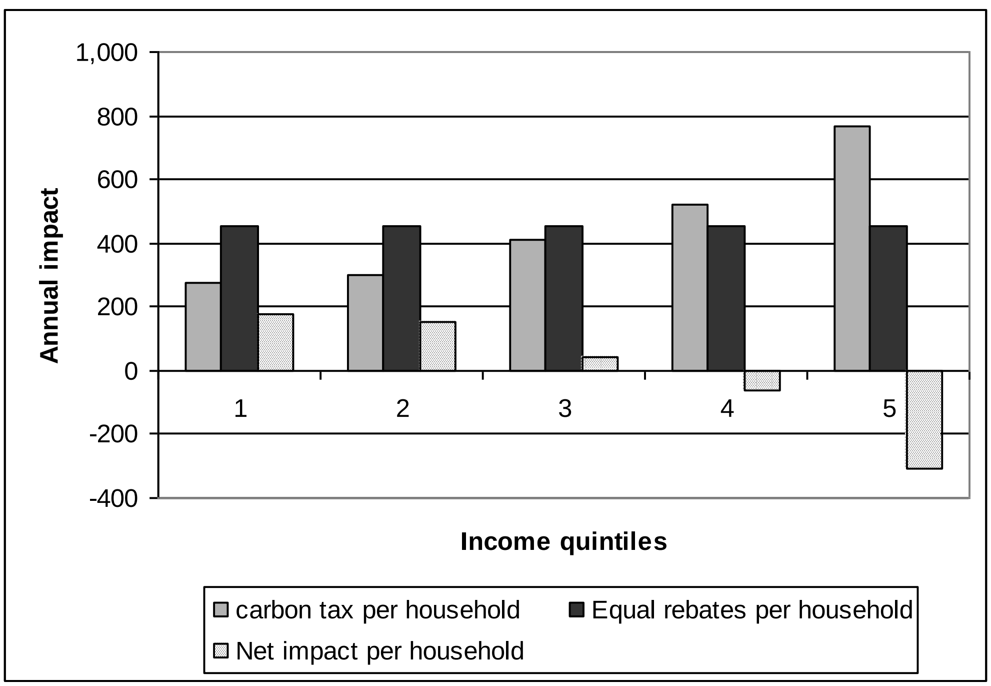
Because the bottom quintile (20% of households) pay a smaller share of the total for each of these other taxes, cutting such taxes would not fully compensate the bottom 20% for their carbon tax payments.

As a result, we need a different method of compensating households for their carbon tax payments. Two possibilities are to provide rebates of equal dollar amounts for every household, or equal dollar amounts per person. In a study that analyzed the economic impacts of a national carbon tax, REMI examined a possibility between these two – paying equal rebates per adult and half as much per child.[44]

2. Equal rebates per household

Figure 3 shows results when equal rebates are given per household, in the 5th year during which the carbon tax is in effect (assuming that the tax starts at $10 per metric ton and rises $5/year to become $30/ton in year 5). All households would receive a rebate of approximately $460 per year. On average, each household in the bottom quintile would pay about $340 a year in carbon tax, while the tax payment rises with income to be $620 for the highest-income quintile. The net impact would be significant gains for the bottom two quintiles, close to break-even for the third quintile, a small loss of about $70/year for the 4th quintile, and a larger loss of about $160 for the highest-income quintile.

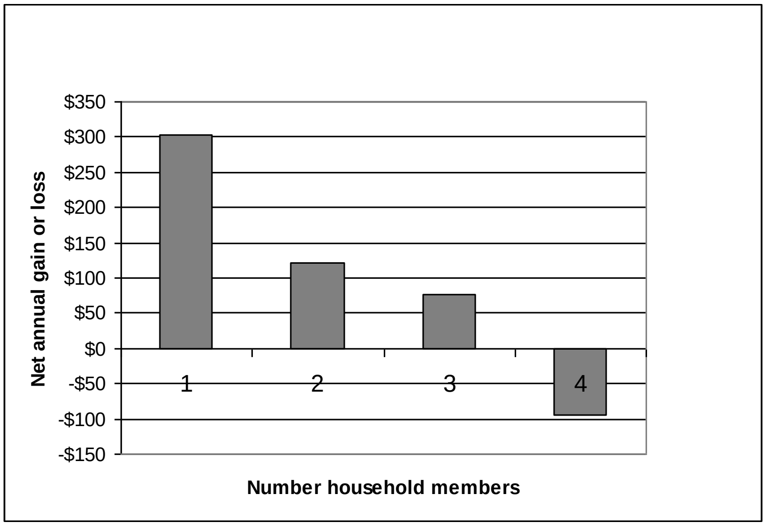
Figure III.3: Impacts with equal rebates per household and $30/ton tax on CO_2



[44] "The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax," Scott Nystrom of REMI (Regional Economic Models, Inc.) and Patrick Luckow of Synapse Energy Economics, June 2014

It is also of concern how households of different sizes fare under the tax-and-rebate system. As shown in Figure 4, for the lowest-income quintile, when each household receives an equal rebate regardless of how many members it has, one-person households come out about $300 ahead, two- and three-person households come out ahead by smaller amounts, and households with 4 or more members average an annual loss of close to $100.

Figure III.4: Equal rebates per household, net impacts by household size for Quintile 1



3. Equal rebates per person

Instead of providing equal rebates per household, which tends to favor smaller households, the system could provide equal rebates per person. It could also be set up in some intermediate fashion – such as equal rebates per adult with half as much per child, or a full payment for the first household member and half as much for each additional household member.

With a $30/ton tax rate, the rebate would be approximately $200 per person. Figure 5 shows that the results by income quintile in this case do not differ greatly from the case when equal rebates are given per household. The impacts are in the same order, with the lowest quintile having the greatest gain and the highest-income quintile having the greatest loss, but the net impacts on each quintile are somewhat smaller than when equal rebates per household are provided.

Figure III.5: Equal rebates per person, quintiles ordered by income/household

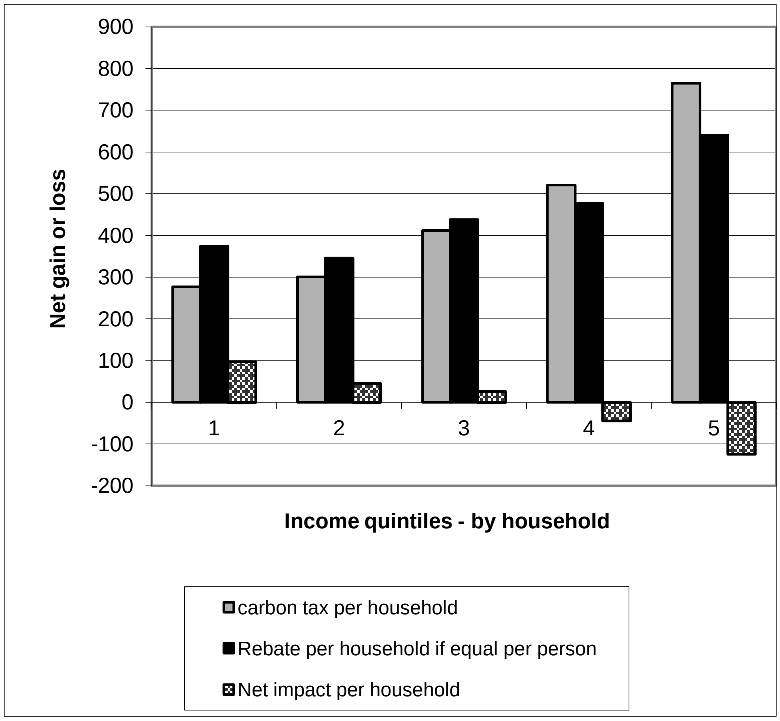
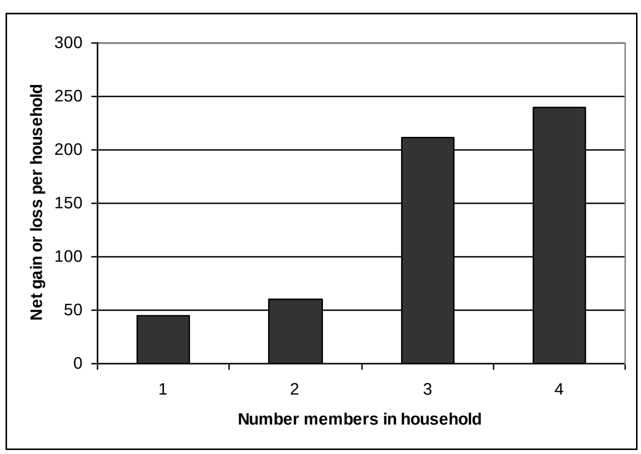


Figure 6 below shows how the net impacts per household vary according to household size when equal rebates per person are given. The results here are strikingly different from those in Figure 4, where equal rebates per household are given. In Figure 4, the smaller the household, the better their net impact, with the largest households experience a loss (on average). In Figure 6, the larger the household the better their net impact. This data suggests that in terms of equity among households of different sizes, providing equal rebates per person yields a better result. An intermediate system, where rebates rise with size of household, but with the increase being less than proportional to the number of household members, might also yield a preferable result.

Figure III.6: Equal rebates per person, net gain or loss by household size in Quintile 1



4. Rebate systems between equal per person and equal per household

Data for Massachusetts indicates that the fairest results may come about from a rebate system that is somewhere between providing equal rebates per person and per household – where "fair" is defined as ensuring that the largest number of low and moderate income households see a net gain from the combination of carbon taxes and rebates. Two "in-between" possibilities are:

- Equal rebates for the first member of any household, with half as large a rebate for each additional household member
- Equal rebates for each adult, with half as large a rebate for each child

Preliminary modeling indicates that such rebate formulas may result in higher percentages of households in the first three quintiles receiving a net benefit, in comparison to equal rebates for every person.[45]

5. Households and quintiles ranked by income per person

It is common practice to look at income distribution in terms of income per household, as we have done above. However, since living expenses rise with the number of household members, going strictly by household income, without regard to the size of the household, does not give a fair picture of households' living standards. An alternative is to rank households according to income per person, and then to divide them into quintiles based on this statistic. Of course, there are economies of scale in household expenses, so that in general expenses will not double when going from one member to two, or triple in going from one member to three. An accurate picture would fall somewhere between the two extremes just described, but will be different for every household.

For purposes of comparison, below we show results from a revenue-neutral carbon tax when households are ranked according to their income per person, and then five quintiles are created, where the 20% of households with the lowest income per capita form the first, or bottom, quintile.

Figure 7 below shows the percentage of the total carbon tax paid by each quintile using this new definition of income rank. It does not appear much different from when we use income per household, but the differences between quintiles are reduced somewhat – with the bottom quintile paying almost 15% of the total carbon tax in Figure 7, versus about 12% when using income per household.

[45] The survey sample sizes for Massachusetts, when divided into multiple categories by income level and family size, may not be large enough for the modeling results to have high statistical accuracy.

Figure III.7: % of total carbon tax paid by each income quintile (quintiles ranked by income per person)

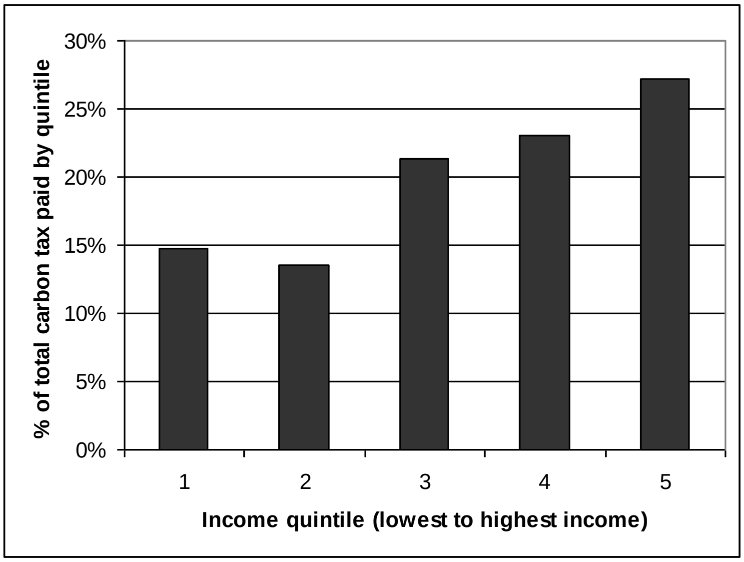


Figure 8 below shows the carbon tax payments, rebates, and net impacts when households are ordered by income per person and equal rebates are given per person. Carbon tax payments would range from about $470 for the bottom quintile to $720 for the top quintile. The bottom quintile would have a net gain of $130 a year, the second quintile $140 a year, the 3rd and 4th quintiles would have losses small enough to treat them as approximately breaking even, and the highest-income quintile would have a net loss of $200 a year.

Figure III.8: Quintiles ranked by income per person, equal rebates per person

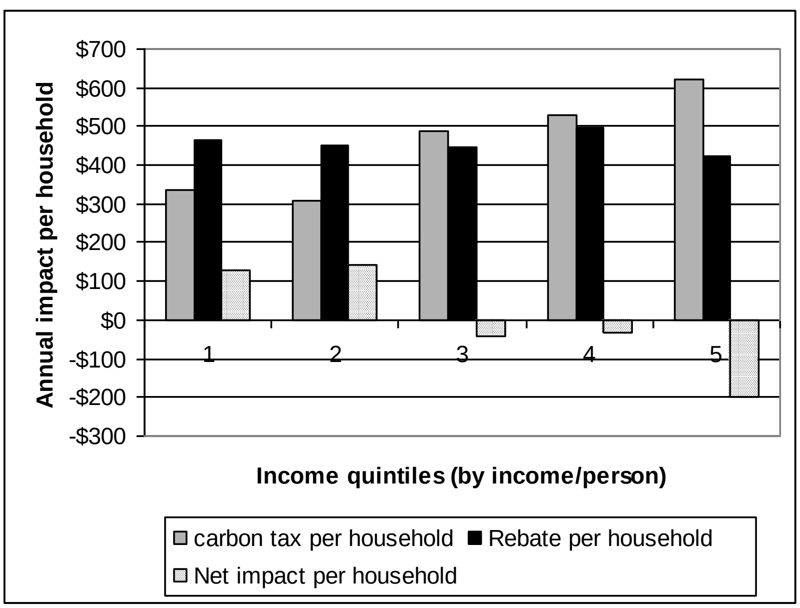


Figure 9 below shows how impacts on the first (lowest-income) quintile differ based on family size when households are ranked by income per person and equal rebates are given per person. Single-person households come out about even, two-person households have a slight gain, and households with 3 people or with 4 or more households have gains of close to $300 a year.

Figure III.9: Quintiles ranked by income/person, with equal rebates per person, impacts on lowest-income quintile by household size

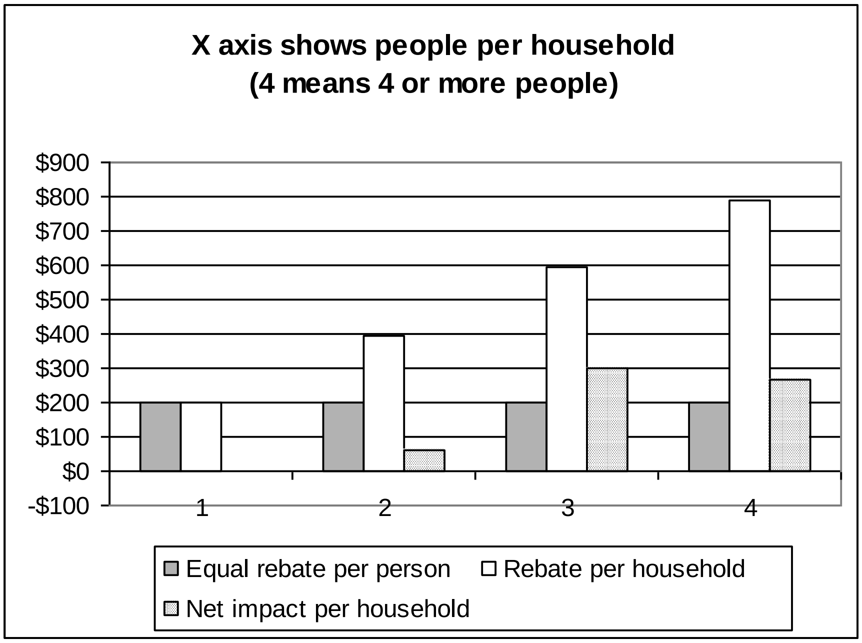


Figure 10 below shows a comparison between the net gains or losses experienced by income quintiles in the four cases that we have examined:

- Households ranked by income per household, equal rebates per household
- Households ranked by income per household, equal rebates per person
- Households ranked by income per person, equal rebates per household
- Households ranked by income per person, equal rebates per person

Figure III.10: Comparison of results for four methods of ranking household incomes and of providing carbon tax rebates, $30/metric ton carbon tax (results rounded to $10)

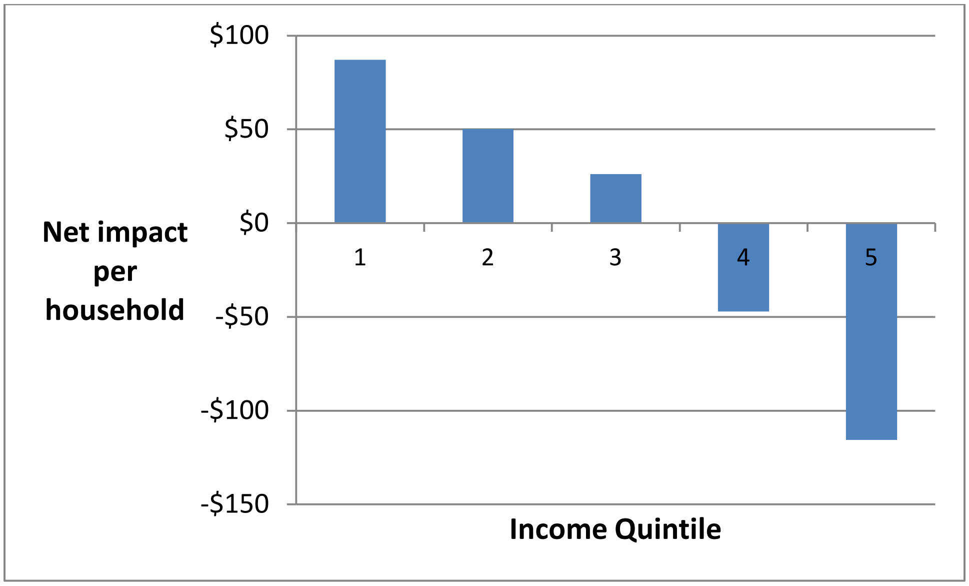
How household incomes are ranked	income per household	income per household	income per person	income per person
How rebates are calculated for each household	equal rebate per household	equal rebate per person	equal rebate per household	equal rebate per person
Income quintile				
1	180	100	120	130
2	150	50	150	140
3	40	30	-30	-40
4	-70	-40	-70	-30
5	-310	-120	-160	-200

Note: columns may not sum to zero due to rounding.

6. Electricity excluded from the carbon fee/tax

As discussed in Section II of this study, there are good arguments for excluding electricity from the carbon tax system, at least in its initial years. Doing so would not qualitatively alter the results shown above in terms of impacts on each income quintile or on households of different sizes, but all impacts would be smaller than when electricity is included. Figure 11 below shows the impacts when equal rebates are given per person.

Figure III.11: Electricity excluded from carbon fee/tax of $30/ton, equal rebates per person



C. Administrative methods for providing rebates to households

There are several different methods by which the rebates could be provided. Criteria for choosing among these methods include:

1) **administrative cost** – how much will it cost the state government to send the rebates to households?

2) **visibility of the rebate** – in order for the residents of Massachusetts to support the carbon tax, it is important that they be aware not only of paying higher prices for fossil fuels but also that the tax revenues are being returned to them.

3) **timing** – particularly for low- and moderate-income households, which may face difficult cash-flow situations in trying to meet their living costs, it may be important for the rebates not to all come at the end of the year, but to come earlier, as the higher fossil fuel prices are being experienced.

1. Households that file state income tax returns[46]

One way to provide the rebates for most households would be through raising the personal exemption on the state income tax. Although low-income households pay little

[46] If the carbon price is termed a "fee" an evaluation will be necessary to see whether returning the funds to the public through tax cuts is appropriate.

in state income tax, and a cut in the income tax **rate** would be of little value to them, all taxpaying households would gain equally from an increase in the personal exemption that is "refundable." The exemption means that a flat amount of income is exempt from the tax. Since all households pay the same 5.2% rate on Massachusetts income taxes, to save households $460 per year the personal exemption would need to increase by approximately $8,850 per year.[47] At present, the personal exemption for a single person is $4,400, for heads of household it is $6,800, and for married couples filing jointly it is $8,800.[48] As a result, the personal exemption would need to more than double for all households in order to make up for carbon tax payments. "Refundable" means that if receiving the carbon tax would cause a taxpayer's tax obligation to drop below zero, they would receive a rebate from the state rather than having a zero tax liability.

A second way in which the rebates could be provided would be through creating a new refundable "carbon tax credit" in the state's personal income tax system, equal to the rebate calculated each year based on that year's carbon dioxide price per metric ton. This would be $150 in the first year, if the tax is set initially at $10 per ton, rising to $460 in the third year. As with the personal exemption, the credit should be refundable.[49,50]

This tax credit could conveniently be provided regularly throughout the year by changing the amount of personal income tax withheld on all paychecks. Wage earners would then not need to wait until the end of the year to receive payments. Adjustments needed would be made in the end-of-year tax filings made by income earners, just as with other provisions of the tax code. In order to increase visibility, when income tax rebate checks are sent out, an insert could be put in the envelope noting that a tax filer's net taxes include that year's carbon tax credit. For those filing electronically and/or having rebates direct-deposited into a bank account, the DOR could send e-mails explaining that a carbon tax credit is being provided. However, DOR is moving toward all-electronic filing, and has said that sending out rebates via paper mail would be a step in the wrong direction.

Visibility of the tax credit could also be increased by sending a carbon rebate check independently of whether the taxpayer must pay additional taxes or receives a rebate based on all other personal income tax

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[47] Calculation: $460 divided by 5.2% equals $8,800.

[48] See http://www.mass.gov/dor/individuals/filing-and-payment-information/guide-to-personal-income-tax/exemptions/table-for-exemptions.html, accessed 9/18/14.

[49] Note that the Department of Revenue (DOR) has expressed concerns about making the credit refundable, due to difficulties that they have experienced with fraud in administration of the refundable Earned Income Tax Credit.

[50] Kazim Ozyurt, Mass. Department of Revenue, by phone, 10/14/14.

provisions. The rebate could still be considered part of the personal income tax system, or could be put into law as a completely separate item. As British Columbia did initially, this rebate could even be provided at the beginning of the year (a "prebate") in order to assist households with covering their higher fossil fuel costs. Doing so would require that the state borrow the money for the early rebates – which at present would be relatively low cost due to extremely low interest rates on short-term bonds.

2. Households that do not file state income tax returns

According to the DOR, approximately 91% of all residents of Massachusetts are in households that file state income tax returns. This leaves 9% of people for whom rebates that go through the income tax system will not benefit them, despite their mainly being low-income households who do not have enough income to file tax returns, and who will therefore be most in need of the rebates. Unfortunately, the state does not have a comprehensive list of all resident households. To reach many or most of these households we recommend that the state utilize agencies that already provide services or income supplements to low-income people. These include:

- **Fuel assistance** - the state's Department of Housing and Community Development (DHCD), along with local agencies throughout the state, provide assistance to families that cannot fully pay for their winter heating costs with their incomes. This is known as LIHEAP (Low Income Home Energy Assistance Program).

- **Supplemental Nutrition Assistance Program** (SNAP, formerly known as Food Stamps) – this program is administered by the state's Executive Office of Health and Human Services. At present about 450,000 households, covering about 850,000 people, receive SNAP in Massachusetts. This is about equal to the number of people in households that do not file state income tax returns – but there is not a one-to-one match. Some SNAP recipients do file tax returns. Officials who administer SNAP say that for other purposes they already share information with both DHCD and DOR, so it would be possible to cross-check lists in order to reach as many families as possible, and also to ensure that no individual or household gets duplicate payments. In addition, the value of carbon tax rebates could be added to the EBT (electronic benefit transfer) cards that are used to provide SNAP benefits, and LIHEAP benefits to some recipients.[51]

On the other hand, the director of the SNAP program cautions that a carbon tax refund could be counted as income according to federal government rules, which could then

[51] Phuoc Cao, Massachusetts SNAP Program Director, by phone, 9/19/14.

affect the eligibility of a household to receive SNAP benefits. To prevent this, it is possible for the state to request a waiver of federal rules, but there is no guarantee that such a waiver would be granted.[52]

These, and possibly other agencies such as those that administer Medicaid, Medicare, and programs for the homeless could be used as vehicles for finding those households that do not file tax returns. In order for the three agencies to compare their lists of recipients, legislation would need to provide them with the authority to share their lists.[53] By doing so, additional families and individuals could be located. The rebate itself could still be sent out as a separate check by the Department of Revenue that is clearly designated as a carbon tax rebate. Alternatively, funds could be distributed through the LIHEAP and/or SNAP systems. This latter possibility could reduce administrative costs, but would have the disadvantage of making the carbon tax rebate less visible to recipients, and of associating the carbon tax rebate with other programs that serve only low-income households.

- **Electric and gas utilities -** Another possibility would be to utilize the electric and gas utilities in the state, which already provide discounts for low-income households. If legislation were to provide authority for sharing of information between state agencies and the utilities, the utilities could be either the first, second, or third point of contact for receiving rebates. An advantage of making them the first point of contact is that utility bills are paid monthly, making it convenient to provide the carbon tax credit throughout the year, as simply a subtraction from utility bills, with presumably low administrative costs.

One disadvantage to making use of the utilities is that they would not cover households which do not have either gas or electric heat, but rather fuel oil or propane. For such households, if they also do not file state income tax returns, LIHEAP and SNAP could help by distributing the rebates.

3. Households that do not file taxes and do not receive public assistance

While the combination of the state's income tax system and several systems that provide benefits to low-income households should reach all but a few percent of people, some people will not be reached. This could be because they have chosen not to apply for

[52] Ibid.
[53] DOR has concerns about sharing their database with other agencies, based on the need for confidentiality of income tax returns.

assistance programs or possibly because they are homeless. The state should make additional efforts to reach such people and to provide them with carbon tax rebates.

4. Other methods of ensuring that low- and moderate-income households do not come out behind

All the tables (above) are based on averages, either for an income quintile, or for a household size within a quintile. While such averages are meaningful, they do not capture the variation in circumstances for every household. For example, many renters can be in a situation where their heating costs are much higher than average because their landlord has not insulated the building nor maintained the heating system. Thus, while the data indicate that **on average** all households in the bottom 60% (three quintiles) by income should come out ahead when the tax and rebate are combined, many households may come out behind. To counteract this, additional steps could be taken to improve the average impacts on low and moderate income households, and/or to provide additional benefits to households in particular circumstances, such as:

- One method would be to use a per-person system, but then to reduce benefits to the top one or two quintiles. For example, rebates could be cut in half for the 4^{th} quintile and eliminated for the 5^{th} (highest income) quintile.

- In addition, a portion of the funds paid in by the business and institutional sectors could be used. For example, the business/institutional sector could receive back 80% of the funds it pays in, while 20% is used to assist the bottom three household quintiles.

5. Possible Adjustments for households with high-carbon heating fuels and high driving mileage

Household income is a primary indicator of vulnerability to increases in energy costs that would come about from a carbon tax. In addition, two other common characteristics of households would add to their vulnerability. First, because heating oil and propane have higher carbon dioxide emissions per unit of energy than do natural gas or electric heat, households with the former heating sources would experience greater increases in their living costs than those with the latter heating sources. Second, households that drive more than the average, due to where they live, the distance between their homes and their workplaces, or other reasons, will tend to pay more in carbon taxes from buying gasoline.

High-carbon heating fuels

At present, households with incomes up to 60% of the state's median income per household are eligible for fuel assistance on their heating bills. This program, termed LIHEAP (Low Income Heating Energy Assistance Program), which relies primarily on federal funds with some supplement from state sources, is administered by DHCD. At present, because the price of heating oil is so much higher than that for natural gas, DHCD adjusts fuel subsidies based on which fuel households utilize, with approximately twice as large a subsidy provided to households that use oil or propane as to those with natural gas.[54]

In 2012, LIHEAP provided assistance to approximately 468,500 individuals in 200,300 households, which DHCD estimates is about one-quarter of those people who are eligible for LIHEAP according to income guidelines.[55] It is also a majority of the households that the Department of Revenue says do not file state income tax returns; which suggests that the LIHEAP rolls could be used to identify most of the people who should receive a carbon tax rebate but are not in DOR's records.

For those households who are not covered by an income-tax system rebate, and whose rebates are provided to DHCD for distribution, DHCD could be provided with the flexibility to adjust rebates on what heating fuel a family or individual has.

Officials who administer the LIHEAP program have said that regardless of what fuel they use, low-income households have little ability to control their use of heat and should therefore be exempt from paying a carbon tax on this fuel. The reasons for lack of control include that many households are renters who cannot invest in efficiency measures for either their heating systems or their buildings; and that they cannot in any case afford to invest in efficiency, which is provided to buildings with low-income occupants at no cost (but a waiting list exists and for rental housing it is up to landlords to cooperate with the program).[56]

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[54] "Fiscal Year 2014 Low-Income Home Energy Assistance Program (LIHEAP) Income Eligibility and Benefit Levels Chart," Massachusetts Department of Housing and Community Development.

[55] "Fiscal Year 2012 LIHEAP Annual Report," Massachusetts Department of Housing and Community Development, page 12.

[56] Gerald Bell, David Fuller, and Aiken Rahmen, Mass. Dept. of Housing and Community Development, July 1, 2014.

High driving mileage

When the carbon tax is $30/metric ton (year 5 in our modeling), total carbon tax paid for household use of gasoline will be approximately $620 million a year. There is concern that for many households that need to drive more than the average due to where they live, work or other needs, the carbon tax on gasoline will be higher than average. If all households are given the same dollar rebate, the high-driving households will suffer a net loss to their incomes.

Although data exists for all households in the state on their vehicles and miles driven, time and budget limitations have not allowed us to fully explore this very large data set (more than five million vehicles). However, we have been able to analyze data on vehicles and miles driven when aggregated by town or city.

The average carbon tax on gasoline per household varies from amounts below $100 per year for some neighborhoods in Boston, to $420 a year in the highest community, with $235 being the statewide average (weighted by number of households in the city or town). The average tax would be at least one-third (33%) above the state average in 155 communities out of 351 total cities and towns, averaging $350 per household. Only a couple of urban areas would have relatively high gasoline carbon tax costs, so we are mainly concerned here with towns.

Suppose the carbon tax law gave an additional rebate equal to 20% of the carbon taxes owed on average from consumption of gasoline, to all households in communities whose average gasoline carbon tax cost was 33% or more above the state average. This would assist one-fifth (21%) of households in the state, in 155 communities, with an average cut in taxes owed of $70 a year. The overall cost of providing this tax reduction would be about $39 million, or about 6% of the total carbon tax revenues on gasoline ($620 million). If the tax cut was paid for by raising taxes owed by the rest of households, the increase would average about 9%, or $22 per household per year.

Instead of giving this additional benefit to all residents of communities with high-driving mileage, the law could restrict the tax cut only to households where the carbon tax on gasoline is a relatively high fraction of household incomes. Unfortunately, we do not have data on the income of every household, but we do have data on the median household income for each city and town. There are 131 communities, again almost exclusively being towns, where the ratio -- (carbon tax costs/median household income in the community) -- is at least one-third higher than the statewide average for this ratio. On average they would be paying about $316 per household, and a rebate of 20% would provide each household $63 a year, or $27 million for all such households (about 4% of the total carbon taxes paid on gasoline). If the additional rebates were paid for by raising taxes for households in the state's other 220 cities and towns, their carbon tax on gasoline would go up by about 6%, or $13 a year.

Figure III.12: Additional rebates equal to 20% of carbon taxes paid on gasoline for residents of high-driving communities – possibly with an income-based limitation

	Additional benefit for all high-driving commun-ities	Additional benefit limited to communities with high carbon tax costs on gasoline relative to median income
Average carbon tax on gasoline for all households	$235	$235
# towns and cities with average driving mileage at least 1/3 above state average	155	131
% of all households in communities with driving mileage at least 1/3 above state average	21%	18%
Average carbon tax cost in communities with high driving mileage (when carbon tax is $30/ton)	$350	$316
Average savings in high-driving towns if 20% cut in carbon tax on gasoline is given to each household	$70	$63
Total cost of providing 20% cut in high-driving towns	$39 million	$27 million
Increased cost per household in all other cities and towns to balance cost of cut in high-driving towns	$22	$13

The calculations above all assume a system where tax reductions are provided according to average driving patterns and median incomes in a city or town. It would be possible to create a more individualized system, where a calculation is made of carbon tax burdens on gasoline for each household. If this were done, it would be critical not to give drivers an incentive to receive an additional benefit by driving more than the 33% above average threshold, or whatever threshold is chosen. In order not to do so, providing the added benefit should be based on miles driven several years earlier, not by miles driven in the most current year.

Such an individualized system could provide benefits to all high-mileage drivers, or only to those with income levels below a certain cutoff. To implement the former system would require only the odometer readings that are taken when cars go through an annual inspection (although reports are that these readings are often inaccurate). For a system that is based on income below a cutoff, a new income-verification system would be needed, based on state income tax returns or income data provided for other programs, such as fuel assistance.

D. Returning Revenues to Businesses and Institutions

Most or all of the business firms and other institutions – including non-profit organizations such as most hospitals and colleges – in the state will see increased costs due to the carbon tax's impact on the price of fossil fuels and possibly electricity. A premise of the present study is that the taxes paid by firms and institutions as a whole will be returned in aggregate. As with households, this does **not** mean that each entity gets back exactly what they pay, which would defeat the incentive value of the carbon tax. However, we do want to offset a large portion of the increased costs, through a formula that is not specifically tied to energy or carbon tax costs.

1. Why the corporate excise tax is not a viable revenue return mechanism

One obvious candidate for the mechanism to rebate funds is the corporate excise tax, which is the primary tax imposed by the state on for-profit businesses. However, there are several problems with using this tax:

1) Non-profit organizations do not pay this tax, and so would see no rebate, although they will face increased energy costs the same as for-profit companies. Non-profits make up a significant share of the Massachusetts economy, including most universities, colleges, and hospitals.

2) Municipal governments, and the state government itself, will also pay more for fossil fuel energy, but as with non-profits they do not pay the corporate excise tax. In combination, city, town, and state governments constitute the third largest sector in the Massachusetts economy.

3) Manufacturers only pay the excise tax on their in-state, not their out-of-state sales, which means that most of their sales are exempt from the excise tax, so they will gain little from a cut in that tax.

4) Companies that are in start-up phases often generate little or no profits in their early years, and so do not pay much in corporate excise taxes, and therefore also would not gain from a cut in this tax.

For these reasons, another criterion or mechanism is needed to return the carbon tax revenues.

We have examined two possibilities in depth, and most commentary from stakeholders to date has favored the first of the two:

1) **Employment** – return the funds in an amount equal to the business or institution's share of total employment (or full-time equivalent jobs) in the state.

2) **Payroll** – return the funds in proportion to the entity's share of total payroll costs (wages and salaries) in the state. Several stakeholders have commented that in certain industries, such as in the investment sector, a number of employees may earn total compensation of millions of dollars a year, and that it would be unfair to rebate funds that include such high amounts. We have not investigated the actual data on this topic; but a possibility would be to limit the amount of compensation for any one employee that is counted toward carbon tax rebates, to a number such as $200,000 per year.

A third possibility, as discussed in Section D.4 below, that would be more complex but would have some advantages, is "benchmarking" within an industry. In such a system each industry as a whole would receive rebates equal to the money it pays in carbon taxes, but particular companies within an industry would receive different levels of rebates based on their degree of carbon emission "efficiency."

Using data on employment and payroll costs for each major industry in the state, we have estimated the carbon tax rebates that the industries as a whole would receive via each of the first two mechanisms.[57] Figure 13 below shows what each industry constitutes as a percentage of the state's Gross State Product (GSP) and employment, along with what energy costs equal as a percentage of the industry's overall expenses – which is a strong indicator of how much a carbon tax will affect their expenses.

[57] U.S. Bureau of Economic Analysis, at http://www.bea.gov/regional/; compiled and modified by REMI. Input-output data on employment, income, and output by industry in MA found at : http://www.bls.gov/emp/ep_data_input_output_matrix.htm

Figure III.13: Massachusetts' 20 largest industries ranked by their percentage of the state's total Gross State Product; along with their percentage of total state employment, and energy costs as a percentage of their overall expenses

Industry	% of total Gross State Product (value added)	% of total state employ-ment	All energy costs as % of output by industry
Real estate	12.1%	3.8%	0.6%
Professional, scientific, and technical services	11.9%	9.5%	0.6%
State and local government	7.7%	9.0%	2.0%
Retail trade	5.0%	9.5%	1.1%
Wholesale trade	4.9%	3.1%	1.6%
Computer and electronic product manufacturing	4.0%	1.3%	0.4%
Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles	3.9%	1.7%	0.2%
Ambulatory health care services	3.9%	4.8%	0.5%
Hospitals	3.6%	4.4%	1.0%
Insurance carriers and related activities	3.2%	1.9%	0.1%
Construction	3.1%	4.9%	4.5%
Securities, commodity contracts, investments	2.5%	2.8%	0.4%
Educational services	2.3%	5.1%	2.6%
Publishing industries, except Internet	2.3%	1.1%	0.4%
Administrative and support services	2.2%	5.0%	4.2%
Management of companies and enterprises	2.2%	1.5%	0.9%
Food services and drinking places	2.0%	6.1%	2.5%
Telecommunications	1.9%	0.5%	1.0%

Industry	% of total Gross State Product (value added)	% of total state employ-ment	All energy costs as % of output by industry
Chemical manufacturing[58]	1.4%	0.4%	10.1%
Federal civilian operations	1.3%	1.1%	3.0%
All manufacturing industries	10.4%	5.5%	3.3%

As Figure 13 shows, the industries for which the largest fractions of their overall expenses go to energy costs are construction, administrative and support services, and chemical manufacturing (although there is uncertainty about the accuracy of the data for chemical manufacturing, which comes from the Bureau of Economic Analysis in the U.S. Department of Commerce).

Figure 14 below shows (1) what each industry would pay in carbon taxes as a percentage of their total operating costs, (2) what they would receive in rebates under an employment-based system, again as a percentage, and (3) what the net impact on each industry's costs would be. Of course, these results can be expected to vary widely among individual companies or institutions. Industries are listed in order of their shares of GSP.

Figure III.14: Carbon tax at $30 per ton CO2e, rebates based on shares of overall state employment, and net impacts on Massachusetts' 20 largest industries in relation to value of output

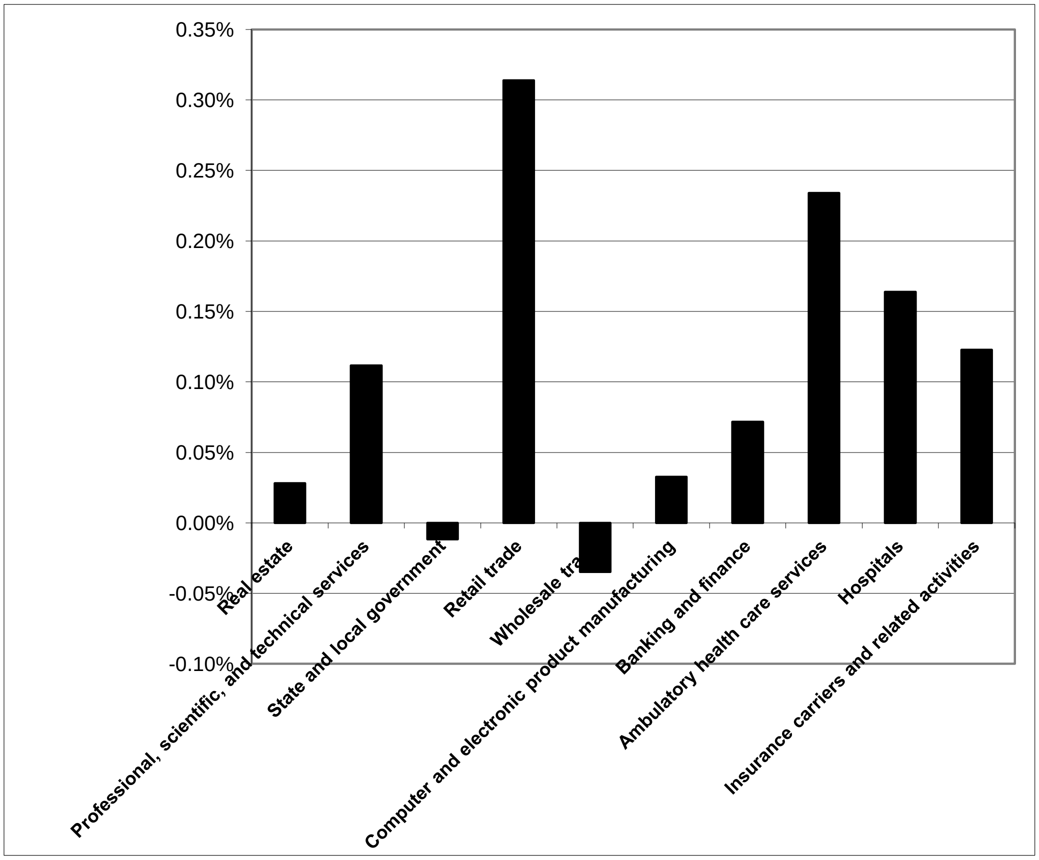
Industry	Carbon tax as % industry output	Rebate as % industry output	Net gain or loss as % industry output
Real estate	0.03%	0.06%	0.02%
Professional, scientific, and technical services	0.05%	0.14%	0.08%
State and local government	0.17%	0.16%	-0.01%
Retail trade	0.08%	0.30%	0.22%
Wholesale trade	0.13%	0.10%	-0.02%
Computer and electronic product manufacturing	0.03%	0.05%	0.02%

[58] Adjusted at 4-digit NAICS (North American Industry Classification System) level to fit the sub-industry structure in Massachusetts.

Industry	Carbon tax as % industry output	Rebate as % industry output	Net gain or loss as % industry output
Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles	0.02%	0.06%	0.04%
Ambulatory health care services	0.04%	0.20%	0.16%
Hospitals	0.07%	0.16%	0.09%
Insurance carriers and related activities	0.01%	0.08%	0.08%
Construction	0.33%	0.21%	-0.12%
Securities, commodity contracts, investments	0.03%	0.09%	0.06%
Educational services	0.16%	0.35%	0.19%
Publishing industries, except Internet	0.03%	0.05%	0.02%
Administrative and support services	0.31%	0.34%	0.02%
Management of companies and enterprises	0.08%	0.11%	0.02%
Food services and drinking places	0.21%	0.40%	0.20%
Telecommunications	0.09%	0.03%	-0.06%
Chemical manufacturing	0.90%	0.02%	-0.88%
Federal civilian operations	0.29%	0.11%	-0.19%
All manufacturing industries	0.26%	0.05%	-0.21%

Figure 15 below shows graphically the net impact on each of the state's ten largest industries from a carbon tax combined with a rebate proportional to the industry's share of overall state employment.

Figure III.15: Net gain or loss from carbon tax and rebate for ten largest industries in MA, as a % of industry output value, at $30 tax per ton of CO_2 emissions[59]



2. Returning revenues by employment share versus payroll share

Figure 16 below compares the net impacts on the state's largest industries for the two methods of providing carbon tax rebates that we have considered – relative to employment and relative to value of payroll. As one would expect, relatively high-wage industries fare better when payroll is used as the criterion, while relatively low-wage industries – particularly retail trade and "food services and drinking places" – fare worse when payroll is used rather than employment. Of possible importance is that state and local government do significantly better under a payroll-based system than under an employment-based system.

[59] One reason that most of the ten largest industries show positive net impacts is that a number of the smaller industries in the state, particularly manufacturing and transportation, have significant net losses. Some can be seen in the table below that provides data on the ten largest manufacturing industries.

Figure III.16: Net impact of carbon tax and rebate – when rebate is proportional to share of overall state employment versus share of overall state payroll

Category	Net impact as % industry output - rebate based on # employees	Net impact as % industry output - rebate based on $ payroll
Real estate	0.02%	-0.02%
Professional, scientific, and technical services	0.08%	0.13%
State and local government	-0.01%	0.06%
Retail trade	0.22%	0.07%
Wholesale trade	-0.02%	0.02%
Computer and electronic product manufacturing	0.02%	0.10%
Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles	0.04%	0.08%
Ambulatory health care services	0.16%	0.18%
Hospitals	0.09%	0.15%
Insurance carriers and related activities	0.08%	0.12%
Construction	-0.12%	-0.17%
Securities, commodity contracts, investments	0.06%	0.10%
Educational services	0.19%	0.11%
Publishing industries, except Internet	0.02%	0.08%
Administrative and support services	0.02%	-0.12%
Management of companies and enterprises	0.02%	0.17%
Food services and drinking places	0.20%	-0.06%
Telecommunications	-0.06%	-0.04%

Category	Net impact as % industry output - rebate based on # employees	Net impact as % industry output - rebate based on $ payroll
Chemical manufacturing	-0.88%	-0.85%
Federal civilian	-0.19%	-0.09%
All manufacturing industries	-0.21%	-0.17%

An example of a professional services company

One small IT services company provides an example of how the carbon tax and rebate would work. This company is relatively energy-efficient in its building operations, where it uses natural gas and electricity, but its largest energy cost is for gasoline. It's total energy costs were a rather small $17,000 out of an operating budget of about $4 million. With a $30 per metric ton carbon tax, this company would pay about $1,200 in carbon taxes. This is about 0.03% of its total costs, well less than the hypothetical 0.05% average for all professional services companies in Massachusetts. On average, all such companies would come out ahead under a system where rebates are proportional to employment, receiving back 0.14% of their total expenses in rebates. This particular company, due to its low energy expenses, would receive a rebate of about $8,100, for a net gain of $6,900, which is about 0.17% of its total annual expenses.

Manufacturing sectors

Figure 17 below shows the carbon tax impacts just for the state's ten largest manufacturing industries. Although most of these industries are small fractions of Massachusetts' entire economy (with only the first two falling within the state's 20 largest industries), in many situations policymakers have indicated a particular concern for manufacturing, so we are breaking out the information here. As can be seen from the right-most column, eight of ten of the industries show a loss even after rebates are provided. However, these losses are small percentages of the industries' total output value (which equals their total expenses), and computer and electronic products, which is the state's largest manufacturing sector, shows a net gain. Only chemical manufacturing shows a net loss that is close to one percent of the industry's total operating costs; and the data for this industry are quite uncertain. The federal Bureau of Economic Analysis data used here show much higher emissions from chemical manufacturing than does data reported to the Massachusetts Department of Environmental Protection.[60]

[60] Data provided 12/15/14 by MassDEP on chemical manufacturing facilities. MassDEP regulations require all facilities with more than 5,000 tons each of GHG emissions to report their annual emissions. See "GHG Reporting Program Summary Report and Facility List, Emissions Year 2012," MassDEP (Published September 2013).

Figure III.17: Massachusetts' 10 largest manufacturing industries - carbon tax, rebates based on shares of overall state employment, and net impacts in relation to the value of their output

Industry	% of overall state employ-ment	Carbon tax as % of industry output	Rebate as % of industry output	Net gain or loss as % of industry output
Computer and electronic product manufacturing	1.3%	0.03%	0.05%	0.02%
Chemical manufacturing	0.4%	0.90%	0.02%	-0.88%
Fabricated metal product manufacturing	0.8%	0.17%	0.09%	-0.09%
Miscellaneous manufacturing	0.5%	0.06%	0.08%	0.02%
Machinery manufacturing	0.4%	0.11%	0.06%	-0.05%
Food manufacturing	0.6%	0.16%	0.05%	-0.11%
Beverage and tobacco product manufacturing	0.1%	0.11%	0.02%	-0.10%
Plastics and rubber product manufacturing	0.3%	0.23%	0.07%	-0.16%
Electrical equipment and appliance manufacturing	0.2%	0.12%	0.07%	-0.05%
Paper manufacturing	0.2%	0.46%	0.05%	-0.40%
All manufacturing industries	5.5%	0.26%	0.05%	-0.21%

3. Should special treatment be given to manufacturing industries?

There are several reasons why special treatment is worth considering for some or all manufacturing industries in Massachusetts, as has been done in other geographic areas that have cap-and-trade regimes:

- Although Massachusetts no longer has large amounts of heavy industry that are very energy-intensive, it still has manufacturing sectors that will come out behind from the combination of carbon tax and rebate, although by less than one-tenth of one percent of their overall operating costs;
- Unlike some of Massachusetts' dominant industries, manufacturers generally face stiff competition from firms in other states and countries;

- Unlike some other sectors that are strongly rooted geographically, such as universities and hospitals, manufacturing has more ability to relocate to other states.

In the European Union's cap-and-trade regime, known as the Emissions Trading System or ETS, manufacturing sectors that are deemed to be vulnerable to competition from nations outside of the ETS are given special consideration. In order to avoid the risk of "carbon leakage" – energy-intensive industries moving to nations that do not limit emissions – such companies are given their allowances for free. For 2013-2014 this includes 170 industrial sectors and subsectors, covering most industrial emissions. Companies that attain a "benchmark" level of reduced emissions may continue to receive allowances for free through 2020, based on their historic emissions.[61]

Similarly, under California's economy-wide cap-and-trade regulations for greenhouse gases,[62] industrial sectors that are deemed vulnerable to leakage and in need of "transition assistance" are allocated allowances at no cost. To be eligible for such assistance, an industrial facility "must have an activity and North American Industrial Classification System (NAICS) code that is listed in Table 8-1 of the Cap-and-Trade Regulations, and have complied with the Mandatory Reporting Regulation (MRR)."[63]

In Massachusetts, out of 17 specific manufacturing industries that have a significant presence in the state, 8 industries would have a net cost (tax less rebate) greater than or equal to 0.1% of the total value of their output – a small fraction, but possibly enough to be significant for industries in competitive situations. Combined these 8 industries constitute only 3.4% of our Gross State Product, but would pay about one-fifth (21%) of the total carbon tax owed by the business/institutional sectors, or about $215 million, with a net loss of $195 million. Chemical manufacturing dominates the numbers, as it would owe about $154 million in carbon taxes and have a net loss of $150 million. Other specific industries that the available data shows as facing significant net losses include fabricated metals, food, paper, and primary metal manufacturing.[64] However, these numbers should be viewed as having a significant potential for inaccuracy, as they are based on nationally-compiled data and may not be an accurate reflection of current conditions in Massachusetts.

The present study indicates that there may be reasons to provide some form of special treatment to certain specific manufacturing industries. But a more in-depth analysis of the actual situation in these industries is needed before stronger conclusions can be reached.

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[61] "The EU Emissions Trading System," European Union, 2013, http://ec.europa.eu/clima/publications/docs/factsheet_ets_en.pdf , accessed 10/2/14.
[62] http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm
[63] http://www.arb.ca.gov/cc/capandtrade/allowanceallocation/allowanceallocation.htm
[64] Authors' calculations based on federal EIA data.

4. "Benchmarking" of business sector emissions

A possible variation of the methods discussed above for providing rebates to companies and institutions is something called "benchmarking" by business sector. The European Union and the state of California, both of which have cap-and-trade systems for reducing GHG emissions, use such a system; and the state of Washington is considering doing so. Rather than distributing revenues relative to employment or payroll, each business and non-profit sector as a whole would receive back the amount of money that it pays in. A benchmark is set that represents a relatively good level of emissions performance for that specific business sector. Then each company in the industry is measured against the benchmark, each year or every couple of years. Companies that reduce their emissions below the benchmark receive greater benefits than those that perform less well in GHG terms. The goal is to provide an extra incentive to business firms to reduce their emissions.[65]

In California, industries are grouped according to NAICS (North American Industry Classification System) codes. The benchmark is set at 90% of average emissions for the industry group. Companies that achieve emissions below the benchmark receive more emissions allowances at zero cost, while others have to buy more of their allowances. This procedure is used since California has a cap-and-trade system, rather than the carbon tax being discussed in this study, where all firms would pay the tax, but then might receive back different size rebates.

Due to the need to preserve confidentiality of each company's particular costs, California only sets a benchmark rate when there are at least five facilities in the industry group. Because Massachusetts is so much smaller than California, with fewer companies in any one industry, confidentiality could present a barrier to implementing benchmarking, at least in some industries.[66]

In the European Union's (EU) emissions trading system, manufacturing industries receive most of their allowances for free at present, but that decreases to 30% in 2020. Allocation of the free allowances is done by benchmarking for manufacturing of each product, with the benchmark set at the GHG emission performance of the 10% best performing installations in the EU.[67]

The state of Washington is considering a benchmarking system, as a result of Executive Order 09-05, which directs the Department of Ecology to "Base the benchmarks on best practices reflecting emission levels from highly efficient, lower emitting facilities in each industrial sector."[68]

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[65] "ENE Comments on the Massachusetts Environmental Tax Reform Study & Analysis," Peter Shattuck and Jordan Stutt, 8/18/14.

[66] Michael Gibbs, Assistant Executive Officer, California Air Resources Board, by phone, 10/23/14.

[67] "Free allocation based on benchmarks," European Commission, http://ec.europa.eu/clima/policies/ets/cap/allocation/index_en.htm, accessed 10/23/14.

[68] "Reducing Greenhouse Gas Emissions: GHG Benchmarking," Department of Ecology, State of Washington, http://www.ecy.wa.gov/climatechange/GHGbenchmarking.htm#whitepaper, accessed 10/23/14.

Benchmarking offers the possibility of inducing greater emissions reductions throughout the state's business sectors, but would add a substantial layer of complexity to a carbon tax system in Massachusetts. While it is worth considering, we have not analyzed further the cost or difficulties in implementing such a system in the Commonwealth, in comparison to the possible benefits, and so do not offer a recommendation other than that further analysis should be done before such a system is put into legislation.

5. Public Transit Systems

The Massachusetts Bay Transit Authority (MBTA) and the state's other 15 regional transit authorities[69] are all energy-intensive operations, using primarily electricity and diesel fuel. Despite being heavy fossil fuel users themselves, public transit agencies greatly reduce overall CO_2 emissions by cutting automobile trips. It is thus essential not to cause harm to transit service, and given the agencies' typically tight budgets, any cost increase could do so.

Due to time limitations we have not conducted a full review of the impacts that a carbon tax would have on these authorities, but preliminary data for the MBTA indicates that it would face significant net losses under a system where rebates are based on either employment or value of payroll. In its Fiscal 2014 budget the MBTA budgeted more than $75 million for energy expenses, which was more than 5% of its total expenses.[70]

One straightforward way to address this problem would be to simply exempt the state's regional transit authorities from the carbon tax; or, if that was not feasible because the tax was imposed earlier in the distribution chain, the DOR could fully refund the transit agencies for their costs. This might have the detrimental result of giving those authorities less encouragement to use electricity and fuels more efficiently and to substitute non-fossil fuels where possible. However, the reductions in greenhouse gas emissions from more transit ridership instead of auto driving are probably the dominant environmental concern here, and so any added expenses that stretch the already-difficult finances of the transit authorities should be avoided.

A more complex solution could also be devised, in which transit authorities pay the carbon tax on their fuel and electricity purchases, but then receive increased subsidies from their member municipal governments. But since the data indicates that the state and municipal governments as a whole will only break even (or face a small loss) after the carbon tax is combined with a rebate based on employment, such transfers to the transit authorities may be difficult to make.

Providing an option to donate carbon tax rebates for use in public programs

An ancillary addition to the carbon tax and rebate system would be to provide taxpayers with the option to donate their rebate to a valuable government program, particularly one that will help to further reduce greenhouse gas emissions. For example, taxpayers could donate to energy

[69] See http://www.massdot.state.ma.us/transit/RegionalTransitAuthorities.aspx

[70] Fiscal Year 2014 Budget, Massachusetts Bay Transit Authority, "Big Green" tab in Excel workbook, rows 579 through 581. $46.5 million for utilities/power, $0.7 million for jet fuel, and $28.3 million for gasoline and diesel fuel. These figures may not include all MBTA departments.

efficiency programs operated within their own communities, either by the current operators (usually contractors for the electric and gas utilities), by the municipal government, or by non-profit organizations.

It is difficult to estimate how much money would be donated through such an option, but it would give municipal governments another reason to promote energy efficiency measures to their residents and businesses.

6. Electricity excluded from the carbon fee/tax

Exclusion of electricity from the fee/tax system substantially reduces total fees or taxes paid by businesses and other institutions, because electricity is a large portion of their total energy bills. Of course, when the fees/taxes are reduced the rebates are also, so the net impacts on each business sector vary to some degree from when electricity is included, but not by dramatic amounts. Figure 18 below shows the results.

Figure III.19: Carbon tax, rebate, and net gain or loss with $30/ton carbon tax; rebate based on number of employees, electricity excluded from the tax

Category	Carbon tax as % industry output $'s	Rebate as % industry output $'s	Net gain or loss as % industry output $'s
Real estate	0.01%	0.06%	0.05%
Professional, scientific, and technical services	0.05%	0.14%	0.09%
State and local government	0.12%	0.16%	0.05%
Retail trade	0.05%	0.30%	0.25%
Wholesale trade	0.10%	0.10%	0.00%
Computer and electronic product manufacturing	0.01%	0.05%	0.04%
Banking and finance	0.01%	0.06%	0.05%
Ambulatory health care services	0.02%	0.20%	0.17%
Hospitals	0.03%	0.16%	0.13%
Insurance carriers and related activities	0.00%	0.08%	0.08%
Construction	0.31%	0.21%	-0.10%
Securities, commodity contracts, investments	0.02%	0.09%	0.07%
Educational services	0.02%	0.35%	0.32%
Publishing industries, except Internet	0.02%	0.05%	0.03%
Administrative and support services	0.30%	0.34%	0.04%
Management of companies and enterprises	0.06%	0.11%	0.05%
Food services and drinking places	0.14%	0.40%	0.27%
Telecommunications	0.07%	0.03%	-0.04%
Chemical manufacturing	0.84%	0.02%	-0.82%

Category	Carbon tax as % industry output $'s	Rebate as % industry output $'s	Net gain or loss as % industry output $'s
Federal civilian	0.26%	0.11%	-0.16%
All manufacturing industries	0.20%	0.05%	-0.14%

E. Conclusions

For households

Several conclusions can be drawn from the data on who would pay carbon taxes, how much they would pay, who would receive how much of a rebate, and what the net impact would be on different income groups and household sizes.

Flat rebates preferable to tax cuts: It is clear that some form of flat rebate will produce more equitable results than cutting the rates of any of the state's major taxes paid by individuals and families – income, property, and sales.

Net impact from combining a carbon tax with a rebate protects most households, on average: whether the rebate is made equal per household or per person; and whether households are ranked by income per household or income per person, the net impacts are positive or approximately neutral for the bottom four quintiles. In almost all cases impacts are positive for households in the bottom quintile regardless of the number of people in the household, with one exception – when rebates are equal per household, households with four or more people lose close to $100 on average per year. In contrast, with equal rebates per person, large households have substantial net gains.

Equal rebates per person preferable to equal per household: the data appears to show, as mentioned in the previous point, that equal rebates per household would leave large households with net losses in income. Equal rebates per person appear to yield equitable results both when evaluated by income quintile and by size of household.

Low and moderate-income households protected in most cases: in all scenarios the bottom three quintiles, meaning the 60% of households toward the lower end of the income spectrum, either have net gains or come out about even. This does not mean that **every** household will do well, because many households have higher than average carbon emissions, which should be addressed by benefits targeted to their specific circumstances.

Net impacts are progressive in terms of impacts by income group: The 4th quintile (next to highest incomes) generally would experience a small loss (which can be interpreted as being close to neutral), while the highest-income quintile experiences larger losses – but still in amounts of two to three hundred dollars per year, not enough to be disruptive for those at the top of the income scale.

Particular groups would face significant losses: portions of the population that have significantly larger than average carbon emissions, for reasons such as heating their homes with oil or driving well more than the average, would pay more than the average in carbon taxes and therefore their net impact would be negative.

For businesses and other institutions

Tax cuts are not a good method of providing rebates: cutting the major tax paid by businesses in Massachusetts, the corporate excise tax, fails as a method for providing rebates, for several reasons described earlier.

Employment or payroll provide a good basis for rebates: it appears that providing rebates on the basis of either a company's share of overall state employment or payroll would yield reasonable net impacts across the economy.

Carbon taxes would be a small fraction of business costs for most industries: in almost all cases, industries that have a significant presence in Massachusetts would face a carbon tax equal to a few tenths of a percent of their total expenses, or less.

Most major industries would have small net gains: while the amounts are quite small, in most cases in the hundredths of a percent, most of Massachusetts' largest industries would experience net gains from a carbon tax combined with a rebate that is based either on employment or payroll. Construction, some manufacturing industries, and transportation industries (trucking, etc.) would experience net losses.

Most manufacturing industries would have net losses: the state's largest manufacturing sector, computer and electronic parts, would have a net gain. But most other manufacturing sectors, such as chemicals, fabricated metal products, food and paper, would face losses ranging from one-tenth to nine-tenths of one percent of their total expenses.

F. Recommendations

- Provide rebates to households on an equal per person basis, or on a basis that mixes per household and per person systems, such as a full rebate for the first household member and one-half of the full rebate for each additional household member.

- Provide rebates at the beginning of the year, or throughout the year, so that they are available to households as they need to pay for higher energy costs.

- For households that file state income taxes, use the Department of Revenue (DOR) to provide refundable carbon tax credits, but do so in a way that maximizes public awareness of the source of the rebates.

- Locate households that don't file income taxes through comparing lists available to DOR and the agencies that administer various low-income benefit programs, such as fuel assistance, SNAP, Medicaid, and utility discount programs. Assign responsibility to one or more of the agencies to send out carbon tax rebates. Provide legislative authority to all relevant agencies to share identifying information in their data bases.

- Provide targeted additional benefits to low-income households that have high carbon emissions that are difficult to reduce in the short run – such as use of oil heat and high driving mileage. But such benefits should be phased out over time so that households are encouraged to make their lifestyles less carbon-intensive.

- To ensure that as few low and moderate income households face losses as possible, consider obtaining additional funds for delivery to them by either:

    - Using some of the rebates that would have flowed to the highest-income households
    - Using a small portion, such as 20%, of the carbon tax funds obtained from businesses and institutions, to provide additional benefits to low and moderate income households, particularly those that can be identified as having high carbon emissions.

- Provide benefits to companies and other institutions (non-profits such as universities and hospitals, along with municipal governments) based on their share of total employment in the state.

- Consider providing targeted benefits to manufacturing industries, or to those particular industries that are relatively energy-intensive, in order to protect the competitiveness of the industries.

- Exempt public transit authorities from the tax, or fully rebate their increased costs for fossil fuels and electricity.

IV. Macroeconomic impacts of the carbon tax and revenue-return method

A. Overview

The macroeconomic impact of policy—the net changes in job creation, personal income, overall growth, the cost of living, and competitiveness—is often the heart of the discussion surrounding changes to taxes or government spending.[71]

Like the other New England states, Massachusetts imports nearly all its fossil fuel resources from other states or countries, with the vast majority of the spending on fossil energy resources leaving the state. Massachusetts could benefit from reducing imports of energy and instead having those funds spent on business sectors where more of the money remains within the state economy.

Overall, the carbon fee/tax modeled here has small but positive impacts on the Massachusetts economy. These include:

- **Jobs:** 2,000 to 4,000 additional jobs by 2020 and 6,000 to 15,000 by 2040; additional jobs and output are concentrated in the service and technology sectors that already form the backbone of the Massachusetts state economy
- **Personal income:** greater real personal income in most of the scenarios tested, even adjusting for a higher cost of living

This section summarizes the three models used to perform the macroeconomic analysis, and then provides detailed fiscal, economic, and demographic results. The following section (V) discusses what these economic changes mean for carbon dioxide emissions. At the end of section V is a short discussion of the technical documentation for the modeling, mathematics, and statistical research used to generate these results.

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[71] See, for instance, the debate on EPA regulation of carbon under Section 111(d) of the Clean Air Act. Gina McCarthy quoted, "This is about protecting our health and our homes. This is about protecting local economies and jobs," <http://www.usatoday.com/story/money/business/2014/06/02/epa-proposes-sharp-cuts-power-plant-emissions/9859913/?siteID=je6NUbpObpQ-939d6MBGZ9XJMPNqGJkixw>, while Senator Mitch McConnell (R-KY) stated, "These regulations are a lose/lose proposition all around—for jobs, for families, for the US economy, and for our nation's competitiveness overseas," <http://www.foxnews.com/opinion/2014/06/02/epa-new-plan-to-target-greenhouse-gases-will-kill-jobs-devastate-middle-class/>. These statements, while conflicting, each make relevant points about the *macroeconomic* implications of EPA regulations in terms of local economic development issues and energy prices' relevance to American competitiveness.

B. Introduction to the Models

Two firms, REMI and Synapse Energy Economics, used three models to perform this portion of the analysis. Each model has its relative strengths and weaknesses. Using them together allows us to utilize their strengths while overcoming their potential blind spots:

1. *The Regional Energy Deployment System (ReEDS),*[72] *a model of the North American electricity grid built by the National Renewable Energy Laboratory (NREL)*
2. *The Carbon Analysis Tool (CAT), an enhancement of the Carbon Tax Analysis Tool (CTAM) first built by Keibun Mori for the state of Washington*[73]
3. *The REMI PI+ model, an economic and demographic model of Massachusetts*

The ReEDS model is a representation of the North American electrical power grid. Its major features are plant characteristics and transmission constraints on the system, including capacity and generation by various types of plant (such as wind, solar, nuclear, hydroelectric, natural gas, coal, etc.), day/night and seasonal cycles of demand, and fluctuations in the ability of plants to generate power because of weather conditions or maintenance cycles. The ReEDS model informed this analysis by providing a realistic, long-term analysis of how the electricity market might change with the introduction of a carbon tax.

Figure IV.1: Example ReEDS Output, 2014

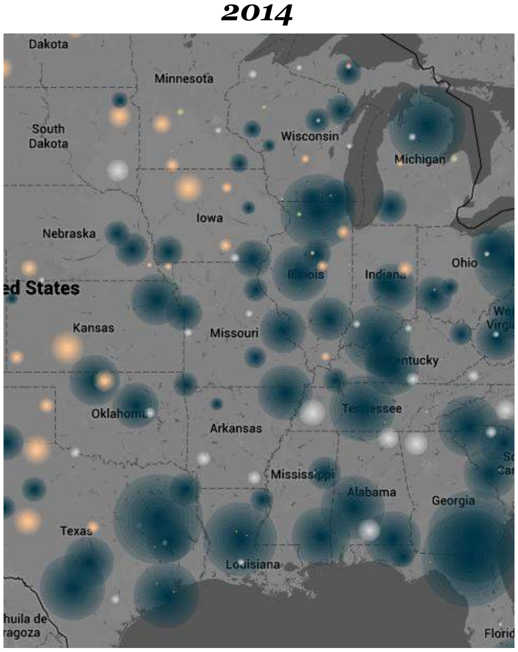
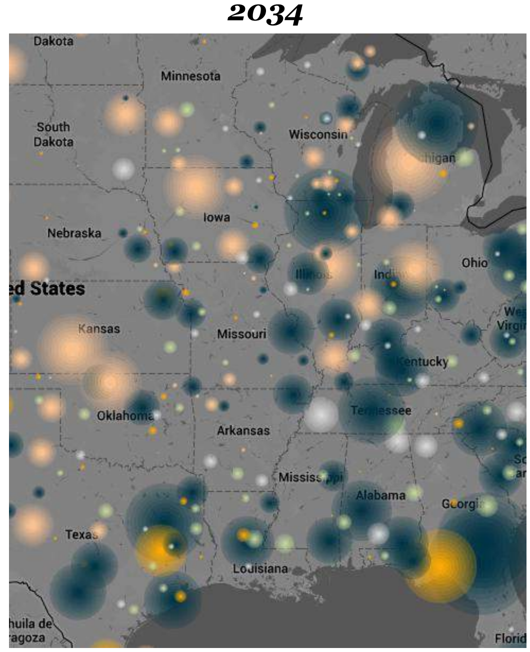


Figure IV.2: Example ReEDS Output, 2034



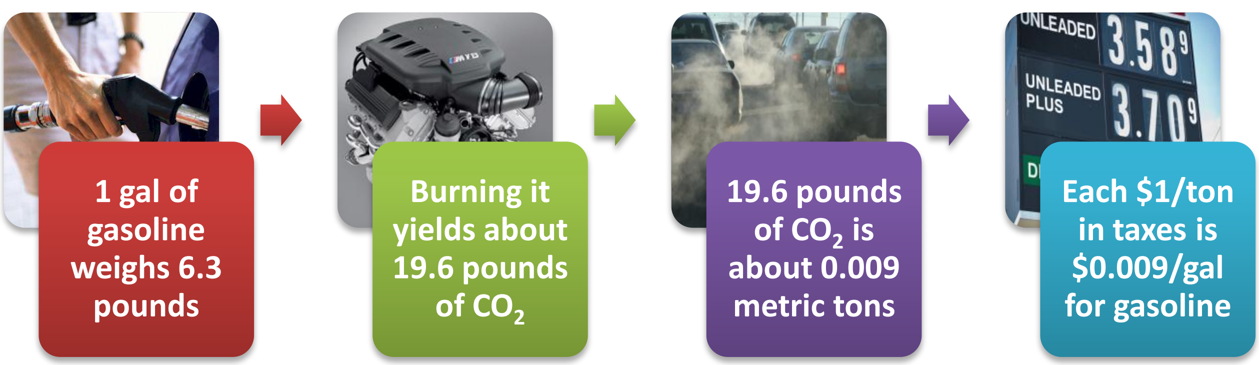
[72] For a description of ReEDS, please see, <http://www.nrel.gov/analysis/reeds/description.html>
[73] Introductory presentation on CTAM by Keibun Mori, Roel Hammerschlag, and Greg Nothstein, <http://epi.boisestate.edu/media/21329/keibun%20mori,%20nothstein%20and%20hammerschlag%20-%20carbon%20tax%20modeling%20for%20washington%20state.pdf>

This shows some of the purpose of the ReEDS model in illustrating the power plants in the United States (in this case, in the Midwest and Southeast) in 2014. The dark blue dots are coal and natural gas plants, the white dots are hydroelectric dams, and the peach dots in the western Midwest and west Texas are large-scale wind farms.

After twenty years, either due to technology, higher fossil energy prices, or a carbon tax, wind and solar power (the gold color, particularly in Florida) become more attractive, and they become much more central to the power generation capacity of the United States. The blue dots, at the same time, are declining from previous levels.

Figure IV.3: Gasoline and Carbon Tax

The CAT model integrates data from the ReEDS model and a forecast from the U.S. Department of Energy (USDOE) called the Annual Energy Outlook (AEO).[74] CAT estimates how much less fossil energy people would buy if it were more expensive due to the carbon fee/tax. For example, a carbon tax of $30 per metric ton of carbon dioxide means that each gallon of gasoline at the pump will cost around $0.27 more than it did before. Why is this? Because one gallon of gasoline, when combusted with the oxygen in the atmosphere, yields 19.6 pounds of carbon dioxide.[75] We then convert this:



One gallon of gasoline emits 19.6 pounds of carbon dioxide into the atmosphere which, when converted, is around 0.009 metric tons. This method can convert all fuel types from their typical unit of sale into a "carbon dioxide content" to apply the carbon price.

How individuals and businesses respond to an increase in the price of gasoline and other types of fossil energy is central to the emissions and economic implications of a carbon tax in the

[74] This forecast, produced by the National Energy Modeling System (NEMS), provides a projection of energy consumption by region in quadrillions of BTUs (thermal units that convert to physical units, such as each gallon of gasoline having 114,000 BTUs of energy), which becomes the foundation of a carbon emission forecast to adjust against a carbon tax, <http://www.eia.gov/forecasts/aeo/>

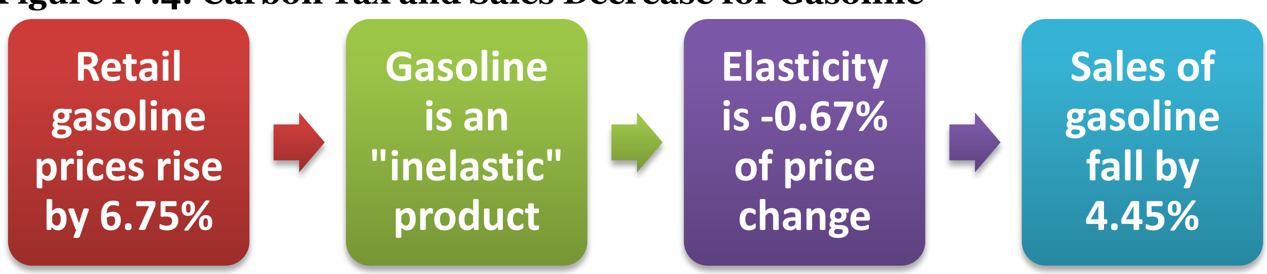
[75] Both these numbers depend on the blend of the gasoline, though these are the national averages with only small deviations from the mean, please see, <http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11>

Commonwealth. To explain, we draw on the economic concept of "price elasticity of demand"—which simply means that people buy less of something when it costs more to buy it. How much less people buy of a given commodity depends on the "elasticity," which is a ratio of the percentage change in consumption to the percentage change in price.[76] For instance, if gasoline prices now are $4.00 and become $4.27 because of the carbon tax, that would mean a 6.75% increase in the price at the pump. The question becomes how much a 6.75% increase influences people to purchase less gasoline by driving less, using more efficient vehicles, or seeking transportation alternatives. If there is a sizeable response to a small price change, economists call the good "elastic."

"Inelastic" goods are the opposite, where a large change in price generates small changes in consumption. Fossil fuel products are comparatively inelastic due to their use in "necessity" activities such as heating, transportation, and industrial production; and the limited availability of low-carbon sources of energy at present. People might try to take fewer trips to the store in a given week, but in most cases, they still need to drive a car to work. This can limit their options—making the response to the price change "inelastic." If the elasticity of gasoline is -67% (a 1% increase in price causes consumption to fall by 2/3 of 1%), then a 6.75% increase in the price of gasoline will cause a 4.46% decrease in gasoline demand.[77] This inelastic response of demand to price changes for fossil fuels influences the macroeconomic, tax revenue, and carbon emission results in the rest of this section.

It is important to note the degree of elasticity increases over time. For example, the demand for gasoline will fall by only small amounts in the first few weeks or months after the carbon tax starts. The -67% elasticity takes as much as ten years to occur once people buy new cars, change their commuting patterns, or even relocate their homes closer to work.

Figure IV.4: Carbon Tax and Sales Decrease for Gasoline



This shows the calculations at the center of the CAT model. Higher prices for fossil energy generate a response as consumers and businesses shift to consuming less or using alternatives, though fossil energy commodities tend to be inelastic, which means the response of consumption is generally less than the price change in comparable percentage terms.

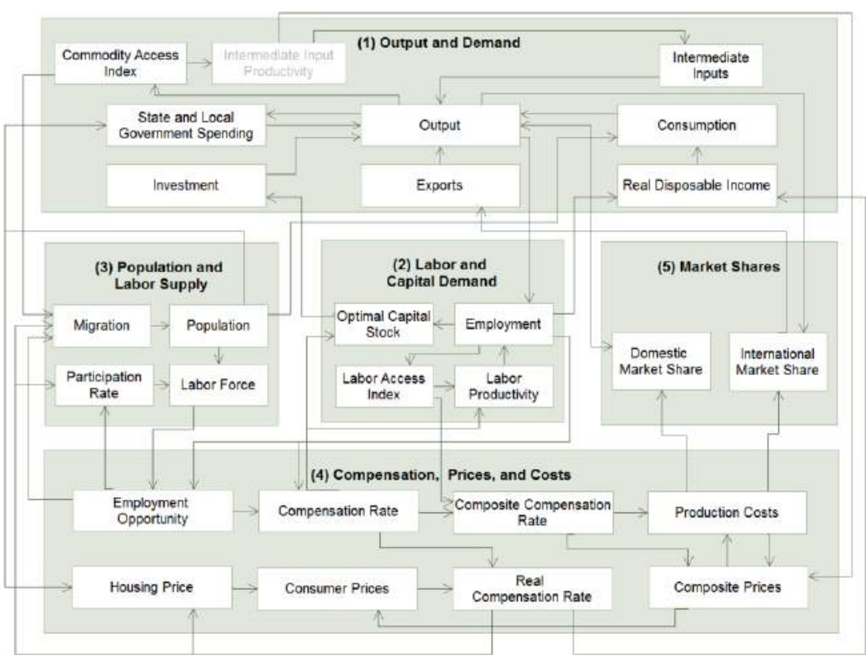
[76] For further background, please see, <http://www.investopedia.com/terms/e/elasticity.asp>
[77] 6.75% * -67% = -4.46%

The third model is REMI PI+, and there are details on its workings in the technical appendix and available online.[78] PI+ is an integrated economic, demographic, and fiscal model of sub-national units of the United States—in this case, the fourteen counties (which is the standard statistical unit from government sources)[79] of Massachusetts agglomerated to the whole state. PI+ uses four quantitative methodologies, each of which analyzes different areas:

1. ***Input-output*** *(IO) tables – illustrate the structure of the economy by showing the flow of dollars between households, industries, and the government*
2. ***Computable general equilibrium*** *(CGE) – models long-term adjustments to the economy in response to price incentives, which is most crucial when discussing something like a carbon tax versus tax cuts and rebates elsewhere*
3. ***New Economic Geography*** *– a concept of economies of scale, where industry and labor clusters give competitive advantages to regions (such as the educational cluster around Amherst and professional services in Boston and Cambridge)*
4. ***Econometrics*** *– mathematic and statistical parameters from historical and observable data necessary to operate the three other methodologies*

Modeling a revenue-neutral carbon tax in REMI means changing variables for energy prices while simultaneously reducing other taxes and increasing rebates. This technique would include the negative effects of higher energy costs for consumers as well as the benefits to lower taxes or rebates in the supply- and demand-side senses in the Commonwealth.

Figure IV.5: REMI PI+ Flowchart



[78] The full model documentation is online, here, <http://www.remi.com/resources/documentation>
[79] The data in the REMI model comes from public sources, including the Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), U.S. Census, and Energy Information Administration (EIA)

This flowchart represents the logical setup of the REMI model through its series of interrelationships. Each rectangle is a concept linked to the others with equations underneath arrows. Block 1, at the top, is the macroeconomy with gross domestic product (GDP) such as consumption and investment. Block 2 is for firm-level production decisions about hiring and capital investments. Households are in Block 3; it includes demographics in the long-term, migration, and consumption patterns. Block 4 is the equilibrium portion where prices and costs, such as wages and the price of housing, take place. Block 5 models the competitiveness of the Massachusetts economy. Changing business conditions may lead to either more or less market share due to the net changes in costs under the carbon tax system.

C. Policy Design

In keeping with the discussion in other sections of the report, this analysis considers policy options for the state to implement a revenue-neutral carbon tax. These options have several dimensions, including the initial tax level in dollars per metric ton of carbon dioxide and the increase over time. It also includes what sources of carbon dioxide and other emissions to tax[80] and the most equitable, efficient ways to rebate the money. While other air emissions related to climate or local air quality could be a part of the tax, this study includes only carbon dioxide with a small markup on natural gas products related to the average rate of methane leakage.[81] We have analyzed three different characteristics of the tax, yielding a total of twelve scenarios: (3) price levels of the tax, (2) ways to redistribute the revenues to households, and (2) ways to redistribute the revenues to businesses, nonprofit institutions, and governments. Twelve scenarios come from the product of 3*2*2. These designs give the state a sense of the overall macroeconomic implications of the carbon tax and the relative strengths and weaknesses of different approaches. Following the precedent of the Canadian province of British Columbia,[82] we began the tax at $10 per metric ton in 2016 and increased it by $5 per year to $30 in 2020. This was the same “tax path” followed by British Columbia.

For the years after 2020, we provide three forecasts. The carbon tax rate rises at either “low,” “medium,” or “high” rates each year—the low at $1.00, the medium at $2.25, and a high of $3.50. One should note these are *real* rates of increase. That is, with indexing, these increases are beyond the general level of inflation throughout the economy.

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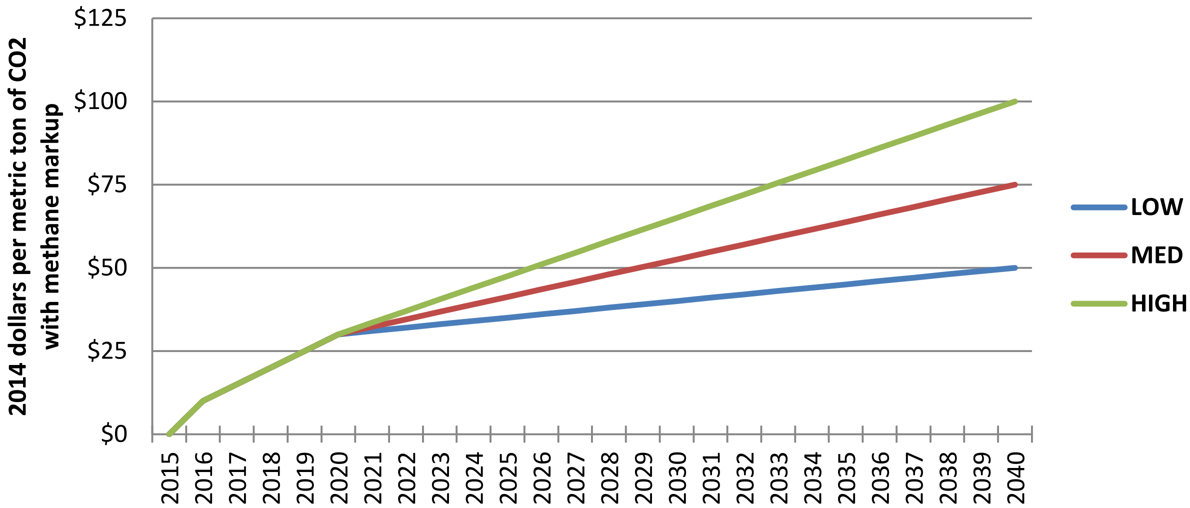
[80] To make implementation more manageable, the tax might apply initially only to major sources of fossil fuels and solely to their carbon dioxide emissions.

[81] The methane adjustment adds 3.5% to the carbon price applied to natural gas.

[82] In British Columbia, these figures were technically in Canadian dollars (CAN) and in the late 2000s before the inflation of the past half-decade, but shifts in the exchange rate and inflation makes them comparable, see, <http://www.carbontax.org/services/where-carbon-is-taxed/>

Figure IV.6: Carbon tax rates over time in three scenarios



This shows the tax paths of our three cases. All follow British Columbia's rate of increase for the first five years. The three cases diverge beginning in year six, with the low case ending at $50 per ton in 2040, the medium case at $75, and the high case at $100.

As discussed in the section regarding the distributional aspects of the carbon tax, we have identified the most efficient and most equitable means to redistribute the money to the state's households, businesses, and institutions. For households, this involves a rebate, a tax exemption or credit, or an increase in benefits through programs that serve low-income households. Funds are disbursed in either an equal amount per household or an equal amount per person.

For businesses and institutions, the two possibilities we considered are a rebate based on a firm's share of total state payroll or a total state employment. Each would produce largely the same macroeconomic results, though a payroll-based rebate would slightly favor industries with high wages (such as professional services or finance) while an employment-based rebate would favor labor-intensive firms and industries that pay relatively lower wages (such as hotel accommodations, food service, and retail trade).

DOER has specified that the rebate system modeled in this study should return all fees/taxes paid by households to that sector, while all the funds paid by businesses and institutions return to those sectors. Keeping the funds in separate "buckets" and returning them to the public on that basis adds to the clarity of the system and ease of administration, and provides one form of equity in the combination of fee/tax payments and rebates.[83]

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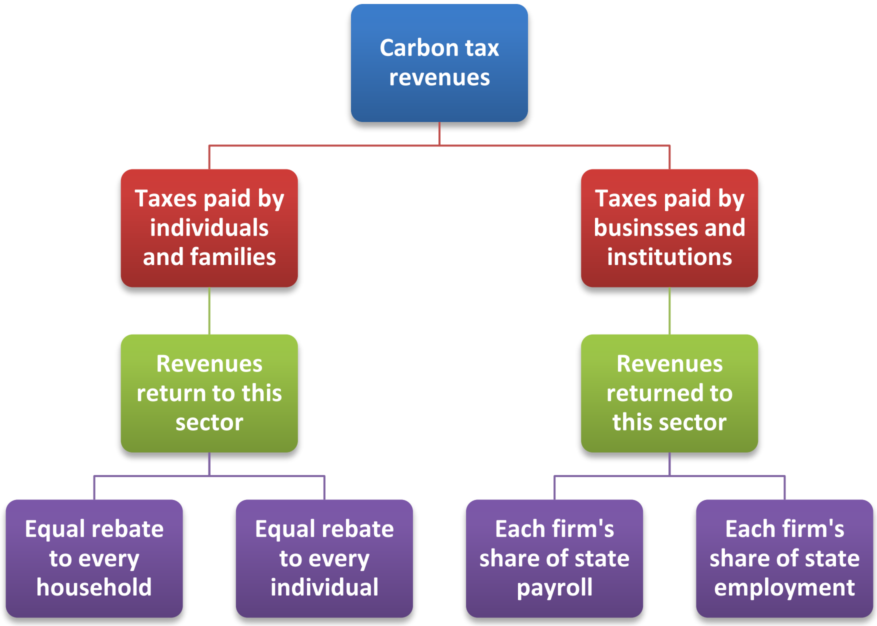
[83] This is equity in the "static," initial sense. It becomes more complicated when businesses begin to pass the cost down to their customers (with higher prices) and investors (with less profits, dividends, and capital income). While the static tax analysis does not take account of these factors, the REMI model includes these in its calculation of the macroeconomic impacts.

Figure IV.7: Alternative Methods of Rebating Carbon Tax Revenues



The flowchart above illustrates the potential paths for the funds rebated in our macroeconomic analysis. Revenues from the carbon tax come from either the household sector on the left or the business/institutional sector on the right. Each of those funds then split into either per person or per household rebates on the left or a share of payroll or a share of state employment on the right. This produces the four revenue cases analyzed below.

Definition of Scenarios

The three dimensions of three tax levels, two systems of revenue recycling to households, and two systems of revenue recycling to groups produces twelve scenarios. Their labeling and coloration for the rest of the report are consistent, as shown here.

First variable = *rate at which the carbon tax increases over time (LOW, MED, HIGH)*

Second variable = *basis for disbursing the rebate to the household sector—HH means equal rebates per household, IND means equal rebates per individual*

Third variable = *basis for distributing rebates to the business/institutional sector—PAY means rebates distributed in proportion to the value of payroll, and EMP means rebates distributed according to the number of employees*

Three variables yield twelve (12) scenarios:

- **(1) LOW, HH, PAY**
- **(2) LOW, HH, EMP**
- **(3) LOW, IND, PAY**

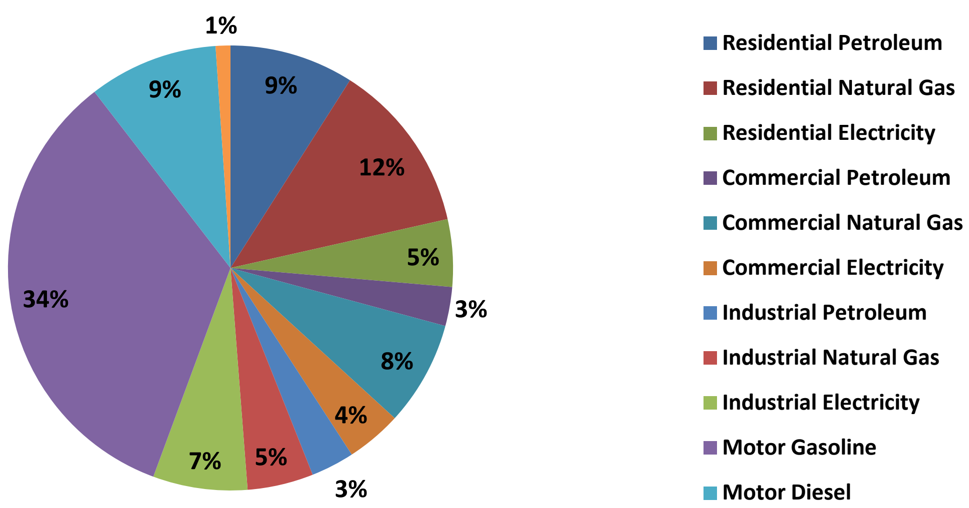
- **(4) LOW, IND, EMP**
- **(5) MED, HH, PAY**
- **(6) MED, HH, EMP**
- **(7) MED, IND, PAY**
- **(8) MED, IND, EMP**
- **(9) HIGH, HH, PAY**
- **(10) HIGH, HH, EMP**
- **(11) HIGH, IND, PAY**
- **(12) HIGH, IND, EMP**

The numbers make it easier to compare the scenarios in relation to the macroeconomic results in the next section. In those cases where only the tax rate is being varied between scenarios, the labeling is simpler, including only the following three categories:

- **LOW**
- **MED**
- **HIGH**

D. Static Analysis of Carbon Tax Revenues

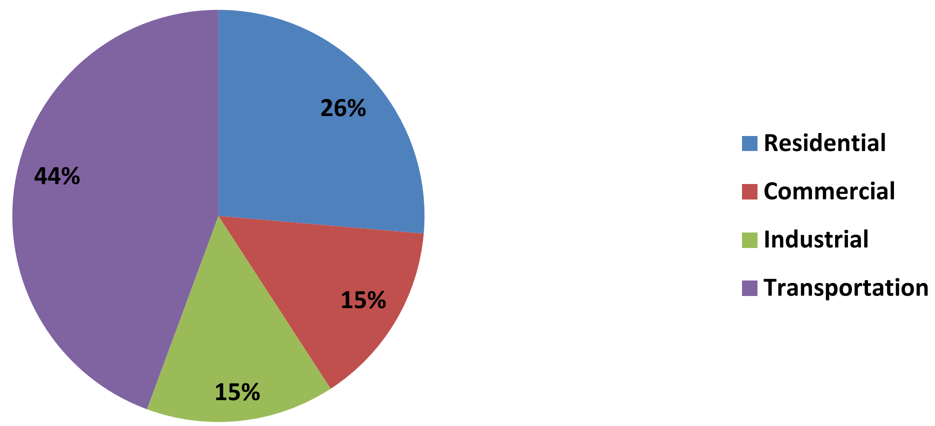
Figure IV.8: Source of Revenues by Sector and Fuel (2020, $30 per metric ton)



This pie chart summarizes the share of carbon tax revenues according to the economic sector and fossil fuel type. These results are for 2020 with a tax beginning in 2016—this is the year of

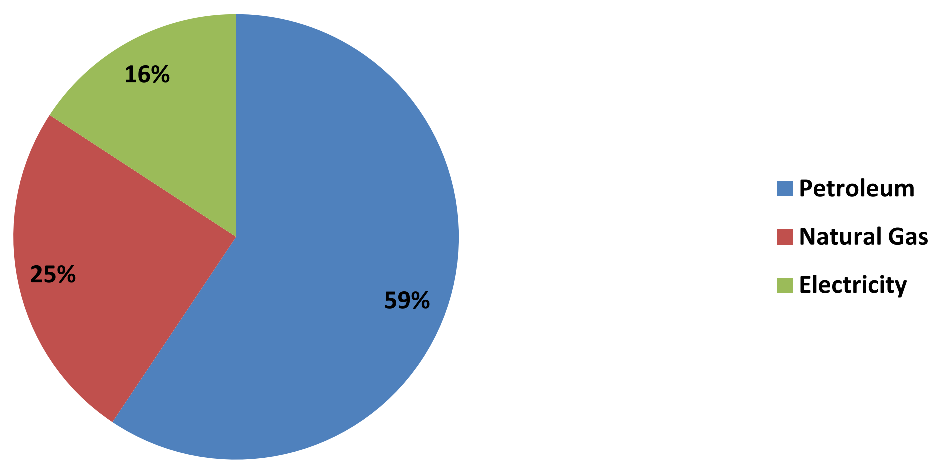
$30 per metric ton to match British Columbia. The lion's share of the carbon tax revenues come from transportation fuels, specifically motor gasoline. The next largest share comes from the thermal sector of residential heating (the blue and the gold categories from 12 o'clock to 3 o'clock of petroleum and natural gas fuels for residential consumers).

Figure IV.9: Source of Revenues by Sector (2020, $30 per metric ton)



This data is the same as that in Figure IV.8 but shows only the distribution of fuel usage among sectors. Transportation includes purchases by households, businesses, nonprofits, and the government. Accounting for this, households would pay around 50% of the carbon tax with business and institutional consumers accounting for 50% of the revenues.

Figure IV.10: Source of Revenues by Fuel (2020, $30 per metric ton)



Petroleum above includes motor transportation fuels and fuel oil for heating, which means it accounts for well over 50% of carbon tax revenues by fuel type. Massachusetts' heavy reliance *on cars and trucks for transportation and a substantial market share for fuel oil in heating (in comparison to the dominance of natural gas in most of the country) contribute to this.*

The results in *Figures IV.8*, *IV.9*, and *IV.10* above illustrate the carbon emissions inventory of Massachusetts, the relative magnitudes of its energy usage by sector and by type of fuel, and the most important factors in applying the carbon tax to the macroeconomic model.[84] Motor gasoline is responsible for one-third of the state's carbon emissions, and therefore it has one-third of the tax placed upon it. This makes the transportation sector and gasoline the most important part of our results in terms of the macroeconomics of reducing emissions. Other factors, still have their impacts, but, for example, the 5% share of emissions due to industrial natural gas pales in comparison to the 34% for gasoline.

The share of emissions from power generation is a relatively small 16% in Massachusetts. This is important to remember in considering the complications of regulating the electricity sector. The amount of carbon dioxide savings from this sector is less than that from the transportation or heating sector because of their initial shares of carbon emissions. Electricity is *relatively* small when comparing its carbon emissions to transportation fuels and heating.[85]

The dominance of liquid and gaseous fuels in terms of tax revenues raises another point about the macroeconomics of the carbon tax — Massachusetts imports nearly 100% of its fossil fuel resources. The state has no measured crude production,[86] no natural gas extraction,[87] and none of the 142 refineries in the United States.[88] There is some economic activity in Massachusetts associated with the distribution and retailing of fossil fuels, which the REMI model includes through the retail and wholesale sectors.

Therefore, a large proportion of the dollars spent on liquid and gaseous fuels in the state go towards production and economic activity somewhere else in North America or oil imports from Canada, Venezuela, and other countries. Reducing imports is often an economic development strategy for countries and regions. The carbon price would reduce demand for carbon-generating products, reduce air pollution, and it would decrease the number of dollars leaving the state. Keeping more dollars in state provides a boost to the Commonwealth's economy.

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[84] All data adapted from the State Energy Data System (SEDS), provided by the EIA under USDOE, <http://www.eia.gov/state/seds/>. The NEMS model provides a forecast of similar data at the regional level (the six states of New England), and the SEDS data provides a consistent format for sharing that data for Massachusetts down to the state-level in the forecast inside the CAT model.

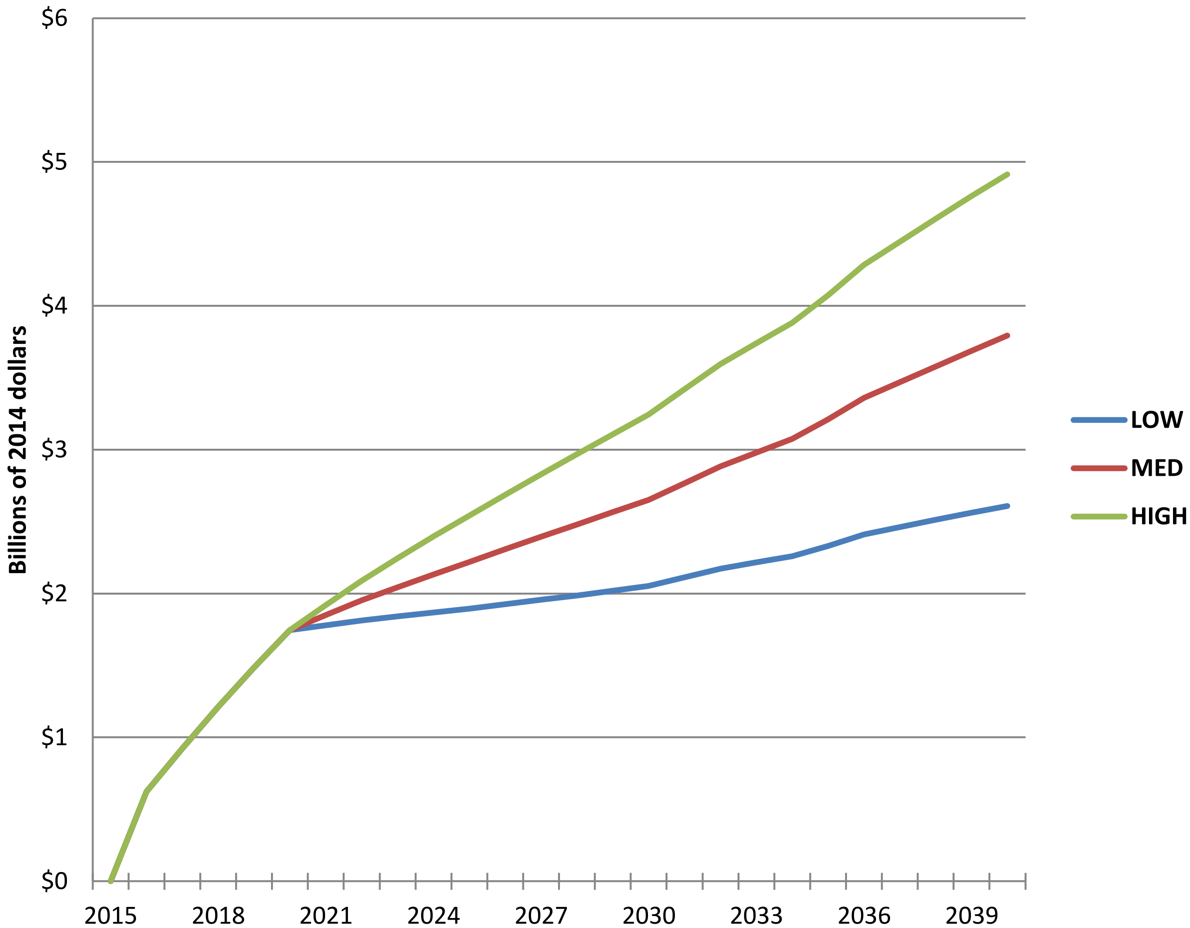
[85] In this study, we used the Massachusetts Department of Environmental Protection's (MA DEP) current estimate that fugitive methane emissions raise the carbon content of natural gas usage by 2.5%. However, intensive research on this topic is underway, and this may change in the future.

[86] Massachusetts not listed, <http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm>

[87] Ibid., <http://www.eia.gov/dnav/ng/NG_PROD_SUM_A_EPG0_VGM_MMCF_A.htm>

[88] Ibid., <http://www.eia.gov/dnav/pet/pet_pnp_cap1_a_%28na%29_8O0_Count_a.htm>

Figure IV.11: Carbon Tax Revenues



Above is the static tax revenue projection from the CAT model.

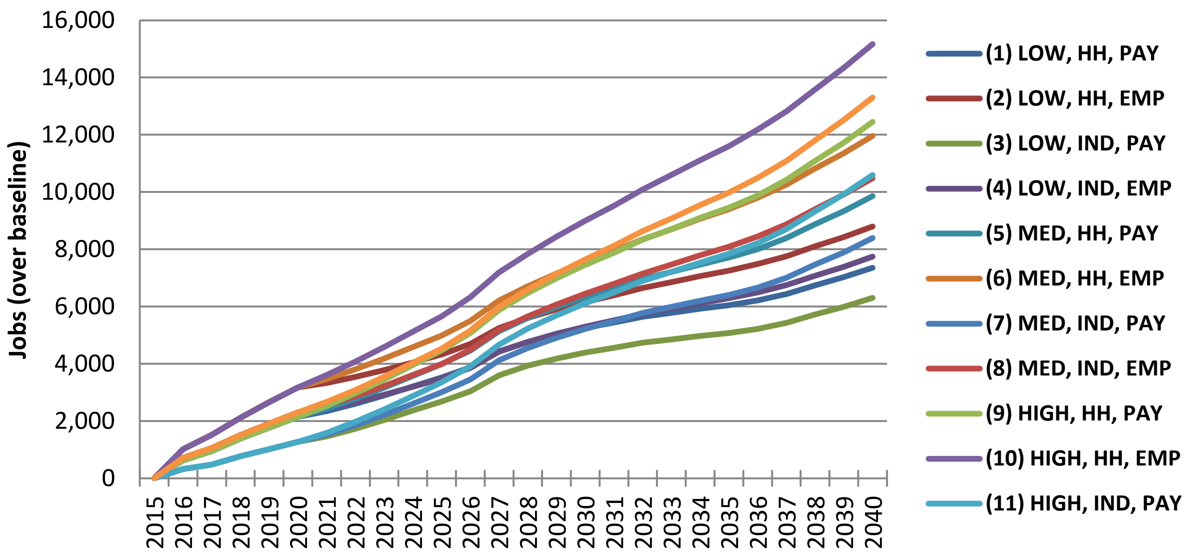
In both absolute terms and relative to the state budget, the revenues would be considerable. For Fiscal Year (FY) 2015 the Commonwealth expected to collect about $25 billion in state tax revenues,[89] with the budget including $36.5 billion in expenditures (with the extra funds due to federal matching for Medicaid, transportation, and other joint state-federal programs).[90] This means the carbon tax by 2020 is equivalent to 7% of state tax revenues and 4.8 of expenditures -- although our study assumes that these funds are returned to the public. The revenue from the tax continues to grow gradually beyond 2020 because of the increases in the tax rate.

[89] *Governing*, <http://www.governing.com/gov-data/state-tax-revenue-data.html>

[90] Data from the Massachusetts Department of Revenue (DOR) and its online Budget Dashboard program, <http://budgetdashboards.itd.state.ma.us/analytics/saw.dll?Portal>

E. Dynamic Analysis of Macroeconomic Impact

Figure IV.12: Total Employment



All scenarios (varying by both tax rates and revenue recycling options) yield a net increase in total employment over the baseline. The cases with a household-based rebate to individual consumers of energy and an employment-based rebate to institutional consumers—such as case (10)—have the overall "best" results compared to the IND, PAY cases such as (3), (7), and (11) graphed above.

There are two key reasons why the revenue-neutral carbon tax and rebate produces an increase in employment in Massachusetts in our simulation. First, a carbon tax reduces energy imports from the rest of the United States and the rest of the world. In 2012, Massachusetts consumed three billion gallons of gasoline.[91] Most of the value/price of gasoline comes from activities performed outside of Massachusetts, such as extraction and refining. However, there are some economic gains from the wholesaling and retailing of fossil energy products in the state.

Local distribution generally accounts for around 25% of the cost of transportation fuels.[92] If the average price of motor gasoline in the state is around $3.50 per gallon, then $7.8 billion "leaks" from the Commonwealth every year due to purchases at the pump.[93] Against a gross state product (GSP) of $446 billion in Massachusetts, this means the leakage from gasoline purchases

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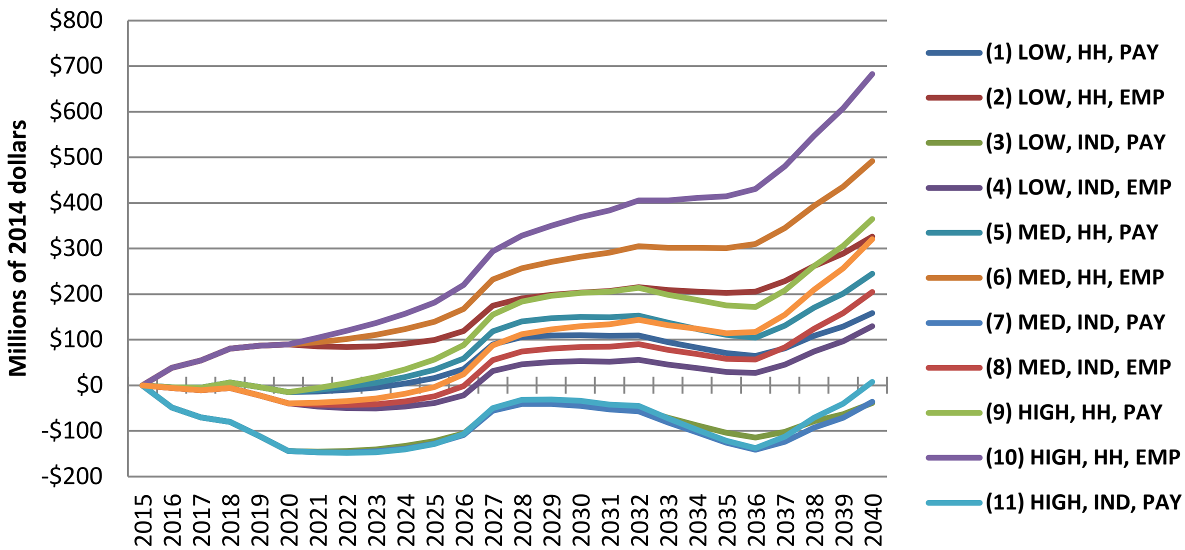
[91] State Energy Data System (SEDS) and author's calculations, please see, <http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US#Consumption>

[92] Cardiff Garcia, "What's keep US gas price aloft," *Financial Times*, April 2, 2012, <http://ftalphaville.ft.com//2012/04/02/945141/>

[93] 3 billion gallons * $3.50 per gallon = $10.5 billion * 25% = $2.7 billion

is 1.75% of GSP.[94] Motor gasoline is around one-third of the carbon tax revenues in our simulations; thus, it appears that 5% to 6% of GSP leaks out of the state due to energy imports. By reducing this leakage a carbon tax yields the employment gains shown in *Figure IV.12*. The second major factor is the greater labor-intensity of other industries in comparison to the energy sector, which the charts and graphs on the following pages explain in detail.

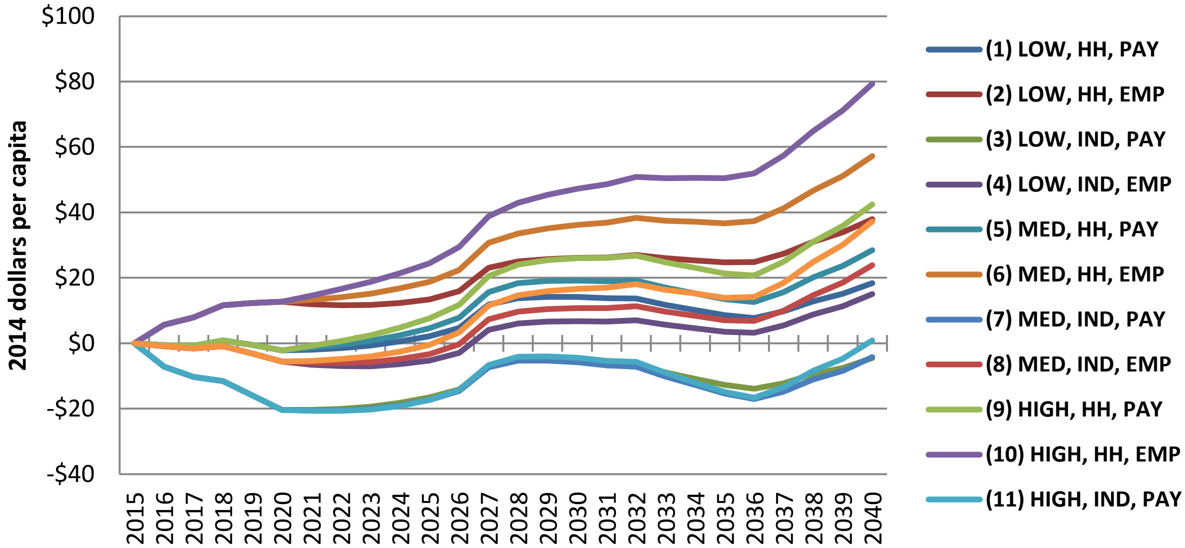
Figure IV.13: Real Disposable Personal Income (RDPI)



These are the results from the PI+ model for "real disposable personal income" (RDPI). RDPI is the REMI definition of income that includes all labor and capital income, transfer payments, all tax cuts and rebates from carbon pricing, a subtraction of taxes, and an adjustment for any changes in the cost of living. Hence, the numbers above take account of any increase in prices from the carbon tax. As with the previous results, the general pattern is positive. Cases (3), (7), and (11) underperform relative to the other option, due to having an individual-based rebate to people and a payroll-based rebate to companies.

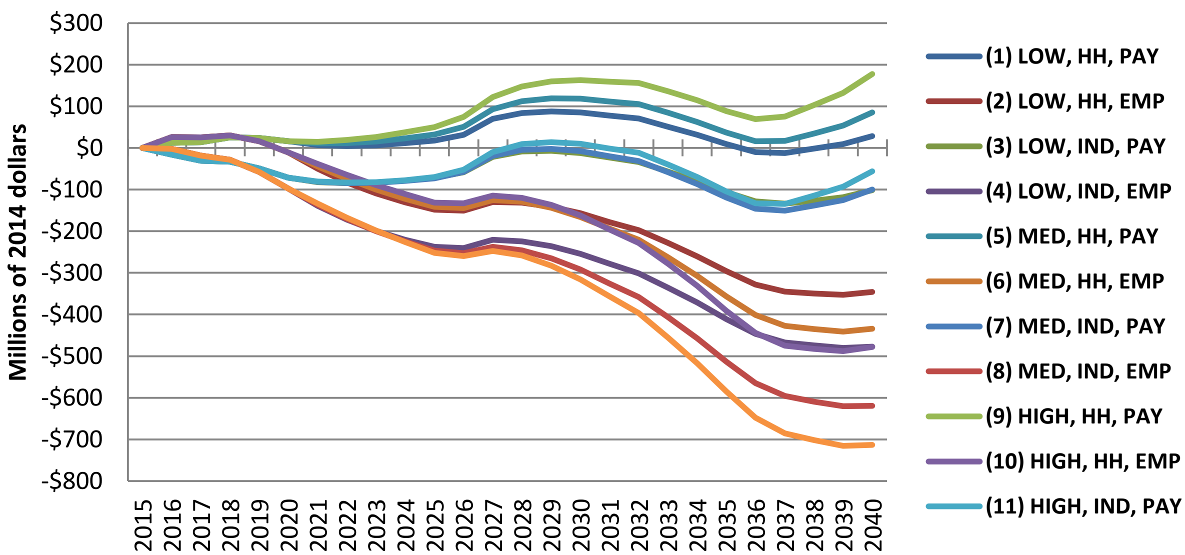
[94] Bureau of Economic Analysis (BEA) most recent release for state economies in 2013, <http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1%23reqid=70&step=10&isuri=1&7003=200&7035=-1&7004=naics&7005=1&7006=25000&7036=-1&7001=1200&7002=1&7090=70&7007=2013&7093=levels>

Figure IV.14: RDPI per capita



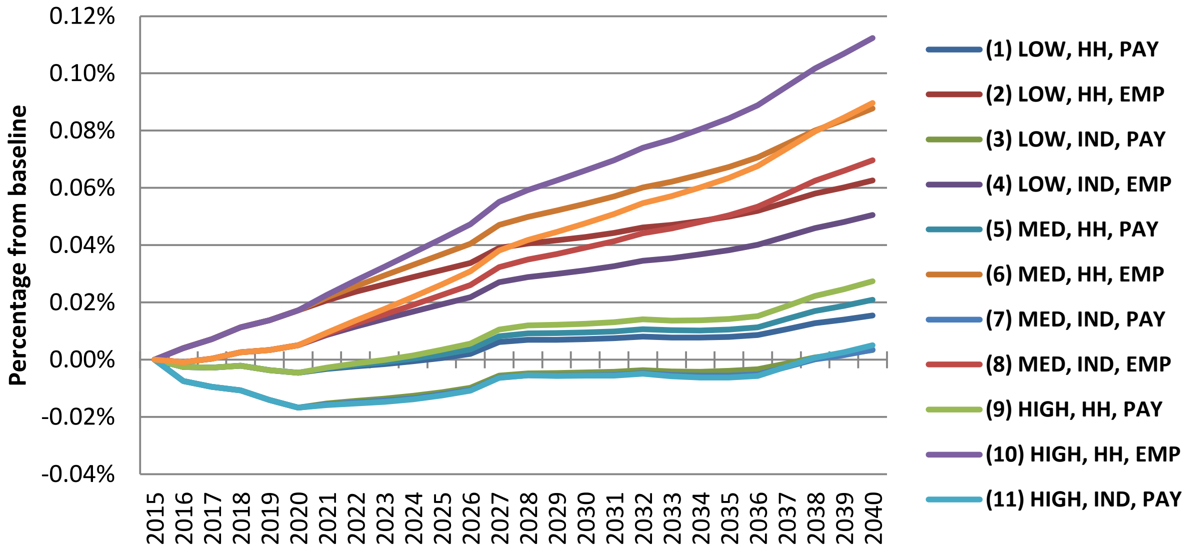
This figure puts the results from Figure IV.13 on a per person basis. For the most part, the pattern is similar, and most of the carbon tax scenarios lead to a net increase in per capita personal income over the baseline by $20 to $80 per year. This comes from the reduction of imports to the state and the additional jobs generating more wages.

Figure IV.15: Gross State Product (GSP)



GSP changes are negative (relative to the baseline) in some of the scenarios. In the worst case, GSP falls by $700 million in 2040, which is 0.15% of the state's total output in 2013 (and will be a smaller percent in 2040). Moreover, total employment and personal income are generally better indicators than GSP of the economic well-being of state residents, as discussed on the next few pages.

Figure IV.16: Labor Share of Income (RDPI over GSP)



This elaborates on the previous figure to describe the impact of the carbon tax and rebates. It shows the labor share of income, defined here as RDPI divided by GSP. While most of the lines are slightly above zero, the changes are quite small—a 0.1% change is $1 out of every $1,000 in the state. Hence, the tax changes here (and the lack of a direct redistribution of funds between labor and capital in the revenue recycling) do not directly move much income between the major sectors of the state economy.

The contrasts in the results between total employment and RDPI (measurably positive) versus GSP (neutral or slightly negative in some scenarios) result from the different methods by which the state could choose to return the funds from the carbon tax to businesses and institutions. The results from *Figure V.17* to *Figure V.26* provide more details. As previously described, we considered two means for the state to send the funds back to businesses and institutions—a rebate based on the firm's share of state payroll or its share of state employment. The results are due to different industries paying different average salaries. For instance, the retail sector employs over 400,000 workers in the Commonwealth but, because of the lower wages within the industry, it pays $13.5 billion in annual wages and benefits. In comparison, the construction industry pays out almost the same amount to all its workers but employs 200,000 workers in total. Therefore, construction workers must make around twice the wages as those in the retail sector per hour.

For our policy designs, an employment-based system would provide more of a rebate to the industries with a large number of relatively lower-paid employees (such as retail, food service, or accommodations). A payroll-based rebate would favor high-wage industries with relatively expensive and productive workers in industries such as management, information, finance, professional services, and manufacturing. The different nature of these two industry sets creates the results where employment, RDPI, and GSP move in slightly different directions. Much of the tradeoff is between increasing employment versus exports (which then leads to greater GSP).

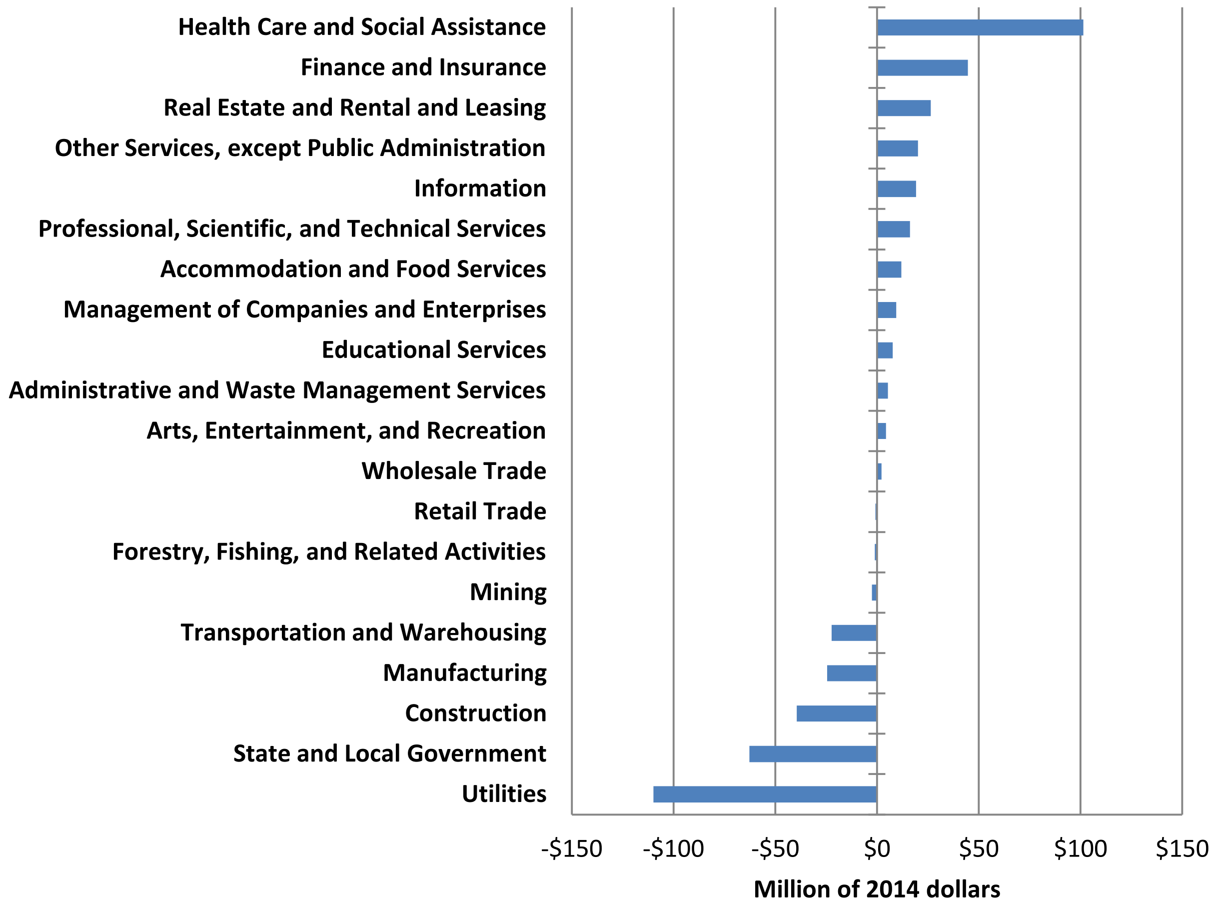
The employment-based rebate does the most to buttress localized and labor-intensive industries that create more jobs for the same number of dollars. However, these industries do most of their business within the state and do not export much to the rest of the world. For instance, it is difficult for a hotel in Springfield to service the market in distant cities such as Albany or Hartford.

The payroll-based system, on the other hand, favors industries with a relatively smaller number of high-skill and high-wage employees. These industries tend to compete on a national, regional, and international scale for market share and export much of their production outside of the state. The largest export industries in Massachusetts at present are professional services, electronics manufacturing, real estate management, and investment banking. These industries produce a bevy of export dollars and GSP, though their share of payroll goes to fewer workers who make higher wages. Consequently, favoring these sorts of industries with a payroll-based rebate helps to generate more GSP but not as many jobs or as much personal income as employment-based rebates.

Computers and electronics manufacturing[95] is the source of much of the difference. This industry employs 60,000 workers in Massachusetts (1.3% of the state's total employment) but produces $18 billion in GSP (4.0% of the total), around 7.8% of exports, and pays 3.6% of all wages. The significant difference between this industry's share of employment and payroll and it's competitive nature on the national and world markets means that it is sensitive to cost changes. With an employment-based rebate, the value added from computer manufacturing falls by $20 million due to the carbon tax. This is about 0.1% of the industry's total production value in the state, meaning that a carbon tax can cause significant swings in the industry's contribution to exports and GSP, though it does not have a large influence on the total level of employment in Massachusetts.

[95] "Industries in the Computer and Electronic Product Manufacturing subsector… manufacture computers, computer peripherals, communications equipment, and similar electronic products, and establishments that manufacture components for such products," <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=334&search=2012%20NAICS%20Search>

Figure IV.17: GSP by Industry, Change Versus Baseline – (5) MED, HH, PAY (2020)[96]



This is the change in the contribution of each major industry to GSP in 2020 with the HH and PAY revenue options. HH and IND are different from each other in terms of scale but not trends; hence, only HH is on display here. The top industries tend to benefit from the increase in consumer spending due to rebates, or because they are service industries with modest energy demands. The industries near to the bottom tend to be energy-intensive (such as manufacturing, construction, and government) or utilities and power generators.

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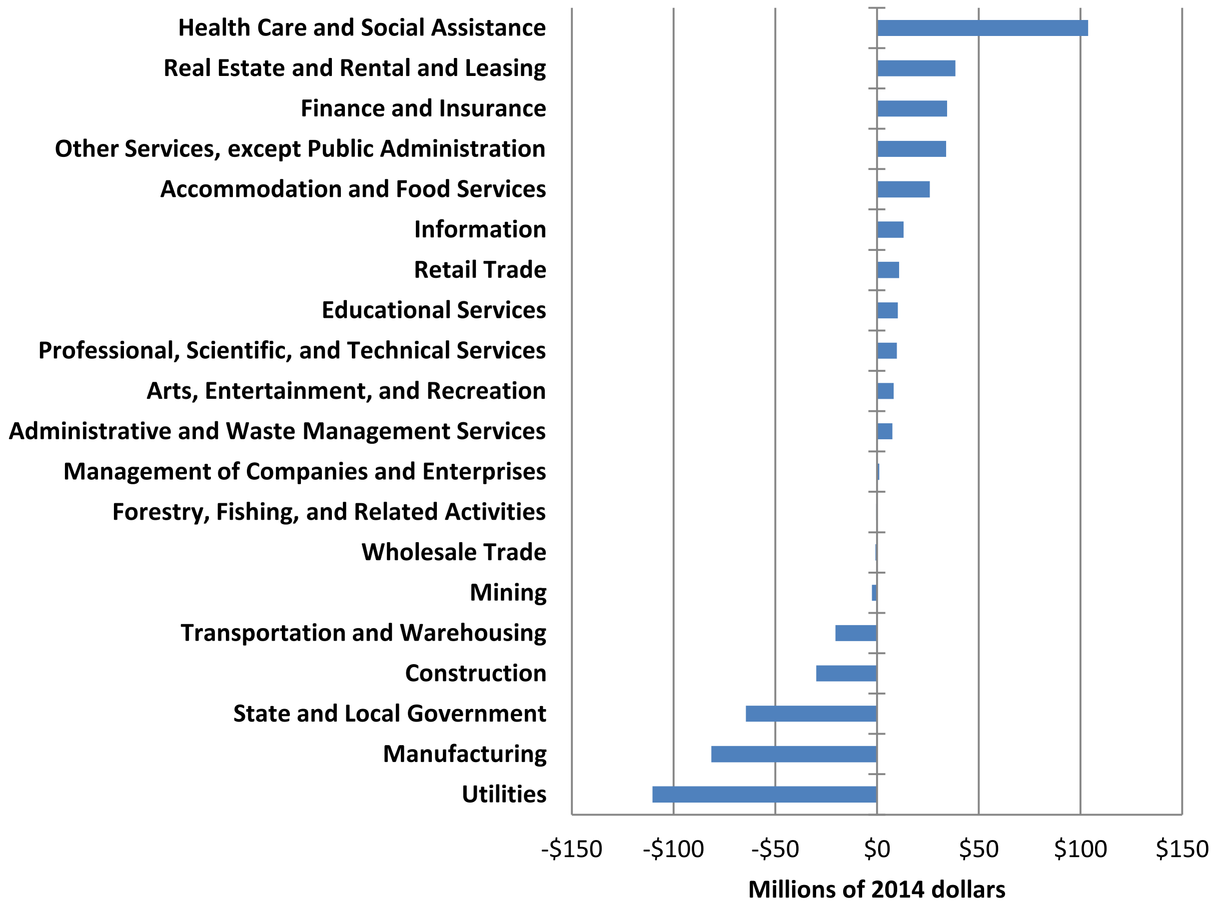
[96] "The main components of this sector are the publishing industries, including software publishing, and both traditional publishing and publishing exclusively on the Internet; the motion picture and sound recording industries; the broadcasting industries, including traditional broadcasting and those broadcasting exclusively over the Internet; the telecommunications industries; Web search portals, data processing industries, and the information services industries," <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=51&search=2012%20NAICS%20Search>

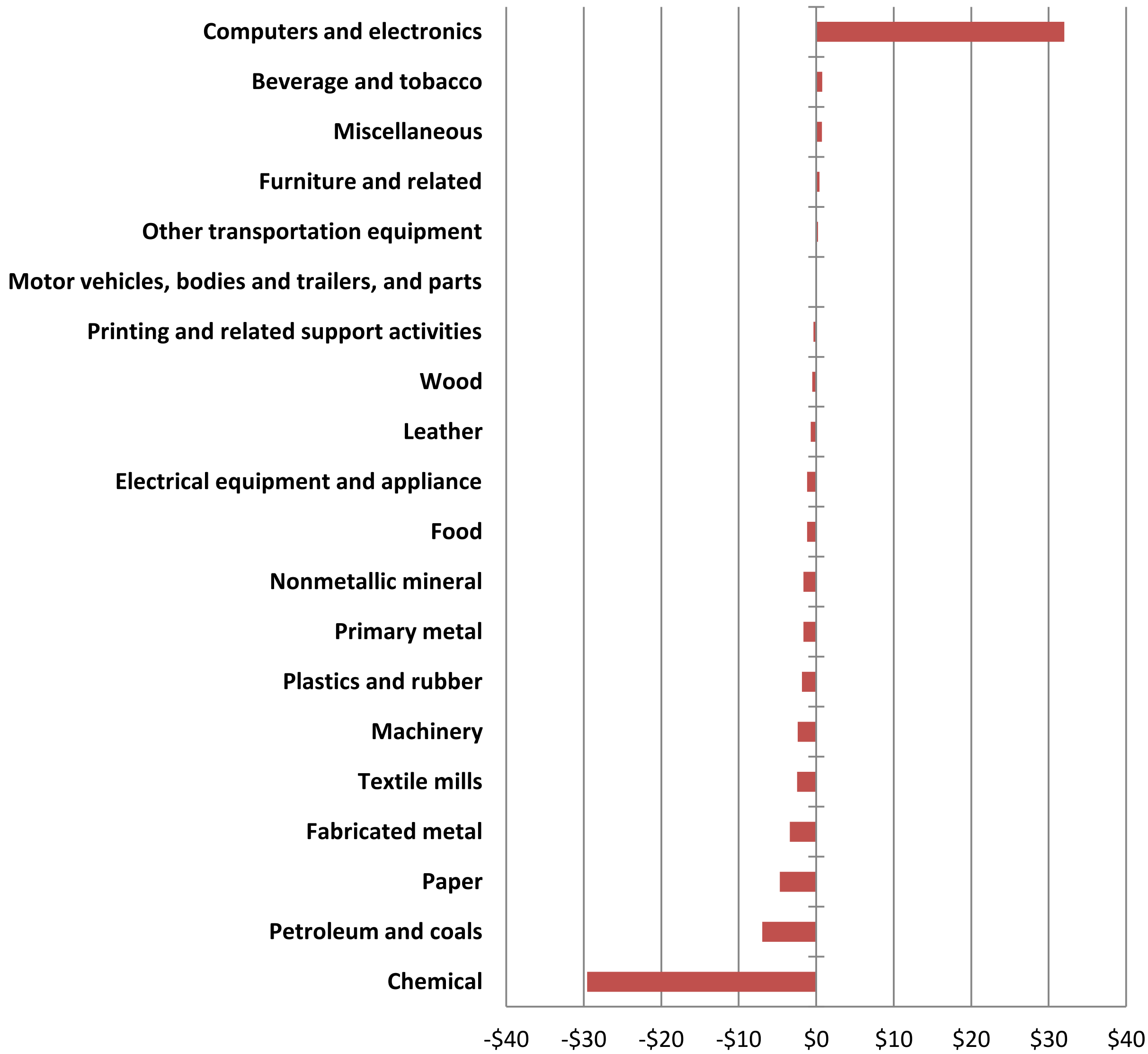
Figure IV.18: GSP by Industry, Change Versus Baseline – (6) MED, HH, EMP (2020)[97]



This differs from the previous figure in the manner described on the previous page. Labor-heavy industries such as other services, food service, and accommodation move up in the list while export-oriented industries (notably finance, insurance, and manufacturing) see their contribution to GSP fall relative to the figure above because of reduced market shares and exports. Both cases are still slightly positive, however, and these mixtures of industries create additional employment for the Commonwealth's economy taken as a whole.

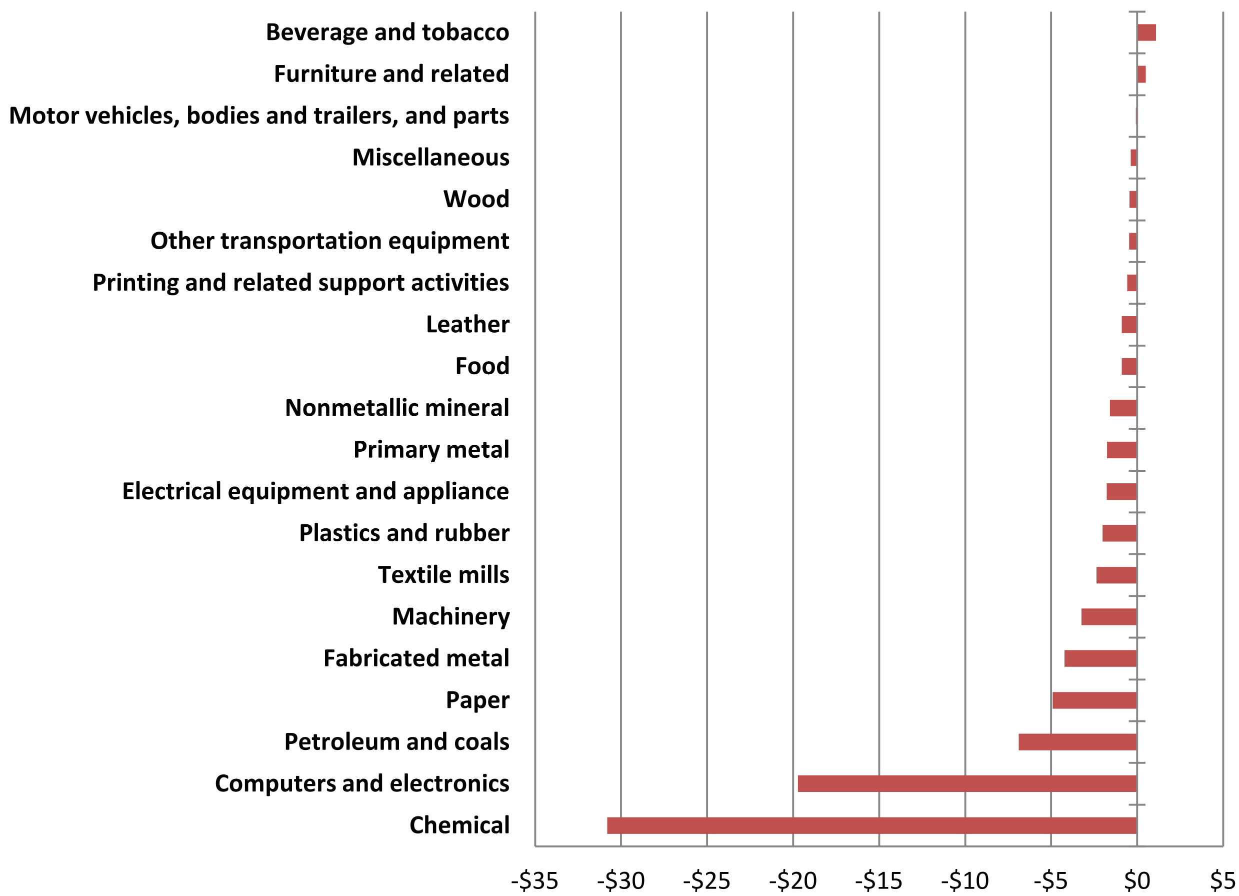
97 "Industries in the Social Assistance subsector provide a wide variety of social assistance services directly to their clients. These services do not include residential or accommodation services, except on a short stay basis," <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=624&search=2012%20NAICS%20Search>

Figure IV.19: GSP by Manufacturing Industry - (5) MED, HH, PAY (2020)



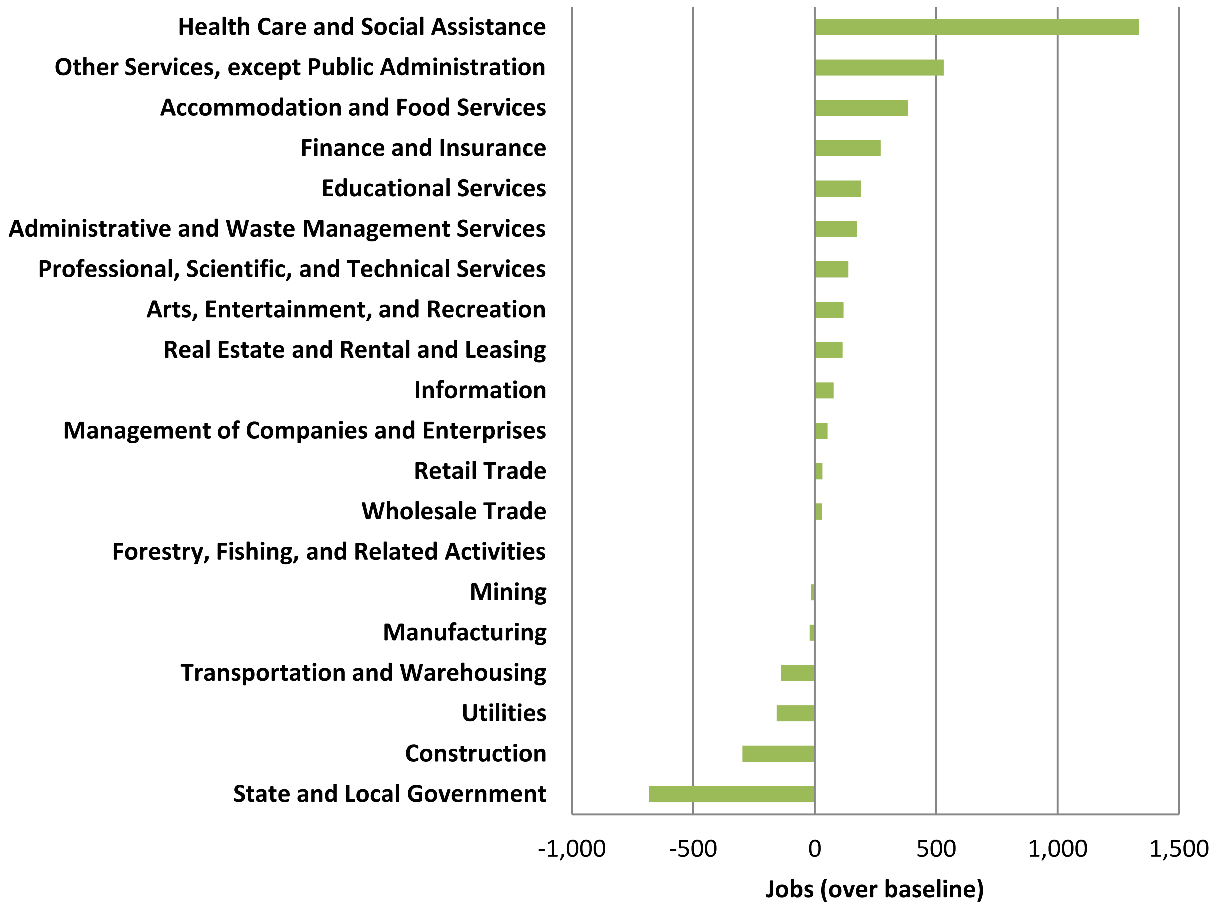
Most manufacturing sectors see little change in their contribution to GSP when revenue recycling comes from the share of payroll. There are two exceptions: (1) chemical manufacturing, which is somewhat energy-intensive; and (2) computers and electronics, which has market shares sensitive to costs. The small quantity of high-wage earners in computers and electronics yields a large rebate to that industry in case (5), which boosts its market share, exports, and the state's aggregate GSP results.

Figure IV.20: GSP by Manufacturing Industry – (6) MED, HH, EMP (2020)



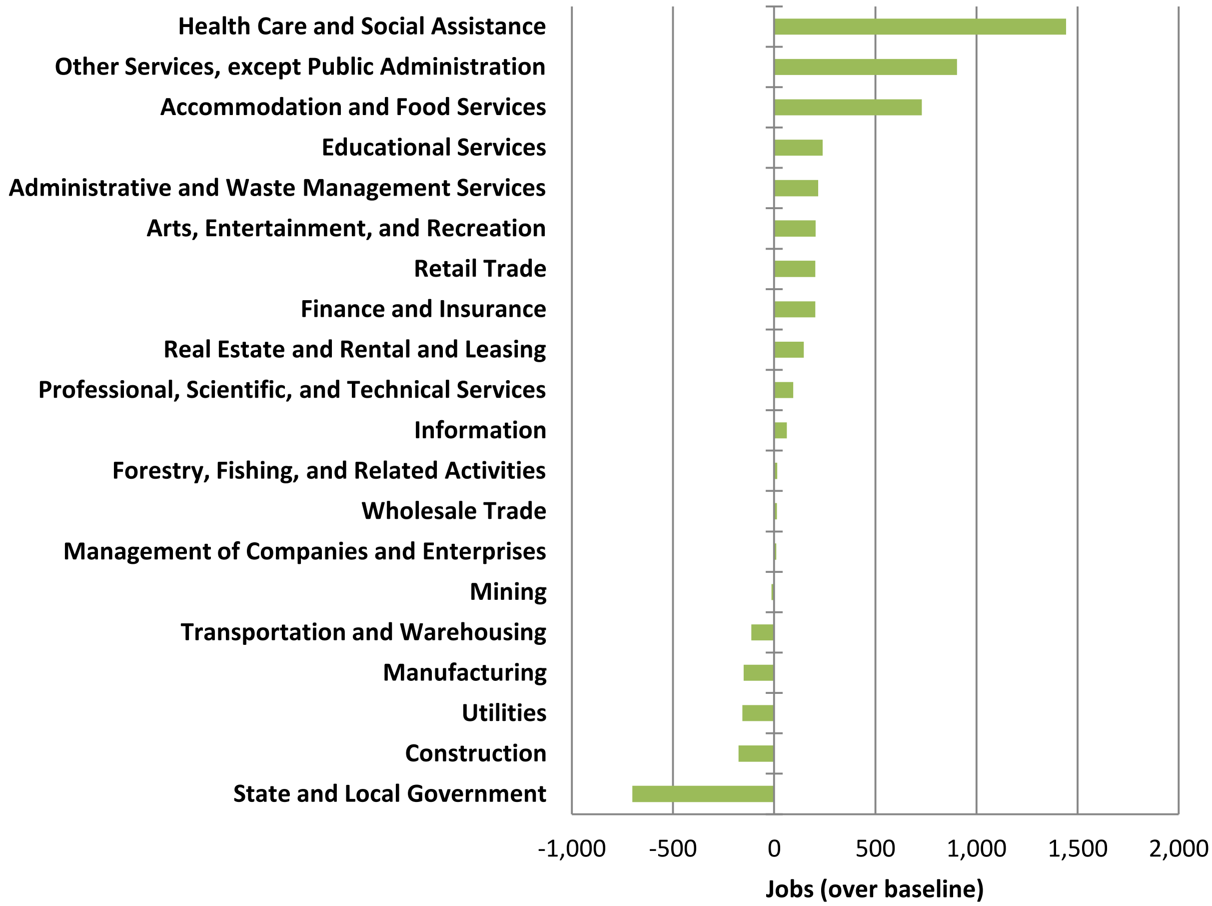
Sensitivity of computers and electronics manufacturing's market share to any change in its operating costs is a key issue here, as well. An employment-based rebate instead of payroll-based one means the industry receives less than 1.5% of the business/institutional rebate instead of more than 3%. That $25 million to $50 million difference, combined with the change in energy costs for the industry, causes its value added to fall by 0.5%, due to the technology sector's competitive nature, which explains these fluctuations in output.

Figure IV.21: Employment by Industry - (5) MED, HH, PAY (2020)



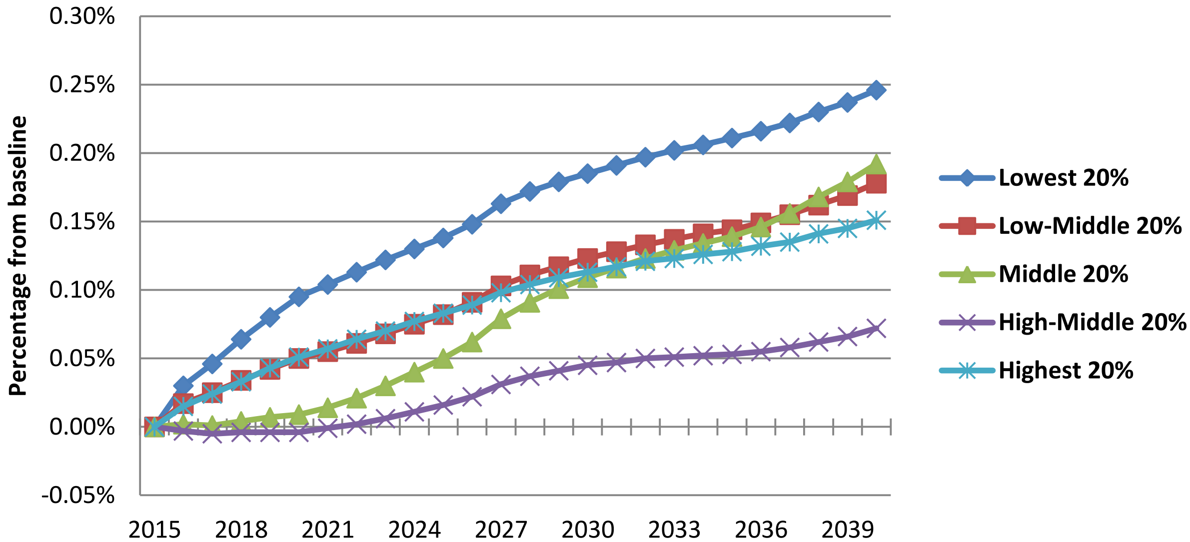
Many industries produce large quantities of dollars for GSP but do not require much employment to do so. Overall, under any of the revenue recycling scenarios, the carbon tax and rebates produce jobs in the localized, labor-intensive industries associated with more spending on staples in the state instead of on energy commodities. The net employment change for all industries combined is 2,100, relative to the baseline quantity.

Figure IV.22: Employment by Industry - (6) MED, HH, EMP (2020)



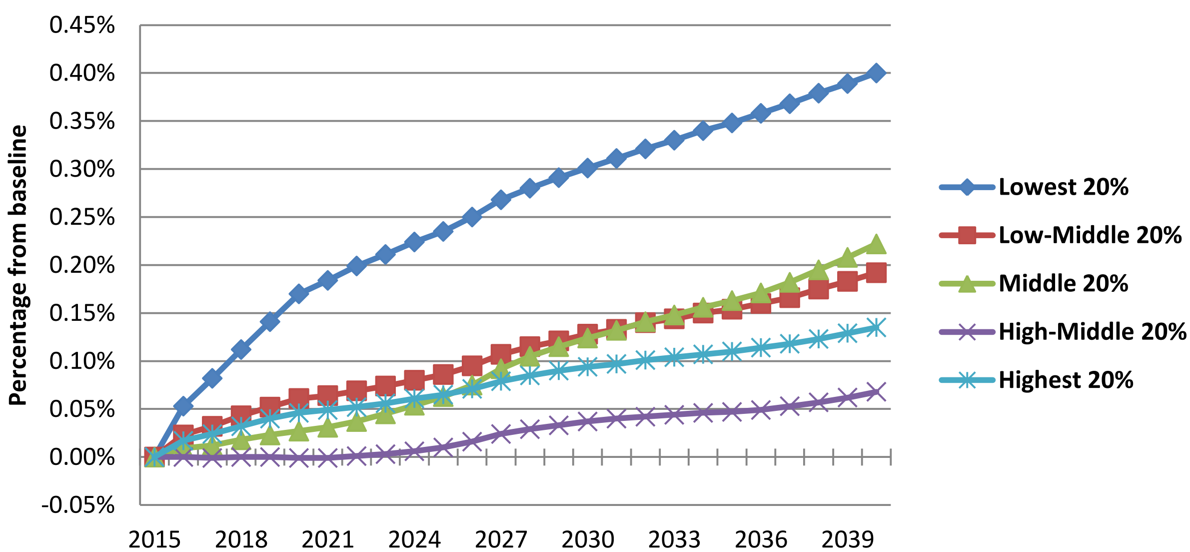
These results mirror those for PAY. On the other hand, EMP generates even more jobs in services, and the increased GSP in manufacturing and other industries on the previous graphs do not translate into many additional jobs because those industries rely mostly on technological and capital inputs instead of labor. Only a few industries see a decline in their overall employment, and those losses are not nearly enough to make up for the gains in the service firms at the top of the graph. The total number of jobs above baseline is 3,200.

Figure IV.23: Additional Jobs (%) by Income Quintile (5) MED, HH, PAY



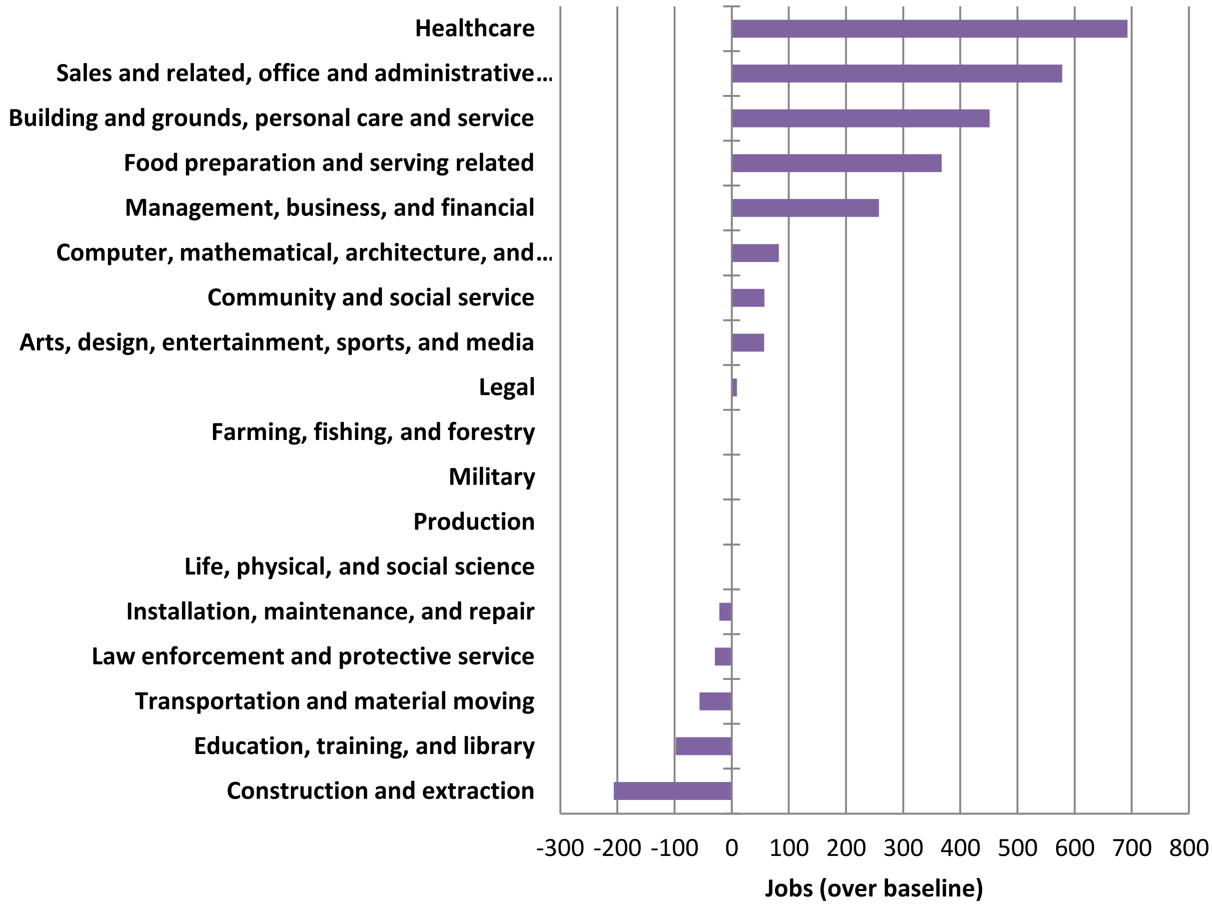
This graph shows the distributional impact of the macroeconomic model in terms of the number of jobs available at each wage quintile. After the simulation, a disproportionate number of the new jobs are in the lowest-paying 20%, with a large quantity of new jobs paying in the next 40% of wage levels. Moreover, all five quintiles gain jobs due to the carbon tax and rebates (with gains concentrated towards the bottom).

Figure IV.24: Additional Jobs (%) by Income Quintile (6) MED, HH, EMP



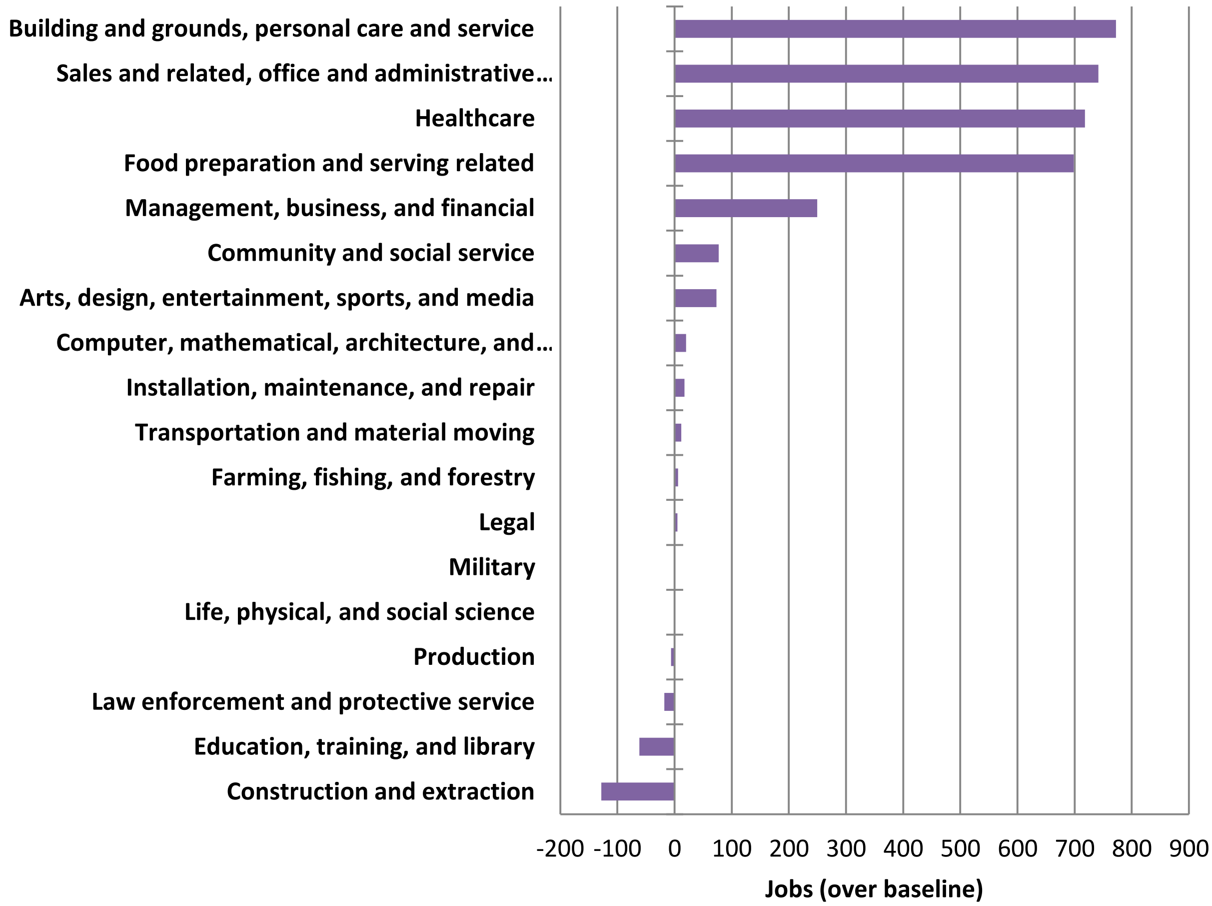
The difference in the distribution of jobs with EMP instead of PAY rebates is because an EMP-based system creates additional jobs for the workers with the lowest 20% of wage levels. The impact for the top 80% of wage earners is around the same between the two scenarios. This returns to the discussion of the industry mixture, where EMP-based rebates favor labor-intensive service firms. These firms produce a large number of jobs, but not as much in terms of personal income or additional GSP. Capital-intensive industries have fewer workers, but *ones who are highly paid and high-skilled. Such firms tend to drive exports and, by extension, GSP.*

Figure IV.25: Employment by Occupation – (5) MED, HH, PAY (2020)



This graph sorts the labor market information from previous figures by occupation instead of by industry. Occupations are the actual types of jobs, skills, and tasks performed by employees—a computer programmer could work for a manufacturer rather than an electronics company, but still be performing similar tasks, for instance. Most occupations gain employees under the carbon tax and rebate, save for a few related to construction and government, in particular.

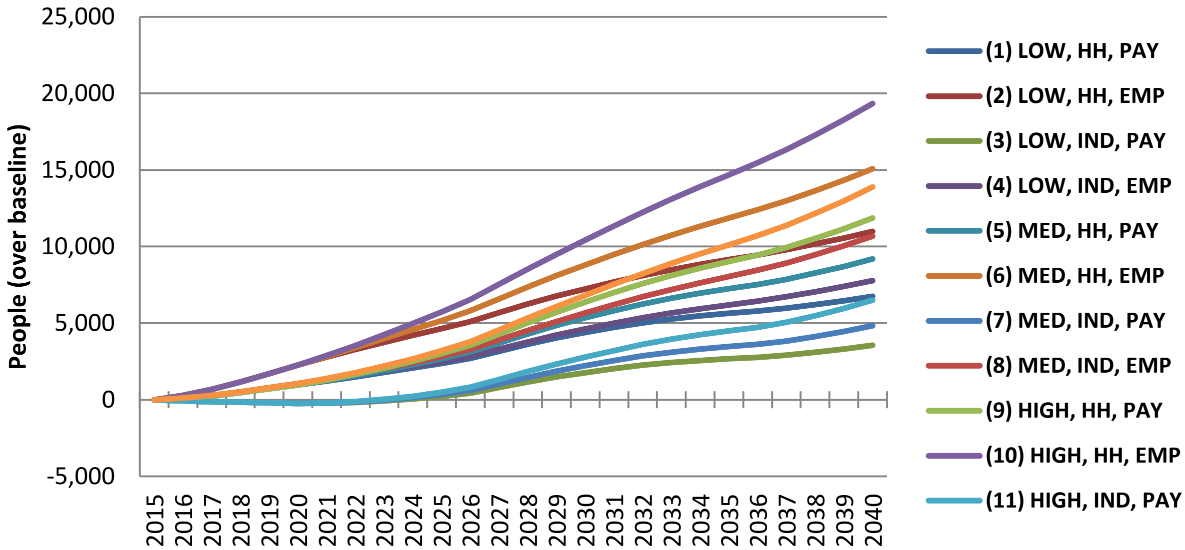
Figure IV.26: Employment by Occupation – (5) MED, HH, EMP (2020)



EMP tends to create more jobs overall than PAY. Using the EMP-based rebate means jobs in service sectors for the lowest 20% of income earners, which includes many of the occupational categories at the top of the figure. It also includes the generally middle-class occupations in healthcare, white-collar office work, and some business operations. Only a few occupations lose significant numbers of jobs.

F. Demographic Impact

Figure IV.27: Population



The population of Massachusetts increases with the increased availability of jobs and additional personal income in the state. The REMI model determines population based on fertility rates and "economic migration," which quantifies labor mobility within the United States in response to labor market conditions. The additional 1,000 to 3,000 jobs in 2020 due to the tax-and-rebate system reduce the unemployment rate, which draws thousands of people in search of work despite a higher cost of living when adjusting for energy prices. Labor moves mostly in family units that include spouses and children. Hence, even 2,000 "direct" jobs bring 4,000 or more people into the state (and their associated demand for housing, healthcare, education, entertainment, and other services).

G. Macroeconomic implications of exempting the electricity sector

As discussed in Section II of this study, at present the electricity sector is 18% of total emissions in Massachusetts and will yield a small fraction of total emission reductions, on the order of 3%, if it is part of the carbon tax/fee. The reasons for this include:

- Due to large-scale conversion from coal to natural gas, emissions from electricity generation in Massachusetts and New England have fallen greatly in the past few years;
- Partially for the same reason, electricity is a relatively low-carbon energy source in Massachusetts compared to coal, petroleum, or even natural gas;
- A larger fraction of the cost of electricity pays for non-fuel costs, including construction of power plants and transmission lines, than is the case for natural gas and petroleum products.

As a result of these facts, we stated in Section II that there are valid reasons why the state might choose not to include electricity generation in a carbon fee/tax. In light of that conclusion, in this subsection we provide the results from macroeconomic modeling with the electric sector excluded from the carbon charge.

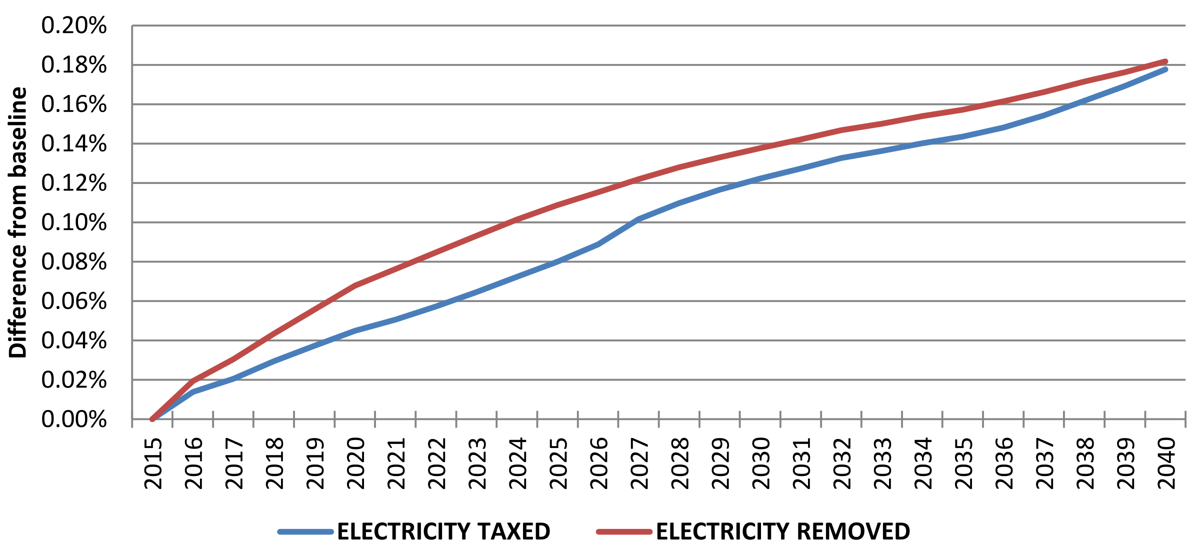
The electricity market is complex in New England, and Massachusetts' participation in RGGI, along with its other electricity-sector policies including energy efficiency programs and the RPS, mean that there are already several active policies addressing emissions from power generation in the state.

This section does not address the appropriateness of exempting the power sector or not, but it provides forecasts of the economic implications of including it or not. The results presented briefly here include impacts on employment and real disposable income. Impacts on carbon dioxide when electricity is excluded are given in Section V.

The results below are for a scenario with these characteristics:

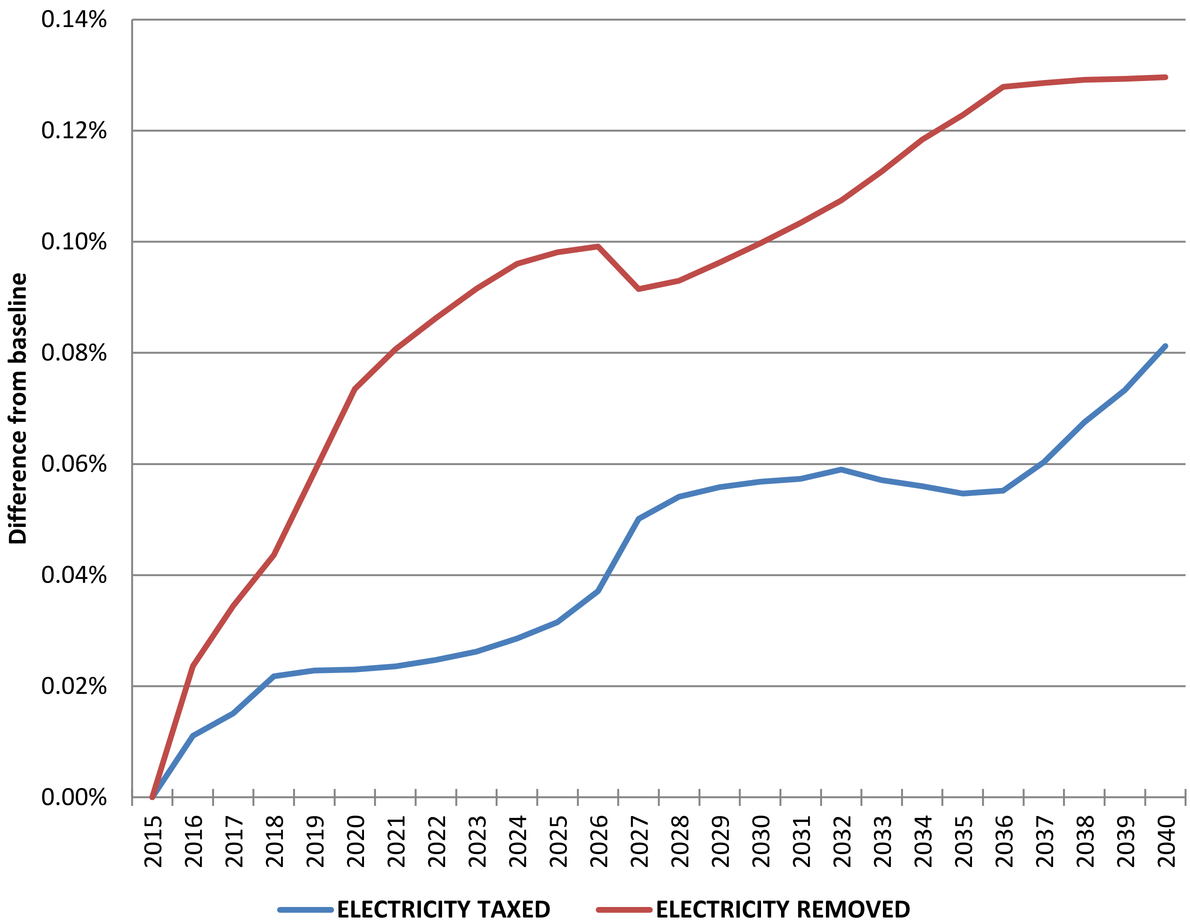
- a rebate to individuals and families based on equal payments per household
- a rebate for businesses and institutions based on their share of state employment.

Figure IV.28: Employment Changes as a Percent of Total State Employment, Electricity Sector Exempted



The figure above shows that removing electricity from the carbon pricing system results in slightly higher employment than including it. However, the difference is small in the context of the entire state economy, never more than approximately 0.02% of total state employment, or one job in every 5,000. Removing electricity creates slightly more jobs in the state because it boosts the computers and electronics industry. This industry has little demand for liquid and *gaseous fuels, but it is a relatively heavy user of electricity for its production processes. The industry is also very sensitive to changes in costs, because it operates on a competitive, global scale, and manufacturing operations can relatively easily move to other locations. Removing the presumed increase in electricity costs due to the carbon fee/tax boosts the computers and electronics industry's output, creates income, and generates the 0.02% difference in employment seen in Figure IV.28.*

Figure IV.29: Percent change in real disposable personal income compared to baseline with no carbon fee/tax, electricity sector exempted



Similarly to employment, this figure shows that real disposable personal income is slightly higher when electricity is removed from the carbon pricing system. The difference in the impact never totals more than 0.08% of the state economy in terms of personal income. The results above derive partially from an increase in the number of jobs and partially from a slightly lower cost of living, which thereby improves real income rates.

V. Carbon Dioxide Emissions

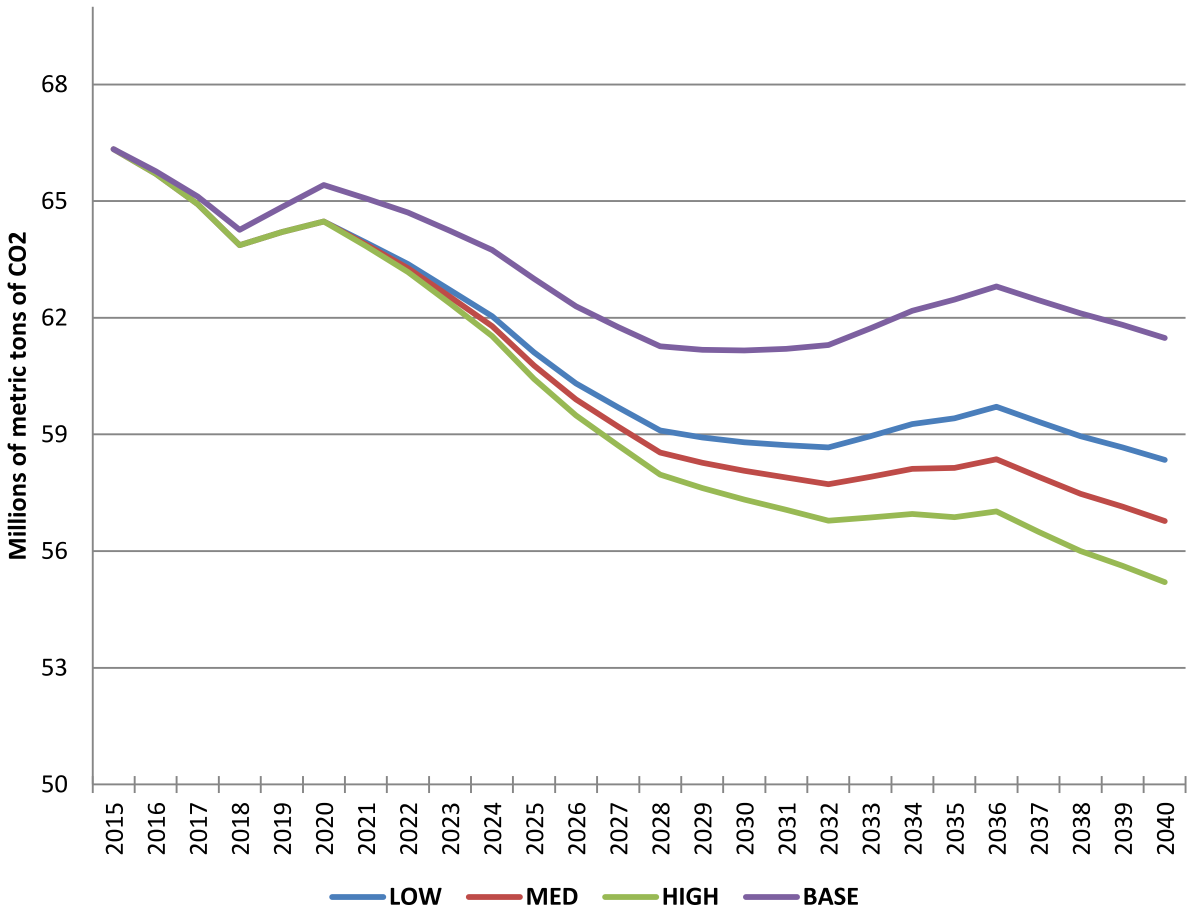
A. Emissions reduction estimates over time by scenario

In this section we discuss the changes in carbon emission that are attributable to the carbon tax. The results are only for the LOW, MED, and HIGH cases because the different revenue recycling options do not generate a significant difference in the eventual total of emissions. What does change the quantity of emission reductions is the carbon tax level. Emission savings are against a baseline (abbreviated BASE) in which the state extends existing policies for energy efficiency and renewable energy, but it does not place a price on carbon dioxide emissions. The BASE forecast derives from the Annual Energy Outlook (AEO) published by the U.S. Energy Information Administration (EIA), which accounts for current, explicit policies such as the renewable portfolio standard (RPS) and the emission limits under the Regional Greenhouse Gas Initiative (RGGI).[98]

However, the EIA forecast does not include long-term regulatory goals such as the overall emissions reductions required in Massachusetts' Global Warming Solutions Act (GWSA). Furthermore, the EIA baseline does not include any adjustments for regulations on carbon emissions from existing power plants recently proposed by the EPA. In all likelihood, however, the EPA regulations will not cause substantial reductions in emissions for the New England region due to the region's relatively low-carbon power sector compared to the rest of the eastern and central United States. Administrative and regulatory goals for carbon dioxide emissions without explicit policy actions to back them up—such as a carbon tax, renewable standard, or efficiency standard—do not factor into the EIA modeling, and therefore they do not show in the results here.

[98] Please see the RGGI homepage, <http://www.rggi.org/>

Figure V.1: Carbon Dioxide Emissions (annual forecast)



Carbon emissions in the CAT baseline fall, because the model assumes that current state policies for renewable power and energy efficiency are extended over time (but not expanded).[99] *The same is true for motor vehicle efficiency. The carbon tax in Massachusetts at the levels modeled would reduce state emissions by several million metric tons per year, with the precise number depending on the carbon tax rates implemented. The total savings, cumulative, over the time horizon above is 50 million metric tons for LOW, 66 million metric tons for MED, and 82 million metric tons for HIGH. These are savings equivalent to the emissions from the states of Nebraska, Arkansas, and Iowa, respectively, if they were not to emit for one year.*[100]

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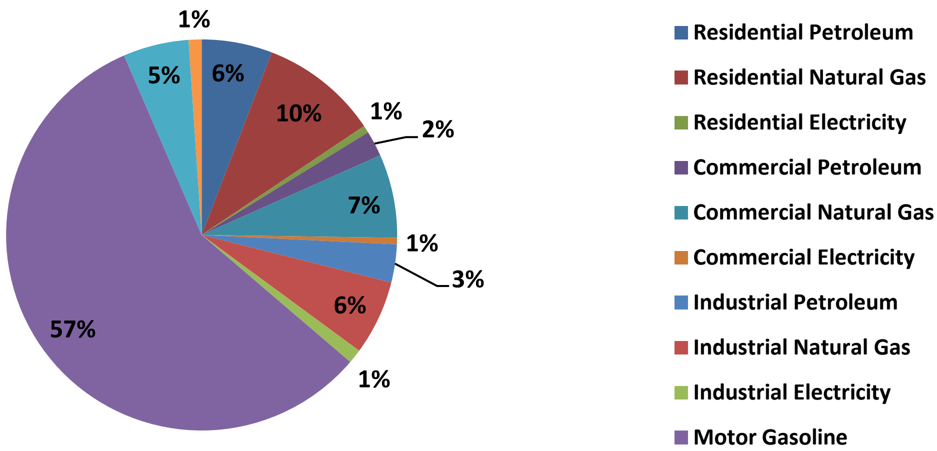
99 The calibration matches EPA data for emissions in 2013, though recent data (before an update to the AEO) reveal a slight drop in state emission relative to the model described here, please see, <http://epa.gov/statelocalclimate/documents/pdf/CO2FFC_2012.pdf>

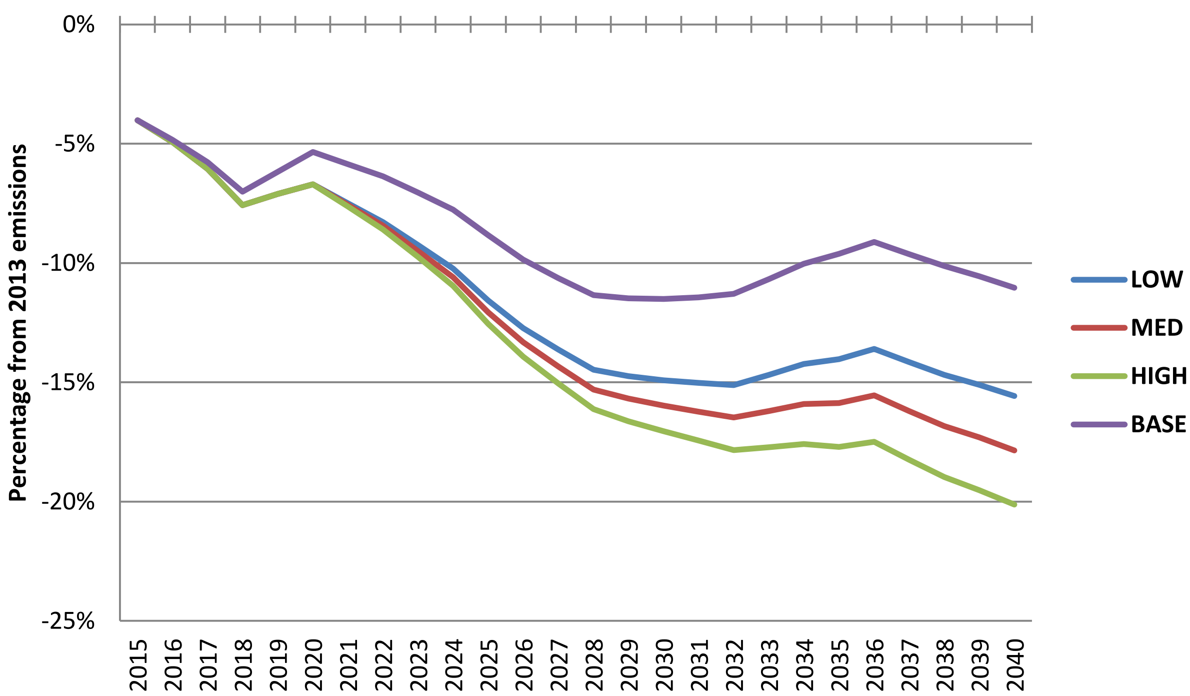
100 Ibid.

Figure V.2: Carbon Dioxide Emissions Savings by Source (2020)



This figure shows the share of emissions cuts from each fuel type. The percentages constitute a percentage of total cuts—not the cuts within any particular fuel type or industry sector. Thus, for example, the pie chart shows that reducing the burning of motor gasoline constitutes 57% of all emissions cuts in Massachusetts due to the carbon tax.

Figure V.3: Carbon Dioxide Emissions (percentage change from 2013)

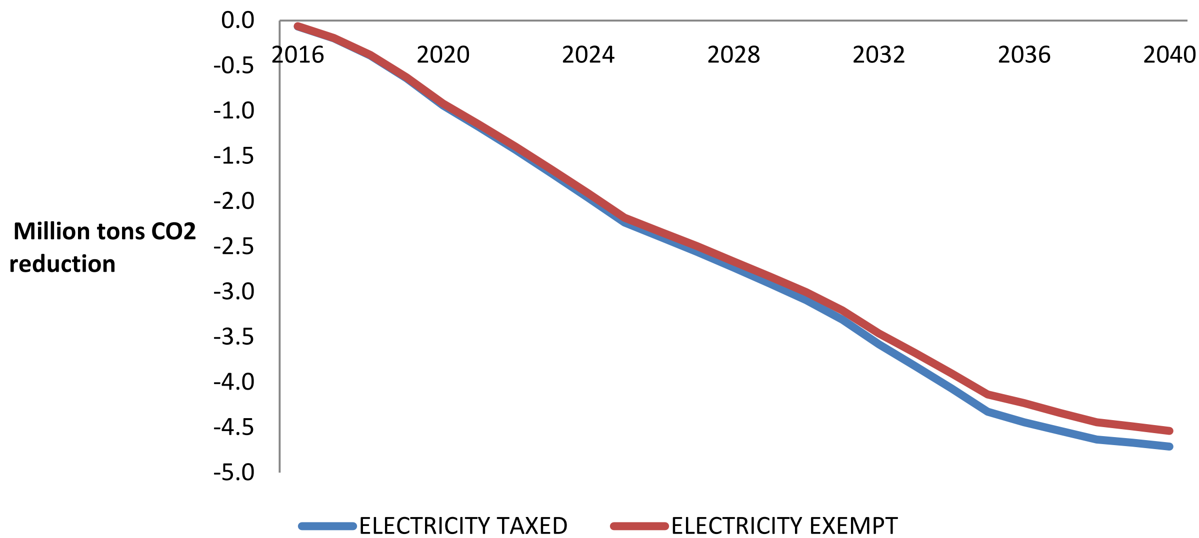


This graph benchmarks the emissions forecast from the previous figures to emissions from 2013. Current policies in the baseline scenario cut emissions by 10% to 11% over the next two decades against a growing economy and growing population. The LOW, MED, and HIGH scenarios reduce emissions by an additional 5% to 10% more by the 2020s.

B. Emission reductions with electricity sector excluded

In Section II of this study we discussed in detail the question of whether the carbon fee/tax should exempt the electricity sector. Here we show diagrammatically the effect that such an exemption would have on emissions savings.

Figure V.4: Electricity Sector Included or Excluded from Pricing System



This figure shows that there is a savings in total emissions by taxing electricity, but only a slight one. Electricity is currently only 18% of total state emissions and under the fee/tax electricity would only account for 3% of total savings. Hence, its exemption would not make more than a small difference in state emissions. New England also has a relatively carbon-light power mixture compared to the central United States, which lessens the impact of placing a carbon price on electricity. Finally, electricity is the least responsive energy source to changes prices (most inelastic) of the energy sources under study here.

C. Factors explaining the degree of emissions reductions

Several factors explain the degree of emissions reduction that the fee/tax yields, as described below.

The carbon tax relative to total energy prices

At $30 per metric ton, the tax is still only a small percentage of the retail price of each fossil fuel energy source. For residential sales of natural gas, for instance, the carbon tax would raise the EIA forecasted price to consumers by 12%. For gasoline, a $30 per ton carbon tax will raise the retail price at the pump by $0.27. This is a 7.7% increase in the price if the average retail price in the state is $3.50 (and 6.8% if the price is $4.00 per gallon).

Inelastic demand for fossil fuel energy

As discussed, gasoline, heating fuels, and electricity are products essential to modern life. Hence, the demand for these commodities is relatively insensitive to price increases, particularly in the short-term. The longer the time horizon, the more demand will fall as households and the group enterprises in the state are able to adjust their lifestyles, vehicles, machinery, and buildings to prices. Based on a number of research studies, the REMI model uses an estimate of -0.38 for the price elasticity of demand for residential sales of natural gas—meaning that when prices rise by 10%, demand falls by only 3.8% after ten years. For motor vehicle fuels, the demand elasticity over ten years is an estimated -0.67. For other petroleum products, the elasticity is -0.44 after ten years. For businesses, the price elasticity for natural gas is -0.38 after a decade. The price elasticity for electricity after ten years is -0.25.

Combining the relatively small price increases with inelastic demand results in moderate drops in carbon dioxide emissions

For natural gas, multiplying the 12% increase in its price by a demand elasticity of -0.38 yields an expected drop in demand for natural gas of 4.6% after ten years. Even a $100 per metric ton tax in 2040 raises residential natural gas prices by 29.3%, which yields an expected drop in total demand for the fuel of around 10%.

Massachusetts is already a relatively low-carbon dioxide state

Several long-term changes to the Commonwealth's economy have already reduced its emissions over time. Massachusetts' economy consists primarily of service and information industries, with only about 10% of total output from manufacturing. Our dominant industries are, for the most part, not energy-intensive, which also means that GHG emissions are relatively low compared to other states. In addition, although electricity generation is the largest source of emissions nationwide, in Massachusetts it is a small fraction of the total. This is both because we are not energy-intensive and because coal-fired generation in the state and in the rest of New England has declined sharply, in favor of natural gas fired generation. In addition, Massachusetts' energy policies have caused a substantial increase in use of electricity from renewable/low-carbon sources, such as biomass, wind, and solar power; and have supported both businesses and households in becoming more energy-efficient.

D. Significance of emission reductions

The data in *Figure V.2* shows that the carbon tax has most of its impact in reducing the demand for vehicular fuels. State efficiency programs do not cover this sector as much. Motor gasoline and diesel fuel make up half of projected carbon tax revenues and 62% of expected reductions in carbon dioxide emissions by 2020. For context, since 1998, emissions from power generation in the state have fallen by a dramatic 46% while emissions from vehicular fuels have risen slightly by 0.3%.[101] **An economy-wide carbon tax would begin to address transportation, which is now the state's largest source of carbon emissions.**

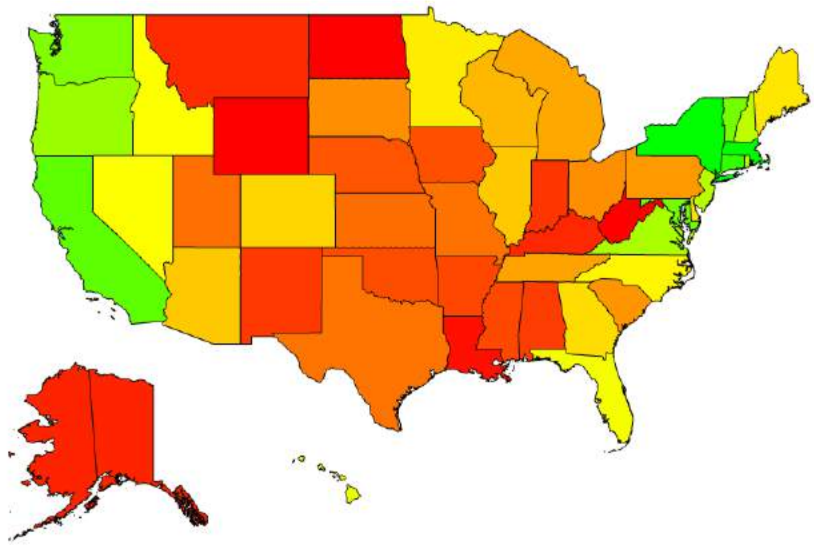
[101] Ibid.

Second, consider the larger economic context of recent years. Two main factors have caused the United States' level of carbon emissions to fall since its peak in 2005: the Great Recession and the drop in natural gas prices from increased supply. The latter is possible now due to the deployment of hydraulic fracturing. The Great Recession and the slow recovery since have reduced the size of the national economy, the number of people driving to work, and overall energy demand. The drop in natural gas prices encouraged the use of natural gas as a fuel for power generation. When not counting "fugitive" methane releases, natural gas emits around half the carbon dioxide for the same energy output as coal. Together, these two factors were enough to reduce carbon dioxide emissions in the United States by around 8.5% in five years.

The carbon taxes proposed in this report of $30 per metric ton in the 5th year and $50 to $100 per metric ton by 2040, depending on the size of the fee/tax, are enough to reduce emissions by 5% to 10%. **This is a large reduction in total emissions, exceeding all but one or two of the mitigation policies already in operation or planned for the state, and would contribute substantially towards meeting the state's long-term GHG reduction requirements.**

Figure V.5: Dollars of GSP for One Metric Ton of Carbon Dioxide (2013)

	A	B
1	District of Columbia	$43,665.52
2	New York	$ 7,749.31
3	Massachusetts	$ 7,020.82
4	Connecticut	$ 6,416.18
5	California	$ 5,893.74
6	Maryland	$ 5,643.01
7	Vermont	$ 5,615.06
8	Washington	$ 5,489.79
9	Oregon	$ 5,159.62
10	Virginia	$ 4,959.66
41	Arkansas	$ 1,792.92
42	Alabama	$ 1,656.50
43	New Mexico	$ 1,627.83
44	Indiana	$ 1,585.85
45	Montana	$ 1,448.47
46	Kentucky	$ 1,422.44
47	Alaska	$ 1,376.65
48	Louisiana	$ 1,136.35
49	North Dakota	$ 936.96
50	West Virginia	$ 843.43
51	Wyoming	$ 556.10



The heat map examines the carbon-intensity of the Massachusetts economy relative to other states. The Commonwealth already has the second most carbon-efficient economy of any state after New York. Existing state policies, the service-heavy industry mixture, and the lack of the heavy manufacturing, agriculture, mining, and power generation that tends to dominate the central and southern parts of the United States all contribute to this carbon-efficient economy in Massachusetts. With a national carbon tax program, prior research by REMI and Synapse Energy Economics has identified the power sector as the likely place for the initial large reductions to emissions. Hence, Massachusetts has already attained most of these savings and is working on the more difficult issue of reducing emissions from transportation and heating.[102] *The carbon tax proves an effective way to begin to address these issues without causing harm to the economy, employment, or real personal income.*

E. Conclusion

The revenue-neutral carbon tax described has a neutral-to-positive impact on the state economy while reducing carbon emissions to a significant degree—more than most of the mitigation policies implemented by Massachusetts to date. The tax yields additional jobs and income for households (either in total or per capita). Although GSP falls below the baseline in some scenarios, it is less meaningful as a measure of economic well-being compared to employment and income. The macroeconomic improvements under a revenue-neutral carbon tax mainly result from two factors:

[102] Scott Nystrom and Patrick Luckow, "The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax," June 9, 2014, *Citizens' Climate Lobby* (CCL), <http://citizensclimatelobby.org/remi-report/>

1. A reduction in energy imports to the state, which causes more money to flow to the state's other industries
2. The rebates tend to provide jobs to localized, labor-intensive industries in the state, which creates more jobs and income

Carbon emissions fall by 5% to 10% of current projections depending on the size of the tax. This is a large reduction in total emissions, exceeding all but one or two of the mitigation policies already on the books or planned for the state, and would contribute towards meeting the state's long term legislative reduction requirements.

F. Technical References

Longer, technical documentation is on the REMI website as well as in the studies of carbon in the REMI PI+ model. Those studies were for Massachusetts in 2013,[103] the state of Washington, King County in Washington (which contains Seattle and Bellevue),[104] California,[105] and the United States divided into nine regions.[106] The equations in PI+ are peer-reviewed and available to the public.[107] The publications by REMI's founder, Dr. George I. Treyz, and his team have appeared in the *Journal of Regional Science*,[108] the *Review of Economics and Statistics*,[109] and the *American Economic Review*.[110] The data inside PI+ comes from public data agencies such as the BEA, BLS, EIA, U.S. Census, the U.S. Department of Defense, the U.S. Department of Education, and other sources.[111] Trends in the macroeconomic portion of the model are from the

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[103] Scott Nystrom and Ali Zaidi, "Modeling the Economic, Demographic, and Climate Impact of a Carbon Tax in Massachusetts," *Committee for a Green Economy* (CGE), July 11, 2013, <http://etr-us.org/wp-content/uploads/2014/01/REMIma.pdf>

[104] Scott Nystrom and Ali Zaidi, "The Economic, Demographic, and Climate Impact of Environmental Tax Reform in Washington and King County," *Environmental Tax Reform* (ETR), December 13, 2013, <http://etr-us.org/wp-content/uploads/2014/01/etr-wa-remi-dec-13-2013.pdf>

[105] Scott Nystrom and Ali Zaidi, "Environmental Tax Reform in California: Economic and Climate Impact of a Carbon Tax Swap," *Citizens' Climate Lobby* (CCL), <http://citizensclimatelobby.org/wp-content/uploads/2014/03/Environmental-Tax-Reform-in-California-Economic-and-Climate-Impact-of...-1.pdf>

[106] Scott Nystrom and Patrick Luckow, "The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax," June 9, 2014, *Citizens' Climate Lobby* (CCL), <http://citizensclimatelobby.org/remi-report/>

[107] For the full PDF of model equations, please see, <http://tinyurl.com/l2nbgn2>

[108] Dan S. Rickman, Gang Shao, and George I. Treyz, "Multiregional Stock Adjustment Equations of Residential and Nonresidential Investment in Structure," *Journal of Regional Science*, Vol. 33 (2), 1993, pp. 207-2019

[109] George I. Treyz, Dan S. Rickman, and Michael J. Greenwood, "The Dynamics of U.S. Internal Migration," *Review of Economics and Statistics*, Vol. LXXV, No. 2, May 1993, pp. 209-214

[110] Please see, <http://cas.umkc.edu/econ/economics/faculty/eaton/Eaton_main/Article%2018.pdf>

[111] For a full accounting of the data sources and estimation procedures in the REMI model, please see, <http://www.remi.com/download/documentation/pi+/pi+_version_1.6/Data_Sources_and_Estimation_Procedures.pdf>

BLS forecast and the Research Seminar in Quantitative Economics (RSQE) at the University of Michigan-Ann Arbor.[112] Other applications of the REMI model in the energy sphere include the aforementioned carbon tax studies at the state level and integration with CTAM. It is also possible to integrate REMI with other models besides CTAM, ReEDS, and CAT, including power grid models such as GPCM®[113] or IPM,[114] or travel-demand models (TDMs) such as TransCAD and Cube Voyager.[115] PI+ provides a flexible framework with a plethora of variables to make this level of integration typical between different dynamic frameworks.

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[112] Their homepage on the Michigan and American economies is here, <http://rsqe.econ.lsa.umich.edu/>
[113] Scott Nystrom and Robert Brooks, "The Macroeconomic Impact of LNG Exports: Integrating the GPCM Natural Gas Model and the PI+ Regional Model," *United States Association for Energy Economics* (USAEE), presented at the annual conference 2012 in Austin, Texas, <http://www.usaee.org/usaee2012/submissions/Presentations/RBAC%20REMI%20LNG%20pdf.pdf>
[114] Please see, <http://www.rggi.org/docs/ProgramReview/February11/13_02_11_REMI.pdf>
[115] Described in the appendix of the TranSight documentation, please see, <http://www.remi.com/download/documentation/transight/transight_version_2.1/TranSight_User_Guide_and_Model_Doc_v2.1.pdf>

Appendices

Appendix A: Glossary

Additionality
Emissions reductions achieved through a given project over and above those that would otherwise have occurred in the absence of the project under a business-as-usual scenario. (that is there is no double counting of things that would have happened naturally or as a result of another government policy)

Aggregator
An aggregator is a wholesale buyer or broker of a utility service.

Allowance
A government issued authorization to emit a certain amount. In greenhouse gas markets, an allowance is commonly denominated as one ton of COe2 per year. The total number of allowances allocated to all entities in a cap and trade system is determined by the size of the overall cap on emissions.

Annual Fuel Utilization Efficiency (AFUE)
A measurement of efficiency for heating appliances. This laboratory-based figure accounts for chimney losses, equipment jacket losses, and cycling losses, but does not include distribution losses or fan/pump energy.

AVEO
Avoided Energy Output

Base Load
A utility's base load is the average amount of electric power that the utility must supply in any period of time.

Baseline
The target, usually the historical emissions from a designated past year, against which emission reduction goals are measured. In Massachusetts, the designated base year is 1990.

Benchmarking
An allowance allocation method in which allowances are distributed by setting a level of permitted emissions per unit of input or output.

Bid stack
Generators make day-ahead bids based on production costs. They are arranged by price (merit order) to form the bid stack, Spot price (market clearing price) is set by finding highest bid needed to match demand.

Biomass
Biomass is carbon-based, biological, non-fossil material that can be used as fuel.

British Thermal Unit (Btu)
A Btu (or BTU) is the amount of heat required to raise the temperature of 1 pound (0.454 kg) of liquid water by 1°F (0.56°C) at a constant pressure of one atmosphere. A Btu can be approximated as the heat produced by burning a single wooden match.

BAU or Business as Usual
The conditions we would expect in a future year without changing existing policies or regulation or market framework.

Cap and Trade
A system designed to limit and reduce emissions. Cap and trade regulation creates a single market mechanism as opposed to a command and control approach that prescribes reductions on a source-by-source basis. Cap and trade regulation sets an overall limit on emissions and allows entities subject to the system to comply by undertaking emission reduction projects at their covered facilities and/or by purchasing emission allowances (or credits) from other entities that have generated emission reductions in excess of their compliance obligations.

Capacity
Electric capacity is the ability of a power plant to produce a given output of energy at a specific instant in time. This output is measured in kilowatts or megawatts.

Carbon Dioxide (CO_2)
Carbon dioxide is a colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere. Fossil-fuel combustion produces more of it than would naturally occur. It is considered a greenhouse gas as it traps heat radiated by the Earth, warming the globe.

Carbon Tax
A surcharge on the carbon content of fossil fuels that aims to charge the cost of the emissions to the atmosphere, increase prices and thereby discourage any wasteful use of the fossil fuels, thus reducing carbon dioxide emissions.

CH_4
Methane

CO_2e
Carbon Dioxide equivalent, describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP) when measured over a specified timescale (generally, 100 years).

Command and Control
A system of regulation that prescribes emission limits and compliance methods on a facility-by-facility or source-by-source basis and that has been the traditional approach to reducing air pollution.

Demand Response-Induced Price Effect (DRIPE)
Demand response-induced price effect occurs when demand is curtailed and the highest-priced peaking plants are at the far end of the order of electricity dispatch. The order in which the electricity is dispatched drives down the market price for all consumers—not just the ones who reduce their electricity use.

Demand Response (DR) Programs
Demand response programs are incentive-based programs that encourage electric power customers to temporarily reduce their demand for power at certain times, in exchange for reductions in their electricity bills. The demand may be reduced by either customers or utilities.

Demand Resources
Demand resources consist of any energy-supplying resources that can be used to provide electric power service. These resources may include fossil-fuel, hydroelectric, or nuclear power plants; distributed renewables; energy efficiency; or other sources of power generation and electricity storage.

Demand Side Management (DSM)
Demand-side management involves utility-sponsored activities designed to save electricity or gas in ways that will produce desired changes in the utility's load graphs. The ultimate goal of demand-side management for most utilities is to avoid the need to invest in new power plants or other equipment.

Distributed Generation (DG)
Distributed generation generates electricity from many small energy sources.

EIA
US DOE Energy Information Administration

Electric Industry Restructuring
Electric industry restructuring is the process of replacing a monopolistic system of electric utility suppliers with competing sellers, allowing individual retail customers to choose their supplier but still receive delivery over the power lines of the local utility.

Electric Grid
An electric grid is a network of shared electric power. Generators feed power into a regional grid; energy is drawn from it on an as-needed basis. Electric power plants consume about 3.3

kilowatt-hours' worth of fuel for every 1 kWh that reaches your home. The rest is lost as heat during generation and as transmission losses through wires.

Feed-in Tariff
This tariff involves set payments for renewable energy project output over a specified number of years. It provides solar, wind and other alternative energy project developers with financial security. Feed-in tariffs can include subsidies. They also include public, standard contract terms.

Forward Capacity Market
The Forward Capacity Market is the market New England uses to procure enough capacity to meet New England's forecasted demand plus reserves approximately three years in advance. Using an auction to achieve the optimal level of supply, the market attracts owners of new generation and demand resources by compensating them for the capacity they produce during peak and shortage events.

Fossil Fuels
Fossil fuels are derived from biological material that has been compressed underground. These fuels include coal, oil and natural gas. There is a limited supply of these resources, and those that were most accessible have already been collected and used.

GHG
Greenhouse Gases

Greenhouse Gases (GHGs)
Greenhouse gases are gases in the atmosphere that contribute to warming the planet by trapping heat energy. The most prevalent of these gases is carbon dioxide, which is released in large quantities when fossil fuels are burned.

Grid
A grid is the layout of an electrical distribution system; a system of interconnected power lines and generators. The system is managed so that electricity is dispatched as needed to meet the requirements of connected customers.

GSP
Gross State Product

HCFCs
Hydrochlorofluorocarbons (HCFCs) are manmade refrigerants commonly found in appliances. They can release chlorine and bromine in the upper atmosphere, eroding Earth's life-preserving ozone layer. Many countries have successfully banned production of HCFCs.

Independent System Operator (ISO)
An independent system operator is a neutral organization – not affiliated with any generation,

transmission or distribution company – that operates, coordinates, controls and monitors and maintains an hour by hour balance of the transmission grid system in a manner that ensures reliable and fair transfers of electricity between generators and distribution companies. Massachusetts is a part of the ISO that covers all of New England.

Investor-Owned Utility (IOU)
An investor-owned utility is a utility owned and operated by private investors, as distinct from a community-owned or cooperatively-owned utility.

Kilowatt-Hour (kWh)
kWh is a measurement that appears on your electric bill to show your usage. One thousand watt-hours equal one kWh. A typical United States household uses approximately 27,022 kilowatt-hours of electricity per year. Ten 100-watt incandescent bulbs lit for one hour consume one kWh of energy.

Leakage
Leakage occurs when activities that reduce greenhouse gas emissions in one place and time result in increases of emissions elsewhere or at later times. For example, a steel firm in a country covered by a state regulation makes reductions by closing one facility and replacing its output with production from a steel plant operating in another state that does not have a GHG constraint.

LCOE
Levelized cost of electricity (LCOE) is often cited as a convenient summary measure of the overall competiveness of different generating technologies. It represents the per-kilowatt hour cost (in real dollars) of building and operating a generating plant over an assumed financial life and duty cycle.

Liquefied Natural Gas (LNG)
Liquefied natural gas is natural gas (primarily methane) that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure. It must be maintained at a low temperature to remain liquid.

Load
Load is the amount of electric power required at a specific time, or over a specific period of time, by a consumer, circuit, or electric company system. On a household level, the electric load is the combined total of the energy used by all electrical devices and lights in a home.

Load-based system
A system in which the covered emitters are electricity retailers responsible for all the emissions associated with the generation of the electricity that they provide to customers, including electricity imported from other states.

Load Management
Load management consists of utility activities designed to influence the timing and amount of electricity customers may use. This is the responsibility of transmission system operators. When system load approaches maximum generating capacity, operators must either find additional supply or find ways to curtail the load in order to prevent blackouts.

LSE
Load Serving Entity, the general industry term for what most people would call a utility, or an electric company. Since there are different types of electric companies, the general term LSE covers all of the different types.

LDC
Local distribution company for retail gas or electricity delivery.

Local Distribution Company (LDC)
A local distribution company is a gas company that earns profits through distributing gas locally, not through its purchase and resale.

Megawatt (MW)
A megawatt is equal to one million watts of electric power. This unit is most often used to describe the capacity of a power plant.

Microgrid
A microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operate connected to a traditional centralized grid (macrogrid). Microgrid generation resources can include fuel cells, wind, solar, or other energy sources. A microgrid's point of linkage with the macrogrid can be disconnected for autonomous functioning. From the grid operator's perspective, a connected microgrid can be controlled as if it was one entity.

MMtCO_2e
Million Metric tons of carbon dioxide equivalent

Non-Utility Supplier
A non-utility supplier is a company other than a utility that provides natural gas or electricity. These companies are also known as "independent power producers."

Net Metering
Net metering is an agreement between a solar electricity system owner and the local electric utility that allows the system owner to buy and sell energy in the form of electric credits. When the solar system produces excess energy, the electric utility buys it at peak prices, literally causing the electric meter to spin backward. When the system is not producing energy, the

system owner can use the credits to buy back energy at off-peak prices. Net metering may also be utilized by wind, combined heat and power, or other onsite distributed generation projects.

Nitrogen Oxides (NO_x)
Nitrogen oxides are a family of poisonous, highly reactive gases. These gases form when fuel is burned at high temperatures. NO_x pollution is emitted by automobiles, trucks, and various non-road vehicles as well as industrial sources such as power plants, industrial boilers, cement kilns, and turbines. NO_x often appears as a brownish gas. It is a strong oxidizing agent and plays a major role in the atmospheric reactions with volatile organic compounds that produce smog on hot summer days.

Off-Peak
Off-peak periods are times when demand for electric power is low.

Off-Grid or Off-the-Grid
An off-grid electricity-generating system operates independently from the utility grid, providing all of the electricity needed at one location.

Peak Demand/Load
Peak demand or peak load is the maximum energy demand or load in a specified time period. Peak demand usually occurs on hot summer days. Residential and commercial air conditioning can require about 40 percent of total electric capacity during peak periods.

Photovoltaics (PV)
A method of generating electrical power by converting sunlight into direct current electricity using semiconducting materials that exhibit the photovoltaic effect. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power

Power Purchase Agreement
A power purchase agreement is a contract between two parties, one who generates electricity for the purpose (the seller) and one who is looking to purchase electricity (the buyer). The company covers the full cost of installing and maintaining an electricity-producing system. In return, the customer agrees to buy the power produced by the system. This allows building owners to pay for power gradually rather than making one large upfront payment.

Regional Greenhouse Gas Initiative (RGGI)
The Regional Greenhouse Gas Initiative (RGGI) is the first market-based regulatory program in the United States to reduce greenhouse gas emissions. A cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont, RGGI is designed to cap and reduce CO_2 emissions from the power sector and to use a portion of the allowance revenues to implement energy efficiency programs. States sell nearly all emission allowances through auctions and invest proceeds in energy efficiency, renewable energy, and other consumer benefit programs. These programs are spurring

innovation in the clean energy economy and creating green jobs in the RGGI states. In 2012, RGGI states implemented a new 2014 RGGI cap of 91 million short tons and a 2.5 percent each year from 2015 to 2020. The RGGI CO_2 cap represents a regional budget for CO_2 emissions from the power sector.

REC

Renewable Energy Certificate - represents the property rights to the environmental, social, and other non-power qualities of renewable electricity generation. RECs are tradable units that represent the commodity formed by unbundling the environmental attributes of a unit of renewable energy from its underlying electricity. The REC market is driven mostly by Renewable Portfolio Standards.

ReEDS

ReEDS (Regional Energy Deployment System) is a model built by the National Renewable Energy Laboratory (NREL) and run by Synapse Energy Economics, Inc. from Cambridge, Massachusetts. The ReEDS model is a national model of power generation in use (such as coal, gas, nuclear, wind, or solar) in different parts of the country and the predicted shifts that exist after implementing a policy or practice, in this case, a carbon tax.

Renewable Portfolio Standard (RPS)

Renewable Portfolio Standards are state-based requirements that a certain amount of total annual electricity sales from each retail generator must be derived from renewable sources. Also known as the Renewable Electricity Standard (RES), in some states.

Smart Grid

A smart grid is an intelligent electric power system that regulates the two-way flow of electricity and information between power plants and consumers.

Sulfur Dioxide (SO_2)

Sulfur dioxide is the chemical compound with the formula SO_2. At standard atmospheric pressure, it is a toxic gas with a pungent, irritating and rotten smell. It is released naturally by volcanic activity and is a potent global warming gas.

Supply Curve Bid

Supply Offer and Demand Bid refer to all information submitted by participants related to the price, quantity, technical parameters and timing of Supply Offers and Demand Bids to provide specific services in the Real-Time Market.

Transmission

Transmission, in the utility industry, is the process of transporting high-voltage electricity from the generation points to distribution facilities. These facilities deliver the electricity at low voltage levels to end users.

Updating: A form of regulation in which taxes or allocations are reviewed and changed over time and/or awarded on the basis of changing circumstances (such as output) rather than historical data (such as emissions, input or output). For example, allowances might be distributed based on megawatt-hours generated or tons of a product manufactured. Taxes might be assessed based on percentage progress.

Upstream system: An upstream approach to a cap and trade system matches the point of regulation with the point of entry of fossil fuels into commerce within the covered region.

Appendix B: Literature Review -- Experience with Carbon Taxes and Relevant Analytical Literature

A literature review was conducted to examine relevant academic articles and other sources on carbon tax issues, especially concentrating on places where carbon taxes have been implemented to illuminate possible applicable lessons. Here are some of the findings from that part of the study:

What factors did the other governments consider when setting carbon taxes?

i. **To set a price on carbon, creating an inventive for efficiency and lower carbon renewables.** Several places cited that since the ongoing use of the global atmosphere, is a "free disposal site" for greenhouse gases and it is a cumulative problem with very high societal costs, taxing has become a favored tool available to governments trying to limit their own emissions.

ii. **It can be done gradually.** Sending a predictable and gradually increasing price signal that can start to be reflected in product cost, will cause some shifts in consumer behavior. Starting low and increasing gradually allows the producer to use new technologies to keep their products competitive and this was a strategy used in a British Columbia to favor producers who reduced their energy use, leading to greater carbon efficiency across of the economy.

iii. **It keeps money in the state economy to create jobs here.** For Massachusetts, whose citizens spend more than 20B$ a year for out of state fuels and electricity, most fuel expenditures take money out of the state and regional economy. One outcome of a carbon tax would likely be the retention of more of these funds in the regional economy to be recycled into more service and other expenditures, leading to more jobs.

iv. **It has worked.** At present, 14 countries and one province (British Colombia) are implementing carbon taxes, the oldest of which were implemented in the early 1990s[116] and the newest of which (France) was passed earlier this year. The literature reports that a carbon tax is an effective mechanism to reduce the rate of emissions being added to the atmosphere and to begin to send a price signal to reflect the price of the emissions released in all products and services that use fossil fuels.

[116] http://www.worldbank.org/content/dam/Worldbank/document/SDN/background-note_carbon-tax.pdf

2. Do Carbon Taxes Help Reach Long-term GHG Reduction Targets?

Most carbon tax programs to date do not have explicit carbon reduction goals but rather use the tax as one part of a larger program that provides incentives to shift to lower carbon options. In BC, there are carbon targets that the government expresses as it is talking about the carbon tax but the tax alone isn't expected to reach these targets. Their targets are:

- a 6% reduction in carbon by 2012 (interim target) from 2007 levels
- a 18% reduction in carbon by 2016 (interim target) from 2007 levels
- a 33% reduction in carbon by 2020 (legislated) from 2007 levels
- an 80% reduction in carbon by 2050 (legislated) and a 2008 price on carbon[117]

3. What is a Revenue-Neutral tax?

A revenue-neutral tax is a tax or setoff tax changes that lets government receive the same amount of money despite the changes in tax laws. The government may lower taxes for one group of people, but raise taxes for another group. This allows the revenue that they receive to remain unchanged (neutral).

3. What gets Taxed in Other States and Countries?

a. Which Fuels?

i. California is regulating electricity and transportation fuels in different ways under their AB32 regulation. On the transportation side they include fuel used in motor vehicle engines, non-road vehicles, locomotives, and marine engines but jet fuel or fuel used by ocean-going vessels as part of the California LCFS.

ii. British Columbia applies the tax to the purchase or use of fuels in BC. There is a security scheme similar to motor fuel taxes to protect provincial revenues and provide for administrative simplicity.

iii. Denmark: all fossil fuels (exemptions see below)

iv. France: taxing all use of gas, heavy fuel oil, coal starting in 2015 including transport fuel and heating oil.

v. Germany:

vi. Iceland: liquid fossil fuels.

vii. Ireland: petrol, heavy oil, auto diesel, kerosene, liquid petroleum gas, fuel oil, natural gas, coal and peat, aviation gasoline.

viii. Japan: All fossil fuels depending on CO2 emissions.

ix. South Africa: direct GHG emissions from fuel combustion and non-energy industrial process emissions.

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[117] From an interview with Tim Lesiuk, Acting Head of the Climate Action Secretariat, Ministry of Environment, Province of British Columbia

x. Sweden: natural gas, gasoline, coal, light and heavy fuel oil, LPG, home heating oil.

xi.

b. Which activities are covered under the tax in other places?

i. In 1990, Finland was the first country to adopt a carbon tax. "While originally based only on carbon content, Finland's carbon tax was subsequently changed to a combination carbon/energy tax. It initially covered only heat and electricity production, but was later expanded to cover transportation and heating fuels." (http://www.worldbank.org/content/dam/Worldbank/document/SDN/background-note_carbon-tax.pdf)

ii. Iceland: importers of gas and diesel oils, petrol, aircraft and jet fuels, fuel oils, liable for tax, whether it is for retail or personal use

iii. Ireland: limited to sectors outside European ETS.

iv. Mexico: fossil fuel sales and imports by manufacturers, producers and importers.

v. UK: energy production from fossil fuels

c. Are any fuels or uses exempt?

i. Denmark: exemptions include sectors covered by the EU ETS, energy-intensive processes, exported goods, fuels in refineries and many transport-related activities.
Fuels used for electricity production are also not taxed by the carbon tax, but instead a tax on electricity production applies.

ii. Ireland: exempts emissions from farming

iii. Sweden: sectors under ETS (recently district heating plants under ETS)

iv. Switzerland: participants in country's ETS

4. What price has been set for Carbon Taxes in other jurisdictions?

Reviewed here is a large sample of carbon tax schemes from around the world. Most are implemented at the national-level, while a smaller number are at state/province or city-levels. Of particular interest in this review are basic data such as the tax rate (USD/tCO_{2e}) and the use of the revenue generated from the tax. Most of the information was drawn from two sources (see below), while other details were collected from the sources given in footnotes.

All prices shown here are the *direct* tax rates, that is, the rates levied by government on various carbon-emitting activities *due to the emission of carbon dioxide or other greenhouse gases*. The governments determine this rate through various means, reflecting a great variety of opinion on the marginal social cost of a unit of GHG emissions. Although reported here as a price per unit of emissions, in most jurisdictions the rate is translated to a price per consumption of fuel or other emitting activity. This conversion rate is calculated either through the carbon content of the fuel or through some other calculation method.

Carbon taxes and emissions trading schemes provide information on the *direct carbon price* in a particular jurisdiction. Including the multitude of government programs directed to energy or focused on combating climate change can yield an *effective carbon price*, which can often greatly exceed the direct price. This argument is sometimes made by economists to defend the claim that taxes and trading schemes are the cheapest and most economically efficient mechanism to internalize the cost of GHG emissions. See http://www.oecd.org/env/tools-evaluation/carbon-prices.htm.

Price data drawn from here:
http://www.worldbank.org/content/dam/Worldbank/document/SDN/background-note_carbon-tax.pdf

Revenue distribution information drawn from here:
http://www.nrel.gov/docs/fy10osti/47312.pdf

COMPARING CARBON TAXES IN OTHER JURISDICTIONS

Jurisdiction	**Price (USD/tCO$_{2e}$)**	**Revenue Distribution**	**Notes**
Boulder, Colorado, USA[118]	$0.41 - $6.68	Energy-efficiency and renewable-energy programs, including rebates, credits and "energy audits" for homeowners and businesses.[119]	Currently only applies to electricity production.
British Columbia, Canada	$27.94	Returned to taxpayers through targeted tax cuts: "The government provides a personal income tax rate cut, a low-income 'climate action tax credit,' a small business rate cut, a general corporate tax rate cut, and industrial and farm property tax	Increased from $US23.29 ($30CDN) in 2012.[120]

[118] Rates paid as a surcharge per kWh depending on type of consumer, from https://bouldercolorado.gov/climate. Converted to $/tCO$_{2e}$ using emissions rates for 2011 of the Public Service Company of Colorado (Xcel Energy), from http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol/.
[119] http://www.dailycamera.com/ci_21941854/boulder-issue-2a-carbon-tax-appears-likely-be
[120] http://www.fin.gov.bc.ca/tbs/tp/climate/A4.htm

		cuts. In addition, British Columbia distributed a one-time check for C$100 to residents in June 2008."	
Costa Rica	n/a	Pays property owners for sustainable development and forest conservation activities. (Payment for Environmental Services program)[121] The money will be used to fund conservation, reforestation, and research in protected areas[122]	3.5% tax on fossil fuels since 1997[123]
Denmark	$31	Environmental subsidies (40% of total) and returned to industry (60% of total)	
Finland	$47.30	Government budget with no earmarks; Also independent cuts in income taxes	
France	$9.45	Finance "energy transition."[124]	Plan to increase to $19.60 in 2015 and $29.75 in 2016.
Iceland	$10	Carbon tax on liquid fossil fuels paid to the treasury	
Ireland	$27.01	Government budget; some subsidies for low-income residents.	
Japan	$2	Fund green initiatives.[125]	
Mexico	$0.77 - $3.86	?	Depending on fuel type
Norway	$4 - $69	Government budget. Used partially to fund special pension fund for all Norwegians.	Depending on fuel type and usage
Quebec, Canada	$3.20	Deposited into a "green fund," supporting programs for GHG reductions and improved public transit.	Quebec has also adopted a cap-and-trade program (Western Climate

[121] http://www.worldbank.org/content/dam/Worldbank/document/SDN/background-note_carbon-tax.pdf
[122] http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=10166
[123] http://assets.opencrs.com/rpts/R40593_20100222.pdf
[124] http://www.reuters.com/article/2013/09/21/france-energy-idUSL5N0HH04K20130921
[125] http://www.reuters.com/article/2012/10/10/us-energy-japan-tax-idUSBRE8990G520121010

			Initiative)
South Africa	$11.26	nothing yet – tax still postponed. Many options identified[126]	Proposed for 2016
Sweden	$168	General government budget	
Switzerland	$68	1/3 of revenue for programs to reduce emissions from buildings; 2/3 redistributed to the population and economy.[127]	
United Kingdom	$15.75	Reductions in other taxes, including a 0.3% cut in National Insurance Contributions to make carbon tax revenue neutral	

Conversion rates from July 18, 2014.

Some suggest setting a carbon tax to achieve an emissions-reduction target. For example, a recent study by experts at Resources for the Future and the National Energy Policy Institute suggests that a carbon tax reaching about $30 per ton of CO_2 by 2020 would be needed to reduce domestic, energy-related CO_2 emissions by approximately 10 percent. To achieve this, the tax should rise at approximately the risk-free rate of interest (near zero right now, but roughly 5 percent in the long run) to balance the value in today's terms of making adjustments in the future."
(http://www.rff.org/centers/climate_and_electricity_policy/pages/carbon_tax_faqs.aspx#Q12

In addition, in South Africa, the National Treasury plans to charge 120 rand ($11) on every metric ton of carbon emitted above a 60 percent threshold from 2016 and raise the rate by 10 percent a year for the following six years. (http://www.bloomberg.com/news/2014-02-26/south-africa-delays-carbon-tax-plans-levies-on-acid-mine-water.html)

5. How the Funds are Used

Most places have been using the revenues generated for the general government budget and in other cases, funds are being returned to the taxpayers (such as in BC). While the academic work suggests that if emissions reductions are the primary goals that spending some significant percentage of the funds on energy conservation can have the greatest impact on future GHG emissions. (http://www.nrel.gov/docs/fy10osti/47312.pdf)

Dallas Burtraw and Samantha Sekar of Resources For The Future note, "Requiring polluters to pay generates revenue, which leads to two fundamental questions. First, who is the owner of the

[126] https://www.thepmr.org/content/carbon-tax
[127] http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=de&msg-id=49576

atmosphere resource and thus to whom should the payment accrue? Second, should efficiency or procedural fairness be the primary consideration in deciding how to use carbon revenue? The second question is relevant from a policy design standpoint because greenhouse gas emissions are ubiquitous and their mitigation will be expensive, requiring a successful climate change policy to be both practical and politically feasible." (http://common-resources.org/2013/two-world-views-on-carbon-revenues/#sthash.wZPM4t3k.dpuf)

They summarize the uses of the resulting revenues into the following categories: tax swaps (eliminating other taxes in exchange for implementing a carbon tax), general revenue, investment in research and development, investment in energy efficiency, dividends (returning the revenue to citizens in a lump sum payment).

The usage varies tremendously from RGGI's allowance auction uses (energy efficiency 63%, dividends 21%, general revenue 11%, and research and development 5%) to British Columbia's (tax swaps 72%, dividends 21% and general revenue 7%). Here are some examples of the different options:

a. **Funds going into general government coffers**
   Iceland, Norway and Sweden all use their carbon taxes on liquid fossil fuels paid to the national treasury.

b. **Funds to energy/environment projects**
   In Costa Rica, the revenue goes to the "Payment for Environmental Services" (PSA) program, which pays property owners to practice sustainable development and forest conservation.

c. **Funds returned to the taxpayers**
   In the Canadian province of British Columbia revenue from the tax is returned to taxpayers through targeted tax cuts: "allowing BC to maintain low taxes on what we want (income, productivity) and to tax what we don't (GHG emissions)[128]" All funds generated by the tax are returned to citizens through reductions in other taxes and rebates. Low-income individuals and families protected by climate action tax credit
   - The tax was designed to protect low wage earners who are the least able to absorb the cost of the carbon tax and least able to benefit from cuts on personal income tax.
   - A full or partial credit is available to approximately one million British Columbians.
   - The credit provides an annual maximum of $115.50 CAD for each adult and $34.50 for each child ($115.50 for the first child in a single-parent

[128] Interview with Tim Lesiuk, Acting Head of the Climate Action Secretariat, Ministry of Environment

household.[129])

6. Effects of the tax

a. On GHG emissions

BC Evaluation of the Program

"Since the tax came in, fuel use in B.C. has dropped by 16 per cent; in the rest of Canada, it's risen by 3 per cent (counting all fuels covered by the tax)." http://www.theglobeandmail.com/globe-debate/the-insidious-truth-about-bcs-carbon-tax-it-works/article19512237/

b. On Energy prices

"A carbon tax would increase energy prices—the amount of increase would depend on the size of the tax and the extent to which it is passed forward to consumers. For example, research shows that a tax of $25 per ton of CO_2 could add about 21 cents per gallon to the price of gasoline and about 25 cents per gallon to the price of diesel fuel. The price of natural gas could increase by about $1 per thousand cubic feet, the price of coal by about $40 per short ton, and the price of electricity by about 1.2 cents per kilowatt-hour." (http://www.rff.org/centers/climate_and_electricity_policy/pages/carbon_tax_faqs.aspx#Q12)

However, this change would not occur in a vacuum. A carbon tax would increase the price competitiveness of natural gas over coal for electricity generation. This would result in upward pressure on natural gas prices and downward pressure on coal prices. This is why the coal industry is so concerned about a carbon tax being adopted. Not only would they be selling less coal, but most likely at reduced profit margins.

A study of the period from 2011 to 2012 found that CO_2 emissions in the US were reduced by 4%. This was driven primarily by a huge switchover from coal to natural gas, together, somewhat, with continued increases in renewable energy production such as wind and bioenergy. The rapid increase in shale gas production reduced the price of natural gas to its lowest level in a decade. This resulted in a 12% reduction in coal consumption and a 3% reduction in coal's share in the nation's fossil fuel mix. (all figures from: http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf)

c. On the economy

i. BC Evaluation of the Program

[129] Source: Navius Research, 2013

"B.C. now has the lowest personal income tax rate in Canada (with additional cuts benefiting low-income and rural residents) and one of the lowest corporate rates in North America."
http://www.theglobeandmail.com/globe-debate/the-insidious-truth-about-bcs-carbon-tax-it-works/article19512237/

ii. Independent research has found that if the carbon tax is maintained in its current form, the average household in BC will be better off by $121 per year in 2020 than if the tax had not been implemented
Source - Navius Research, 2013

iii. New industries with high GHG emissions can put emissions targets at risk, but with new investments there is the opportunity for a customized approach

iv. BC's commitment to the carbon tax has not deterred investment – responsible natural resource development remains an attractive opportunity for industry in the province

d. Green communities

i. Local governments that sign the BC Climate Action Charter pledge to become carbon neutral, measure and report on their community's greenhouse gas emissions profile, and work to create compact, energy-efficient communities; 182 of 190 BC local governments have signed the charter. The Climate Action Revenue Incentive Program is a conditional grant program that provides funding to signatories to the Charter that is equivalent to 100 percent of the carbon taxes they pay directly for the fuel they use.

EVALUATIONS OF CARBON TAX APPROACHES

The carbon tax has been called "The Tax Favored By Most Economists," by the Brookings Institute (http://www.brookings.edu/research/opinions/2013/03/12-taxing-carbon-gale):

"The basic rationale for a carbon tax is that it makes good economic sense: unlike most taxes, carbon taxation can correct a market failure and make the economy more efficient. Although there are substantial benefits of energy consumption, there are also substantial societal costs – including air and water pollution, road congestion, and climate change. Since many of these costs are not directly borne by those who use fossil fuels, they are ignored when energy production and consumption choices are made, resulting in too much consumption and production of fossil fuels. Economists have long recommended a tax on fossil-fuel energy sources as an efficient way to address this problem.

Not surprisingly, most analyses find that a carbon tax could significantly reduce emissions. Tufts

University economist Gilbert Metcalf estimated that a $15 per ton tax on CO_2 emissions that rises over time would reduce greenhouse gas emissions by 14 percent. Another study estimated that the European countries' carbon taxes have had a significant effect on emissions reductions.

Although a carbon tax would be a new policy for the federal government, it has been implemented in several other countries … Estimates suggest that a well-designed tax in the United States could raise amounts ranging up to 1 percent of GDP, revenue that could and should be used to reform other taxes or address the country's substantial and unsustainable medium- and long-term budget deficits.

A carbon tax could have other benefits too, including reducing the American economy's dependence on foreign sources of energy and creating better market incentives for energy conservation, the use of renewable energy sources, and the production of energy-efficient goods. The permanent change in price signals from enacting a carbon tax would stimulate new private sector research and innovation in developing energy-saving technologies and in harnessing renewable energy. The implementation of a carbon tax also offers opportunities to reduce and reform federal spending on other energy-related programs.

Two problems are sometimes raised in response to a federal carbon tax proposal. The first is its impact on low-income households, who use most of their income for consumption. However, this regressivity could be offset in any of a number of ways, including refundable income tax credits or payroll tax credits. Thus, while this is clearly a concern, it should not be prohibitive to implementing a carbon tax.
The second concern is whether the U.S. should act unilaterally. Without cooperation from the rest of the world, critics fear that a U.S. carbon tax would reduce economic activity here and make little difference to overall carbon emissions or levels. This view, however, understates the value of a permanent price signal for research and development and the social and environmental value of the reduction in carbon emissions that would come from U.S. action. It also discounts the experience of other countries that unilaterally created carbon taxes; there is no evidence that they paid a significant price, or any price at all, in terms of economic activity levels. If there is ever going to be multilateral action to limit carbon emissions, the US – as the largest per-capita emitter of carbon dioxide – needs to take a leading role. No one is claiming the carbon tax is a perfect outcome. But relative to the alternatives, it has an enormous amount to offer."
(http://www.brookings.edu/research/opinions/2013/03/12-taxing-carbon-gale)

EFFECT OF A CARBON TAX ON ENERGY PRICES

THE CITY OF BOULDER, COLORADO
In 2006, Boulder, Colorado implemented the United States' first carbon tax on electricity emissions, at a rate of approximately $7 per ton. In 2012, Boulder voters extended the tax until 2017. (The program has been deemed a great success, to the extent that the referendum extending it was passed with 82% voter approval.) Those proceeds of the Boulder tax (so far

between $600,000 and $1.8 million a year) are used for energy efficiency and renewable energy programs. Most of this money comes from industrial customers, who pay approximately $9,600 a year; businesses and individual households pay only around $94 and $21 respectively. (http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=9442&section=news_articles&eod=1)

CANADA

BRITISH COLUMBIA

Factors that seem to have made the British Columbia Carbon Tax plan successful:

- The tax started low (CAN$10 ($8.93 US) per ton of CO_2^e), and increased by CAN$5 per ton ($4.46 US)/per year through 2012 (currently at CAN$30).
- The tax has led to significant reductions in refined petroleum products. From 2000-2007 per capita fuel consumption declined by 2% more than in the rest of Canada annually; but 2008-12, it declined by 5.6% more than in the rest of Canada - a substantial difference. (http://www.sustainableprosperity.ca/dl872&display)
- The data does not support the idea that the tax has benefitted the economy of British Columbia. However, the data does not indicate any harm to the economy in terms of GDP per capita growth rates since the tax began. In comparison to the rest of Canada, its economy has performed very slightly better. (http://www.sustainableprosperity.ca/dl872&display)
- The tax is designed to be revenue-neutral. This aspect of the tax may be the most important in terms of explaining its political viability. The government has returned more in tax cuts than it has received in carbon tax revenue. "Overall, the tax has brought in some $5 billion in revenue so far, and more than $3 billion has then been returned in the form of business tax cuts, along with over $1 billion in personal tax breaks, and nearly $1 billion in low-income tax credits (to protect those for whom rising fuel costs could mean the greatest economic hardship). According to the B.C. Ministry of Finance, for individuals who earn up to $122,000, income tax rates in the province are now Canada's lowest." (http://grist.org/climate-energy/heres-why-b-c-s-carbon-tax-is-super-popular-and-effective/)

QUEBEC

Quebec adopted a CAN$3.50 per metric ton of CO2 tax in 2007. The money raised (about CAN$200 million per year) is used for climate mitigation programs. (http://www.nrel.gov/docs/fy10osti/47312.pdf) Quebec deposits the money into a "green fund." The fund is used to support GHG emissions and to make improvements to public transportation. (http://www.nrel.gov/docs/fy10osti/47312.pdf)

EUROPE:

Denmark
Denmark's tax was implemented in 1992. The tax is charged in conjunction with an energy tax. At $16.41/metric ton of CO_2 it raises $905 million per year. About 40% of the money is used for environmental subsidies and the other 60% is returned to industry. "The one country in which carbon taxes have led to a large decrease in emissions is Denmark, whose per capita carbon dioxide emissions were nearly 15 percent lower in 2005 than in 1990. And Denmark accomplished this while posting a remarkably strong economic record and without relying on nuclear power. … Denmark avoids the temptation to maximize the tax revenue by giving the proceeds back to industry, earmarking much of it to subsidize environmental innovation. Danish firms are pushed away from carbon and pulled into environmental innovation." (http://www.nytimes.com/2008/03/25/opinion/25prasad.html)

France
In December, the French Parliament passed a carbon tax that went into effect in May, 2014. The tax is part of an overall package aimed at cutting France's fossil fuel use by 30 percent by 2030, setting levy's on nuclear power and raising renewables to 23 percent of its overall energy mix by 2020.

Approved last year as part of the 2014 budget, the carbon tax fulfills both of the country's top priorities: to reduce the deficit to 3.6% of GDP and to reduce their reliance on nuclear energy, transitioning to efficiency and renewable energy. The tax is levied on natural gas, coal and heating oil based on carbon content of the fuel and is expected to raise EUR 340 million this year. In 2015, it will start to apply to transportation fuels.

The tax is also placed on nuclear energy. Almost all the money from the first years of carbon taxes will be funneled into the transition to renewable energy.

People that work in the fishing and transport industries are exempt from the carbon tax. The tax starts at 7 euros per ton of carbon, rising to 14.5 euros in 2015 and 22 euros in 2016. For the poorest households, the government will subsidize the carbon tax.

Industrial companies that trade in EU's cap-and-trade program are exempt, as is the fishing industry as a whole. The goal is to cut the use of fossil fuels 30% by 2030 and to reduce overall energy demand 50% by 2050. At the same time, it will raise renewables to 23% of energy by 2020 (from 13% now), while dramatically increasing green jobs.

Ireland
"Carbon Tax was introduced in Ireland in the 2010 budget by the Green Party/ Fianna Fáil coalition government at a rate of €15/tonne CO_2 which was applied to motor gasoline and diesel and to home heating oil (diesel). Electricity was exempted as electricity generation from fossil fuel power stations was covered under the EU ETS. Solid fuels including coal and turf were also exempted. In 2011 the new government coalition of Fine Gael and Labour raised the carbon tax by 33% to €20/tonne. Farmers were granted a tax relief to compensate for this increase." (http://en.wikipedia.org/wiki/Carbon_tax)

Netherlands

"The Netherlands introduced a carbon tax in 1990, which was then replaced by a tax on fuels." (http://www.sbs.com.au/news/article/2013/10/29/factbox-carbon-taxes-around-world). In addition to a carbon/energy tax on fuel, the Netherlands also adopted a carbon-based tax on packaging. The tax varies from a low of $26.90/ton of wood, to $602.75 per ton of plastic and $1,219.00 per ton of aluminum. The tax reduced GHG emissions by imposing a cost that results in lower packaging weight which reduces the impact on the environment. However, "the Netherlands abolished its Packaging Tax in 2013 in favor of a Packaging Waste Control Levy payable by companies that introduce more than 50,000 kilos of packaging onto the Dutch market." (https://www.kpmg.com/global/en/issuesandinsights/articlespublications/green-tax/pages/material-resource-efficiency-waste-management.aspx).

Norway

In 1991, Norway adopted its first carbon tax. Currently it covers approximately 68% of Norway's GHG emissions. The tax is highest for gasoline ($61.76 per metric ton CO_2) and lowest for natural gas. The funds go to general government accounts, however the funds are used in conjunction with offshore drilling licenses funds to create a special pension fund of nearly $373 billion. Unlike other countries with a carbon tax, Norway has continued to see rising GHG emissions (15% from 1991 to 2008), although this has been in conjunction with a 70% increase in GDP. (http://www.nrel.gov/docs/fy10osti/47312.pdf)

Sweden

Sweden enacted a tax on the use of coal, oil, natural gas, petrol and aviation fuel used in domestic travel in 1991. The tax was $100 per ton of Co_2 and was later raised to $150. It has cut its carbon pollution by 9 per cent between 1990 and 2006. The tax is paid mostly by the transportation sector, buildings for space heating, and power generation. Oil accounts for 96% of the revenues from the tax, although it produces less than three-quarters of CO_2 from fuel combustion, because of various exemptions.
(http://www.sbs.com.au/news/article/2013/10/29/factbox-carbon-taxes-around-world)

Switzerland

Switzerland has a carbon tax that includes all fossil fuels, unless they are used for energy production (in which case they are covered by a different program). Companies can be exempt from the tax if they participate in the country's emissions trading system instead. The tax amounts to $37.60 per metric ton of CO_2. One-third of the revenue is being devoted to a 10-year program for climate-friendly building renovations including energy efficiency and deep retrofits, renewable energy systems, waste heat capture and advanced engineering for building systems.
(http://www.sbs.com.au/news/article/2013/10/29/factbox-carbon-taxes-around-world)

United Kingdom

The United Kingdom had a sizable carbon tax, which will be frozen at 2015 levels of $29.06 per ton. Britain's carbon price floor, which came into effect in April 2013 aiming to ensure power producers pay at least 30 pounds per ton for emitting carbon dioxide (CO_2) by 2020, to help spur investment in low carbon technology and encourage utilities to switch from burning coal to gas. The tax will still rise from $15.35 per ton to $29.06 per ton starting in April, 2015 and then remain at that level for the next 5 years. The tax is paid by power generators on top of their requirements under the EU's Emissions Trading System, which, like the RGGI system, requires generators to hold one carbon allowance for every ton of carbon dioxide (CO_2) they emit. http://uk.reuters.com/article/2014/03/19/uk-britain-budget-carbon-idUKLNEA2I02620140319)

Costa Rica

Costa Rica has ambition to be the first carbon-net neutral nation by reducing its emissions and nurturing its forests. They have a suite of policies to help achive this but one part of that is a requirement for all carbon emitters to "mitigate" all of the carbon dioxide they emit. Tourists and businesses will be charged a voluntary "tax" to offset their carbon emissions, with one ton of carbon valued at $10, according to *La Nación*. The money will be used to fund conservation, reforestation, and research in protected areas. To augment the development of C-Neutral, the country is cultivating a carbon certificate market that aims to not only boost carbon capture and storage in the nation's forests, but also help maintain their scenic beauty." (http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=10166)

Japan

Japan has a legislated a $2.68 per ton carbon tax on fossil fuels (coal and LPG/LNG) with half the revenue will fund low-emissions technologies and the other half to be returned to companies (in the form of reduced income taxes, for example). Besides, companies that face more competition in the global market and energy-intensive industries will be taxed less at the beginning to allow time for adaptation.

In a macroeconomic analysis of the tax as it was being designed,
" The results from the model suggest that FY2012 Tax Reform has only a small impact on emission levels and no significant impact on GDP and employment. The potential costs of reducing emissions to meet the 25% reduction target for 2020 are quite modest, but noticeable. GDP falls by around 1.2% compared to the baseline and employment by 0.4% compared to the baseline. But this could be offset, with some potential economic benefits, if revenues are recycled efficiently. This paper considers two revenue recycling scenarios. The most positive outcome is if revenues are used both to reduce income tax rates and to increase investment in energy efficiency.[130]"

[130] An Assessment of Japanese Carbon Tax Reform Using the E3MG Econometric Model, Soocheol Lee, Hector Pollitt, and Kazuhiro Ueta http://www.hindawi.com/journals/tswj/2012/835917/ as accessed July 17, 2014.

STATES CONSIDERING CARBON TAXES

Oregon

In Oregon, the Portland State University's Northwest Economic Research Center released a study called: "Carbon Tax and Shift: How to Make it Work for Oregon's Economy" in March of 2013. The approach that the report is considering is based on the British Columbia carbon tax in that it is revenue-neutral in the following exploratory scenarios:

1) apply 70% of the tax revenues to cut corporate taxes, 20% to cut personal income taxes, and 10% for reinvestment in industrial energy efficiency programs;
2) 50% of the revenues go to a cut corporate taxes, 25% to cut personal income taxes, and 25% for industrial and residential energy efficiency and transportation infrastructure.
3) Starting at $10/ton of CO_2 and rising by $10 per year to $60/ton, or roughly twice the level of BC's tax, would, by 2025 was found to reduce the state's greenhouse gas emissions by 12-13% below baseline projections and generate $2.1-$2.2 billion a year in revenue.

Washington State

Governor Jay Inslee signing of a bill mandating a study of the best ways to reduce greenhouse gas emissions and from that study a recommendation of a carbon tax was developed. Recently, Washington State has commissioned its own study of

Third, former University of Washington economist Yoram Bauman recently (April 11, 2013) filed a ballot initiative to institute a carbon tax in Washington state. The proposed carbon tax would duplicate British Columbia's tax level of $30 per metric ton, while also rising at 5% a year. The ballot measure would "lower the state sales tax from 6.5% to 5.5% [note that the 1 percentage point reduction in the state sales tax rate in line with the proposal for NY State, above], eliminate the business and occupation tax on manufacturing, and increase certain tax credits and exemptions." Under the measure, tax revenues would also pay for (unspecified) energy efficiency projects. Go towww.carbonWA.org for more info or to contact the initiative organizers.

SUPPORT STATEMENTS

Vermont Governor Peter Shumlin expressed support for a regional carbon tax in December 2013. "'Vermont can't do a carbon tax in isolation. However, it is shortsighted and irresponsible to continue to burn carbon and not pay for it when we burn it," said Shumlin. "So I would love to see a national approach to that issue, if not national, regional.'" (http://digital.vpr.net/post/governor-supports-regional-carbon-tax-combat-climate-change).

SETTING THE PRICE OF CARBON

"Ackerman and Stanton argue that unrealistically low damage assumptions combined with over-discounting cause the official SCC of $21 to be many times too low. Using a range of assumptions from models and assessments that they consider more realistic, they calculate SCC

values ranging from $56 to $893. … If a carbon tax is meant to internalize the social cost of carbon, it needs to aim high. While there are downsides to setting the carbon tax very high initially, it needs to rise (and be expected to rise) briskly enough to induce as much reduction in CO2 emissions as fast as our economy can deliver."
(http://www.carbontax.org/blogarchives/2011/08/04/why-setting-the-social-cost-of-carbon-is-like-sound-parenting/)

CONCLUSIONS - LESSONS LEARNED FROM THE LITERATURE REVIEW

i. For a carbon tax to make an impact it must be sizable enough to affect economic decisions. The purpose of the payment is to compensate society for the social cost of carbon.

ii. For a carbon tax to be politically feasible it must start at a lower level and then rise on a regular basis. However, in many jurisdictions these subsequent increases have been postponed due to a variety of economic and political reasons.

iii. Revenue-neutrality is an important component of obtaining political support for a carbon tax. Using revenue to fund conservation programs can accelerate the reduction in GHG.

iv. Industry support for anti-GHG (outside of the fossil fuel industry) has been increasing. Recently Coke, Nike, the U.S. military, the insurance industry and banking. Former Secretary of the Treasury, Henry M. Paulson, Jr., has unequivocally come out in support of immediate action on implementing a significant carbon tax.

v. Two very successful jurisdictions in terms of political support for a carbon tax and satisfaction with the use of the proceeds are British Columbia and Denmark. Denmark collects approximately $905 million. About 40% of the revenue is used for environmental subsidies and the other 60% is returned to industry. In British Columbia "overall, the tax has brought in some $5 billion in revenue so far, and more than $3 billion has then been returned in the form of business tax cuts, along with over $1 billion in personal tax breaks, and nearly $1 billion in low-income tax credits (to protect those for whom rising fuel costs could mean the greatest economic hardship).

Appendix C: Annotated Bibliography for Literature Survey and Additional Resources

1. Ackerman, F. & E. A. Stanton (2011). *Climate risks and carbon prices: revising the social cost of carbon*. Economics for Equity & Environment. Accessed July 16, 2014 from http://www.e3network.org/social_cost_carbon.html

2. Baber, K. (2009). *How to lower costs of climate change policies for consumers*. Policy Brief. Washington State Budget & Policy Center. Accessed July 17, 2014 from this site: http://budgetandpolicy.org/schmudget/2009schmudgetdocuments/climate.pdf

3. Barrett, J. P., J. A. Hoerner, S. Bernow & B. Dougherty (2002). *Clean energy and jobs: a comprehensive approach to climate change and energy policy*. Washington, DC: Economic Policy Institute. Accessed July 16, 2014 from: http://www.epi.org/files/page/-/old/studies/cleanenergyandjobs.pdf

4. Boyce, James K. (2014). Climate policy as wealth creation, Dollars & Sense, accessed July 14, 2014, http://truth-out.org/news/item/24938-climate-policy-as-wealth-creation
   This article is adapted from a lecture Boyce delivered, on March 31, as part of the "Climate Change Series" at the University of Pittsburgh Honors College, describes a carbon tax and dividend option and offers some ideas about its implementation and value in comparison with other options.

5. Bruvoll, A. & B. M. Larsen (2004). Greenhouse gas emissions in Norway: do carbon taxes work? *Energy Policy, 32*: 493-505. http://ideas.repec.org/p/ssb/dispap/337.html
   Norway has a relatively high carbon tax, implemented in 1991. Although total emissions have increased, this study finds a significant reduction in emissions per unit of GDP over the period due to reduced energy intensity, changes in the energy mix and reduced process emissions. They also find that the carbon tax effect has been modest and that a mix of other policies was required to get the CO_2 emissions reduction of 14% Norway has achieved. This study finds that the carbon taxes contributed to a 2 percent reduction but that it was supportive to other policies out in place over time.

6. Burtraw, D. and S. Sekar (2008). Two World Views on Carbon Revenues, *RFF DP 13-32*, http://www.rff.org/rff/Documents/RFF-DP-13-32.pdf
   This paper explores alternative ways of considering how atmospheric resources are viewed in the context of a carbon tax. If the atmosphere is seen: 1) as the property of

governments, the decision of how to use the revenue is fundamentally a fiscal problem, or if it is seen as 2) common property, then compensation is due to owners of the resource when it is used (is then payment should be delivered to individuals). This very interesting paper gets to the philosophical underpinnings of the carbon tax and issues of property rights and social relations.

7. Carlson, C. & G. E. Metcalf (2008). Energy tax incentives and the alternative minimum tax. *National Tax Journal, 61*: 477-491. http://www.ntanet.org/NTJ/61/3/ntj-v61n03p477-91-energy-tax-incentives-alternative.pdf
This article considers the design of a national tax on greenhouse gas emissions for the United States and discusses the optimal tax base, tax rate (including the use of the revenues and rate changes over time) and trade. They conclude "a well-designed carbon tax can capture about 80% of U.S. emissions by taxing fewer than 3,000 taxpayers and up to almost 90% with a modest additional cost". They suggest that the rate authority be given to an agency to adjust over time based on new information about abatement costs. Further, the authors suggest that adjustments be made to the income tax to ensure that a carbon tax is revenue neutral.

8. Celebi, M. & F. Graves (2009). *CO_2 price volatility: consequences and cures*. The Brattle Group Discussion Paper. Accessed July 16, 2014 from http://brattle.com/system/publications/pdfs/000/004/714/original/CO2_Price_Volatility_January_2009.pdf

9. Congressional Budget Office (2008). *Policy options for reducing CO_2 emissions*. Accessed July 16, 2014 from http://www.cbo.gov/publication/41663

10. Dinan, T. (2012). *Offsetting a carbon tax's costs on low-income households*. Working Paper 2012-16. Congressional Budget Office. Accessed July 16, 2014 from http://www.cbo.gov/sites/default/files/cbofiles/attachments/11-13LowIncomeOptions.pdf

11. Ellerman, A. D., H. D. Jacoby & M. B. Zimmerman (2006). *Bringing transportation into a cap-and-trade regime*. Cambridge, MA: MIT Joint Program on the Science and Policy of Global Change. http://web.mit.edu/ceepr/www/publications/jp-pubsabstracts/Reports/JPRep136.pdf
This paper explores the integration of the federal CAFÉ Standards for vehicles into a cap and trade program to allow inter-sector trading and more options for carbon reduction strategies and incentives when more sectors are covered. The authors also explore the implications of maintaining two independent systems of emissions regulation, and the

gains to be had from integration. They do not conclude a simple approach for making this work.

12. Finkelstein, A. (2007). *E-Z Tax: tax salience and tax rates*. Cambridge, MA: National Bureau of Economic Research.
http://www.nber.org/papers/w12924
This paper looks at how different tax collections processes are related to how the rate is perceived. The study analyzes toll rates change after adopting electronic toll collection and finds that electronic toll collection decreases resistance to the tax itself. The study finds that toll rates increase following the adoption of electronic toll collection end up 20 to 40 percent higher than they would have been without electronic toll collection.

13. Friedman, L. S. (2010). Should California include motor vehicle fuels in a greenhouse gas cap-and-trade program? *Journal of Comparative Policy Analysis, 12*(3). Accessed July 17, 2014 from http://ssrn.com/abstract=1162865

14. Galston, W. A. & M. MacGuineas (2010). *The future is now: a balanced plan to stabilize public debt and promote economic growth*. Washington, DC: The Brookings Institution. Accessed July 16, 2014 from http://www.brookings.edu/~/media/research/files/papers/2010/9/30%20public%20debt%20galston/0930_public_debt_galston.pdf

15. Gayer, T. (2009). On the merits of a carbon tax. P*olicy options for reducing greenhouse gas emissions: hearing before the Committee on Energy and Natural Resources, United States Senate*. 111th Cong. 1. Accessed July 16, 2014 from http://www.energy.senate.gov/public/index.cfm/2009/12/hearing-9ca3cc78-9d83-c810-ca1c-72ea462f8d27

16. Gayer, T. & A. Morris (2010). *How climate policy could address fiscal shortfalls*. Brookings. Accessed July 16, 2014 from http://www.brookings.edu/research/reports/2010/08/20-climate-policy-gayer-morris

17. Global Utmaning (2009). *Carbon taxation – a forgotten climate policy tool?* Stockholm: Global Utmaning. Accessed July 16, 2014 from http://indiaenvironmentportal.org.in/files/Carbon%20taxation.pdf

18. Goulder, L. H. (1994). *Environmental taxation and the "double dividend:" a reader's guide*. NBER Working Paper No. 4896. Cambridge, MA: National

Bureau of Economic Research. Accessed July 16, 2014 from http://www.nber.org/papers/w4896.pdf

19. Hassett, K. A., A. Mathur & G. E. Metcalf (2009). The incidence of a U.S. carbon tax: a lifetime and regional analysis. *The Energy Journal, 30:* 157-179.

20. Houser, T., R. Bradley, B. Childs, J. Werksman & R. Heilmayr (2008). *Leveling the carbon playing field*. Washington DC: Peterson Institute For International Economics, World Resources Institute.

21. Horne, M. and E. Petropavlova (2012). British Columbia's Carbon Tax: Exploring perspectives and seeking common ground.
This important review of the British Columbia carbon tax offers insights into how it is working. The tax on almost all fossil fuel combustion in the province (77% of emissions) has a rate initially set at $10 per ton of GHG emissions (expressed in carbon dioxide equivalent; CO2e), rising by $5 per ton per year until it reached $30 per ton on July 1, 2012. It includes poll results from along the process, and assesses the impact of the program.

22. Johnson, K. C. (2006). A sensible policy approach for greenhouse gas regulation. http://ssrn.com/abstract=945570 OR at: http://dx.doi.org/10.2139/ssrn.945570
This paper examines the Swedish nitrogen oxide program as a model for a Greenhouse Gas tax that offers price stability and the cost certainty of a tax while being revenue-neutral for the regulated industries. The author argues that this approach offers both long-term incentives for carbon reduction and a stable investment climate to move create a rapid orderly transition to a low-carbon economy. In contrast to a conventional carbon tax, which applies to a regulated firm's entire CO_2 emissions, a refunded benchmarking tax effectively applies the net tax to only a portion of its CO_2 emissions based on how its "emission intensity" (tons CO_2 generated per MWh power output) compares to the industry average. For example, if a power plant's CO_2 emission intensity is 1 ton/MWh and the industry average is 0.9 ton/MWh, then a tax rate of $100/ton would effectively be applied only to the 0.1 ton/MWh difference, resulting in a net regulatory cost of $10/MWh. If the industry average is 1.1 ton/MWh, the difference would be negative and the firm would receive a net subsidy of $10/MWh. It concludes that a refunded tax would create high marginal incentives for emission reduction without imposing high regulatory costs on industry. "

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26. Liu, J. H. and J. Renfro (2013) Carbon Tax and Shift: How to make it work for Oregon's Economy. Northwest Economic Research Center Report. http://www.pdx.edu/nerc/carbontax2013.pdf

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28. Marron, D. & E. Toder (2013). *Carbon taxes and corporate tax reform*. Urban-Brookings Tax Policy Center. Accessed July 17, 2014 from http://www.taxpolicycenter.org/UploadedPDF/412744-Carbon-Taxes-and-Corporate-Tax-Reform.pdf

29. Mathur, A. & A. C. Morris (2012). *Distributional effects of a carbon tax in broader U.S. fiscal reform*. Brookings Climate and Energy Economics Project. Available at: http://ssrn.com/abstract=2212993 This article is an interesting combination of writers from the American Enterprise Institute and The Brookings Institution. The report studies distributional aspects of a carbon tax and it finds that a carbon tax is a regressive tax but that tax swaps take away this problem because they can lower the overall burden of the carbon tax (as a share of household income) on the poor. The authors suggest that if about 11 percent of the tax revenue was directed towards the poorest twenty percent of the population through greater spending on social safety net programs or other approaches designed to help the poor (more than would otherwise occur), then on average those households would be no worse off after the carbon tax than they were before.

30. McKibbin, W. J., A. Morris, P. J. Wilcoxen & Y. Cai (2012). *The potential role of a carbon tax in U.S. fiscal reform*. Climate and Energy Economics Discussion Paper. Washington, DC: The Brookings Institution. Accessed July 16, 2014 from http://www.brookings.edu/research/papers/2012/07/carbon-tax-mckibbin-morris-wilcoxen

31. Metcalf, G. E. (2007). *A proposal for a U.S. carbon tax swap: an equitable tax reform to address global climate change*. The Hamilton Project discussion paper 2007-12. Washington, DC: Brookings Institution. Accessed July 16, 2014 from http://www.hamiltonproject.org/files/downloads_and_links/An_Equitable_Tax_Reform_to_Address_Global_Climate_Change.pdf

32. Metcalf, Gilbert, Sergey Paltsev, John Reilly, Henry Jacoby and Jennifer Holak (2008). *Analysis of US carbon tax Proposals, Report #160,* Cambridge, MA: MIT Joint Program on the Science and Policy of Global Change. http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt160.pdf
The authors suggest that starting with a low tax rate combined with a low rate of growth in the tax rate will actually not reduce emissions significantly. Second, they suggest including other non-CO2 gases warming gases to have a net effect of reducing the costs (they can fall by 20% with inclusion of the other GHG)s. They find that a carbon tax is somewhat regressive and that reverting some of the tax to workers and others will reduce the regressivity of the tax. A carefully designed rebate can handle this problem. They end by proposing that cap and trade or cap and tax (with a rebate) approaches or a hybrid of cap and trade and a carbon tax can each be effective at reducing GHG emissions.

33. Metcalf, G. E. & D. A. Weisbach (2009). The design of a carbon tax. *Harvard Environmental Law Review, 33*: 499-556. Accessed July 16, 2014 from http://www.law.harvard.edu/students/orgs/elr/vol33_2/Metcalf%20Weisbach.pdf

34. Morris, A. C. (2013). Proposal 11: the many benefits of a carbon tax. *15 Ways to Rethink the Federal Budget*. The Brookings Institution. Accessed July 16, 2014 from:http://www.brookings.edu/~/media/research/files/papers/2013/02/thp%20budget%20papers/thp_15waysfedbudget_prop11.pdf

35. Nachmany, M., S. Fankhauser, T. Townshend, M. Collins, T. Landesman, A. Matthews, C. Pavese, K. Rietig, P. Schleifer & J. Setzer (2014). *The GLOBE climate legislation study: a review of climate change legislation in 66 countries*. Fourth Edition. London: GLOBE International and the Grantham Research Institute, London School of Economics. http://www.qualenergia.it/sites/default/files/articolo-doc/IVCCL.pdf
This work is a review of the carbon and climate change policies in 66 countries, (including the European Union as a single entity), which are together responsible for approximately 88% of global emissions of greenhouse gases. It details all of the strategies used in these countries including carbon taxes and serves as a good overview document.

36. Nordhaus, W. D. (2007). To tax or not to tax: alternative approaches to slowing global warming. *Review of Environmental Economics and Policy, 1:* 26-44. Accessed from the internet on June 30, 2014. www.econ.yale.edu/~nordhaus/homepage/nordhaus_carbontax_reep.pdf
The analysis provides a very high level discussion of issues such as the benefit of a carbon tax on ultimate targets, the volatility of carbon prices, the inefficiencies of taxation and ease of implementation. It concludes that price-type approaches such as carbon taxes have major advantages for slowing global warming.

37. Parry, I. W. H. & R. C. Williams III (2011). *Moving U.S. climate policy forward: are climate taxes the only good alternative?* RFF Discussion Paper 11-02. Washington, DC: Resources for the Future. Accessed July 16, 2014 at: http://www.rff.org/RFF/Documents/RFF-DP-11-02.pdf

38. Parry, I. W.H., R. C. Williams III & L. H. Goulder (1998). *When can carbon abatement policies increase welfare? The fundamental role of distorted factor markets*. Discussion Paper 97-18-REV. Washington, DC: Resources for the Future. Accessed July 16, 2014 from http://rff.org/rff/Documents/RFF-DP-97-18-REV.pdf

39. Rausch, S. & J. Reilly (2012). *Carbon tax revenue and the budget deficit: a win-win-win solution?* MIT Joint Program on the Science and Policy of Global Change Report No. 228. Accessed July 16, 2014 from http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt228.pdf

40. Reilly, J., H. D. Jacoby & R. G. Prinn (2003). *Multi-gas contributors to global climate change, climate impacts and mitigation costs*. Pew Center on Global Climate Change.

41. RFF (2012). *Considering a carbon tax: frequently asked questions*. Resources for the Future. Accessed July 16, 2014 from http://www.rff.org/centers/climate_and_electricity_policy/Pages/Carbon_Tax_FAQs.aspx

42. Shapiro, R., N. Pham & A. Malik (2008). *Addressing climate change without impairing the U.S. economy: the economics and environmental science of combining a carbon-based tax and tax relief*. The U.S. Climate Task Force. Accessed July 16, 2014 from

http://www.sonecon.com/docs/studies/CarbonTaxReport-RobertShapiro-2008.pdf

43. Sinden, Amy (2009). Revenue-neutral cap and trade. *Environmental Law Reporter, 39*: 10944. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1458624
The author suggests that because 32 – 40% of U.S. GHG emissions are released as the result of individual choices that regulation alone won't effect. The article discusses 1) A "cap and dividend" approach which auctions all allowances and returns the revenue to individuals on a per capita, equal shares basis, and 2) A "fair-share cap-and-trade" which distributes the allowances themselves to individuals, also on a per capita, equal shares basis and sets up a system for the individuals to sell their allowances to fossil fuel producers and importers. Both schemes give the individual consumers some way of reducing their net tax cost. The article suggests that a fair-share cap-and-trade reinforces carbon reduction and holds the global atmosphere as a limited, commonly held resource to which each individual on earth has an equal claim.

44. Sumner, Jenny, Lori Bird, and Hillary Smith. Technical Report, NREL/TP-6A2-47312, (2009). Carbon Taxes: A Review of Experience and Policy Design Considerations. http://www.nrel.gov/docs/fy10osti/47312.pdf
This extensive report reviews existing carbon tax policies in the US and internationally and in the United States and analyzes carbon policy design and effectiveness.

45. Stern, N. (2007). *The economics of climate change, The Stern Review*. Cambridge, UK: Cambridge University Press. http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf
This report (called "The Stern Report"), considers the evidence of the economic impacts of climate change, and on the costs and benefits of action to reduce greenhouse gas emissions. While not explicitly about carbon taxes, it helps to frame the costs of carbon and climate economics.

46. Weitzman, M. L. (2009). *On modeling and interpreting the economics of catastrophic climate change. Review of Economics and Statistics, 91*(1): 1-19. Accessed July 16, 2014 from http://dash.harvard.edu/handle/1/3693423

47. Weitzman, M. L. (2014). *Can negotiating a uniform carbon price help to internalize the global warming externality?* Discussion Paper 14-61. The Harvard Project on Climate Agreements. Accessed July 17, 2014 from http://belfercenter.ksg.harvard.edu/files/dp61_weitzman.pdf

In this paper, the author argues that a uniform international carbon price will serve as a better surrogate for an international agreement such as the Kyoto Protocol and may even be superior to effect change. He suggests that such a price could be set quickly and that each country can then keep and use the revenue as they see fit; but that setting the price is essential and will cause efficiencies that caps themselves and alone won't do.

Appendix D: Supplementary Tables to Section III

Figure 1: Impacts with equal rebates per person, for all combinations of people per household and income quintile (households ranked by income/household)

People per house-hold	Income quintile	Income after tax	Income before tax	Carbon tax per house-hold	Equal rebate per person	Rebate per household if equal rebates given per person	Net impact per house-hold
1	1	$2,994	$2,800	$152	$197	$197	$45
2	1	$2,413	$2,277	$334	$197	$395	$60
3	1	$1,131	$1,143	$380	$197	$592	$212
4+	1	-$1,114	-$1,278	$550	$197	$789	$239
1	2	$19,904	$20,902	$220	$197	$197	-$23
2	2	$19,922	$21,428	$429	$197	$395	-$34
3	2	$22,233	$21,585	$345	$197	$592	$247
4+	2	$20,140	$19,261	$478	$197	$789	$311
1	3	$42,048	$50,677	$298	$197	$197	-$101
2	3	$46,441	$48,805	$463	$197	$395	-$68
3	3	$40,988	$42,197	$400	$197	$592	$192
4+	3	$48,919	$46,700	$512	$197	$789	$277
1	4	$69,554	$85,626	$281	$197	$197	-$84
2	4	$78,658	$83,045	$495	$197	$395	-$100
3	4	$85,379	$89,982	$699	$197	$592	-$107
4+	4	$88,722	$89,745	$574	$197	$789	$215
1	5	$174,605	$170,223	$593	$197	$197	-$396

People per house-hold	Income quintile	Income after tax	Income before tax	Carbon tax per house-hold	Equal rebate per person	Rebate per household if equal rebates given per person	Net impact per house-hold
2	5	$160,641	$170,958	$642	$197	$395	-$247
3	5	$196,139	$195,616	$928	$197	$592	-$336
4+	5	$214,094	$220,965	$765	$197	$789	$24

Note: "4+" for household size means 4 or more people

Figure 2: Impacts on all Massachusetts industries

Category	Rebate $ millions	Carbon tax, $ millions	Net impact (rebate-carbon tax), $millions
Real estate	$40	$26	$13
Professional, scientific, and technical services	$98	$39	$59
State and local government	$93	$100	-$7
Retail trade	$98	$28	$70
Wholesale trade	$33	$41	-$8
Computer and electronic product manufacturing	$14	$8	$5
Banking and finance	$18	$5	$12
Ambulatory health care services	$50	$10	$40
Hospitals	$46	$21	$25
Insurance carriers and related activities	$19	$2	$18
Construction	$50	$80	-$30

Category	**Rebate $ millions**	**Carbon tax, $ millions**	**Net impact (rebate-carbon tax), $millions**
Securities, commodity contracts, investments	$29	$9	$19
Educational services	$53	$26	$27
Publishing industries, except Internet	$11	$6	$5
Administrative and support services	$51	$48	$3
Management of companies and enterprises	$16	$12	$3
Food services and drinking places	$63	$34	$29
Telecommunications	$5	$14	-$9
Chemical manufacturing	$4	$155	-$151
Federal civilian	$11	$31	-$20
Utilities	$2	$0	$2
Nursing and residential care facilities	$24	$14	$10
Rental and leasing services; Lessors of nonfinancial intangible assets	$3	$6	-$3
Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services	$4	$3	$1
Fabricated metal product manufacturing	$8	$16	-$8
Miscellaneous manufacturing	$5	$4	$1
Repair and maintenance	$10	$3	$6
Personal and laundry services	$19	$3	$17
Social assistance	$24	$5	$20
Machinery manufacturing	$4	$9	-$4

Category	**Rebate $ millions**	**Carbon tax, $ millions**	**Net impact (rebate-carbon tax), $millions**
Food manufacturing	$6	$20	-$14
Accommodation	$9	$18	-$9
Federal military	$5	$7	-$3
Other transportation equipment manufacturing	$3	$3	$0
Membership associations and organizations	$17	$3	$15
Performing arts and spectator sports	$13	$1	$12
Beverage and tobacco product manufacturing	$1	$5	-$5
Amusement, gambling, and recreation	$11	$4	$7
Plastics and rubber product manufacturing	$3	$11	-$8
Waste management and remediation services	$3	$4	-$1
Truck transportation	$5	$29	-$25
Transit and ground passenger transportation	$6	$4	$3
Forestry and logging; Fishing, hunting, and trapping	$2	$2	-$1
Electrical equipment and appliance manufacturing	$2	$4	-$2
Couriers and messengers	$4	$21	-$16
Paper manufacturing	$2	$19	-$17
Printing and related support activities	$3	$5	-$2
Air transportation	$2	$33	-$32
Farm	$2	$14	-$12

Category	Rebate $ millions	Carbon tax, $ millions	Net impact (rebate-carbon tax), $millions
Petroleum and coal products manufacturing	$0	$0	$0
Broadcasting, except Internet	$1	$1	$1
Scenic and sightseeing transportation; Support activities for transportation	$2	$3	-$1
Rail transportation	$1	$9	-$8
Warehousing and storage	$3	$1	$1
Nonmetallic mineral product manufacturing	$1	$8	-$7
Textile mills; Textile product mills	$1	$3	-$1
Primary metal manufacturing	$1	$23	-$22
Private households	$7	$0	$7
Motion picture and sound recording industries	$2	$0	$2
Museums, historical sites, zoos, and parks	$1	$3	-$2
Furniture and related product manufacturing	$1	$1	$1
Oil and gas extraction	$0	$0	$0
Apparel manufacturing; Leather and allied product manufacturing	$1	$1	$1
Wood product manufacturing	$1	$1	-$1
Pipeline transportation	$0	$1	-$1
Agriculture and forestry support activities	$1	$0	$1
Support activities for mining	$0	$0	$0
All manufacturing industries	**$57**	**$289**	**-$232**