12-1-2014

Economic and Emissions Impacts of a Clean Air Tax or Fee in Oregon (SB306)

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Citation Details

Liu, Jenny H.; Renfro, Jeff; Butenhoff, Christopher; Paruszkiewicz, Mike; Rice, Andrew. (2014) Economic and Emissions Impacts of a Clean Air Tax or Fee in Oregon (SB306). Northwest Economic Research Center (NERC). Portland State University, College of Urban and Public Affairs.

State of Oregon **Research Report**

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Research Report #4-14 **December 2014**

Economic and Emissions Impacts of a Clean Air Tax or Fee in Oregon (SB306)

The Oregon Legislature passed Senate Bill 306 (SB306) during its 2013 Regular Session, which directed the Legislative Revenue Office (LRO) to conduct a study of the economic and greenhouse gas emissions impacts of implementing a clean air tax or fee in Oregon. After an open RFP process, LRO (with the assistance of a Technical Advisory Committee) chose and contracted Portland State University's Northwest Economic Research Center (NERC) to conduct the analysis.

The Oregon Legislative Revenue Office (LRO) also contracted with Edward Waters (local economist and consultant) to provide quality monitoring and assurance for the Study. Mazen Malik was tasked with leading the study, and other LRO staff including Christine Broniak and Vijay Satyal provided support and feedback.

LRO and the study team continued to utilize the Technical Advisory Committee to assist with methodology design and to provide feedback throughout the process. The technical advisory committee was made up of representatives from:

- Oregon Legislative Revenue Office (Paul Warner)
- Oregon Legislative Fiscal Office (Paul Siebert)
- Oregon Business Development Commission (Michael Meyers)
- Oregon Department of Revenue (Mary Fitzpatrick)
- Oregon Department of Transportation (Jack Svadlenak)
- Oregon Department of Environmental Quality (Colin McConnaha, David Collier)
- Public Utility Commission (Aster Adams, Jason Klotz)
- Oregon Department of Energy (Phil Carver, Jessica Shipley, Bill Drumheller, Julie Peacock)

The Northwest Economic Research Center (NERC) is based at Portland State University (PSU) in the College of Urban and Public Affairs (CUPA). The Center focuses on economic research that supports public-policy decision-making and relates to issues important to Oregon and the Portland Metropolitan Area. The Director of NERC is Dr. Tom Potiowsky.

NERC assembled a team of economists, physicists, and other researchers to perform the study. The NERC team was led by Jenny H. Liu (NERC Assistant Director) and Jeff Renfro (NERC Senior Economist). The research team also included Christopher Butenhoff, Mike Paruszkiewicz, and Andrew Rice. Additional research assistance on this project was provided by NERC research assistants: Janai Kessi, Kyle O'Brien, and Marisol Cáceres Lorenzo.

In order to customize the impact of a carbon tax on the price of electricity in each of six regions in the state of Oregon, NERC required region-level electricity demand data from several utilities. This data was generously provided by Consumers Power Inc., Midstate Electric Cooperative Inc., PacificCorp, Portland General Electric, and Wasco Electric Cooperative. The study team is grateful for the data, which improved the quality of the modeling results.

Additional data was also provided by Clean Energy Works of Oregon, the Oregon Department of Agriculture, and the Oregon Department of Energy. The study team thanks them for their generosity.

NERC and LRO obtained input from Legislative Committees on the initial study outline and proposed methodology. The study team and LRO also met with a variety of stakeholder groups representing Oregonians who would be affected by the tax. The goal of these conversations was to get feedback on the proposed study methodology and to better understand the modeling outputs that would be most useful to the different groups, including business, utilities, low-income representatives, and labor representatives potentially affected by the policy. After the study outline and methodology were finalized, NERC continued monthly update meetings with LRO to ensure progress. NERC, LRO and the technical advisory team convened once every quarter for a total of 4 meetings, with additional meetings and consultations with subcommittees, formed within the technical advisory team. Naturally, towards the end of study period, meetings updates and contacts became much more frequent to ensure the timely completion of the study.

The rest of the report is the product of the efforts of the study team and reflects the research and expertise of the team's collective work.

Liu, Jenny H.; Renfro, Jeff; Butenhoff, Christopher; Paruszkiewicz, Mike; Rice, Andrew. (2014) Economic and Emissions Impacts of a Clean Air Tax or Fee in Oregon (SB306). Northwest Economic Research Center (NERC). Portland State University, College of Urban and Public Affairs. http://www.pdx.edu/nerc/sites/www.pdx.edu.nerc/files/carbontax2014.pdf

Portland State UNIVERSITY

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Executive Summary

In this study, the carbon tax is applied to fossil fuels combusted in the state as well as imported electricity at maximum levels of between \$10 and \$150 per metric ton of CO_2e. The tax is applied to fuel purchases at the wholesale level, except for electricity purchases wherein it is levied on the final consumer. The study features results from scenarios that demonstrate the effects of different revenue repatriation and expenditure options in order to demonstrate tradeoffs between different policy choices. These include scenarios featuring personal and corporate income tax reductions, targeted low-income and worker support, targeted business investment, and energy efficiency investments among others. Because of Oregon constitutional requirements, carbon tax revenue collected on sales of transportation fuels must be allocated to the State Highway Fund. The modeling incorporates this requirement, but also features scenarios in which these revenues are used to offset existing transportation taxes and fees or for other transportation-related projects.

The study team created a forecast of Oregon CO_2e (carbon dioxide equivalent) emissions out to 2034 to serve as a baseline for estimation. The Oregon Greenhouse Gas Emissions Inventory, Energy Information Administration (EIA) data, and utility Integrated Resource Plans (IRPs) were used to calibrate the baseline forecast to ensure that the study results were compatible with ongoing work on emissions forecasting in the state.

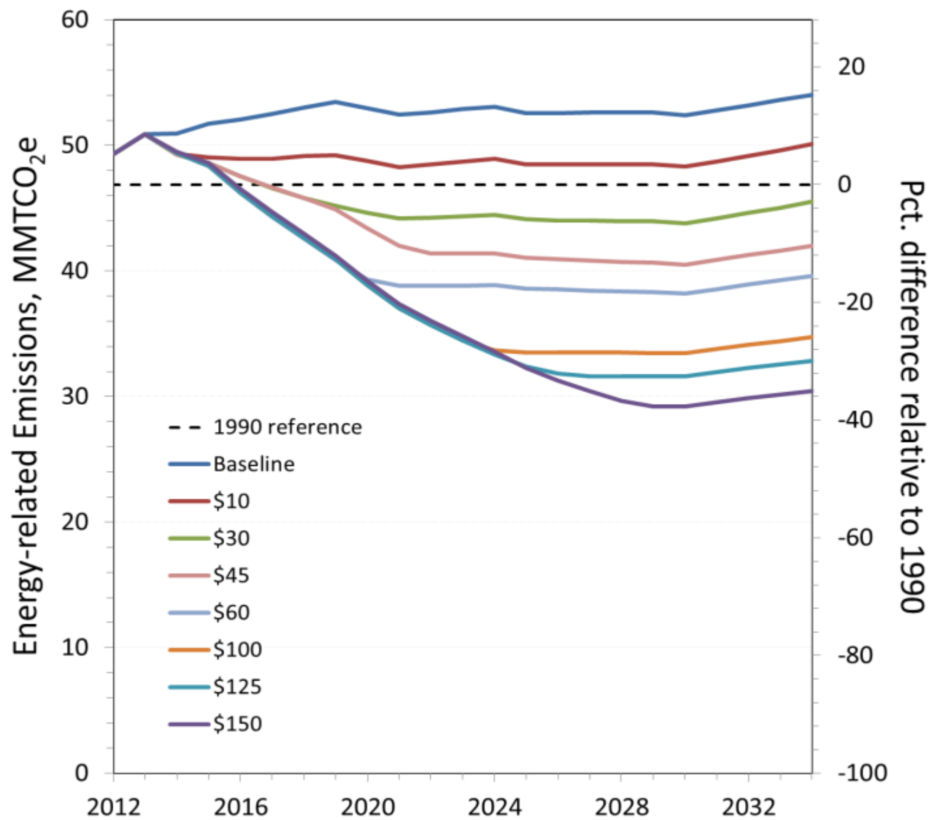
For economic modeling, NERC utilized a customized version of the Regional Economic Modeling Inc. (REMI) software. The model split Oregon into six regions (Central, Eastern, Metro, Northwest, Southwest, and Valley) and features impact results for 70 industry sectors within each region. During the initial phases of the project, NERC worked with REMI to customize the model output estimates to more accurately reflect Oregon's economic structure. During this same period, the study team developed average carbon intensity estimates for electricity consumed in each region based on published data as well as data requested directly from utilities.

A basic modeling input was the deviation in fuel price from expected baseline prices due to the assessment of the carbon tax. To calculate this expected price change, the study team used the Energy Information Administration's Extended Policy forecast. This forecast includes all existing state and federal laws, and assumes that laws with sunsets which are normally extended will continue to be extended. This forecast is derived from EIA's National Energy Modeling System (NEMS) and includes expected price by fuel type. Annual changes from the EIA's expected baseline prices resulting from alternative carbon tax levels and the average carbon content of each type of fuel were used as model inputs.

Changes in household energy demand and business output resulting from the increase in energy prices under each carbon tax scenario were then used to update the emissions model. The expected change in emissions was calculated, which also determined the estimated tax revenue under each scenario. This estimated tax revenue was fed back into the economic model according to the assumptions of each repatriation and expenditure scenario. The final results are dynamic estimates of changes in emissions and key economic variables (e.g., employment, output, and compensation) under an array of alternative carbon tax and revenue repatriation/expenditure scenarios.

Figure 1 shows the expected emissions levels under a range of carbon prices and one set of revenue repatriation and expenditure scenarios[1]. The dotted line represents the 1990 level of emissions from in-state combustion and imported electricity use. In the estimation process, the differences in impacts between scenarios were small relative to the size and output of the Oregon economy. While this figure shows results for one particular set of scenarios, similar expected emissions levels were estimated for most of the other scenarios examined.

Figure 1 - Energy-Related Greenhouse Gas Emissions for the C.4 Carbon Tax Scenario



[1] Emissions units are million metric tons of CO_2 equivalent emissions. Note: The C.4 scenarios are revenue neutral (excluding transportation-based revenues) with repatriated revenue distributed 70% to corporate income tax cuts and 30% to personal income tax cuts.

Figure 2 shows the expected revenues at alternative carbon price levels.[2] As with the previous figure that shows impacts on emissions, this figure shows results from a single set of scenarios. However, the differences in carbon tax revenues estimated under the different scenarios are relatively small. Since the expected impacts on employment and output are small relative to the size of the overall economy, once the tax rate reaches its cap we expect carbon tax revenues to be relatively stable going into the future.

Figure 2 - Total State Revenue Generated for Different Carbon Tax Rates

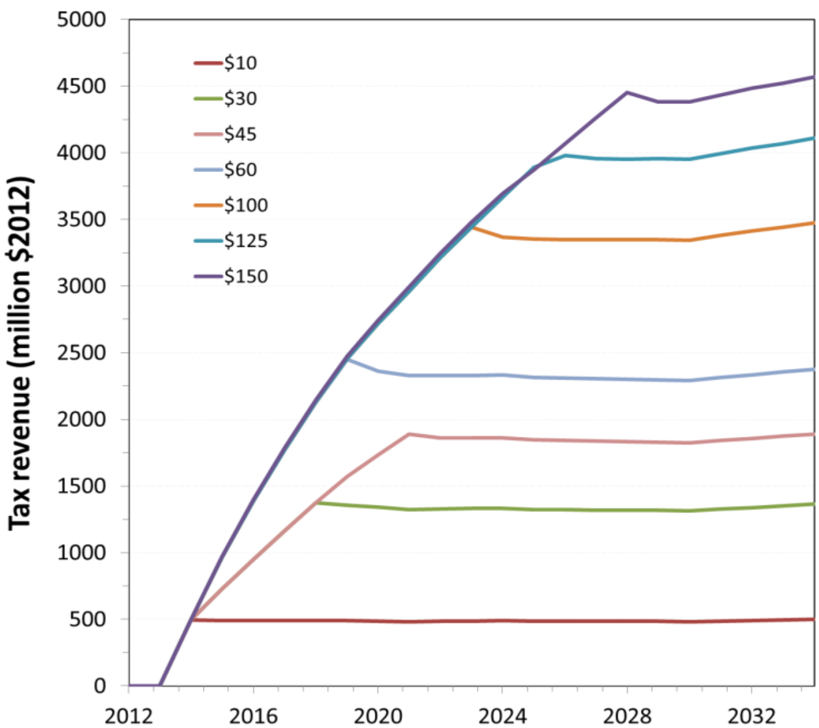


Table 1 summarizes the estimated emissions impacts, carbon tax revenues, and employment and output impacts under each scenario at a range of carbon prices. Emissions, employment and output impacts are reported as a change relative to the forecast baseline. The values are all relatively small when compared to the size of the overall Oregon economy. Even in the most negative scenarios, overall employment and output growth will remain positive - the carbon tax acts as a small drag on economic growth. The table reports impacts in the year that the carbon price cap is reached. The impacts vary by year for each scenario. The Results section of the report (pg. 21) graphs the impacts of each scenario over the course of the forecast period.

[2] Revenues for carbon prices of $45/ton and below are shown on the lower branch in the diagram. These scenarios feature a $5/ton annual increase in the tax rate until the price cap is reached. For prices above $45/ton (shown on the upper branch), the assumed annual increase is $10/ton until the cap is reached.

Revenue usage scenario A in Table 1 (Rows) signifies the extreme case of the tax revenue not being returned to the economy and kept in reserve funds. Grouping B shows the revenue neutral scenarios, while grouping C is revenue neutral with the exception of transportation taxes and fees. The D scenarios show the results of returning the revenue to the economy by the way of tax cuts and public expenditures or targeted investments. The last grouping, E scenarios, assume non-transportation revenues are used for tax cuts while the remaining revenues are used for transportation projects which differ from the current Highway Trust Fund expenditure patterns.

Table 1 - Results Summary: Annual Impacts in the year Carbon Price reaches cap

		Maximum Level of Carbon Tax (per $mTCO_2e$)				
		$10	$30	$60	$100	$150
Emissions Impact		–7%	–15%	–26%	–35%	–43%
Tax Revenue[3]		$490M	$1,350M	$2,350M	$3,450M	$4,550M
Revenue Usage Scenarios: A	Employment		-15K to 25K	-27K	-37K	
A	Output		-0.6% to -0.4%	-1.1%	-1.35%	
B	Employment	-1.1K	-4K	-8K	-9K	-14.5K
B	Output	-0.05%	-0.2%	-0.5%	-0.5%	-0.7%
C	Employment	0	+4K	+7K	+5.5K	+2K
C	Output	-0.02%	-0.05%	-0.3%	-0.3%	-0.7%
D	Employment		+5K	-13K to -9K		
D	Output		-0.3%	-0.5%		
E	Employment		0	-5K		
E	Output		-0.3%	-0.5%		

In response to Section J of SB306, this study also includes a discussion of how the carbon tax would compare and interact with specific Oregon statutes. A table summarizing the conclusions can be found on pg. 71, followed by a more detailed analysis of each set of statutes and potential interactions.

Overall, this study finds that the impact of a carbon tax policy which repatriates the revenue back to the economy would have relatively small impacts on employment and output, although the benefits and costs of the policy would vary across geographic regions, income levels, and industries. Revenues could be used to offset negative impacts, but any repatriation or expenditure necessarily takes revenue away from other priorities. The choice of revenue-use methods will ultimately determine the overall impact of the tax policy. Applying the tax to a

[3] In inflation-adjusted 2012 dollars

broad base will help reduce inefficiencies and ensure the expected levels of carbon tax revenues and emissions reductions are achieved.

Introduction

Oregon Senate Bill 306 (SB306) passed during the 2013 Legislative Session, requiring the Legislative Revenue Office (LRO) to conduct a study of the economic and greenhouse gas emissions impacts of implementing a clean air tax or fee in Oregon. Portland State University's (PSU) Northwest Economic Research Center (NERC) was contracted by LRO at the end of 2013 to conduct the analysis.

I. Background and Process

In March 2013, NERC published a research report titled "Carbon Tax and Shift: How to make it work for Oregon's Economy" (Liu and Renfro, 2013)[4]. That previous study analyzes a carbon tax and tax shift in Oregon as a means of reducing market inefficiencies by placing a meaningful price on carbon emissions, using a combination of CTAM (Carbon Tax Analysis Model), EIA's (Energy Information Administration) energy forecasts and IMPLAN, an economic input-output model. The report details Oregon-specific changes in revenue and emissions estimates for several carbon prices, economic and fiscal impacts, and various revenue repatriation and expenditure scenarios, including the reduction of income taxes and introduction of low-income assistance. The current study expands upon NERC's previous research of a carbon tax in Oregon to satisfy the requirements laid out in SB306.

NERC and LRO obtained input from Legislative Committees on the initial study outline and proposed methodology. The study team and LRO staff also met with a variety of stakeholder groups representing Oregonians who would be affected by the tax. The goal of these conversations was to get feedback on our proposed methodology and to better understand the modeling outputs that would be most useful to the groups, including business, utilities, low-income representatives, and labor representatives potentially affected by the policy. In addition, LRO assembled a technical advisory team to assist with the study. This group includes representatives from LRO, Legislative Fiscal Office (LFO), Oregon Department of Transportation (ODOT), Oregon Department of Revenue (DOR), Public Utility Commission (PUC), Oregon Department of Energy (ODOE), Oregon Business Development Commissions (OBDC), and Department of Environmental Quality (DEQ). After the study outline and methodology were finalized, NERC continued monthly update meetings with LRO to ensure progress. NERC, LRO and the technical advisory team convened once every quarter for a total of 4 meetings, with additional meetings and consultations with subcommittees formed within the technical advisory team. Towards the end of study period, meetings updates and contacts became much more frequent to ensure timely completion of the study.

The remainder of this section provides a brief review of the history, prevalence, and mechanics of carbon pricing that informed our analysis. For the purposes of this report, the key details of this review are the concepts of the "social" costs of carbon emissions, the nuanced structure of

[4] Authored by Dr. Jenny Liu, Assistant Director, and Jeff Renfro, Senior Economist, with support from the Energy Foundation and PSU's Institute for Sustainable Solutions (ISS).

a carbon tax, and an efficient means to repatriate the revenue it generates. We then summarize the technical modeling used throughout this study, followed by detailed results for various model scenarios, discussion, and an analysis of the tax's potential costs and effectiveness to other measures which reduce greenhouse gases (as required by SB306 section J).

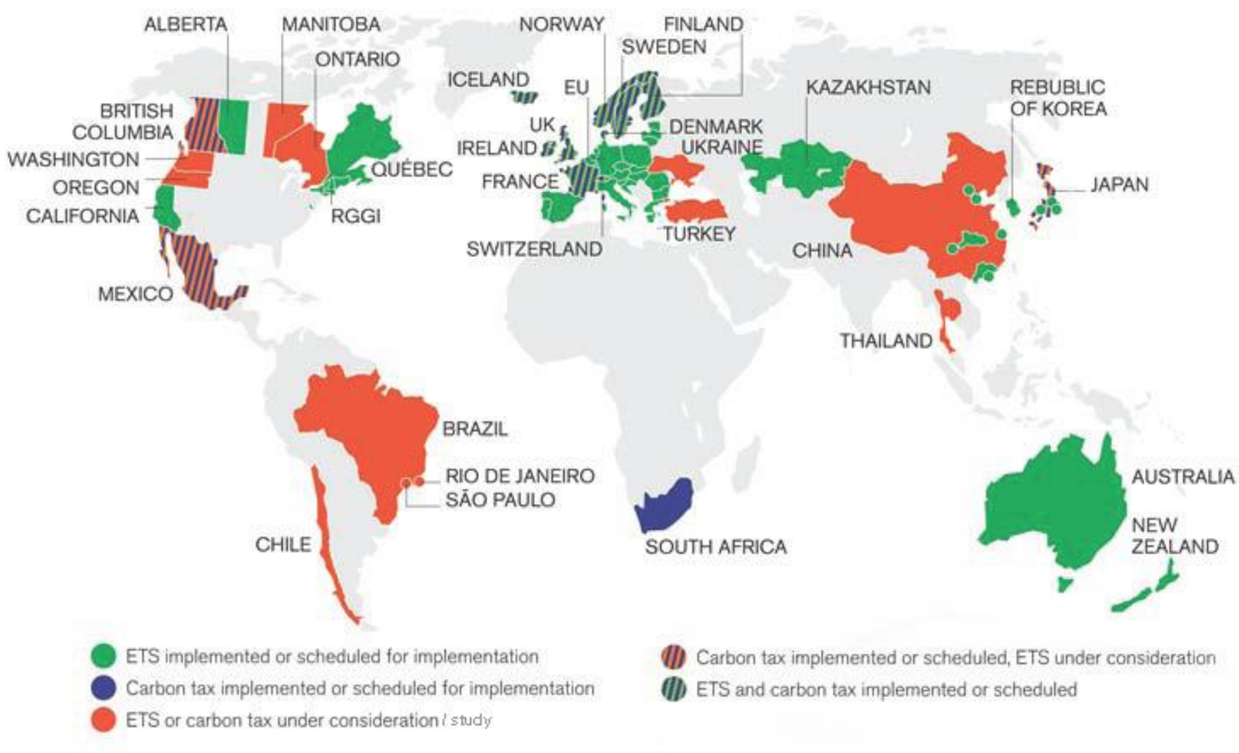
Carbon Pricing Background

In December 2004, the Governor's Advisory Group on Global Warming proposed greenhouse gas reduction goals for Oregon in its report: by 2020, achieve a 10% reduction below 1990 greenhouse gas levels; and by 2050, achieve a "climate stabilization" emissions level at least 75% below 1990 levels (State of Oregon 2004). In 2007, House Bill 3543 codified these emissions goals and established Oregon's Global Warming Commission to make recommendations for reaching these goals. On a global scale, reports such as the Stern Review (2006) and the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (2014) have shown that accumulated concentration levels of carbon dioxide (CO_2) in the atmosphere generate negative externalities on society through "health impacts, economic dislocation, agricultural changes, and other effects that climate change can impose on humanity" (Bell and Callan, 2011). IPCC's Working Group I studied the physical science of climate change and concluded that "[w]arming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCC, 2013).

By pricing carbon emissions (or carbon equivalent emissions), economists believe that the negative externalities on society can be internalized into the decision-making processes of market actors, reducing economic inefficiencies. The U.S. Interagency Working Group on Social Cost of Carbon's (SCC) 2013 technical update study quantifies the negative externalities of carbon emissions as the social cost of carbon. The study utilizes three integrated climate change assessment models (DICE, PAGE and FUND) to estimate the average SCC in 2010 to be equal to $12.18, $35.43 and $56.47 per metric ton of CO_2 and the average SCC in 2020 to be equal to $13.29, $47.61 and $67.55 per metric ton of CO_2 (2012 U.S. dollars) at discount rates of 5%, 3% and 2.5%, respectively (IWGSCC, 2013). Additionally, a report by CDP (2014) indicates a growing trend in major global corporations incorporating carbon pricing into "their business planning and risk management strategies", with more than 150 companies reporting this practice to CDP.

Typically, carbon pricing mechanisms take on one of two forms: carbon tax or carbon cap-and-trade. A carbon tax is placed explicitly on carbon dioxide or carbon dioxide equivalent emissions, usually expressed as dollars per metric ton of CO_2e. This market mechanism provides guaranteed (or predetermined) prices of carbon emissions within the economic system, but allows market actors to determine their own response to the carbon price signal. Currently, carbon taxes have been implemented in 12 nations and one sub-national jurisdiction[5] with other regions under consideration or study.

Figure 3 - Existing, Emerging, and Potential Carbon Pricing Instruments[6]



(Source: World Bank 2014. State and Trends of Carbon Pricing 2014. Washington, DC: World Bank)

On the other hand, a carbon cap-and-trade (emissions trading) mechanism provides guaranteed amounts of carbon emissions through its cap, and allows for the price to fluctuate. Both of these instruments can reduce carbon emissions, and can generate revenues through either taxation or emissions permit trading. Currently, emissions trading is in effect in one region (European Emissions Trading Scheme or EU ETS), three nations, and 13 sub-national jurisdictions[7]. Figure 3 summarizes existing, emerging and potential carbon pricing mechanisms around the world at regional, national, and subnational levels (including both carbon emissions

[5] National carbon tax: Costa Rica, Denmark, Finland, France, Iceland, Ireland, Japan, Mexico, Norway, Sweden, Switzerland and UK; Sub-national carbon tax: British Columbia, Canada (World Bank, 2014).

[6] Note that Australia's carbon pricing and emissions trade scheme has been abolished as of July 2014. This graph was created prior to that date. Also note that areas that indicate ETS or carbon tax under consideration may indicate ETS or carbon tax under consideration or *study*, as is the case in Oregon.

[7] Regional emissions trading: EU ETS; National emissions trading: Kazakhstan, New Zealand and Switzerland; Sub-national emissions trading: Alberta, California, six Chinese pilots, three Japanese schemes, Quebec, RGGI (World Bank 2014).

trading and carbon taxes). However, carbon price levels resulting from these carbon tax and carbon cap-and-trade schemes vary significantly due to differences in implementation.

This study will focus on analyzing economic and carbon emissions impacts of various carbon tax levels and scenarios for the usage of carbon tax revenues in Oregon. The study focuses on this carbon reduction method in particular due to its lower administrative burden and effectiveness in reaching greenhouse gas emissions goals.

II. Carbon Tax Structure

Administrative Structure

A carbon tax is efficient when its rate is set at a level that is equivalent to the full marginal social cost of carbon (SCC), and it is also effective when it achieves its intended policy objectives. The proposed tax is, of course, hypothetical; therefore it is designed to address efficiency and cost-effectiveness. This requires attention to the measure's reach (i.e. the portion of the economy subjected to the tax), its level (the predetermined price imposed on the carbon content of fuels) and its revenue repatriation and expenditure scheme.

Another important consideration is the administrative cost associated with its collection. Current programs in Oregon that already employ similar mechanisms for revenue collection and usage include Oregon Department of Transportation's (ODOT) gas tax (less than 1%)[8] and the Energy Trust of Oregon's (ETO) public service charge[9]. ETO's administrative costs have fluctuated between 2.87% and 6.39% of annual expenditures since its inception, with an average of 4.30% over its lifetime and 3.33% for the last 5 years. As such, a carbon tax may minimize its administrative costs (and maximize cost-effectiveness) by piggy-backing on current existing tax collection structures.

Tax Base - The proposed carbon tax will be levied on each $mTCO_2e$ (metric ton of carbon dioxide equivalent)[10] generated from combustion of fossil fuels within Oregon and imported electricity (where combustion occurs out-of-state, but consumption occurs within Oregon). The tax will be collected at the wholesale level in order to minimize administrative burden and cost whenever possible. While better efficiency and effectiveness may be reached by implementing the carbon tax on all goods imported and consumed within Oregon, it is currently infeasible to obtain sufficient data on the carbon content of all goods imported into the state.

Tax Rate – In 2007, Oregon HB 3543 codified state-level greenhouse gas emissions goals of reaching 10% below 1990 levels by 2020 and at least 75% below 1990 levels by 2050. Research

[8] ODOT Program Budget

[9] Oregon Department of Transportation (ODOT) has collected a state-level motor vehicle fuels tax since 1919. Since 2002, Energy Trust of Oregon (ETO) has collected and redistributed revenue through the public service charge program through investor-owned utilities for energy efficiency.

[10] Here per $mTCO_2e$ refers to metric tons of carbon dioxide equivalence and includes emissions from non-CO_2 greenhouse gases associated with fossil fuel combustion processes, including methane and nitrous oxide, weighted by their global warming potentials on a 100-year time horizon.

reports such as those published by Stern (2006) and the Intergovernmental Panel on Climate (IPCC 2014) have shown that accumulated concentration levels of carbon dioxide (CO_2) in the atmosphere generate negative externalities on society through "health impacts, economic dislocation, agricultural changes, and other effects that climate change can impose on humanity" (Bell and Callan, 2011), resulting in economic inefficiencies. As mentioned above, a range of social costs of carbon have been estimated by U.S. and international research agencies. In addition, current carbon pricing schemes around the world range from a low of $1-$4 per $mTCO_2$ in certain scenarios in Mexico[11] to a high of $168 per $mTCO_2$ in Sweden[12]. One of the only sub-national level carbon taxes exists in British Columbia where it was introduced in 2008 at $10CAD per $mTCO_2$ and gradually increased to its current rate of $30CAD per ton.

Our analysis considers maximum carbon tax rates of $10, $30, $60, $100 and $150 per $mTCO_2$. We assume that the carbon tax starts at $10 per ton in 2014, and incrementally increases by $5 or $10 per year until it reaches the maximum statutory rate. Economic impacts and environmental impacts (greenhouse gas emissions) are estimated for the time period of 2014 to 2034.

This study considers only **greenhouse gas emissions** associated with the combustion of fossil fuels used for energy purposes, including petroleum fuels used for transportation, natural gas used for heating, and coal and other fossil fuels used for electricity generation. It is on these emissions that the carbon tax is levied. Throughout this report we use the terms "energy emissions", "energy-related emissions", and "combustion emissions" interchangeably. Oregon's emissions inventory also includes emissions released from non-energy related processes such as soil and manure management, industrial activities, or refrigeration. Due to their heterogeneous nature, measuring and taxing these emissions are not included in this study, as discussed elsewhere in this report (see Other Considerations). Although carbon dioxide (CO_2) is the main gas released during fossil fuel combustion, a small amount of methane (CH_4) and nitrous oxide (N_2O) emissions are also produced. Emissions from all three greenhouse gases are reported in CO_2-equivalent (CO_2e) units based on their 100-year time horizon global warming potentials.

Revenue Repatriation and Expenditure

Revenues from the carbon tax can be repatriated or expended in the Oregon economy through various channels. Structuring the use of carbon tax revenues to ensure revenue-neutrality presents an appropriate starting point for analysis. Revenue neutrality implies that all revenues

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[11] Mexico's carbon tax was implemented in 2014 and covers approximately 40% of all greenhouse gas emissions. However, this tax is not levied on the full carbon content of fuels, but on the difference in carbon content between fuels and natural gas. Natural gas is not taxed. (World Bank, 2014)

[12] In Sweden, a combination of carbon tax and carbon emissions trading has been implemented since 1991. Households and services are fully covered by the carbon tax (which includes all fossil fuels used for heating and motor fuels), but industries participating in the EU ETS may be exempted. The Swedish carbon tax covers approximately 25% of all greenhouse gas emissions (World Bank, 2014).

collected from the carbon tax would be repatriated back through reductions of other taxes, such as the personal or corporate income taxes[13]. British Columbia implemented its revenue-neutral carbon tax in 2008, designating the majority of the revenues towards corporate and personal income tax cuts.

Describing the use of carbon tax revenues can be complicated. In this report, we will use the words "repatriation" and "expenditure" to describe different types of revenue usage:
Repatriation: returns revenues directly to taxpayers through cuts in existing tax rates
Expenditure: revenues are targeted to specific use by government policy. Funds are collected by government then allocated to specific government uses.

In the early stages of this study, the research team met with a representative from the Oregon State Legislature's Legislative Counsel. We were advised that carbon tax revenue collected on transportation fuels and fees would be allocated to the State Highway Fund based on current constitutional requirements. As noted later in this report, transportation-related revenues make up a large portion of total carbon tax revenues; their use has a significant impact on economic outcomes.

State Highway Fund

Since 1942, the Oregon Constitution (Article IX, Section 3a) dedicates net revenues from motor vehicle registration and title fees, driver license fees, motor vehicle fuel taxes and weight-mile taxes (heavy vehicle fees) to the State Highway Fund. Because the proposed carbon tax would be applied to motor vehicle fuels, many of the revenue repatriation and expenditure scenarios allocate funds collected from gasoline and use fuels directly to the State Highway Fund.

Oregon was the first state to collect a \$0.01/gallon gas tax in 1919, and currently levies a tax of \$0.30/gallon on gasoline and use fuels (all other motor vehicle fuels[14]), \$0.09/gallon on aviation gasoline and \$0.01/gallon on jet fuel. The Oregon State Highway Fund is apportioned to the state, county and city levels according to statute[15], and is designated for the "construction, improvement, maintenance, operation and use of public highways, roads, streets and roadside rest areas" (ODOT, 2014 (2)). During fiscal year 2013-2014, ODOT collected \$482,493,884 from the tax on motor vehicle fuels, about 48.9% of total receipts. Repatriation and expenditure scenarios are structured to reflect current distribution of State Highway Funds by ODOT. Additional scenarios with alternative distributions are analyzed as well.

[13] Economists generally view income taxes as distortionary taxes, as they create negative incentives for workers and businesses that lead to economic inefficiencies in the market. On the other hand, the carbon tax is considered a Pigouvian tax on the negative externalities generated by carbon emissions. Set at an efficient level (equivalent to the marginal social cost of carbon), the carbon tax incorporates the social costs of carbon emissions into the decision-making processes of all market actors.

[14] Use fuel includes premium diesel, biodiesel, and any fuel other than gasoline used to propel a motor vehicle on public roads. Biodiesel dispensed into motor vehicles is also taxed at \$0.30 per gallon. (ODOT *Current Oregon Fuel Tax Rates*, 2014)

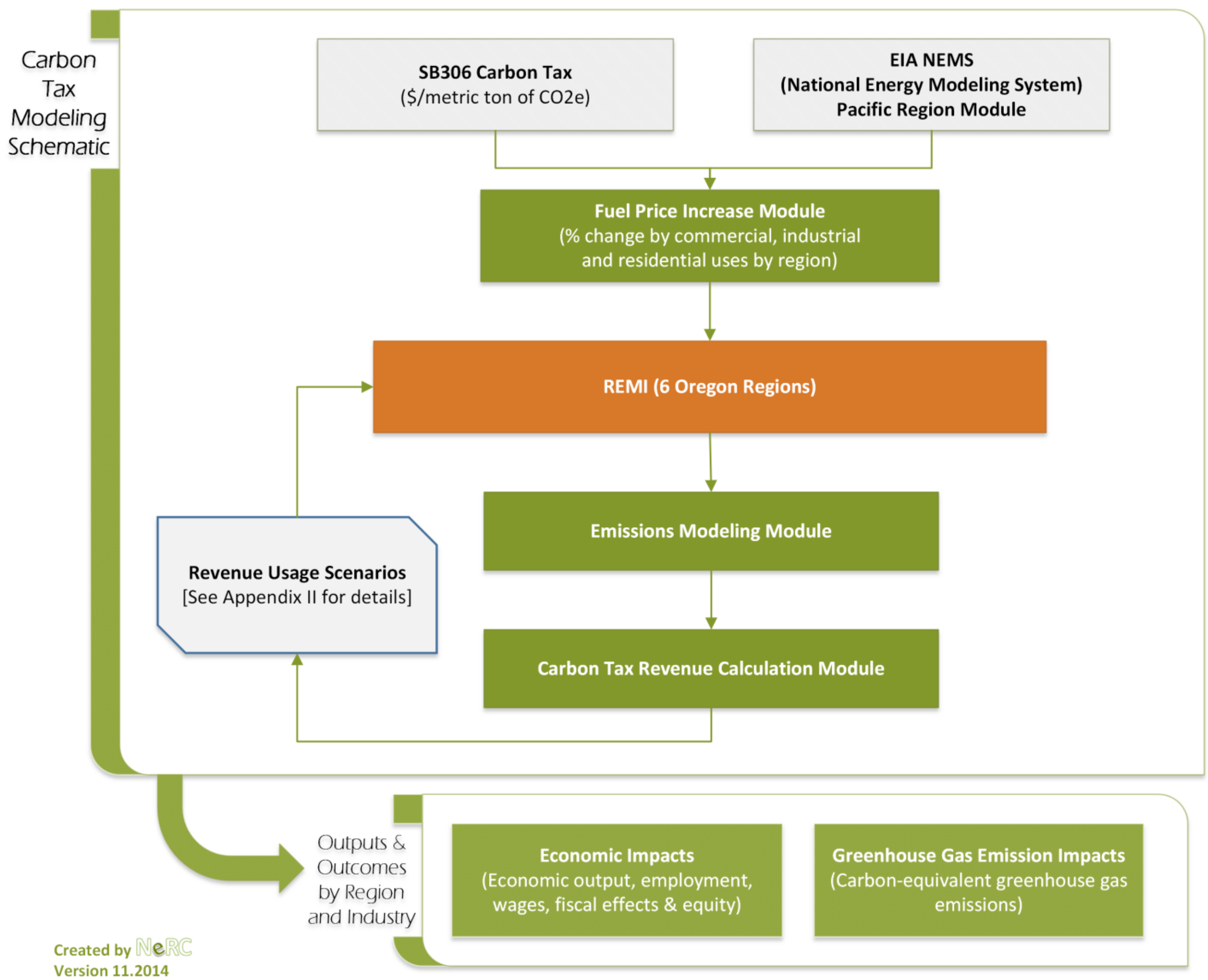
[15] ORS 366.739, 366.742, 366.747, 366.749 and 366.752. Approximately 59% is apportioned to the state, 25% to counties and 16% to cities.

Methodology

An overview modeling and methodology schematic is presented in Figure 4 below. The study team starts with carbon tax levels ($/metric ton of CO_2e) and energy price and demand forecasts from the Energy Information Administration (EIA). In the *Fuel Price Increase Module*, these inputs are then customized for each of six Oregon regions, fuel type and industry, and translated into fuel price increases that serve as inputs into REMI, the dynamic economic impact model described below. Outputs from REMI then feed into the *Emissions Modeling Module* to characterize greenhouse gas emission impacts under each modeling scenario, and these results are translated into tax revenues within the *Carbon Tax Revenue Calculation Module*. Finally, carbon tax revenues are applied through the REMI model under the different *Revenue Usage Scenarios* (see detailed schematic in Appendix II) to estimate the overall dynamic impacts on the economy.

For more details on our modeling methodology, see Appendix I (pg. 96).

Figure 4 - Carbon Tax Modeling Schematic



I. Emissions and Revenue Modeling

Modeling future emissions of greenhouse gases based on economic scenarios is central to understanding the impacts of a carbon tax on Oregon greenhouse gas emissions. The primary objectives of the emissions model developed for this work are to calculate the impact of a carbon tax on energy-related greenhouse gas emissions (relative to an economic baseline estimated without a carbon tax), and to calculate the revenue generated from a tax levied on fossil fuel greenhouse gas emissions (Figure 4). The *Emissions Modeling Module* and *Revenue Calculation Module* are described below.

To study the effect of a carbon tax on emissions, an array of scenarios were constructed which phase-in a carbon tax beginning in 2014 at $10 per $mTCO_2$ and increase at a rate of $5 per $mTCO_2$ per year (lowest tax scenarios) or $10 per $mTCO_2$ per year (highest tax scenarios) to maximum tax rates of $10, 30, 45, 60, 100, 125 and 150 per $mTCO_2$. Carbon tax scenarios are used as inputs which changes the price of fuel in the Regional Economic Model (REMI). Fuel is broken down into purchases of electricity, natural gas, and petroleum fuels.[16] Based on the economic scenarios, the REMI model provides estimates of how fuel demand (in inflation-adjusted 2012 dollars) will change in future years (annually). Fuel demand is further resolved for the 70 economic sectors and the six regions of the State providing an assessment of how fuel purchases in a particular sector and area are affected by different carbon tax rates.

As a general rule of thumb, a carbon price of $1 per $mTCO_2$ corresponds to a $0.01 increase in the price of a gallon of gas. For natural gas, we expect a carbon price of $10 per $mTCO_2$ to lead to a 3% increase in price and a carbon price of $100 per $mTCO_2$ to increase prices by 31%. Electricity price changes vary by region: at a carbon price of $10 per $mTCO_2$ electricity prices would increase by 1.5 – 5% and at a carbon price of $100 per $mTCO_2$ electricity prices would increase by 17 – 51%, depending on the region.[17]

To estimate greenhouse gas emissions associated with changes in fuel demand, a baseline (without a carbon tax) emissions forecast was constructed from a forecast of baseline fuel demand. The baseline in-state demand forecast for natural gas and petroleum fuels was obtained from the US Department of Energy, Energy Information Administration National Energy Modeling System (US DOE EIA NEMS, 2014 Annual Energy Outlook) forecast for the Pacific region prorated for the State of Oregon (Mori, 2012). Baseline emissions from the use of natural gas and petroleum fuels were calculated from baseline demand forecast using fuel-specific emissions factors ("carbon intensities") derived from EIA and projected changes in demand within the petroleum fuel category (Mori, 2012). For natural gas and petroleum fuels, we consider only "in-boundary fuel" emissions which are the direct result of the combustion of fossil fuels, i.e., not including emissions associated with upstream fuel supply. Electricity is treated independently as it includes emissions associated with in-state electrical use of power

[16] The petroleum fuels category includes all energy demand not included in electricity and natural gas, but is primarily motor gasoline and distillate fuel oil in the State of Oregon.
[17] For a detailed breakdown of electricity carbon intensities by region, see Table 5 (pg. 96)

generated out-of-state (Oregon's Greenhouse Gas Emissions Through 2010, In-Boundary, Consumption-Based and Expanded Transportation Sector Inventories, ODEQ, ODOE, ODOT, 2013). Baseline emissions for electricity use were calculated from forecasted in-state electricity retail sales data. Additionally, electrical utilities within the state of Oregon have different fuel mix profiles and therefore differing emissions factors. Utility-based Integrated Resource Plans and utility load data were used to forecast utility-specific emissions factors and to calculate average electricity emissions factors for each of the six study regions. For all energy demand, emissions were disaggregated for the 70 economic sectors and six regions according to projected fuel demand (in 2012 dollars) from the baseline REMI case.

The implementation of a carbon tax changes energy demand through changes in fuel prices. Energy demand changes are tracked annually in the REMI model, and these drive changes in greenhouse gas emissions. Forecast fuel purchases of electricity, natural gas and petroleum fuels were obtained from REMI under each of the carbon tax scenarios through year 2034 for each of the 70 economic sectors and six state regions. Comparing the adjusted forecast fuel purchases from each scenario with the baseline case allows us to adjust the baseline emissions forecast under each carbon tax scenario. The result is a forecast of emissions for each of the 70 economic sectors in each of the six regions generated from use of electricity, natural gas and petroleum fuels that is consistent with both the REMI economic forecasts and baseline energy demand forecasts for the state. For additional detail on this methodology, see Appendix I (pg. 96)

State total fossil fuel-based greenhouse gas emissions are aggregations of results for each economic sector and region. Total annual tax revenue generated by the carbon tax for each scenario is calculated by multiplying estimated statewide emissions times the annual fee on carbon under the scenario.

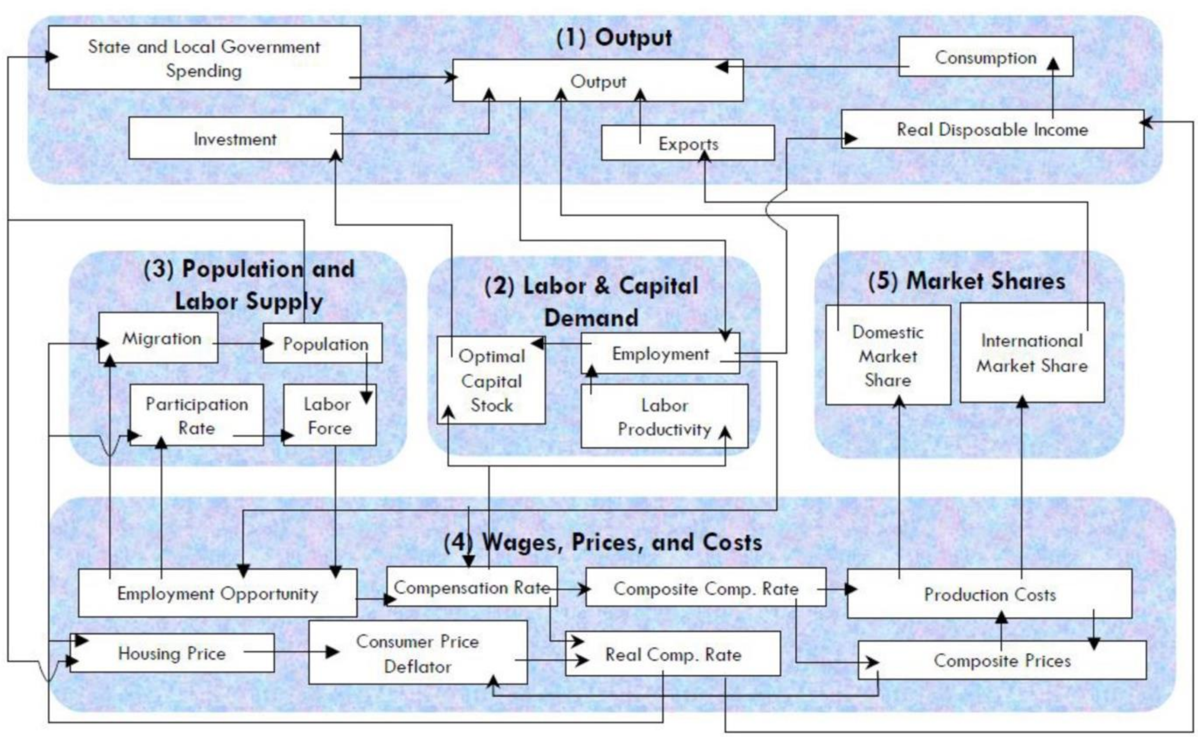
II. Economic Modeling (REMI PI+ Model)

NERC used a six-region model of the Oregon economy developed by Regional Economic Models, Inc. to analyze the dynamic effects of a carbon tax across the state. The REMI model is widely used for planning and policy analysis at the national, state, and local level. It integrates input-output, econometric, and general equilibrium approaches from economics to produce realistic simulations of the complicated channels through which economic shocks move through the economy. It is thus a dynamic forecasting tool; by first estimating the complex historical relationships between economic entities and activities, the model is able to project outcomes for virtually any set of user-defined policies and economic circumstances.

Data underlying the REMI model includes historical personal income, employment, and population at each geographic level from the Bureau of Economic Analysis, Bureau of Labor Statistics, and US Census Bureau. The responses of firms and households to any economic shock will vary across industries and regions, so these data are incorporated at a high level of disaggregation. The model also uses historical fuel costs, housing prices, corporate tax rates and structures, and several other supplemental time series to estimate particular regional characteristics. Employment projections from the BEA and BLS are incorporated into REMI's baseline forecast, to which alternative scenarios can be compared.

REMI is designed to capture complex interactions between industries and locations. For example, in its production process a packaging manufacturer in Portland may require wood fiber originating in the southern Willamette Valley, electronics manufactured in the western Metro region, and transportation services based in central Oregon. A "shock" to any link in that chain will have both upstream and downstream effects in the model simultaneous with all of the effects happening in other supply chains. Household and population dynamics are similarly represented; households (like firms) respond to exogenous shocks according to standard economic theory. This means, for example, that workers will tend to relocate towards better employment opportunities and away from higher living costs. This movement in turn interacts with labor and housing markets over time, creating a fully dynamic system akin to textbook representations of the macroeconomy. Figure 5 illustrates the basic structure of the model economy in REMI. The schematic represents a single geographic region; equally complex links are modeled between regions including migration, inter-regional competition, and cross-border price effects, but for simplicity these linkages are not pictured here.

Figure 5 - REMI Model Schematic

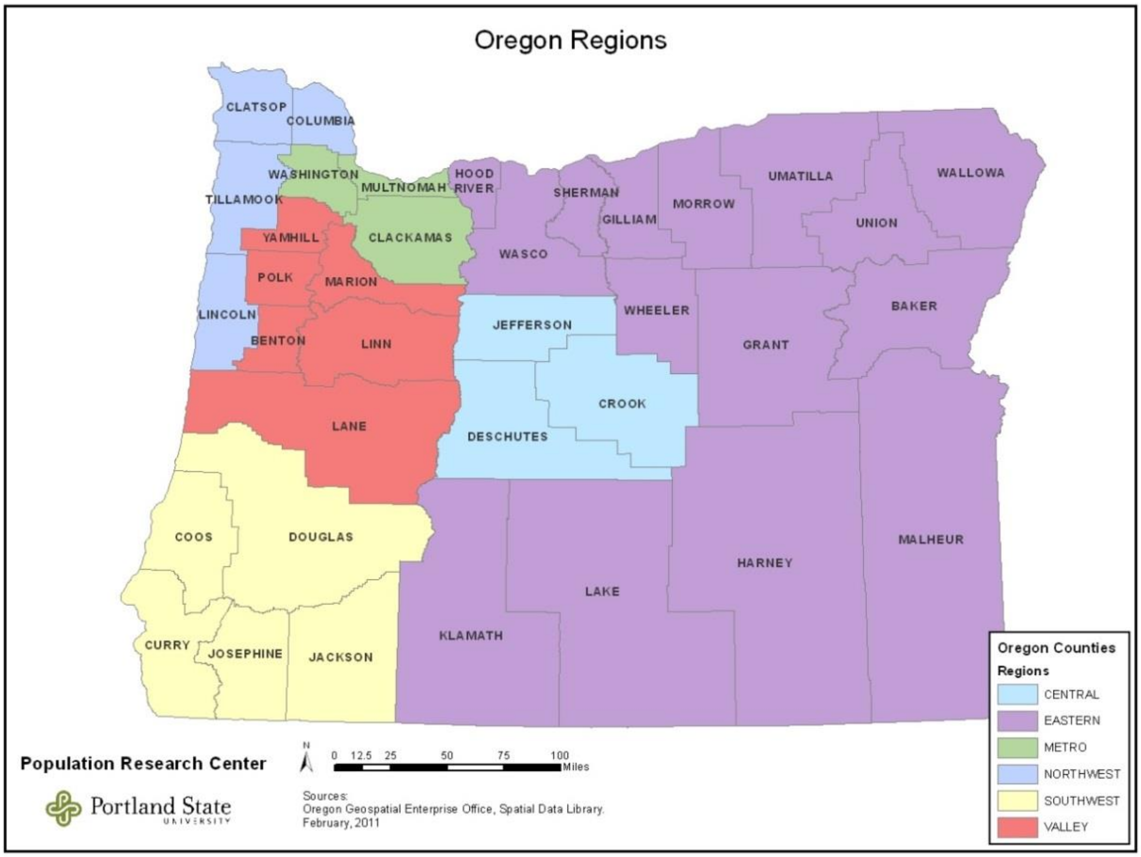


The magnitudes of supply-side and household demand effects (the arrows in Figure 5) depend on the responsiveness of numerous variables to economic signals and conditions. These response elasticities and multipliers are estimated econometrically by REMI, using observed data to estimate expected responses to simulated shocks in the economy. For this study, especially relevant elasticities include the price elasticity of demand for fuel and other goods and services (also central to the C-TAM model), and the marginal propensities of households to consume different goods and services. In REMI, households of different income levels have appropriately different spending and saving habits. When carbon tax revenues are repatriated or allocated to the different household income quintiles, it is thus possible to track the demand and output impacts across individual industries, which then trigger additional effects in accordance with each industry's estimated response to changes in input prices, interest rates, etc.

The model starts with a detailed representation of the six regions of the Oregon economy (Metro, Northwest, Central, Eastern, Southwestern, and Valley), and introduces changes that cycle through thousands of linkages according to observed relationships. Figure 6 shows a map of the six Oregon regions used in the model.

For this study, NERC augmented the dynamic processes through which REMI equilibrates to reflect the nexus of carbon emissions, emissions tax revenues, employment, and economic output. To briefly illustrate, a carbon tax is introduced in REMI according to the fuel consumption of households and firms in different industries. This creates output and fuel demand effects as consumers and firms respond to higher energy costs, as well carbon tax revenues which are returned to the economy. Simply allowing REMI to reach a new equilibrium after this one-time shock would conceptually omit an indirect channel of adjustment: the tax, demand response; revenue repatriation and expenditure occurring in the first year will also affect the demand response and revenues generated in subsequent years (fuel demand will have fallen somewhat, and revenues will follow suit). The method chosen for revenue repatriation and expenditure will alter these economic outcomes, which will affect the carbon tax revenue collected. NERC incorporated this iterative revenue feedback from our emissions model for each scenario in order to capture this effect; while feedback impacts at lower tax levels were essentially too small to measure, they did become noticeable at tax levels above \$100 per $mTCO_2e$.

Figure 6 - Study Regions



Results

As noted in the modeling schematic (pg. 15), energy price changes resulting from a carbon tax alter the expected level of fuel demand and economic output. These changes are used to estimate changes in greenhouse gas emissions from the forecast baseline. Revenue estimates derived from these expected changes are fed back into the economic model to derive the final scenario results. This section begins with a description of the analytical baseline and an explanation of the estimation of impacts on emissions and carbon tax revenues. The Scenario Results subsection reports net economic impacts incorporating the combined effects of the energy price changes and revenue use scenarios.

I. Baseline Scenario

Over approximately the next two decades (2012 to 2034) Oregon's energy-related emissions of greenhouse gases are projected to increase by about 10% under a no carbon-tax baseline scenario derived from on the U.S. Department of Energy's Energy Information Administration's National Energy Modeling System's (EIA-NEMS) fuel demand forecasts and ODOE's projection of Oregon's demand for electricity (ODOE, 2014) (Figure 7)[18]. This is in contrast to a trend over the past decade during which Oregon a ~10% decrease of total greenhouse gas emissions relative to a peak in the year 2000 (ODEQ, 2013). The baseline forecast predicts that energy-related emissions will be 13% higher in the year 2020 relative to 1990 levels and 15% higher in the year 2034, the last year of our modeling period. Thus under the baseline scenario, Oregon would fail to meet its goal of reducing emissions 10% below 1990 levels by 2020 and would also be on a difficult track to meet its 2050 goal of a 75% emissions reduction.

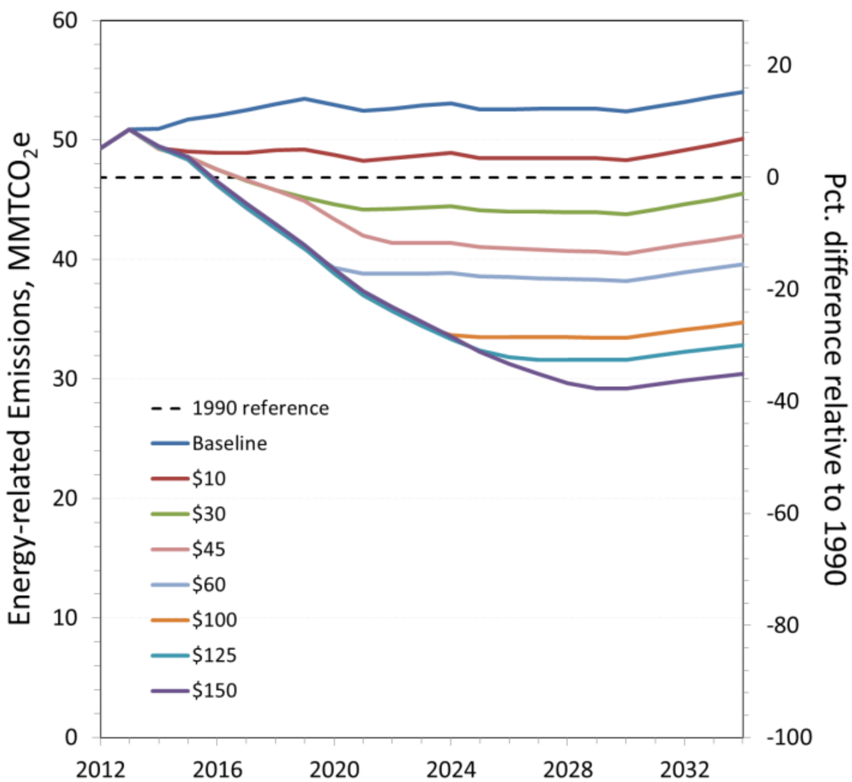
This forecast rise in emissions is driven primarily by a projected 17% increase in consumption of natural gas both for electricity production and other uses. EIA-NEMS baseline energy forecast assumes continuation of current laws and regulations; as such these projections do not include new EPA rules that seek to limit emissions from electric power plants (i.e., US EPA 111D), though these rules if implemented will certainly have a significant impact on Oregon's emissions apart from the effects of a carbon tax.

Under the baseline scenario, combined emissions from natural gas and electricity consumption are estimated to increase by over 20% by the year 2034, while emissions from the use of petroleum fuels are estimated to decrease by 3%. Combining all sectors and regions of the state, the respective contributions of emissions from natural gas, electricity consumption, and petroleum fuel combustion to total energy emissions are approximately 18%, 35%, and 46%, respectively. Emissions are heavily concentrated in the Metro and Valley regions, which together account for more than 80% of the state emissions. In the baseline scenario, energy-

[18] The difference in the paths between carbon prices of $45/ton and below, and prices above $45/ton is caused by the assumed phase-in of annual price increases. We assume that for carbon prices of $45/ton or below, the price starts at $10/ton and increases by $5/ton per year until the cap is reached. The assumed phase-in for carbon tax levels above $45/ton is $10/ton per year until the price cap is reached.

related emissions are expected to increase over the next twenty years in all regions except for the Eastern and Northwest regions where emissions are projected to fall 2-5%.

Figure 7 - Energy-related Greenhouse Gas Emissions for the Baseline and C.4 Carbon Tax Scenarios[19]



[19] Baseline (no carbon tax) and 1990 emissions are shown for reference. The latter includes emissions from the consumption of electricity but does not include emissions from non-combustion processes.

Table 2 - Projection of Average Greenhouse Gas Emissions under the Baseline and C.4 Scenario[20]

	Emissions (mmT CO_2e)	Reduction from baseline (%)	Change from 1990 levels (%)	Revenue (millions 2012 $)
Baseline case				
(no carbon tax)	53.1	0.0%	13.5%	0
Carbon tax scenarios				
$10/metric ton	49.2	7.4%	5.1%	490
$30/metric ton	45.1	15.0%	-3.6%	1350
$45/metric ton	41.6	21.7%	-11.1%	1870
$60/metric ton	39.2	26.2%	-16.2%	2350
$100/metric ton	34.5	35.1%	-26.4%	3450
$125/metric ton	32.2	39.4%	-31.3%	4020
$150/metric ton	30.3	42.9%	-35.2%	4550

II. Carbon Tax Scenarios

In agreement with other studies, we find the assessment of a carbon tax in Oregon reduces energy demand and energy-related greenhouse gas emissions relative to the baseline scenario by an amount that is largely proportional to the carbon tax rate (Table 2). Because fuel demand is driven mostly by economic activity, the size of the emissions reductions depends not only on the carbon tax rate, but also on how the revenue collected from the carbon tax is returned to the economy.

For example, if the repatriation or expenditure scenario stimulates significant economic activity and therefore increases fuel demand, we expect the total emissions reductions to be somewhat less than under certain other revenue use options. In principle, while the amount of emissions reduction will vary under the different scenarios, in practice we find that the repatriation and expenditure scenarios have a relatively small impact on total economic activity and output (at least within the set of revenue-neutral scenarios). Consequently there are only small differences in greenhouse gas emissions between the scenarios. For example, there is less than a 1% difference in emissions levels between the 100/0 and 0/100 corporate/personal income tax split scenarios. Even if all the revenue generated by a carbon tax were stored away in a reserve fund rather than repatriated to taxpayers or otherwise spent, greenhouse gas emissions would be reduced by only an additional 1.5%.

The most important influence on the size of the emissions reductions is therefore the carbon tax level itself, and not how the tax revenue is spent. In the discussion that follows, we illustrate reductions in greenhouse gas emissions using the 70/30 tax split scenario with highway

[20] Emissions changes relative to baseline scenario and 1990 levels, and tax revenue from each scenario. Reported values are averages of years 2029–2034, a reference point after

transportation funding (i.e. the C.4 scenarios, Figure 7), although the amount of emissions reduction would nearly identical under any of the other comparable carbon tax rate scenarios.

We find that emissions decrease shortly after the introduction of a carbon tax and continue to fall until approximately one year after the maximum tax rate is reached and stabilize thereafter (Figure 7). Emissions do not return to the baseline level even years after the maximum carbon tax is reached. The timing of the emissions reductions depends on how the tax is phased in and when the maximum tax rate is reached. For example, results show that emissions decline up to 2015 for a $10/ton tax but continue to decline up to 2029 under a phased-in $150/ton tax.

The amount of emissions reductions depends on the carbon tax rate. This study finds that a $30/ton carbon tax will reduce statewide energy-related emissions by 8 mmTCO$_2$e (million metric ton of CO_2 equivalent) which is a 15% reduction relative to the baseline scenario; a $100/ton tax will decrease emissions by 19 mmTCO$_2$e, which is a 35% reduction relative to the baseline case. For comparison, in British Columbia petroleum fuel use subject to the $30/ton carbon tax dropped by 17% in the years 2008-2013 after the implementation of its carbon tax while increasing 3% in the rest of Canada (Sustainable Prosperity, BC's Carbon Tax Shift After Five Years: Results An Environmental (and Economic) Success Story, 2013)[21]. We find that emissions reductions scale linearly with the size of the carbon tax up to approximately $45/ton. Above this level, emissions reductions continue but at a slower pace relative to the carbon tax indicating some diminishing returns in the amount of emissions reductions achievable at higher tax rates.

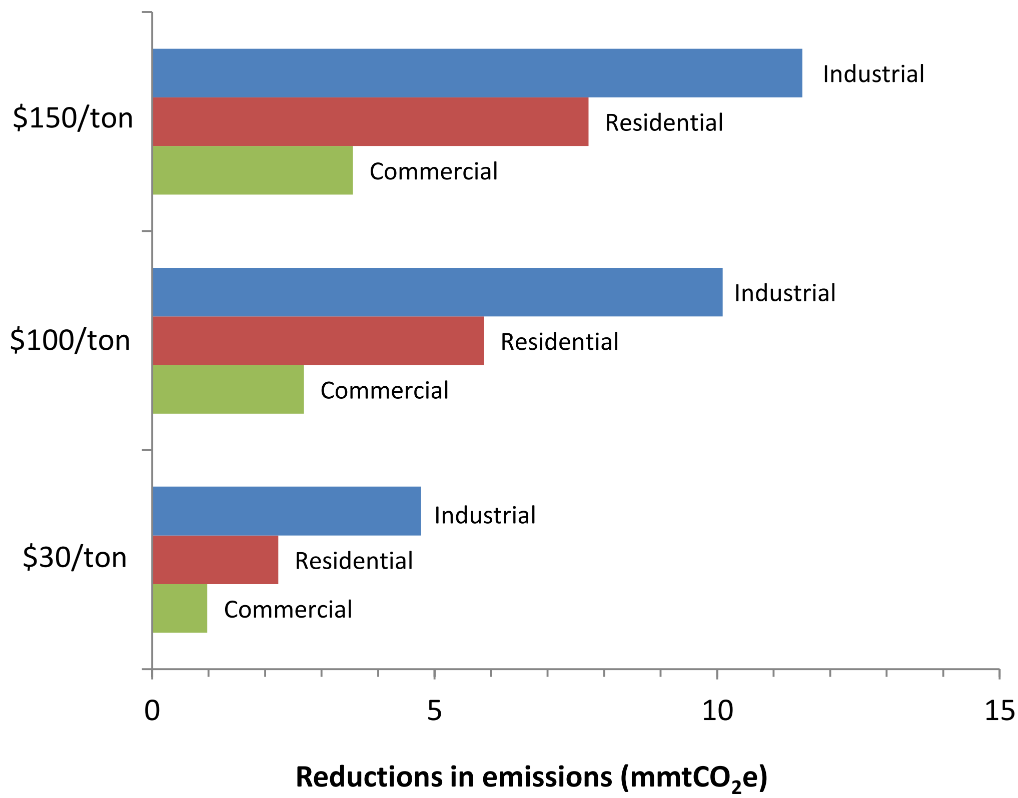
At a carbon tax of $10/ton, we find that energy-related emissions remain above 1990 levels through 2034, the end of our modeling period. But for tax rates of at least $30/ton, emissions fall below 1990 levels. In fact as the rate is increased from $30 to $150/ton, emissions in the year 2034 decrease relative to 1990 levels by 4% to 35%, indicating that a carbon tax can make a significant contribution to Oregon's overall greenhouse gas emissions goals of 10% reduction by 2020 and 75% reduction by 2050 (OGWC, 2013). In particular our analysis suggests that a carbon tax rate of $60/ton or higher could alone provide the reductions necessary to achieve a 10% reduction from 1990 levels by 2020 (assuming non-energy greenhouse gas emissions are constant).

However results of this study suggest that the longer term goal of 75% reduction by 2050 will not be achievable through the implementation of a carbon tax alone at tax rates up $150/ton. Additional mechanisms to lower emissions will be needed. As pointed out in a recent Oregon report (OGWC, 2013), without significant changes in the electricity fuel mix (which produces over 30% of state emissions), it will be very challenging – if not impossible – to meet this 2050 goal. Our emissions analysis here is based on the most recent Oregon utility Integrated Resource Plans which do not project the substantial shifts in utility electricity profiles that would be needed. However future implementation of external rules such as the US EPA regulation of emissions in power generation could complement the effects of a carbon tax

[21] Note: comprehensive greenhouse gas emissions data is not yet available for BC for the period 2008-2013

towards reducing statewide emissions in the long-term. Similarly the implementation of statewide strategies to reduce greenhouse gas emissions (e.g., pathways outlined in the 2013 Oregon Statewide Transportation Strategy) would also complement a carbon tax policy and result in additional emissions reductions that are not included in this study.

Figure 8 - Emissions Reductions from the Industrial, Residential and Commercial Sectors at Three Different Tax Rates[22]



Emissions Reduction by Sector

The breakdown of Oregon's economy into 70 industry sectors and six regions by REMI provides additional insight into where we expect emissions reductions to occur under a carbon tax policy. We find that emissions reductions are largest in the aggregated industrial sector, followed by the residential and commercial sectors. However, results of this study suggest that the longer term goal of 75% reduction by 2050 will not be achievable through the implementation of a carbon tax alone at tax rates up $150/ton. Additional mechanisms to lower emissions will be needed. As pointed out in a recent Oregon report (OGWC, 2013), without significant changes in the electricity fuel mix (which produces over 30% of state emissions), it will be very challenging – if not impossible – to meet this 2050 goal. Our emissions analysis here is based on the most recent Oregon utility Integrated Resource Plans which do not project the

[22] Emissions changes relative to baseline scenario and 1990 levels, and tax revenue from each scenario. Reported values are averages of years 2029–2034, a reference point after which emissions have stabilized under each scenario.

substantial shifts in utility electricity profiles that would be needed. However future implementation of external rules such as the US EPA regulation of emissions in power generation could complement the effects of a carbon tax towards reducing statewide emissions in the long-term. Similarly the implementation of statewide strategies to reduce greenhouse gas emissions (e.g., pathways outlined in the 2013 Oregon Statewide Transportation Strategy) would also complement a carbon tax policy and result in additional emissions reductions that are not included in this study.

Reductions in industry are largest typically in electricity and natural gas fuels, whereas reductions in the residential sector are largest in transportation fuels (Figure 8). We note that in this study, emissions from the combustion of transportation fuels are included within the three aggregated sector's total emissions, unlike some studies where transportation is broken out as a separate sector. This is because REMI outputs energy purchases by fuel type for each sector and not by how the energy is being used within that sector (except for the residential sector where transportation fuel purchases are disaggregated).

For purposes of this report, of the 70 REMI sectors we focused particular attention on emissions reductions in Oregon's "key industries" as identified by Business Oregon. Collectively, the REMI sectors within the key industries contribute about 20% of Oregon's total energy-related emissions and experience about 15% of Oregon's total emissions reductions if a carbon tax were implemented. Average projected emissions reductions below the baseline scenario for key industries are ~9% at a tax rate of $30/ton, ~17% at a rate of $60/ton, ~25% at $100/ton, and ~33% at $150/ton. In addition to these key Oregon industries, other large emissions reductions occur in the petroleum and coal manufacturing, primary metal manufacturing, construction, real estate, and truck transportation sectors.

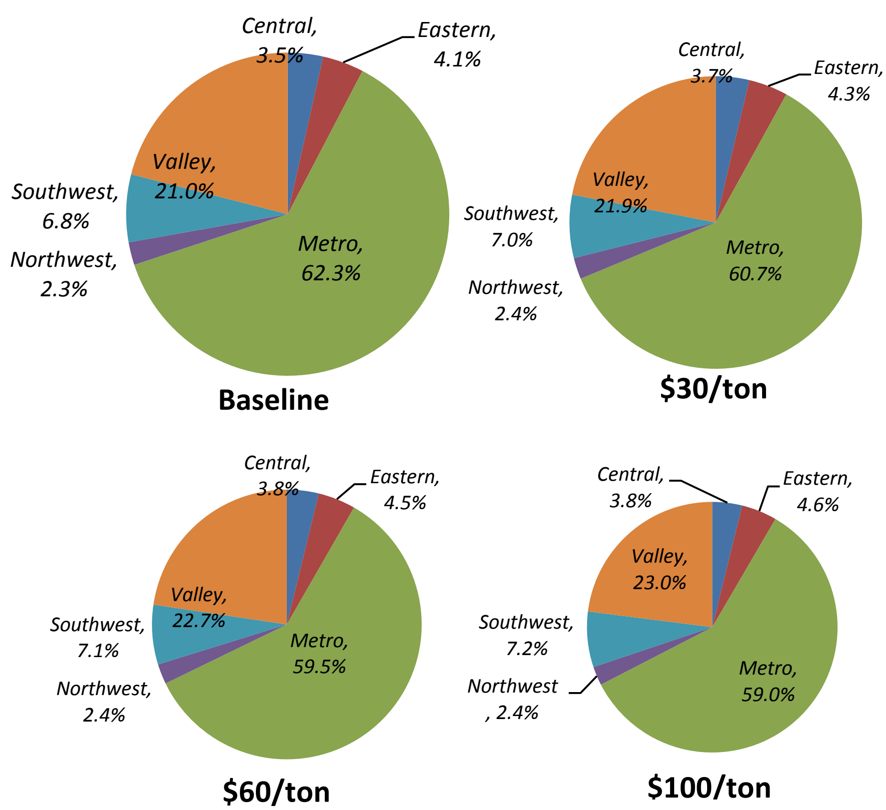
Emissions Reductions by Region

Not surprisingly, the Metro region produces the majority of Oregon's energy-related emissions (Figure 9). Over 60% of total state emissions come from the Metro region, while the Valley contributes a little more than 20%. The remaining (approximately 20%) of total state emissions are distributed roughly evenly among the other four regions with a slight preponderance in the Southwest.

The impact of a carbon tax on emissions is similar across regions. At a specified tax level, the percent reduction in emissions is nearly the same for all regions, which generally maintains the relative distribution of emissions between regions that is observed in the baseline scenario. This result is consistent with the previous finding that a large share of the emissions reductions under a carbon tax come from reduced consumption of energy by households. Therefore we expect emissions reductions to scale with regional population. As the carbon tax increases, we do see a slight shift in emissions away from the Metro region to all other regions. For example at a tax of $100/ton the Metro region's share of total state emissions falls by about 3% relative to the baseline. This likely reflects the additional emissions reductions in the relatively energy-intensive commercial and industrial sectors that are concentrated in the Metro region compared to the other regions.

Across all sectors and regions, the relative contributions to total emissions reductions from natural gas, electricity, and petroleum fuels consumption are 43%, 25%, and 32% respectively at a carbon tax rate of $45/ton. These percentages are somewhat sensitive to the tax rate; at a $150/ton carbon tax rate for example the respective contributions to total emissions reductions are 39%, 31%, and 30%.

Figure 9 - Regional Distribution of Oregon's Energy-related GHG Emissions Averaged Over 2029-2034[23]



Comparison to Previous Carbon Tax Studies

The current work reaches a different conclusion than the previous report by NERC (Liu and Renfro, 2013) about Oregon's ability to reach its emissions reduction targets with a carbon tax. The previous study found that Oregon's emissions would not fall below 1990 levels by 2035 even with a carbon tax of $60/ton, the highest rate considered by that study. In contrast, the current study estimates that a $60/ton tax rate would push emissions more than 15% below 1990 levels by 2020 which would surpass Oregon's goal of a 10% reduction by 2020. It is

[23] Pie chart areas are proportional to total emissions; 53, 45, 39, and 35 mmtCO_2e for the baseline, $30/ton, $60/ton, and $100/ton tax scenarios, respectively.

important to realize, however, that the 2013 study only considered in-boundary emissions - or only emissions generated in Oregon - and did not include emissions associated with in-state consumption of electricity that is generated outside the state. The current study *does* include these "carbon-by-wire" emissions in its estimates, which explains a significant amount of the differences in the emissions calculated in each study. Because much of the out-of-state electricity generation is from coal-fired plants, emissions associated with imported electricity are disproportionately high. Specifically electricity from conventional hydroelectricity and other renewable sources supplied 70% of the Oregon's net electricity generation in 2013 (and has been as high as 80% in former years) (Energy Information Agency, Oregon State Energy Profile, 2014). However electricity is delivered to and from neighboring states by way of the Western Interconnection, and the electricity consumed in Oregon that is supplied through utilities is roughly 45% from coal and natural gas fired power plants (ODOE, 2014 (4)). This results in significantly higher average carbon intensity for electricity consumed within the state, and correspondingly higher emissions for electricity from this source of energy than the average carbon intensity of electricity produced within the State. For example, emissions from out-of-state generation of electricity consumed in Oregon were about 10 mmTCO$_2$e in 2010, or about half of the total emissions associated with electricity usage in Oregon. The amount of emissions reductions calculated from a carbon tax depends on which emissions are included in the inventory; therefore, we would expect emissions reductions to be larger for an inventory that includes all emissions associated with electricity use compared with one that only includes emissions from in-state generation.

This analysis raises an important question: what emissions accounting method should be used to assess Oregon's progress toward reaching its emissions reductions goal? The Oregon policy that sets the emissions reductions goals, ORS 468A.205, only specifies that "Oregon's greenhouse gas emissions" are to be reduced, but does not specify what emissions are to be included in meeting its goals. However the Oregon Global Warming Commission, which was created by the same legislation and is charged with both recommending mitigation policies and evaluating Oregon's progress in meeting these goals, does consider carbon by-wire emissions to be part of Oregon's emissions portfolio, and recommends reducing these emissions to put Oregon on track to meet its reductions targets (OGCW*,* 2013). Therefore the inclusion of out-of-state emissions associated with Oregon's electricity consumption in the current study is consistent with the OGWC and its policy recommendations. This study finds that from an emissions perspective, an economy-wide price signal set by a carbon tax can be an effective carbon emissions reduction mechanism for Oregon.

For additional reference, it is worthwhile to compare the effects of a carbon tax on projected emissions reductions with results from recent studies in other states, although direct comparison is not possible. A recent study of a carbon tax in the State of California found that at a tax rate of $50/ton, energy-related emissions would be ~8% below the baseline case and could achieve ~5% reduction below 1990 levels by 2020 (REMI, 2014). At $100/ton the study found emissions 10% below 1990 levels could be reached by 2024. Similarly, a recent study found that a carbon tax rate of $100/ton was needed in the State of Washington to achieve reductions of 15% below baseline projections and to meet the goal of 10% below 1990 levels

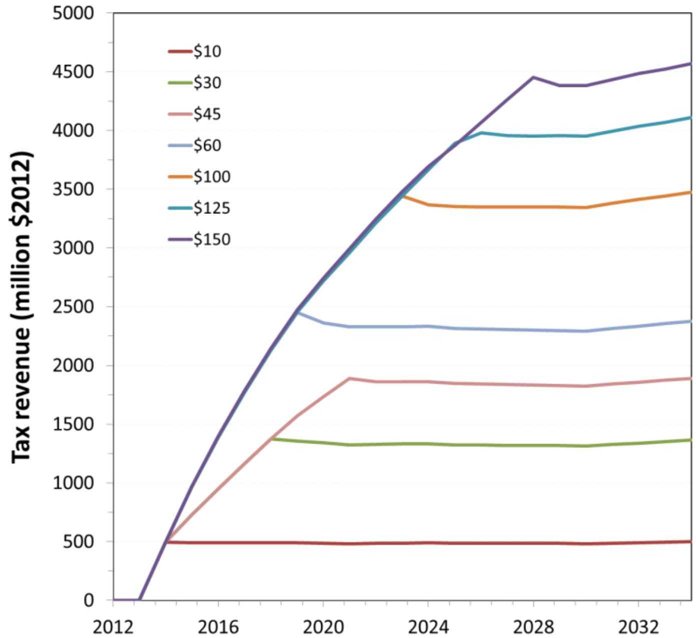
(Mori, 2012). Compared with our study for Oregon, the relatively higher carbon tax rate needed in Washington to achieve these emissions reductions is likely related to the lower average carbon intensity for electricity consumed in Washington. In contrast, a recent study of a carbon tax in Massachusetts found that a tax rate of $45/ton was sufficient to achieve 10% reductions below the baseline projection and 19% below 1990 levels, largely due to the fact that Massachusetts's greenhouse gas emissions are currently already near 1990 levels (REMI, 2013). Finally, it is important to note that in addition to regional differences between these studies, methodological differences in economic and energy modeling between studies may also result in disparities in the projected emissions outcomes.

III. Revenue

This study predicts that total annual state revenue generated by the carbon tax will range from $500 million (in inflation-adjusted 2012 dollars) to $4.6 billion as the tax rate is increased from $10 to $150/ton (Figure 10). About 35% of the total revenue comes from the residential sector with the remainder split almost evenly between the commercial and industrial sectors. At $30 per ton the estimated tax revenue is $1.4 billion or $370 per capita. For comparison, British Columbia reported tax revenue of $CN1.2 billion for 2012-2013 from its $30 carbon tax. Similar to emissions, tax revenue scales up nearly linearly for the carbon tax rate up to $60/ton, then increases at a slower rate and somewhat flattens at the highest tax rates. Our study further indicates that tax revenue is stable and varies less than 2% after the tax rate has reached its cap. The stepped increase in revenues, which mirrors the path of the decrease in emissions, is due to the size of the assumed annual carbon price increase under the different tax rate scenarios[24].

[24] Revenues for carbon prices of $45/ton and below are shown on the lower branch in the diagram. These scenarios feature a $5/ton annual increase in the tax rate until the price cap is reached. For prices above $45/ton (shown on the upper branch), the assumed annual increase is $10/ton until the cap is reached.

Figure 10 - Total State Revenue Generated by a Range of Carbon Tax Rates



These revenue estimates feed back into the economic model as tax cuts and/or public expenditures. The overall economic modeling results for each scenario are produced by combining the effects of the price increase due to the carbon tax with the revenue repatriation and expenditure impacts. Ultimately the impacts on emissions and economic variables are driven by behavioral changes in response to the increase in fuel prices and the use of revenue generated by carbon tax on the resulting level of greenhouse gas emissions.

IV. Revenue Repatriation and Expenditure Scenario Results

The following scenario results are intended to provide information on the expected economic impacts for a variety of tax collection and revenue-use options. Our intent is to demonstrate the tradeoffs between different policy options. As our model runs demonstrate, there is no one optimal strategy for implementation. In all scenarios, there are winners and losers that vary across region, industries, and income classes. Dedicating tax revenues to one priority necessarily leaves less revenue for everything else.

Figure 11 - Simplified Schematic of Revenue Usage Scenarios

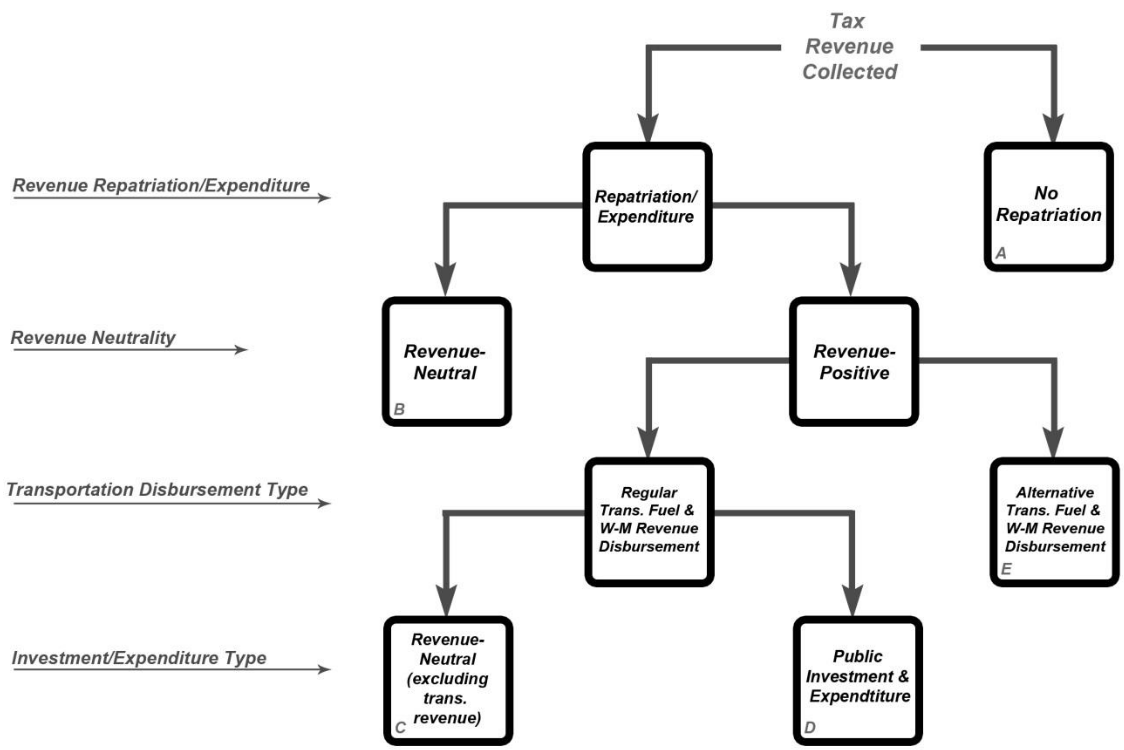


Figure 11 is a simplified version of the detailed modeling schematic featured in Appendix II (pg. 108).The scenarios and underlying variants are grouped by type based on carbon tax revenue allocation.

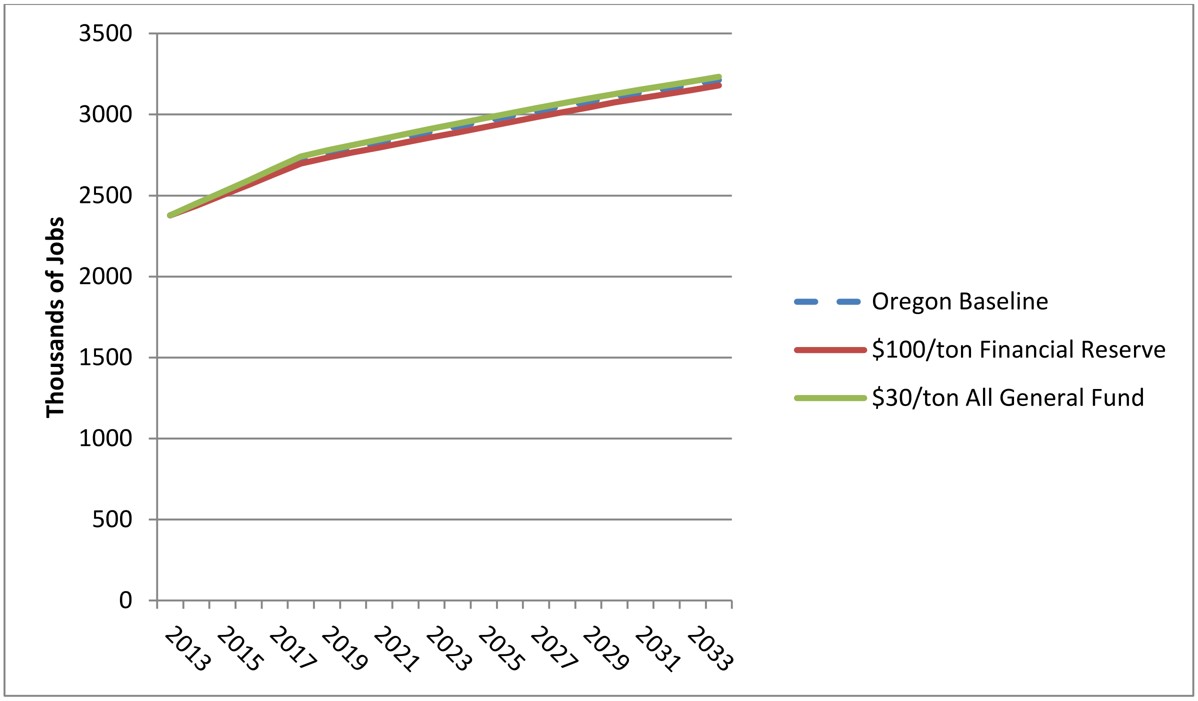
- **Scenario A** features variants which use all revenue for government expenditures or financial reserves (no repatriation).
- The variants in **Scenario B** use all revenue to reduce existing taxes and fees
- **Scenarios C** and **D** assume that transportation-related revenues are dedicated to the State Highway Fund.
    - **Scenario C** features variants which use the non-transportation funds to reduce existing taxes
    - **Scenario D** variants reduce taxes and use some revenue for other public investment or expenditures
- **Scenario E** assumes that the constitutional requirement related to transportation-related revenues is changed, so that those revenues can be used for other types of transportation projects. These variants also use non-transportation revenues to reduce existing taxes.

Overall, the differences between scenarios in which most of the revenue is returned to the economy are fairly small relative to the size of the Oregon economy. For carbon prices less than $100/ton, even the scenarios with overall negative impacts have a relatively small overall effect. Regionally, we find that the Portland Metro Area consistently fares worse than other study regions, based largely on its industrial mix. Across industries, the impact on energy-intensive sectors varies based on the ability of that industry to pass on price changes. We do find that the carbon tax is regressive, but this effect on low-income households can be offset through certain policies. The section on low-income assistance and other income support suggests several methods for implementing a low-income assistance program.

Figure 12 shows the baseline forecast for employment for Oregon. For context, we have also added the employment impacts for Scenario A.1.100, which assumes that all carbon tax revenues are dedicated to state financial reserve funds and are not repatriated or spent, and the impacts from Scenario A.4.30, which assumes all carbon tax revenues are allocated to the general fund. With an expected decline from the baseline of over 35,000 jobs, Scenario A.1.100 has the largest impact of any considered in the report. As Figure 12 shows, when compared to the overall state-level of employment, the change is small (a little more than 1% below forecast baseline employment levels). Even in this extreme scenario, job growth is still positive, although the carbon tax does act as a drag on growth. The “all general fund” ($30/ton price cap) Scenario A.4.30 results in the largest job growth, but the positive impact is small relative to the overall employment level. **This study reports scenario results in terms of deviation from the expected employment, output, and compensation baselines. In cases where figures show negative impacts, they are negative with respect to the levels projected in the future and do not imply absolute declines.**

There were too many scenario runs to report everything here, but Appendix II (pg. 108) features a schematic showing all model runs by type and some additional results. For this report, we are presenting the scenario outputs which we found most interesting and which best demonstrate important policy trade-offs. **In order to assist in comparing results, each scenario includes a “Jobs Index” measure of the mean number of net jobs per million dollars of revenue collected.** The employment impact in each scenario changes over time, so we also calculated impacts in terms of net jobs added or lost per million dollars of revenue each year, and averaged those amounts over the estimation period.

Figure 12- Baseline Employment Forecast Compared with Results under Selected Scenarios



Key Industries

SB306 instructs us to pay particular attention to industries identified by the Oregon Business Development Commission. These key industries are:

- Outdoor Gear and Activewear
- Advanced Manufacturing
- High Tech
- Forestry and Wood Products
- Clean Tech

This report shows impacts for these key industries for selected scenarios; focusing on them when it is of particular relevance or interest. Outdoor Gear and Activewear, Advanced Manufacturing, High Tech, and Forestry and Wood Products are all represented by distinct industry categories in the models. However, Clean Tech is not as tightly defined as the other key industries, which can lead to some potentially misleading results. For example, the NAICS code for the Construction industry is included in the definition of Clean Tech. Some of our scenarios result in large employment gains in the construction industry, which is then interpreted as driving employment gains in Clean Tech. However, there is not anything particularly "clean" or "technological" about the type of construction projects we are envisioning. As a result, when reporting on key industry impacts in aggregate, we leave out Clean Tech (partly because of double-counting issues). Another point to note when discussing these key industries is that Wholesale Trade is a part of all of these industries. Rather than try to apportion it to each category, we chose to separate it out and report on it in isolation.

In general, we see small negative impacts for the Outdoor Gear and Activewear, Advanced Manufacturing, and High Tech Sectors. Forestry and Wood Products is negatively affected in most years, but the impact does turn slightly positive in some scenarios. In all scenarios, Wholesale Trade experiences negative economic outcomes. We find that industries at the end of the supply chain (retail and some service industries are other examples) are generally negatively affected by the carbon tax. These industries do not have the same ability to pass price increases on without loss of revenues. Table 3 reports the employment, output, and compensation[25] impacts for each of the key industries each year of the projection period (2013-2034) under Scenario C.4.30 [Employment Impact for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts].

Table 3 – Summary of Key Industry Impacts[26]

Employment (Change)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Outdoor Gear and Activewear	2	-5	-14	-26	-40	-54	-64	-71	-78	-84	-87	-90	-93	-96	-98	-100	-101
Advanced Manufacturing	16	5	-15	-32	-52	-78	-89	-92	-90	-87	-78	-68	-60	-52	-44	-35	-22
High Tech	5	-10	-33	-59	-86	-119	-138	-148	-153	-157	-161	-159	-158	-157	-154	-151	-147
Forestry and Wood Products	16	14	6	-3	-14	-32	-41	-46	-49	-48	-47	-44	-39	-34	-30	-21	-12
Wholesale Trade	47	32	2	-35	-79	-158	-193	-219	-241	-260	-276	-288	-302	-313	-325	-333	-340
Subtotal	86	36	-54	-155	-271	-441	-525	-576	-611	-636	-649	-649	-652	-652	-651	-640	-622
Clean Tech	2,234	3,090	3,835	4,513	5,113	4,620	4,423	4,318	4,270	4,246	4,238	4,266	4,272	4,283	4,291	4,306	4,335
Total	2,320	3,126	3,781	4,358	4,842	4,179	3,898	3,742	3,659	3,610	3,589	3,617	3,620	3,631	3,640	3,666	3,713
Output (% Change)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outdoor Gear and Activewear	0.00%	-0.01%	-0.04%	-0.07%	-0.11%	-0.15%	-0.17%	-0.20%	-0.23%	-0.24%	-0.26%	-0.27%	-0.27%	-0.29%	-0.29%	-0.30%	-0.30%
Advanced Manufacturing	0.00%	-0.06%	-0.16%	-0.26%	-0.38%	-0.52%	-0.62%	-0.70%	-0.76%	-0.81%	-0.85%	-0.87%	-0.89%	-0.90%	-0.92%	-0.92%	-0.92%
High Tech	0.00%	-0.01%	-0.02%	-0.03%	-0.05%	-0.07%	-0.08%	-0.09%	-0.10%	-0.11%	-0.11%	-0.12%	-0.12%	-0.13%	-0.13%	-0.13%	-0.13%
Forestry and Wood Products	0.02%	0.01%	-0.04%	-0.08%	-0.14%	-0.22%	-0.28%	-0.32%	-0.36%	-0.39%	-0.41%	-0.43%	-0.45%	-0.47%	-0.48%	-0.48%	-0.48%
Wholesale Trade	0.06%	0.04%	0.00%	-0.04%	-0.09%	-0.17%	-0.20%	-0.22%	-0.24%	-0.26%	-0.27%	-0.27%	-0.28%	-0.28%	-0.29%	-0.29%	-0.29%
Clean Tech	0.11%	0.13%	0.14%	0.13%	0.13%	0.07%	0.03%	0.01%	-0.01%	-0.03%	-0.05%	-0.05%	-0.06%	-0.07%	-0.08%	-0.08%	-0.09%
Compensation (% Change)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outdoor Gear and Activewear	0.00%	0.00%	-0.02%	-0.04%	-0.06%	-0.10%	-0.13%	-0.14%	-0.15%	-0.15%	-0.16%	-0.17%	-0.17%	-0.17%	-0.17%	-0.18%	-0.17%
Advanced Manufacturing	0.02%	0.00%	-0.04%	-0.06%	-0.07%	-0.11%	-0.10%	-0.12%	-0.10%	-0.08%	-0.08%	-0.06%	-0.04%	-0.01%	-0.01%	0.03%	0.03%
High Tech	0.00%	-0.01%	-0.04%	-0.07%	-0.11%	-0.17%	-0.20%	-0.21%	-0.22%	-0.22%	-0.23%	-0.23%	-0.21%	-0.21%	-0.21%	-0.20%	-0.19%
Forestry and Wood Products	0.04%	0.04%	0.07%	0.06%	0.12%	0.06%	0.08%	0.08%	0.05%	0.08%	0.08%	0.08%	0.10%	0.10%	0.14%	0.14%	0.16%
Wholesale Trade	0.04%	0.04%	0.00%	-0.03%	-0.07%	-0.14%	-0.17%	-0.20%	-0.21%	-0.22%	-0.23%	-0.22%	-0.23%	-0.23%	-0.23%	-0.23%	-0.23%
Clean Tech	0.33%	0.43%	0.49%	0.54%	0.57%	0.47%	0.44%	0.41%	0.40%	0.39%	0.38%	0.38%	0.38%	0.38%	0.37%	0.37%	0.37%

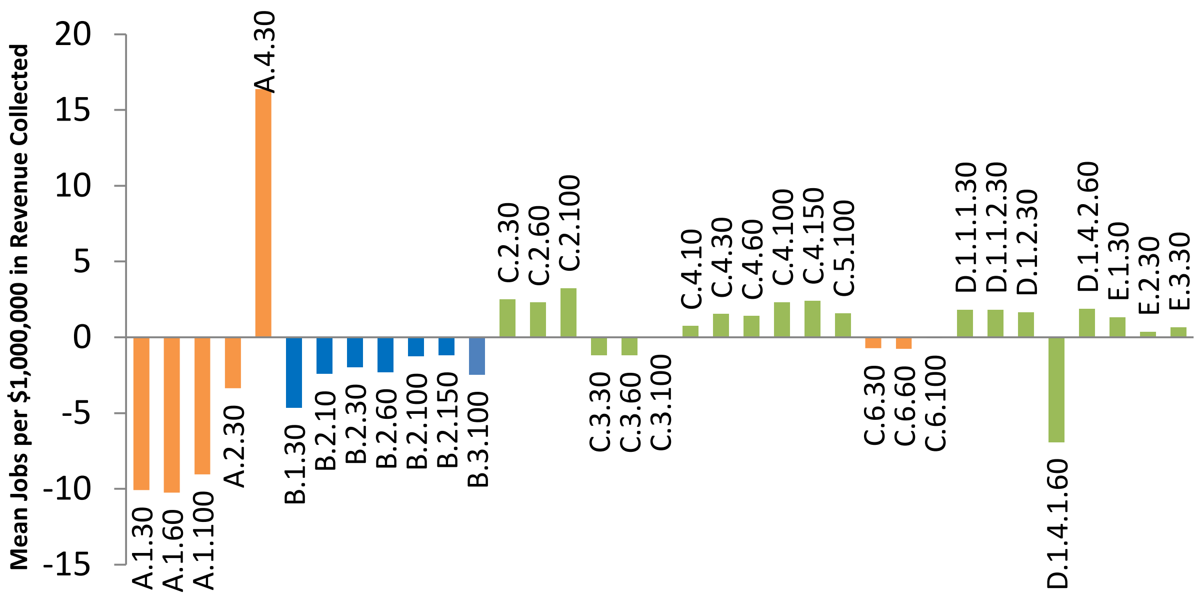
Figure 13 summarizes the Jobs Index measures calculated by the study team to assist in scenario comparison. The Jobs Index represents the mean ratio of state-level employment impacts to carbon tax revenue collected. As an example, if the Jobs Index for a scenario is -10 it

[25] Compensation includes wages, salaries, and employer-provided benefits

[26] Table 3 ends in 2030 due to space constraints.

means the scenario produces a decrease of 10 jobs for every $1 million of revenue collected, on average. A Jobs Index of +10 means that under the scenario an average of 10 jobs were added for every million dollars in carbon tax revenue collected.

Figure 13 - Scenario Jobs Index Summary

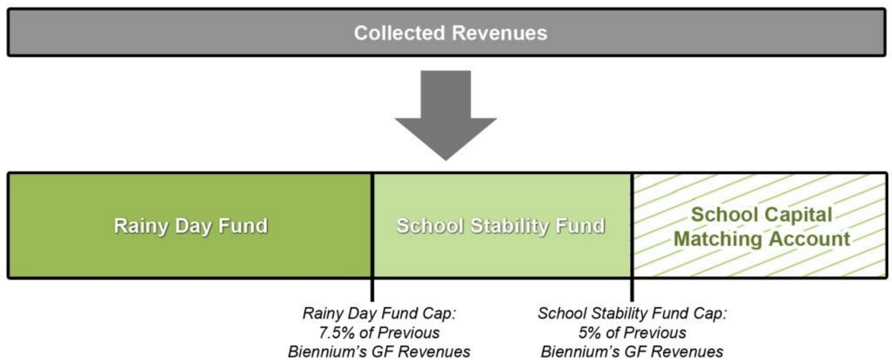


In the following scenarios descriptions, if a scenario is described as "revenue neutral (excluding transportation revenues)" it means that transportation-related revenues are dedicated to the Highway Trust Fund, and the remaining revenues are repatriated through tax cuts. The revenue neutral scenarios in Scenario B are truly revenue neutral because transportation-related revenues are used to reduce existing transportation taxes and fees.

Scenario A - No Repatriation

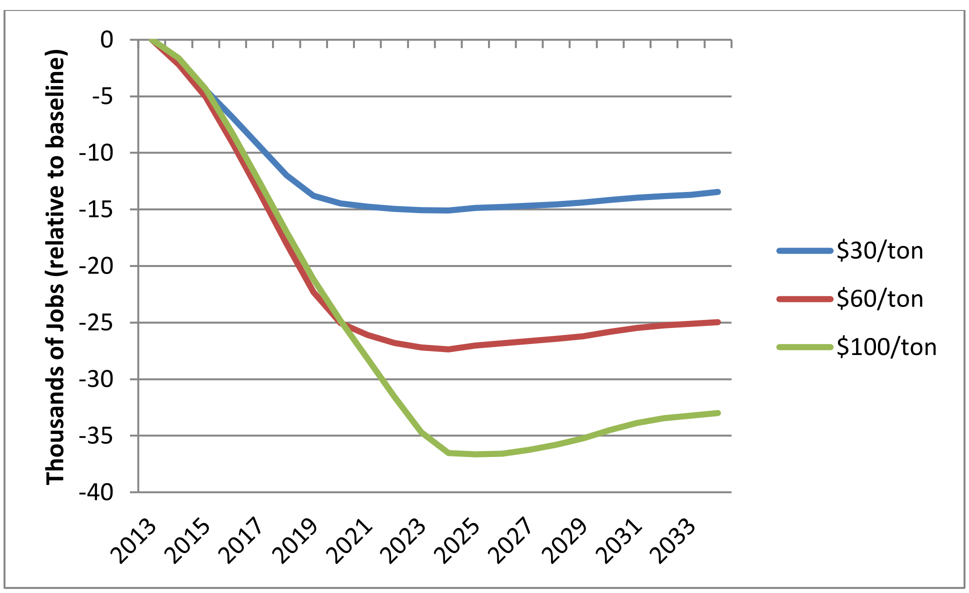
In order to better understand the extent of the negative economic impacts of the modeled fuel price increases, we ran several scenarios that did not include repatriation or combinations of repatriation and expenditure. Once the revenues are collected, they could be allocated to three Oregon reserve funds: the Oregon Rainy Day Fund, the Education Stability Fund, and the small Legislative Ending Balance Fund (Figure 14). The Oregon Rainy Day Fund is capped at 7.5% of General Fund revenues collected in the previous biennium, which would mean just over $1B today. The Education Stability Fund is capped at 5% of General Fund revenues (around $700M today), but once the cap is reached additional funds can be deposited in the fund's school capital matching account. At a carbon price of $60/ton, these funds would reach their cap before carbon tax revenues were exhausted. However for purposes of our financial reserve scenarios, we assume that the rules regarding reserve caps are relaxed so that the carbon tax revenues are not used in a way that immediately impacts expenditures in the Oregon economy.

Figure 14 - Reserve Fund Schematic



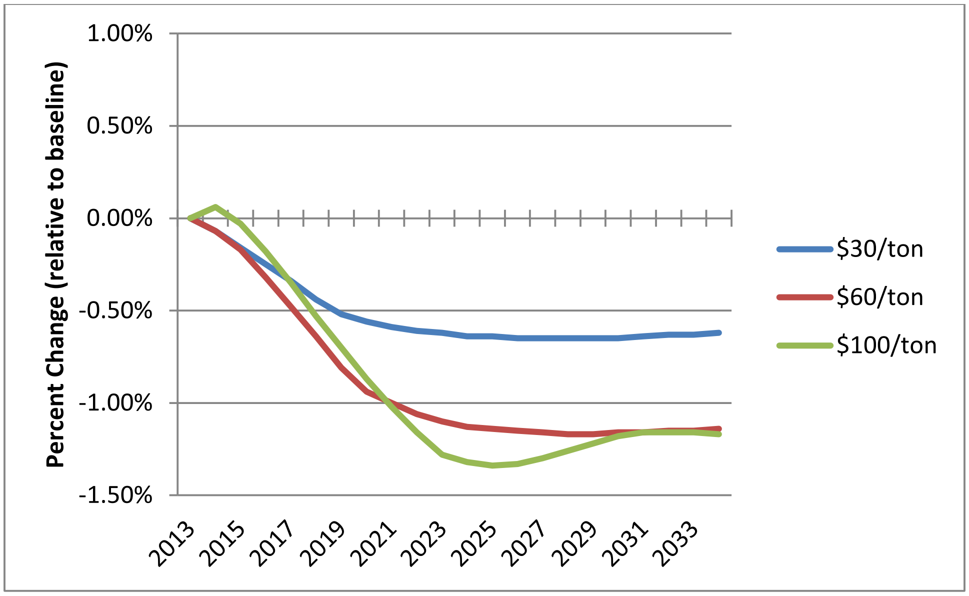
It is extremely unlikely that this option would be considered, but we have included it in the report as a theoretical exercise. The outcome of this scenario shows the impacts of the increase in energy prices including negative impacts that would be at least partially offset by the repatriation and expenditure methods. These results could also be interpreted as the impacts on the Oregon economy in the event of a federal carbon tax in which the revenues were not used directly to benefit Oregon (such as revenues used to pay down the federal debt).

Figure 15 - Employment Impact for Financial Reserve Scenarios (Scenario A.1)



Jobs Index- $30/ton: -10.090; $60/ton: -10.246; $100/ton: -9.051

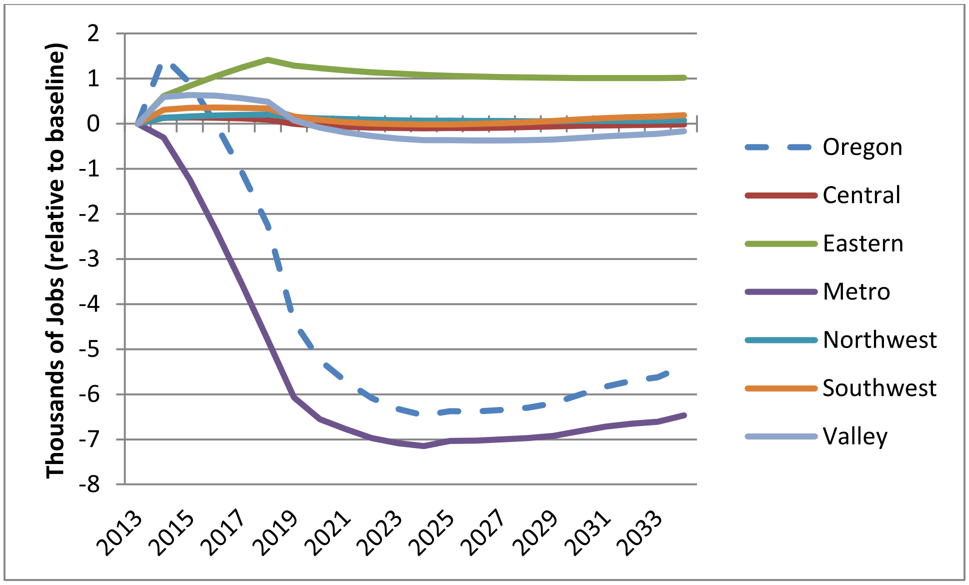
Figure 16 - Output Impact for Financial Reserve Scenarios (Scenario A.1)



The financial reserve scenario (Scenario A.1) represents a worst-case outcome for Oregon employment impacts since no carbon tax revenues are returned to the local economy. It should be noted, however, that even in this extreme scenario overall employment is still growing, just at a rate lower than what we would expect without a carbon tax. At $100/ton, the negative employment impact for the state bottoms out at around 37,000 jobs below the forecasted level for 2024 before recovering slightly.

As an alternative to directing all revenues toward reserves, we have also considered a scenario in which the funds collected from transportation-fuel use are dedicated to the Oregon State Highway Fund, and the remainder is allocated to the previously mentioned reserve accounts (Scenario A.2). Transportation fuel and the Oregon State Highway Fund were addressed earlier in the report (pg. 13), but for this scenario, these funds should be thought of as additional public funding for road construction and maintenance spread around the state according to ODOT's estimate of the future State Highway Fund spending distribution.

Figure 17 - Employment Impacts for Highway Funds and Reserve - $30/ton (Scenario A.2.30)

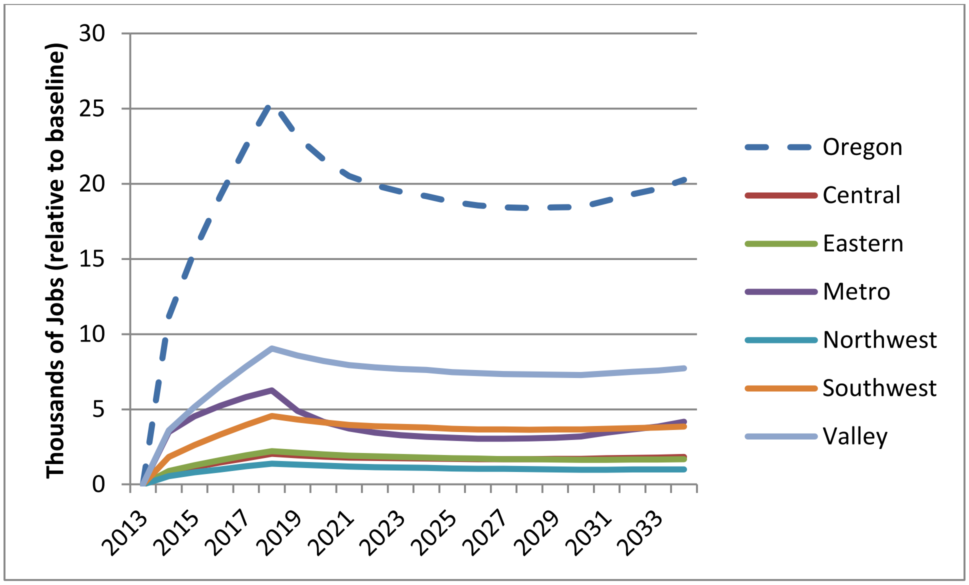


Jobs Index: -3.365

In this scenario, spending reduces the negative employment outcomes for the state, which are about 50% less than in the all-reserve scenario. The increased energy prices still have a negative effect on the economy, but the increase in the Highway Trust Fund acts as a public works stimulus across the state, with some regions even experiencing a net positive employment change in some years.

Our final No Repatriation scenario dedicates all carbon tax revenues to increasing the state General Fund (Scenario A.4). Within the model, we allocated funds to different government expenditure categories according to the mean distribution of funds from the 1999-2001 to 2013-2015 biennia. These state and local government spending inputs were then distributed to our modeling regions according to the population distribution.

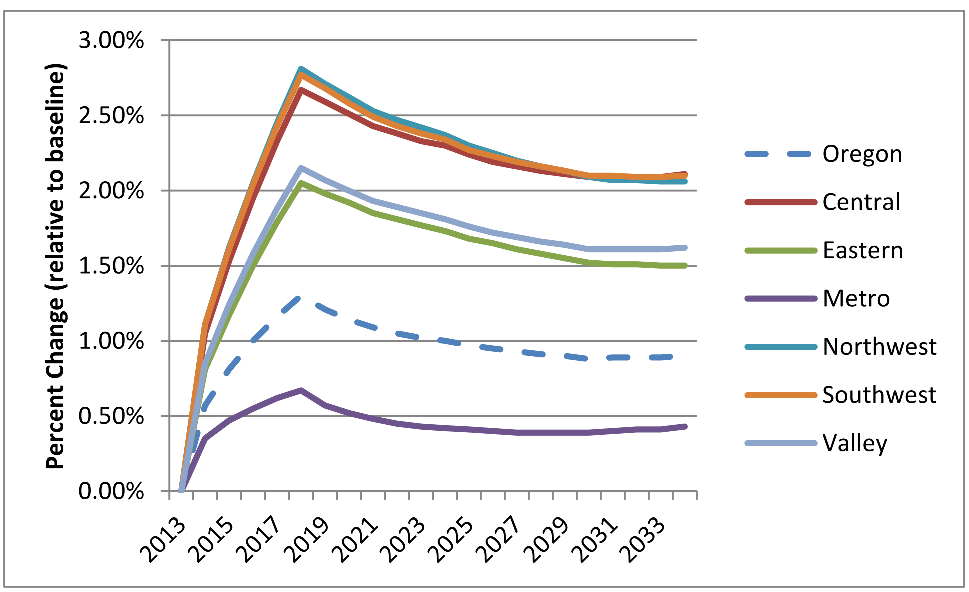
Figure 18 - Employment Impact for All General Fund Scenario - $30/ton (Scenario A.4.30)



Jobs Index: 16.378

This scenario is the opposite of the all-reserve scenarios in that it results in the highest net increase in employment, because state and local governments hire large numbers of additional employees. We allocated the revenue in this scenario according to the distribution of historical government spending, which means that a relatively large portion goes toward education and the hiring of teachers. Figure 19 shows the impact on compensation.

Figure 19 - Percentage Change in Compensation- $30/ton (Scenario A.4.30)

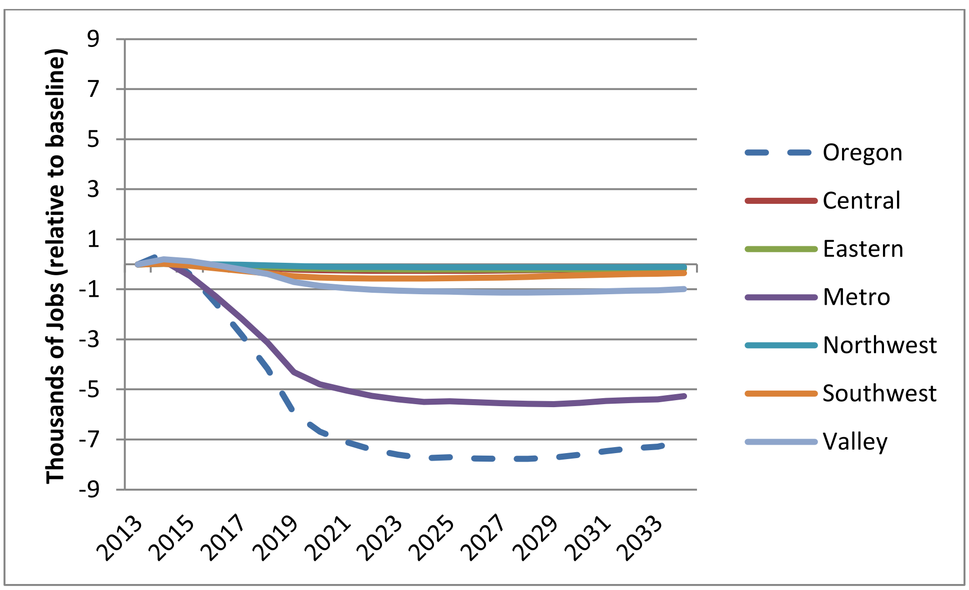


Scenario B - Revenue Neutral

Revenue neutrality is a key feature of the British Columbia Carbon Tax, which served as a point of reference for this study. Because the Oregon Constitution requires revenues from taxes on transportation fuels to be used on transportation-related projects, achieving true revenue neutrality is more complicated in Oregon. According to current constitutional requirements, a carbon tax applied to transportation fuels would significantly increase revenues dedicated to the State Highway Fund which would make the policy revenue positive. For the revenue neutral scenarios in this section, we assume that carbon tax revenues collected from transportation fuel use and from commercial vehicles could be used to offset existing fuel taxes. To satisfy the cost responsibility clause in the constitution, we split these revenues in two categories: revenues from private vehicle use and revenues from commercial/industrial transportation. The revenues from private vehicle use are used to offset existing fuel taxes on households, while the remaining transportation revenues are used to offset weight-mile tax payments. Repatriation of non-transportation revenues are split between personal and corporate income tax cuts.

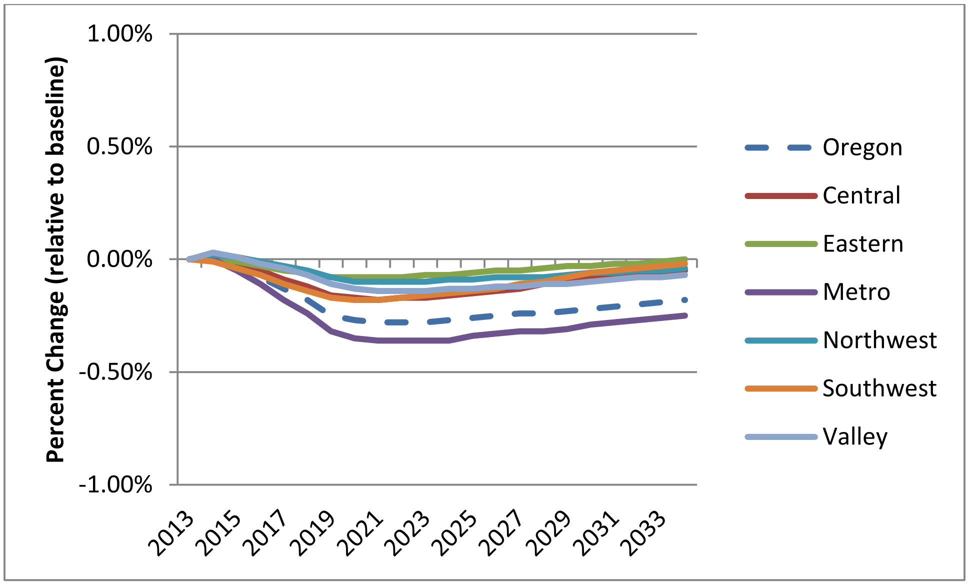
For Scenarios B.1, we assumed all non-transportation revenues were repatriated back to households in the form of personal income tax cuts.

Figure 20 - Employment Impact for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax - $30/ton (Scenario B.1.30)



Jobs Index: -4.641

Figure 21 - Compensation Impact for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax- $30/ton (Scenario B.1.30)

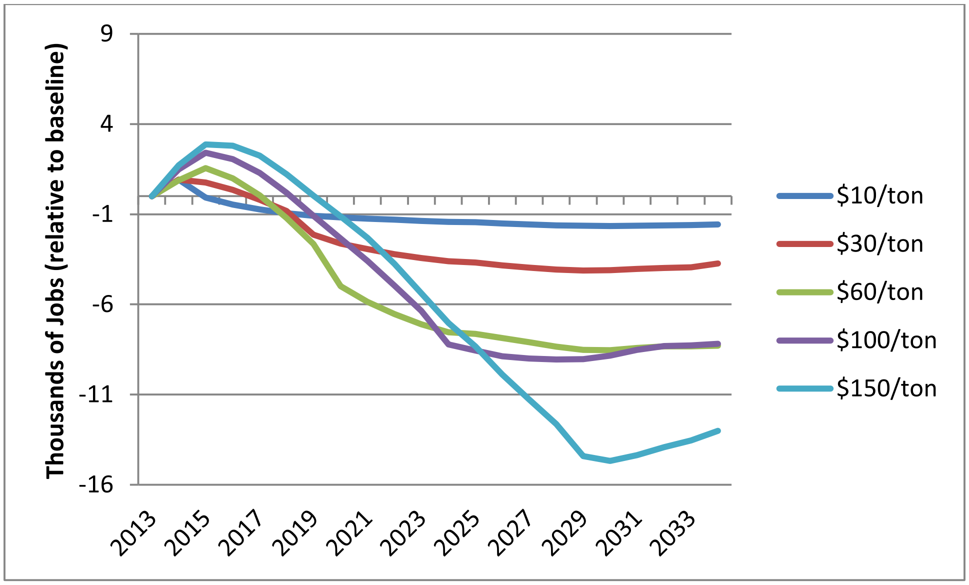


In many of the scenarios, real wages decline because, although the impact on wages is small, the increase in the price of energy reduces the purchasing power of those wages.

In the revenue-neutral scenarios, there are no large public works projects in the form of increased road construction and maintenance. As a result, the overall economic outcomes show less positive feedback because individuals and firms spend the repatriated funds on goods and services originating from both inside and outside of Oregon, rather than directed investment projects which ensure that a greater share of the direct economic impacts of the repatriation remain within Oregon.

Scenarios B.2 feature a repatriation scheme that returns 70% of non-transportation revenues through corporate income tax cuts, and the remaining 30% of non-transportation revenues as personal income tax cuts, while transportation revenues still are returned to tax payers.

Figure 22 - Employment Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2)



Jobs Index- $10/ton: -2.420; $30/ton: -1.976; $60/ton: -2.280; $100/ton: -1.250; $150/ton: -1.163

Figure 23 - Output Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2)

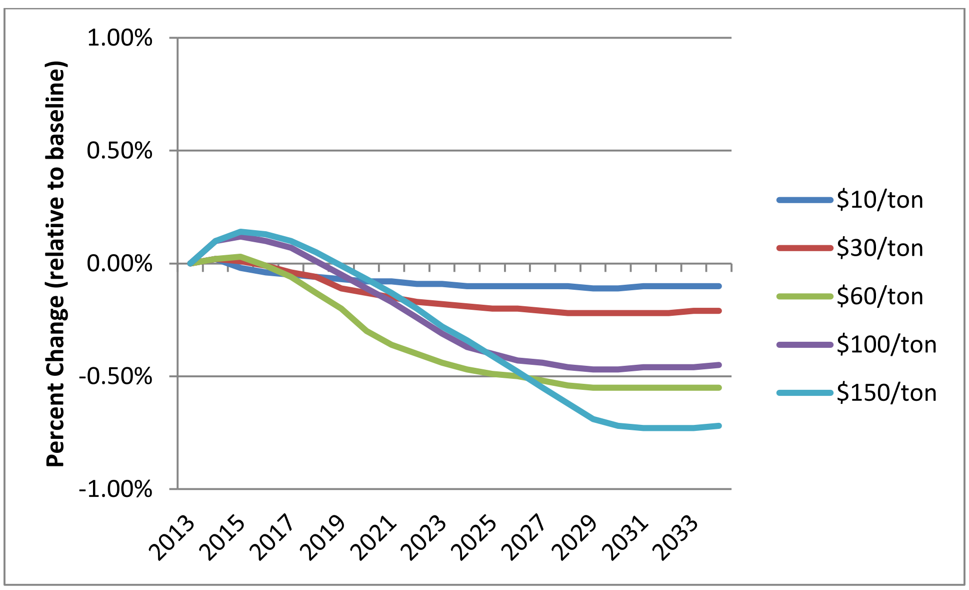


Figure 24 - Key Industry Employment Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario B.2.30)

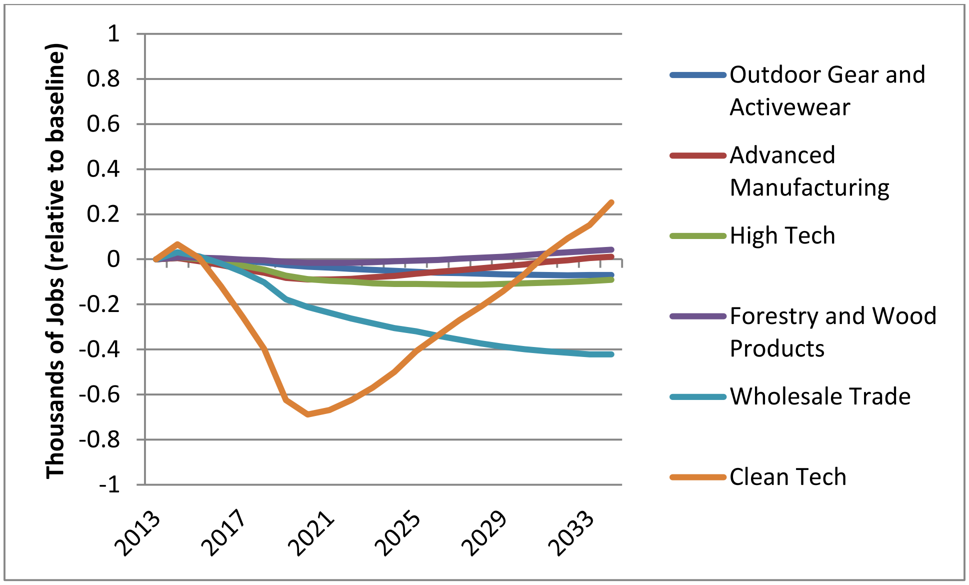
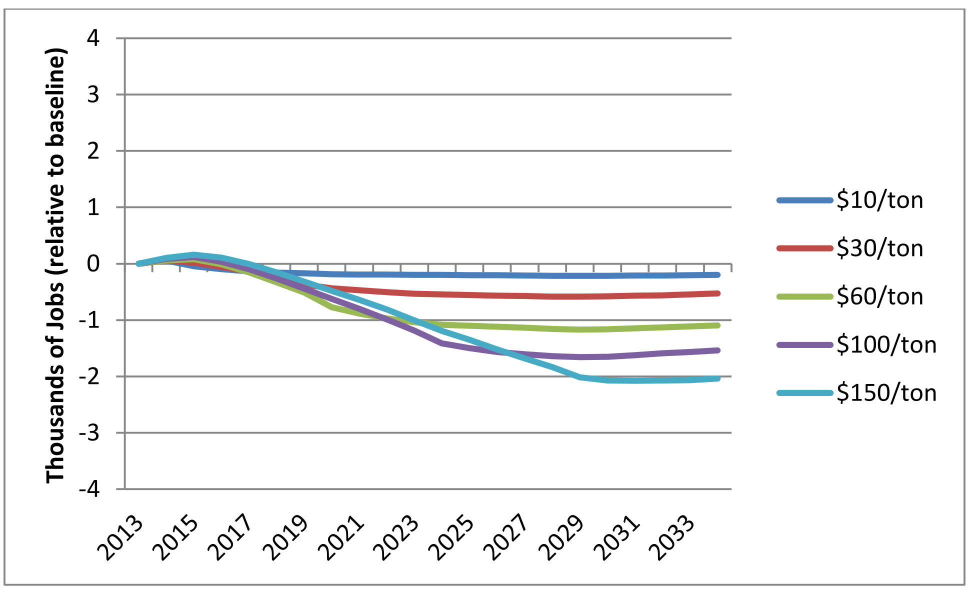


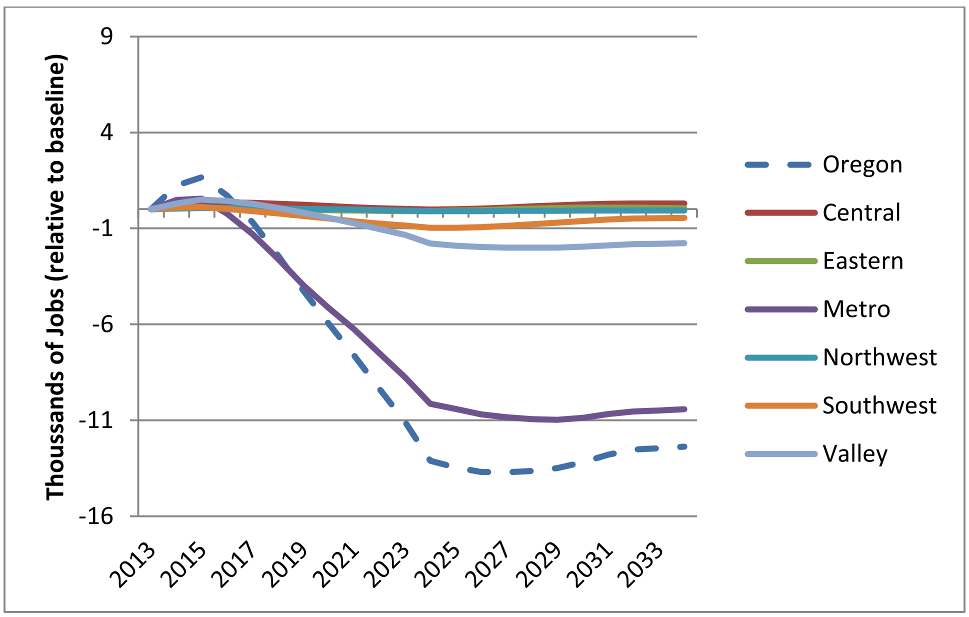
Figure 25 - Key Industry Aggregate Employment Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2)



In these scenarios (shown above in Scenario B.2), we see the initial adjustment to higher capital costs by substituting labor, with the resulting increase in employment. After this adjustment and round of new investment, employment drops below the forecast levels due to higher energy prices. Again, we see that without the employment stimulus of public works projects, the tax cuts are not enough to fully counteract the impact of the change in energy prices.

At carbon prices above $60/ton, repatriated revenues could generally eliminate corporate income taxes altogether. In some of our scenarios, we assume that corporate income taxes are eliminated and that Oregon corporations receive additional tax relief in the form of sellable tax credits. In Scenario B.3, we eliminate the corporate income tax and dedicate the rest of the funds to personal income tax cuts. It is important to keep in mind however, that both the amount of revenue generated by the carbon tax and the expected corporate income tax revenues change over time. Recently, corporate income tax revenues have been in the neighborhood of $450M per year. We assume that baseline corporate income tax collections will remain a more or less constant share of gross state product over time.

Figure 26 - Employment Impacts for Revenue Neutral with Non-Transportation Revenue Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario B.3.100)



Jobs Index: -2.450

In comparison to Scenario B.2.100 (where total 70% of non-transportation revenues are dedicated to corporate income tax cuts), the negative impact on Oregon employment is slightly larger because increased employment triggered by corporate tax cuts fails to offset the negative employment effect resulting from the reduced household expenditures.

Revenue Positive

Our revenue positive scenarios are split by the treatment of carbon tax revenues from transportation fuels. For most of the following scenarios, we assume that these revenues will be distributed according to ODOT's estimate of future Highway Fund spending (Scenarios C and D). For others, we assume that constitutional requirements are altered in order to allow those funds to be spent on other transportation-related projects (Scenario E).

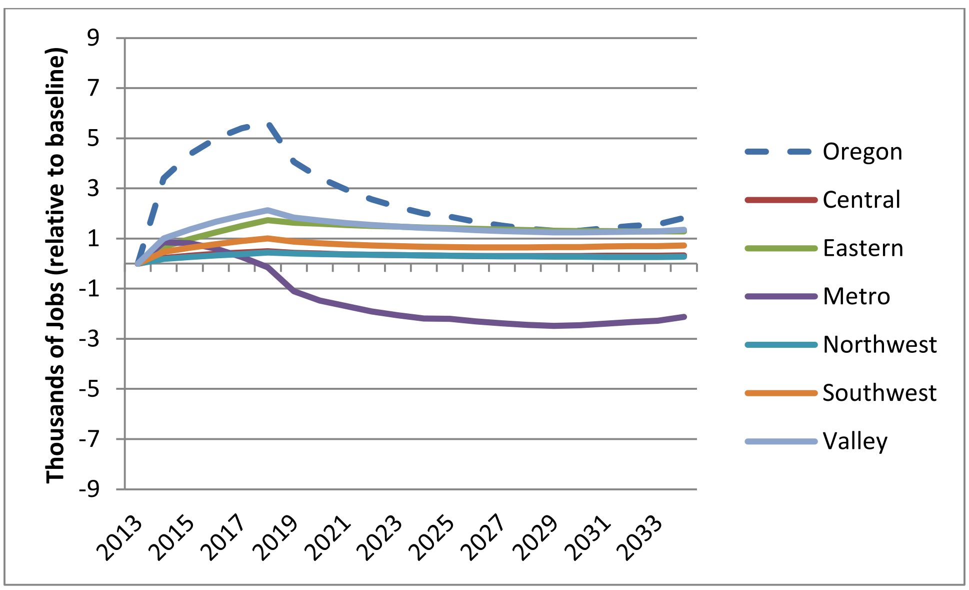
The scenarios that feature the normal transportation-fuel revenue disbursement are further split into two additional categories: those repatriating the remaining revenues solely to businesses and households as tax cuts (Scenario C), and those using revenues for a combination of tax cuts and expenditures on other public priorities (Scenario D).

Scenario C - Revenue Neutral (Excluding Transportation Revenue)

These scenarios dedicate the revenues not coming from transportation fuel use to cutting income taxes or providing direct income support, while transportation revenues are spent in the same highway fund fashion.

Scenario C.2 dedicates all non-transportation revenues to reducing corporate income taxes. At $100/ton, corporate income taxes will have been eliminated and additional tax relief is provided to firms through transferrable tax credits.

Figure 27 - Employment Impact Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction-$30/ton (Scenario C.2.30)



Jobs Index: 2.493

In contrast to the completely revenue-neutral scenarios, a significant portion of revenues are dedicated to the Highway Trust Fund. The resulting road maintenance and construction activity creates a positive economic impact which is spread throughout the state; the growth is further compounded by corporate investments resulting from better transit connections. The Portland Metro region still experiences negative economic impacts. The weighting system used (currently) by ODOT to distribute highway trust fund dollars gives greater weight to miles traveled in rural areas. Portland Metro receives the largest portion of road maintenance and construction funds, but it is small relative to the size of the economy. The public works investment does not create enough employment to offset the negative employment impacts in some energy-intensive industries. Elsewhere in the state, the investment in new roads represents a large increase in activity relative to their size of the local economies.

Figure 28 - Key Industry Employment Impact Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction- $30/ton (Scenario C.2.30)[27]

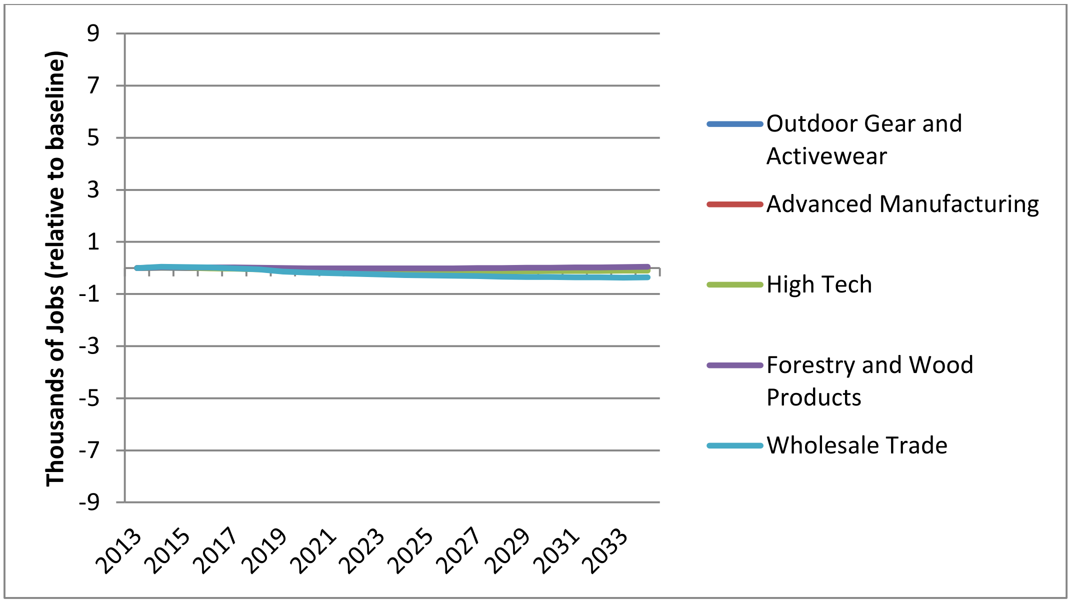
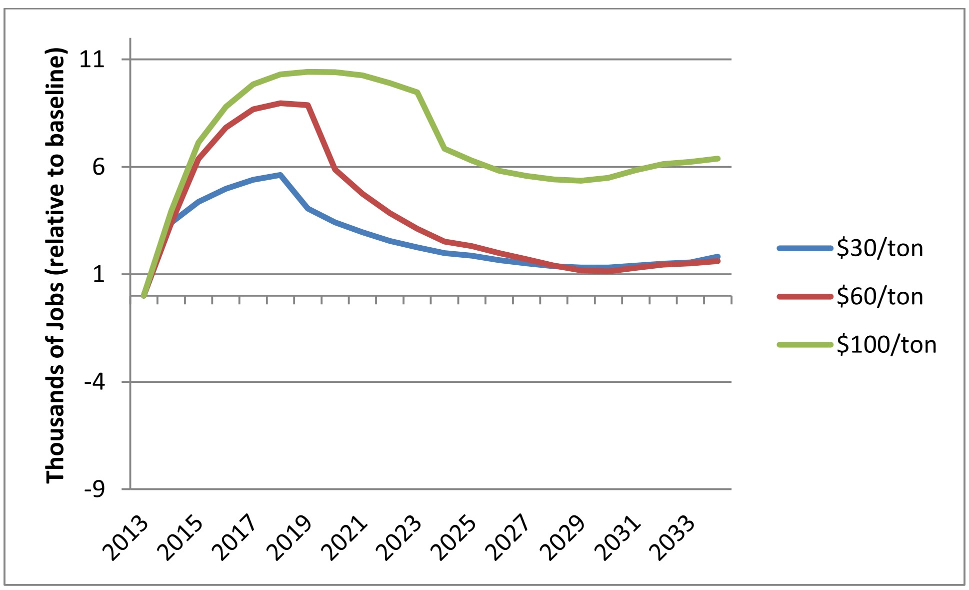


Figure 29 - Oregon Employment Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction (Scenario C.2)

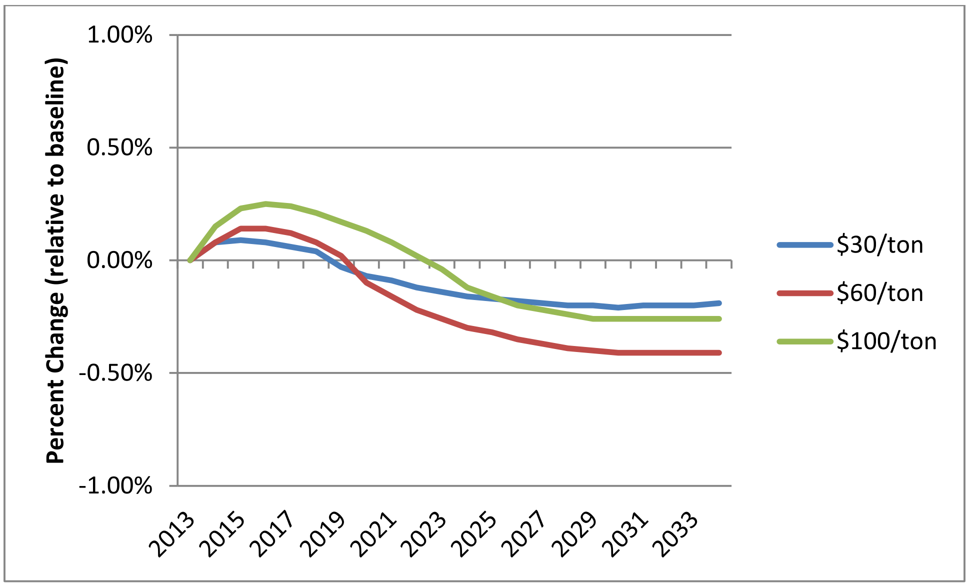


Jobs Index- $30/ton: 2.493; $60/ton: 2.296; $100/ton: 3.241

[27] Clean Tech has been left out of this chart because in this scenario, the Clean Tech impacts are dominated by the positive impact on road construction employment which are not reflective of actual clean tech activities.

Figure 29 shows total employment impacts for the state for $30/ton, $60/ton, and $100/ton scenarios. Figure 30 shows total economic output impacts for the same scenarios.
Carbon prices of $100/ton incentivize a longer period of adjustment away from more energy-intensive production methods. Somewhat counter-intuitively, this produces greater positive employment impacts at higher carbon price levels. Employment is created through investments in new technologies and the substitution away from capital (discussed earlier in the report) due to increase in the cost of capital relative to labor.

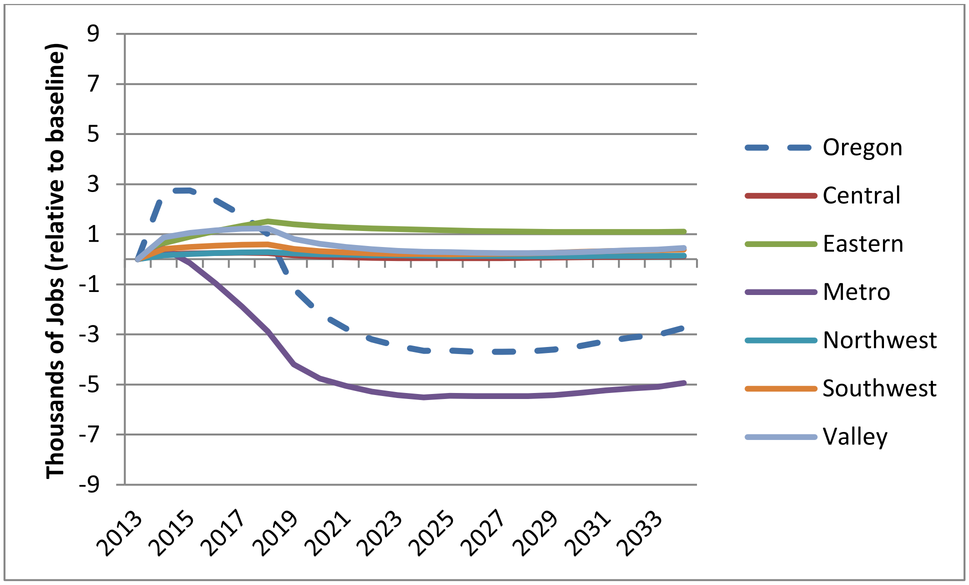
Figure 30 - Oregon Output Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction (Scenario C.2)



In other scenarios, higher carbon prices eventually result in larger negative impacts on output. It is possible that our forecast timeline does not extend far enough into the future to see output impacts fully stabilize.

Scenario C.3 is the flipside of the previous scenario. Transportation revenue is the same, while all non-transportation revenue is dedicated to cutting personal income taxes.

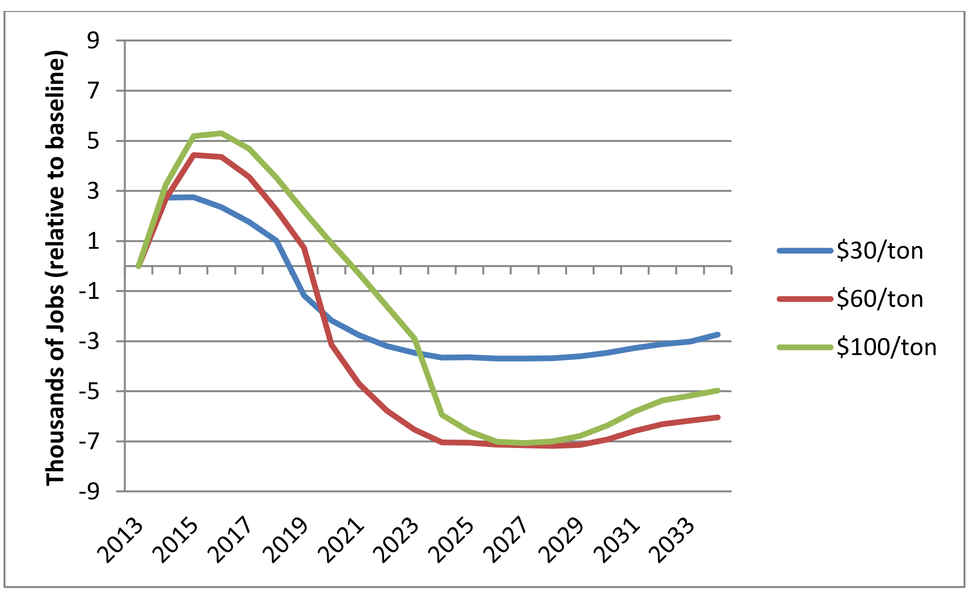
Figure 31 - Employment Impact Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction- $30/ton (Scenario C.3.30)



Jobs Index: -1.157

In Scenario C.3.30, the same dynamic is driving the employment results. The state-level impacts are negative in most years because the positive employment impacts from the increase in highway spending combined with the increase in household disposable income are not enough to offset the negative impacts on businesses. Households spend their additional disposable income on both Oregon and non-Oregon goods, creating some leakage.

Figure 32 - Oregon Employment Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3)



Jobs Index- $30/ton: -1.157; $60/ton: -1.186; $100/ton: -0.010

Figure 33 - Oregon Output Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3)

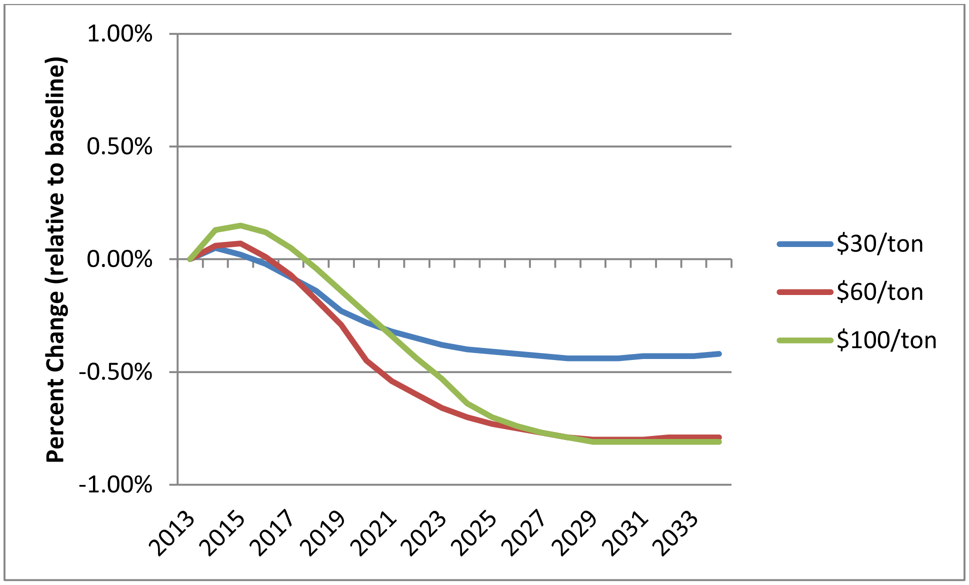
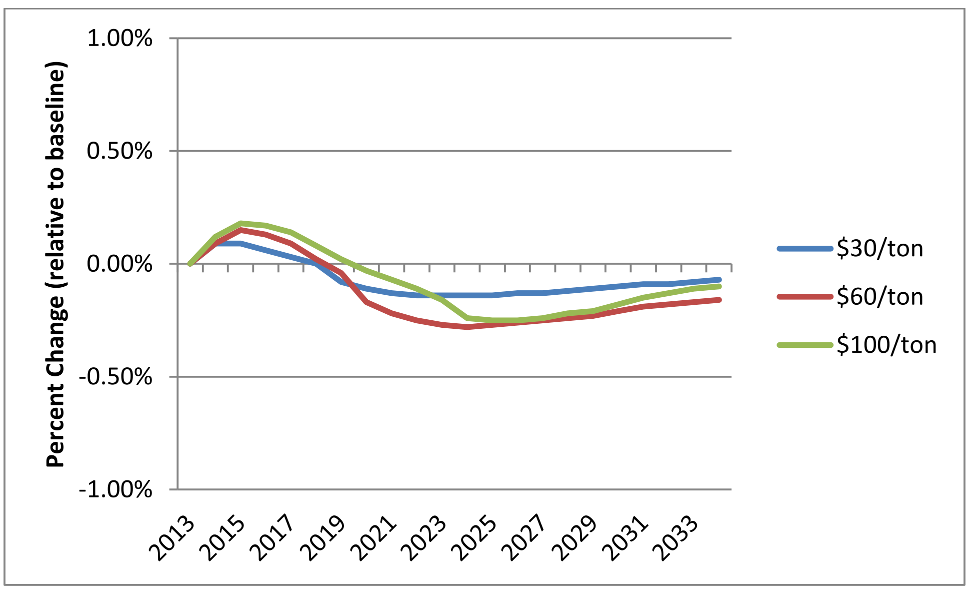
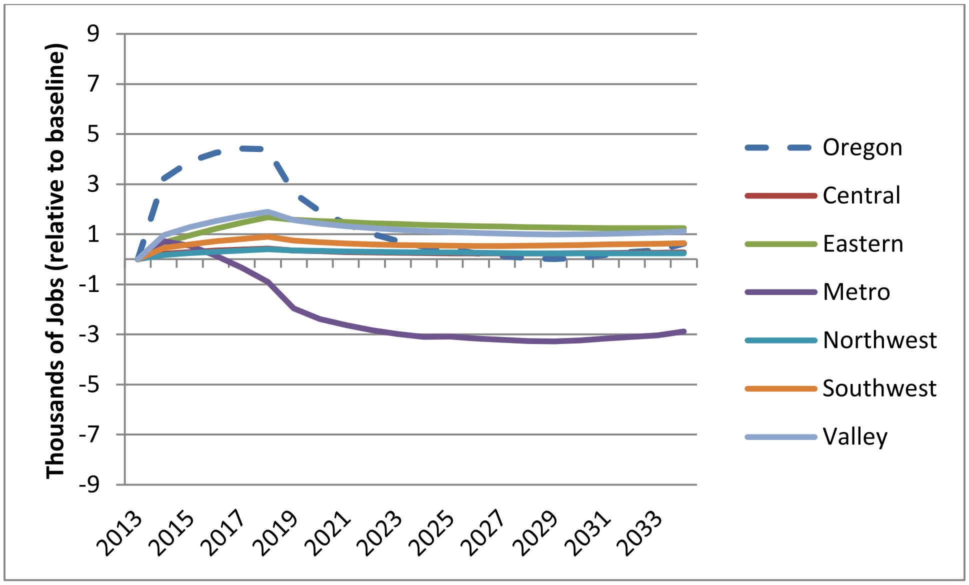


Figure 34 - Oregon Compensation Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3)



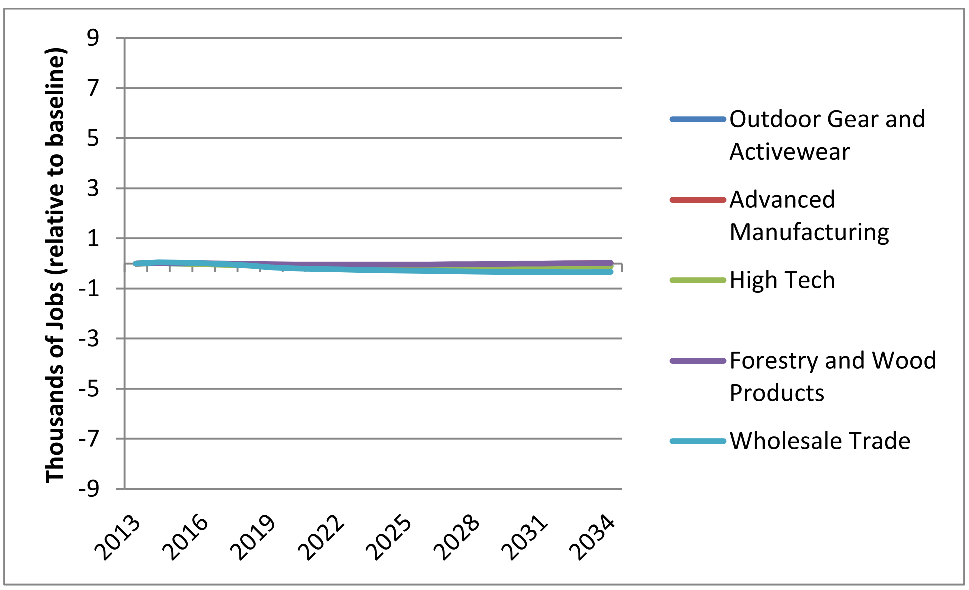
Scenario C.4 divides the available revenues, with 70% going to corporate income tax cuts and 30% to personal income tax cuts, while keeping the same transportation revenue expenditure pattern. This split serves as a convenient comparison case across multiple scenario types.

Figure 35 - Employment Impact for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario C.4.30)



Jobs Index: 1.519

Figure 36 - Key Industry Employment Impact for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario C.4.30)[28]

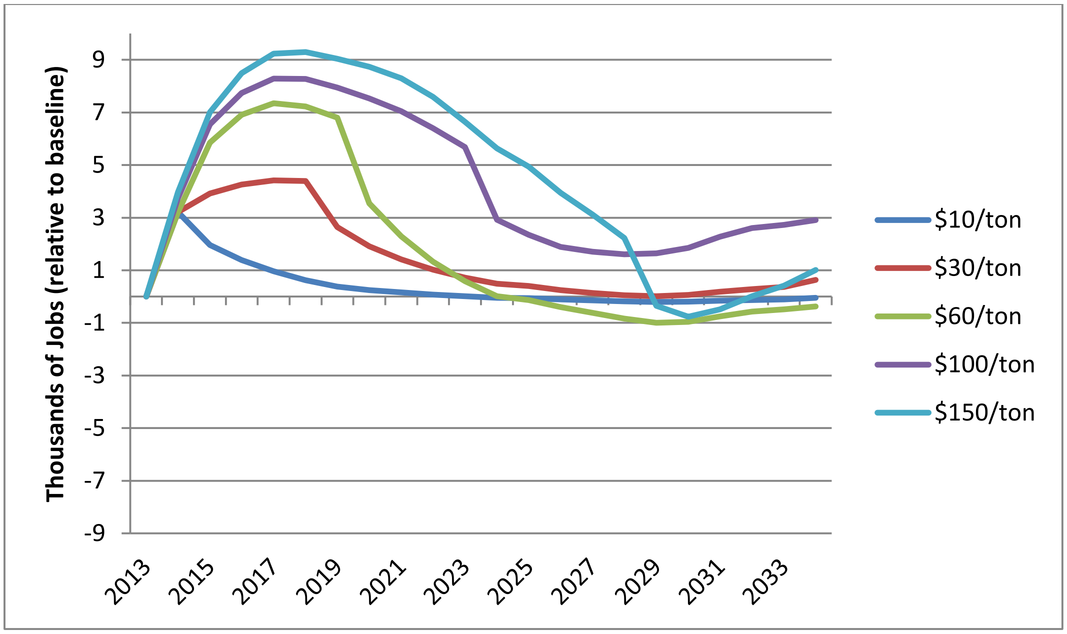


Allocating more revenue to corporate income tax cuts has greater projected positive employment impacts, relative to devoting more revenues to personal income tax cuts. The

[28] Clean Tech has been left out of this chart because in this scenario, the Clean Tech impacts are dominated by the positive impact on road construction employment which are not reflective of actual clean tech activities.

Portland Metro Region still experiences negative employment impacts, but the negative effect is small compared to other scenarios.

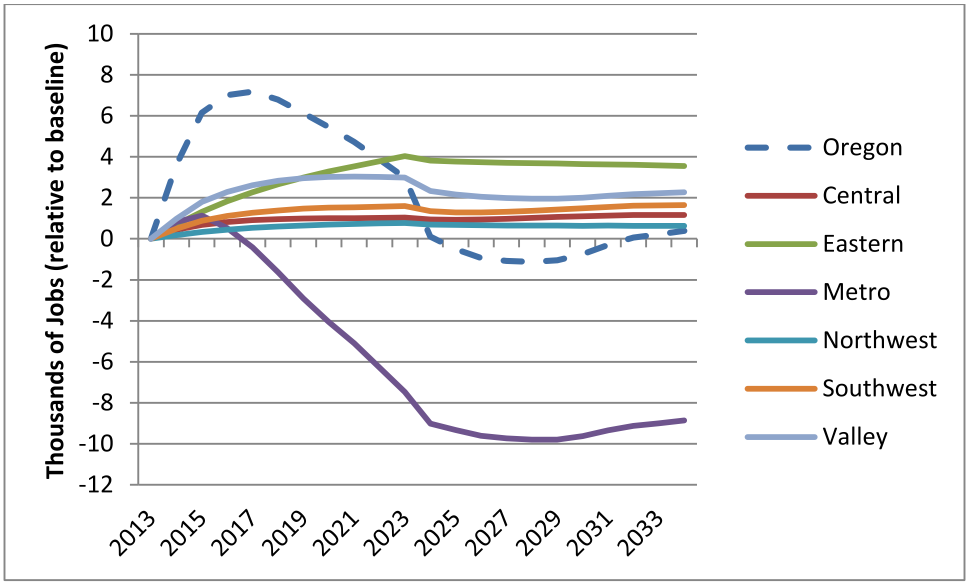
Figure 37 - Employment Impact for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario C.4)



Jobs Index- $10/ton: 0.740; $30/ton: 1.519; $60/ton: 1.386; $100/ton: 2.304; $150/ton: 2.394

Following the example of Scenario B.3 (pg. 40), Scenario C.5 allocates enough revenue to eliminate corporate income taxes and dedicates the rest to personal income tax cuts. In this scenario, no tradable tax credits are made available to firms, so revenue repatriation is limited by current corporate tax liability.

Figure 38 - Employment Impacts for Revenue Neutral (Excluding Transportation Revenue) Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario C.5.100)



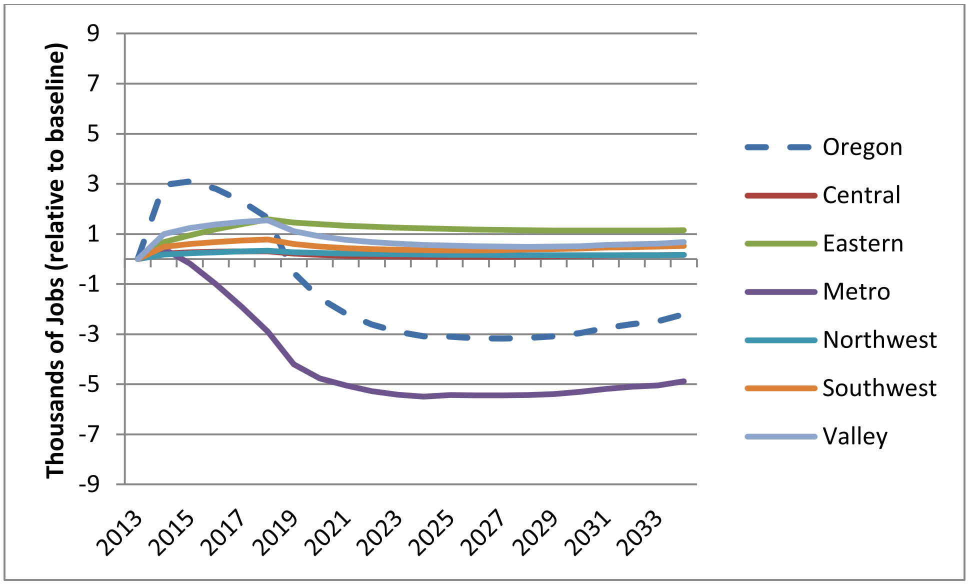
Jobs Index: 1.576

The results in Scenario C.5.100 are similar to C.4.100 above, but the overall job impacts are slightly more negative because more revenue is allocated to personal income tax cuts, which leads to greater leakage out of the state.

Carbon fee and dividend program (Scenario C.6)

In Oregon and at the national level, there is grassroots support for implementing a carbon fee and dividend program. Rather than using the revenues to offset existing taxes, the fee and dividend approach would return revenues to the economy through direct payments. This strategy begins from a different philosophical starting point. It conceives of citizens as equal owners of environmental quality. The dividend acts as partial compensation for reduced environmental quality resulting from carbon release. There are a variety of strategies for structuring the dividend with some suggesting payments altered by household size, or counting children as a set fraction of an adult. For this study, we chose to model the dividend as an equal payment to all Oregonians 18 years of age or older. The funds are distributed according to the distribution of the adult population. Scenario C.6 estimates the effect of the using the dividend model at different carbon prices.

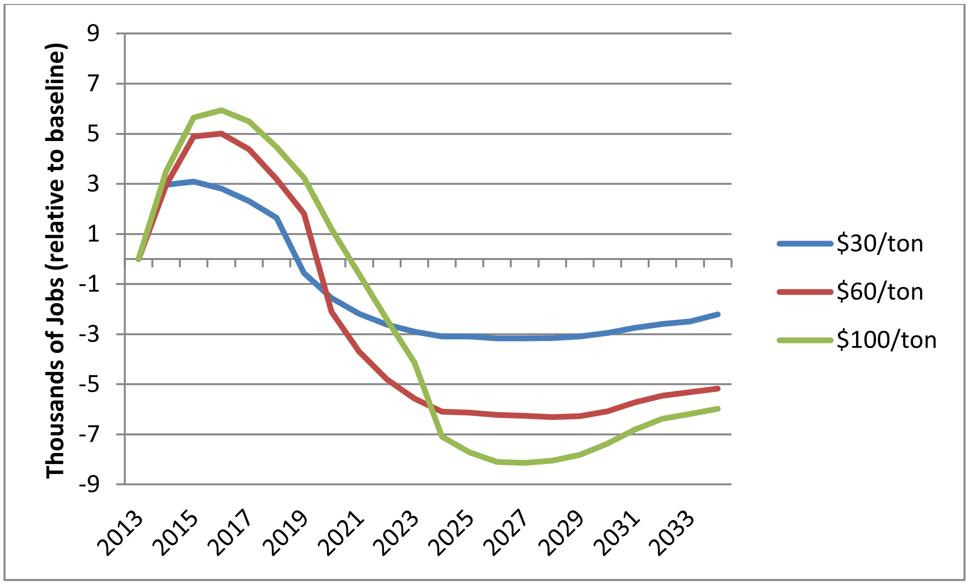
Figure 39 - Employment Impacts for Citizen Dividend (Excluding Transportation Revenues) - $30/ton (Scenario C.6.30)



Jobs Index: -0.725

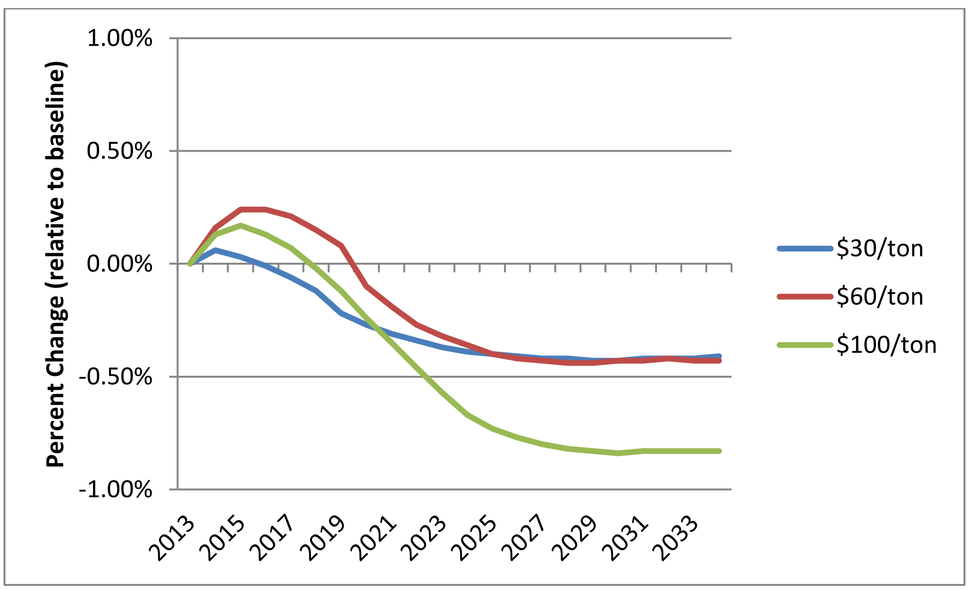
The outcomes in this scenario are similar to scenarios which devote all revenues to personal income tax cuts. The difference between the two is that repatriation based on personal income tax payments increases with income level whereas dividend payments do not. By distributing the revenues more evenly across all adults, more funds are in the hands of lower-income households who have a larger marginal propensity to consume. The economic impacts are greater because lower-income people tend to spend more of the income, and spend it on things like food and rent which are more likely to be produced locally. While Transportation revenues are still spent according to the highway fund patterns.

Figure 40 - Employment Impacts for Citizen Dividend (Excluding Transportation Revenues) (Scenario C.6)



Jobs Index- $30/ton: -0.725; $60/ton: -0.765; $100/ton: -0.072

Figure 41 - Output Impacts for Citizen Dividend (Excluding Transportation Revenues) (Scenario C.6)



Scenario D - Public Investment and Expenditure

The Public Investment and Expenditure Scenarios assume that transportation-related revenues are dedicated to the state's Highway Trust Fund, and that some portion of revenues is used to reduce corporate and personal income taxes. These scenarios also identify other state goals and dedicate carbon tax revenues toward investments and expenditures in these areas.

Low Income/Worker Assistance

Energy expenditures represent a much higher percentage of overall expenditures for low-income households than for high-income households. We expect high-income households to pay more in carbon taxes, but the burden of the tax will be greater on low-income households as it impacts spending on essential items. To offset this regressivity, we used data from the Bureau of Labor Statistics (BLS) Consumer Expenditure Survey (CES) to estimate the net impact of increased energy prices and income tax rate cuts for each income quintile in each study region.

Scenario D.1.1 explores ways to offset the harm of the tax on low-income households and workers in negatively-affected industries. Scenario D.1.1.1 looks at offsetting the expected net decline in income for the bottom three income quintiles, while Scenario D.1.1.2 expands the analysis to include offsetting indirect price increases due to higher energy prices as well as implementing targeted income support.

A policy that raises the price of energy economy-wide will place extra burden on low-income households because they tend to spend a larger portion of their income on energy-related purchases. Using the Bureau of Labor Statistics Consumer Expenditure Survey (CES), we calculated the portion of expenditures that are energy-related for income quintiles in Oregon. For this study, we counted electricity, natural gas, home heating fuel, and transportation expenditures as energy-related. For the poorest quintile, these account for about 25% of expenditures while for the highest income quintile it is 4%. Higher-income households also tend to pay a greater portion of taxes so a cut in the tax rate will benefit them more than low-income households.

For each income quintile in each of our six regions, we calculated the expected increase in energy expenditures and the expected benefit of personal income tax rate cuts. We found that the bottom three quintiles were consistently left worse off by the tax and repatriation scheme. The amount of offset needed to close this gap varies by quintile, region, and the carbon price but the range of aid considered was between $14 to just over $100 per tax filer.[29,30]

When considering the best methods for repatriating additional funds to low-income individuals, we sought out existing programs or agencies already engaged in these activities. Low-income workers could have most or all of this benefit delivered through the tax code. Repatriating revenues annually when households file a tax return would create the strongest price signal[31], but may prove too great a burden for households living in poverty. A shift in the payroll tax formula could return funds to workers monthly rather than annually. Electricity, natural gas, and other home heating expenses are paid monthly so there would be little separation

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[29] To calculate the impacts of changes in personal income tax rates, we used aggregated data from the Oregon Department of Revenue. As a result, we use tax-filers as a unit of analysis which is not the same as adult population or household count.
[30] See Appendix III (pg. 150) for a breakdown of net impacts by quintile, by region.
[31] The price signal is the incentive to use less fossil fuels created by the increase in price due to the carbon tax.

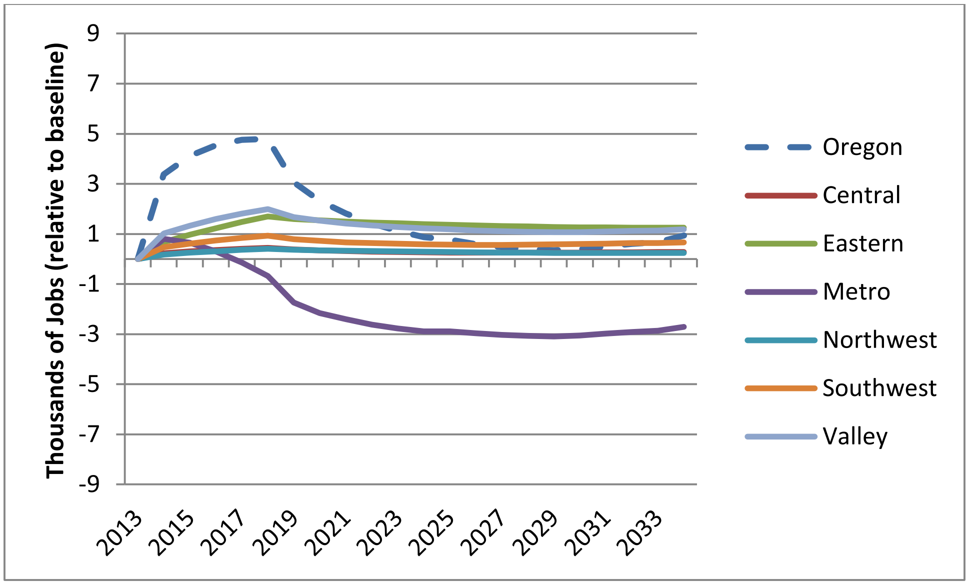
between increased energy prices and repatriated revenues, thereby weakening the price signal. It would be up to policymakers to balance the need to provide timely income support with a desire to alter behavior to reduce greenhouse gas emissions by the maximum amount possible. An alternative to these repatriation methods would be an expansion of the state's Earned Income Tax Credit (EITC). The credit functions as a negative income tax and is used as a mechanism to provide income support to low-income tax filers. This existing program could be expanded and used to distribute funds monthly or annually.

Providing support to low-income individuals outside of the workforce would be more difficult but there are existing programs that directly assist low-income Oregonians with energy costs (e.g. direct utility bill payments). One solution would be to distribute pre-paid debit cards. The program could be modeled on the EBT cards that Oregon currently uses in the Supplemental Nutrition Assistance Program. Individuals could go through an application process in which the level of burden of the carbon tax would be established. Once eligibility is established, the individual would receive regular top-ups on their card.

Funds could also be devoted to existing programs that subsidize energy purchases for low-income households directly. These programs offer funds to pay utility bills and can assist participants in applying for programs that reduce their utility bills before delivery. To further offset the burden, existing programs already provide home renovations and appliance upgrades to improve the energy efficiency of low-income housing. These programs apply to single-family housing as well as multi-family rental units. Following the passage of the American Recovery and Reinvestment Act (ARRA) in 2009, the budgets of these programs were greatly increased suggesting that there is existing capacity to expand.

For Scenario D.1.1.1.30, we assume that transportation revenues are dedicated to the highway trust fund, and the remaining revenues are split 70% to corporate income tax cuts and 30% to personal income tax cuts. We calculate the impact of this distribution on each income quintile in each region, then distribute repatriated revenue from the top quintile to the bottom three quintiles until the net effect of the tax and repatriation on them is zero. As a note, we find that the fourth and fifth income quintiles show a net positive effect on income after the increase in energy prices and tax cuts. For this scenario, we only offset the negative impact of the increase in energy expenditures.

Figure 42 - Employment Impacts for Low-Income Assistance Scenario- $30/ton (Scenario D.1.1.1.30)



Jobs Index: 1.801

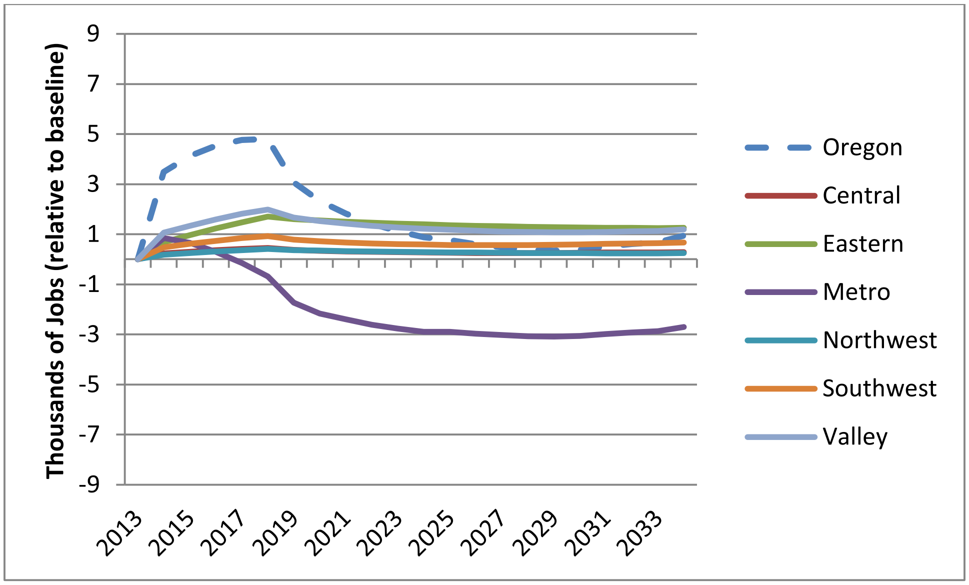
As in the citizen dividend scenarios, this scenario pushes repatriated revenues toward lower-income people who have higher marginal propensities to consume. As expected, the overall employment impacts in this scenario are more positive/less negative than those with just a tax rate cut because more of the repatriated funds are spent locally.

For Scenario D.1.1.2, we wanted to explore offsetting a broader range of new costs. Based on our analysis, we find that for every 1% increase in the aggregate energy price, there is a 1.05% increase in the aggregate price for all other non-energy expenditures. The increase in the energy price works its way through the economy and increases the price of some goods.

This scenario also demonstrates the effects of targeted income support for groups hurt by the implementation of the tax. We do not find large employment impacts in most sectors at lower carbon prices, but if an industry that accounts for a significant portion of economic activity in an area experiences employment declines due to the tax, it may be difficult for some workers to transition to new employment. Direct, targeted income support could be used to assist workers during extended periods of unemployment or provide support until retirement age is reached for older workers.

We followed the Congressional Budget Office's (CBO) estimate of the indirect costs associated with energy price increases to estimate the cost of providing additional income support (Dinan, 2012). The CBO estimates that indirect cost burdens are 30% of energy price increases. For Scenario D.1.1.2, we used the same net income impact calculation from the previous scenario, but chose to offset 130% of the cost of energy price changes.

Figure 43 - Employment Impacts for Low-Income Assistance and Targeted Income Support Scenario- $30/ton (Scenario D.1.1.2.30)



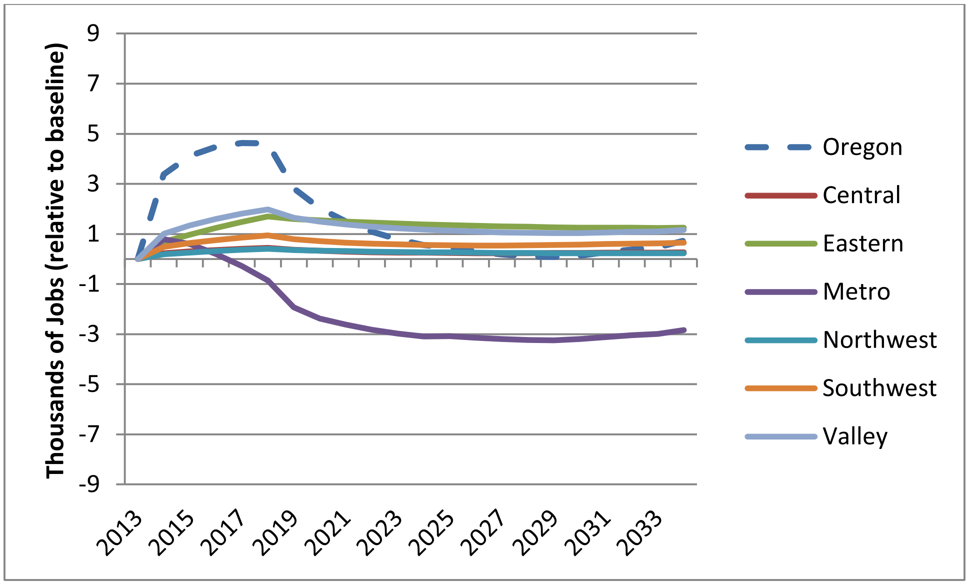
Jobs Index: 1.813

The employment impacts are close to the impacts in the previous scenario. The impact of the additional income in the hands of individuals with a higher marginal propensity to consume is relatively small.

Scenario D.1.2 estimates the effect of dedicating revenues to the expansion of current public energy efficiency programs employed in the state of Oregon using revenues from the clean air tax or fee. Because public-purpose charge expenditures represent the largest sources of direct investment into energy conservation and renewable energy programs, we obtained additional data from organizations that utilize public-purpose charge revenues (including Energy Trust of Oregon, Oregon Department of Energy and Oregon Public Utilities Commission) to help characterize the impacts of dedicating a portion of the clean air tax or fee revenues toward energy efficiency and conservation in these areas. Background on Oregon's public-purpose charge is provided in the following section.

For the modeling inputs, we dedicated an amount of revenue equal to ETO's 2013 revenues ($161M) and distributed it between construction, investment, and administrative activity according to their budget breakdown. We chose to model this after ETO's experience to ensure that the scale of this scenario was reasonable. These investments were distributed across the study regions according to the population distribution.

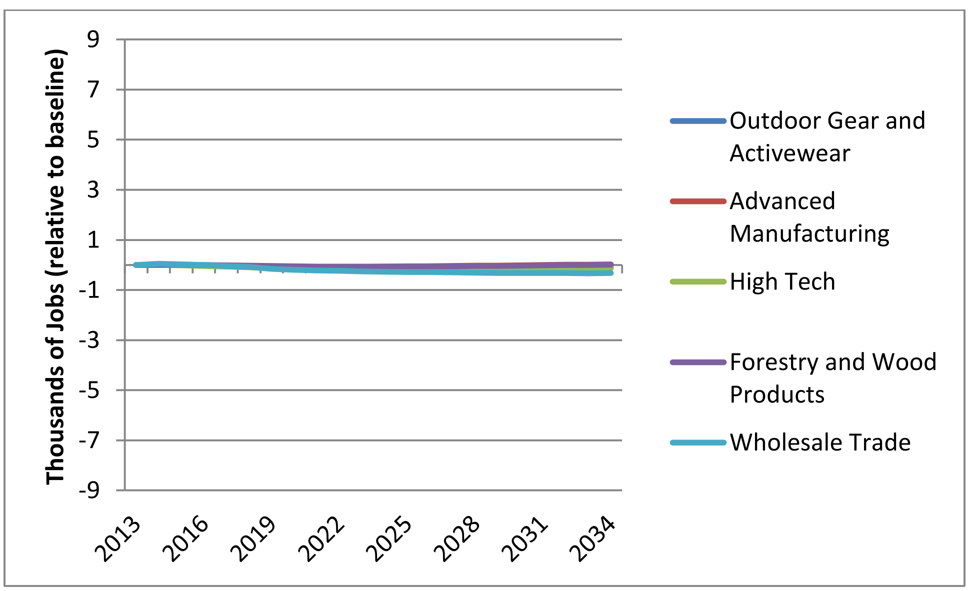
Figure 44 - Employment Impacts Energy Efficiency Investment- $30/ton (Scenario D.1.2.30)



Jobs Index: 1.625

The employment impacts for the state are positive in every year of our forecast period (although generally negative for the Metro region). The energy investment expenditures function similarly to the highway expenditures. Direct investment throughout the state leads to increased employment and the long-term benefits of the investment spending also tend to remain within the state.

Figure 45 - Key Industry Employment Impacts Energy Efficiency Investment- $30/ton (Scenario D.1.2.30)[32]



[32] Clean Tech has been left out of this chart because in this scenario, the Clean Tech impacts are dominated by the positive impact on road construction employment and are not reflective of actual clean tech activities.

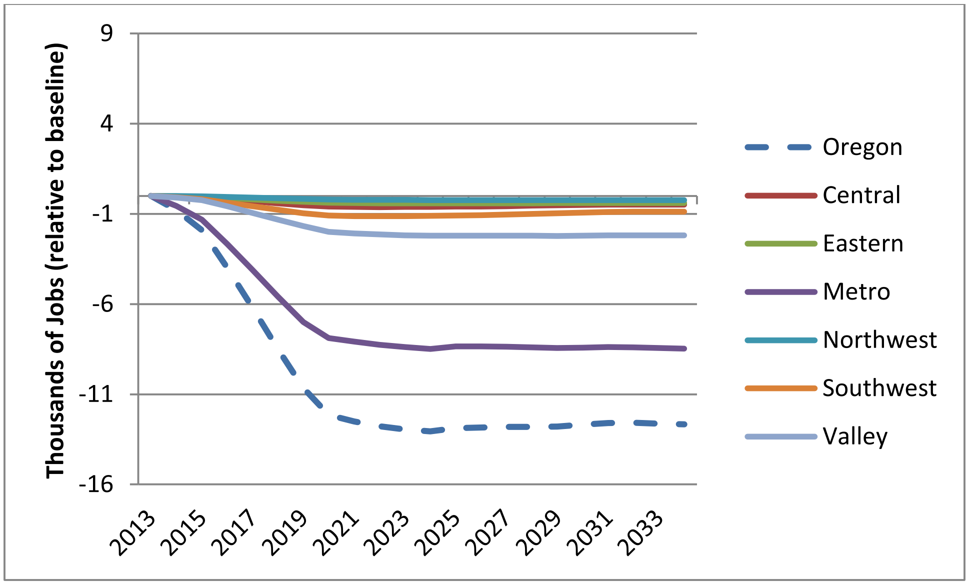
In this study, we have attempted to incorporate as many dynamic effects as possible. The Energy Efficiency scenarios were one area where we were unable to do this. By investing in energy efficiency projects, industries should lower their energy intensity of output. Within the modeling, industries do alter energy intensity based on the changes in energy prices. But we do not have enough data to estimate how energy intensity would change as a result of these targeted investments in a way that feeds dynamic changes in other parts of the economy. We expect the impact of this policy on emissions and revenue to be small.

Direct assistance to industries struggling under the carbon tax, or identified as strategically important

Scenario D.1.4 examines ways to directly assist industries that are either struggling under the carbon tax, or identified by policymakers as being strategically important to the Oregon economy. We look at two methods for assisting industries: exemptions and dedicated investments. In these scenarios, we looked at assisting the Outdoor Gear and Activewear, Advanced Manufacturing, High Tech, Forestry and Wood Products, and Clean Teach Industries. SB306 required us to highlight effects on these industries (identified by Business Oregon) in the analysis. These scenarios use this list as our set of targeted industries, but conclusions drawn here could easily be applied to other industries.

If a particular industry appears to be burdened by the carbon tax, or if policymakers want to avoid even the chance of extra burden for key industries, an exemption from the tax would hold industries harmless. In Scenario D.1.4.1, we exempted the Business Oregon industries from the tax (within the modeling, we undid the energy price increase for these industries), but kept the tax rate cut uniform across the economy. These industries would not pay the tax on the front end, but would still receive the benefits of a cut in the corporate tax rate. This leads to a reduction in the amount of revenue available to reduce personal and corporate income taxes, but does nothing to the revenues dedicated to the Highway Trust Fund.

Figure 46 - Business Carbon Tax Exemptions: Employment Impacts- $60/ton (Scenario D.1.4.1.60)

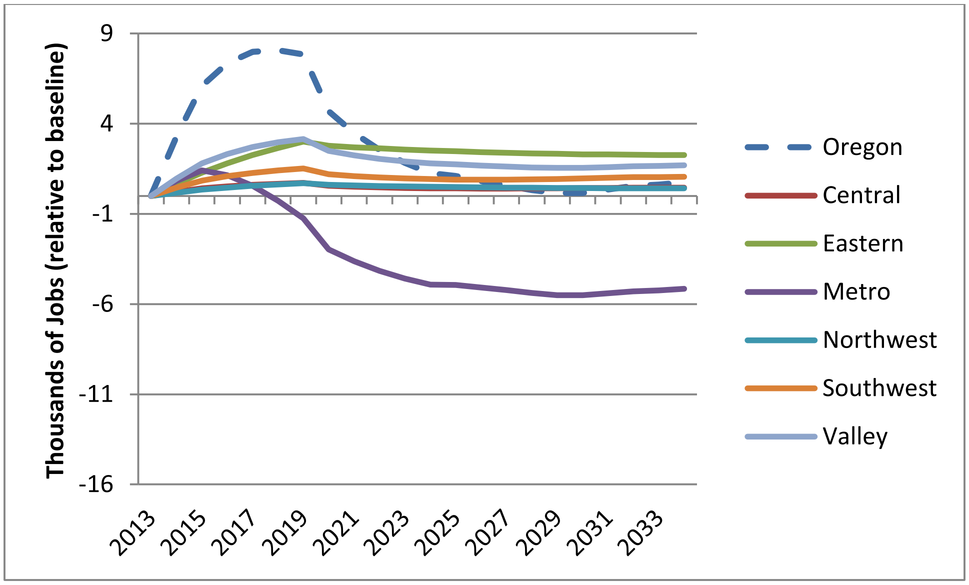


Jobs Index: -6.909

While Business Oregon's Key Industries are held harmless in this scenario, by exempting them a significant portion of carbon tax revenues are no longer collected. There is less revenue to repatriate to offset the negative impacts of the energy price changes in the rest of the economy, and the overall impact for Oregon (and in all regions) is negative. In this scenario, all other industries are effectively subsidizing the economic activity of the key industries. Because of the negative impacts for the non-exempted industries, the exempted industries also end up with small job losses because of the overall economic declines.

An alternative to exemptions would be to undo the burden on industries after the fact by devoting additional investment funds to targeted industries. In Scenario D.1.4.2, we used the same group of Business Oregon industries as our test case. We ran a scenario in which a carbon tax of $60/ton is imposed, and after the dedicated revenues go to the Highway Trust Fund, the remaining revenues are split 70% toward corporate income tax cuts and 30% toward personal income tax cuts. Then, we looked at the negative employment impact (in cases when there was one) for the key industries. We then ran several scenarios in which revenues were directed to additional tax credits for these negatively-affected industries before any remaining revenue was allocated to overall corporate and personal income tax cuts. At $60/ton, we found that 10% of revenues (after Highway Fund revenues have been removed) were enough to offset negative employment impacts for these sectors.

Figure 47 - Business Investment Fund Employment Impacts- $60/ton (Scenario D.1.4.2.60)



Jobs Index: 1.849

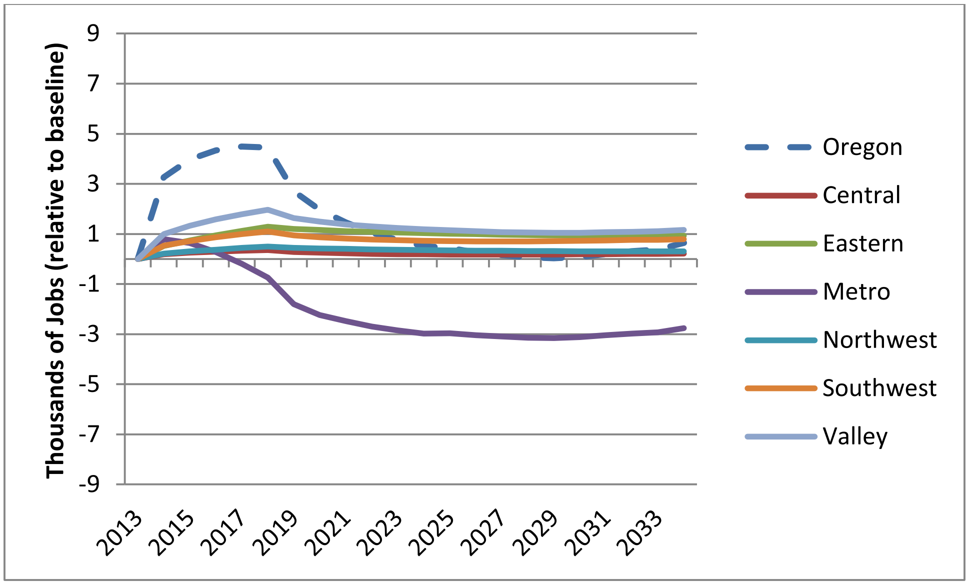
By collecting revenues from all businesses on the front-end, there is more revenue to repatriate. Over time, the key industries adjust to the higher energy prices by changing production methods and increasing energy efficiency. This adjustment reduces the burden of the carbon tax over time. In the exemption scenario, this adjustment never takes place. In this scenario, the rest of Oregon still provides a subsidy to these industries, but it is a subsidy given to industries that are also actively adjusting to energy price changes.

Scenario E - Alternative Transportation-Related Carbon Tax Revenue Disbursement

This set of scenarios investigates the economic impacts of using transportation-derived revenues from a carbon tax somewhat differently than the current allocations under the Highway Trust Fund. For all variants under Scenario E, all revenues from carbon taxes applied to transportation fuels and commercial vehicles still flow to transportation projects; however the mix of projects varies from the status quo allocation. The remaining carbon tax revenue is dedicated to corporate income tax cuts (70%) and personal income tax cuts (30%).

Scenario E.1 still envisions revenues going to the Highway Trust Fund, but the fund’s expenditures are now distributed to each region according to unweighted Vehicle Miles Traveled (VMT) rather than the distribution that normally occurs based on “weighted” VMT. The effect is to decrease the amount of construction and maintenance dollars allocated to rural areas, and increase urban highway funding particularly in the Portland Metro Area.

Figure 48 - Employment Impacts for Unweighted VMT Disbursement- $30/ton (Scenario E.1.30)

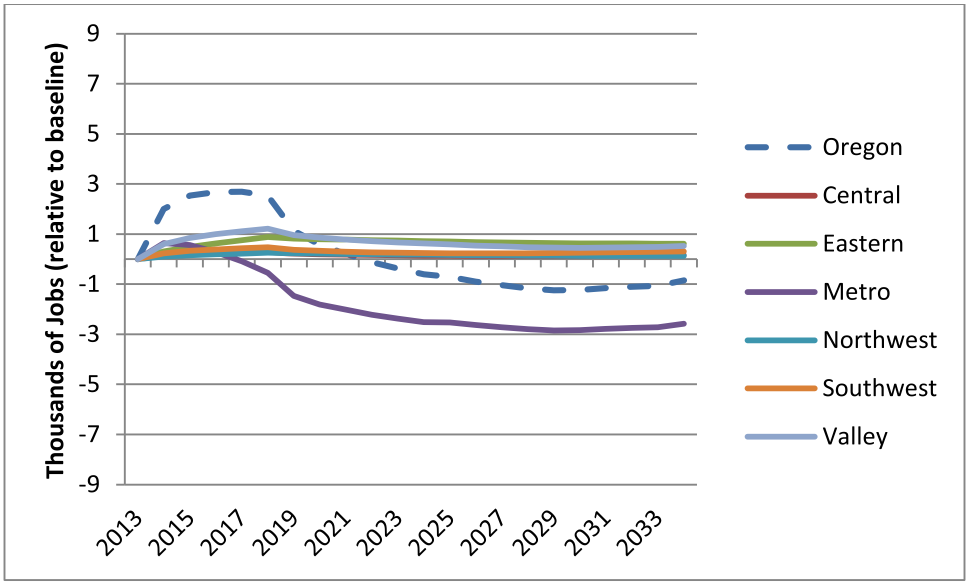


Jobs Index: 1.306

By using actual, unweighted VMT rather than weighted VMT, more of the revenues are disbursed to the Portland Metro Area. Relative to similar scenarios, Portland has smaller employment losses but the positive employment impact in the other regions is reduced. As noted elsewhere in the report, this public works investment is small relative to the total economic activity of the Portland economy. The employment declines in the service sector and some energy-intensive sectors in the Metro region are not offset by the increase in road construction and maintenance.

Scenario E.2 dedicates revenues from household (residential) purchases of motor gasoline to reductions in the gas tax rate. In this way, the carbon tax on household motor gasoline use would be revenue neutral.

Figure 49 - Employment Impacts for Revenue Neutral (Excluding Non-Residential Transportation-based Revenues) with 70% of Non-Transportation Revenues used for Corporate Income Tax Cuts and 30% of Non-Transportation Revenues for Personal Income Tax Cuts- $30/ton (Scenario E.2.30)

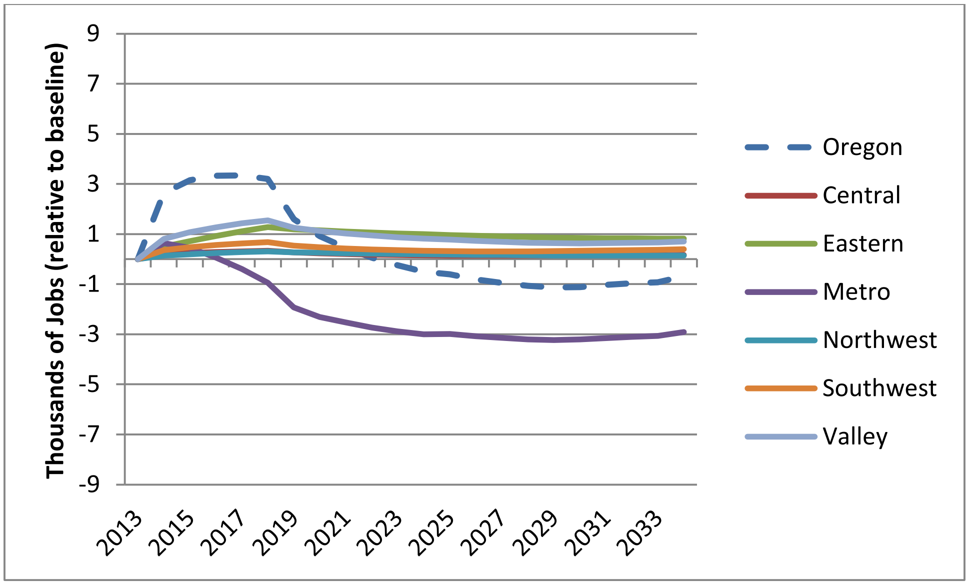


Jobs Index: 0.350

Scenario E.2.30 reduces the positive job impacts of the increase in road funding, but repatriates some of those funds directly back to households.

Normally, the list of projects eligible to be funded from the Highway Trust Fund is narrowly focused on road construction and maintenance. In Scenario E.3, we imagine that half of these funds are still devoted to transportation projects but the types of eligible projects are expanded. For modeling purposes, we used a broad investment category that could be thought of as construction of light rail, construction of bike lanes, purchases of buses, or any type of transportation investment intended to make long-term infrastructure changes.

Figure 50 - Employment Impacts for 50% of Transportation-based Revenues Dedicated to Non-Highway Transportation Projects with Remaining Revenues Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario E.3.30)



Jobs Index: 0.634

Because we used a broad investment category, a greater amount of leakage is built into the simulated economic activity, but this effect is small

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Other Considerations

Border Tariffs

A potential risk of Oregon implementing a carbon tax on its own is the creation of a competitive disadvantage for some industries. If price increases cause Oregon consumers to change their purchasing patterns and move toward the purchase of goods from outside of Oregon that are not subject to the tax, then the policy could potentially harm the Oregon economy while also moving carbon emissions out of the state. According to our analysis, the impact to competitiveness should be small but border tariffs could be useful for offsetting negative impacts in particular industries or at higher carbon prices.

A border tariff based on carbon content would be conceptually similar to the carbon tax, but its application is necessarily different. Oregon would have no ability to directly place taxes on fossil fuels or any portion of the production process outside of its jurisdiction. In order to apply a border tariff on goods, the carbon-content associated with the production of the good would need to be known. Based on that carbon content and the price of carbon, a tax could be applied to goods from outside of Oregon, eliminating any competitive disadvantage to Oregon firms.

Early on in the research project, we spoke with a Legislative Counsel attorney about the ability of Oregon to implement a border tariff on carbon. We were advised that as long as all goods (Oregon-produced goods and goods produced outside of Oregon) are treated the same, the border tariff would not run afoul of interstate commerce laws. As long as no advantage for Oregon goods or disadvantage for non-Oregon goods is created, the policy would be allowable.

While a border tariff is theoretically possible, the current state of carbon measurement would make implementation extremely difficult, if not impossible. A key feature of the carbon tax is that the actual tax paid is based on emissions. That may seem like an obvious point, but it is what allows the incentive structure to efficiently move the economy toward lower carbon output. When the tax is applied based on actual emissions, there is an incentive for firms and households to reduce their tax burden by reducing fossil fuel usage. If the link between emissions and tax burden is broken, people will seek to reduce their tax burden through some other means.

There is not currently a database of carbon intensities by product, nor is there a requirement for firms to measure carbon emissions in the production process. The first step toward implementing a border tariff would be to collect data or create a reporting requirement to accurately gather information on the carbon intensities of products. We feel that it is unlikely that Oregon could impose this requirement unilaterally. In the case of goods that are produced outside of the United States, Oregon may not have the authority to require foreign firms to report on carbon emissions in the production process.

An alternative to collecting data from the manufacturer would be to derive average emissions intensities for types of goods. For an example, rather than collect data on emissions intensities associated with different brands of televisions, one television emissions intensity could be used.

While this would be significantly simpler, it would also degrade the effect of the price signal. If manufacturers are able to make their products more competitive by reducing fossil fuel usage then there is a strong incentive to reduce emissions. If all manufacturers of a particular good are subject to the same tax, there is no incentive to reduce emissions because the reduction will not be reflected in the price charged to consumers.

Additionally, the border tariff would require administrative staff as well as investigative staff to validate the reported emissions data. The administrative burden of the policy would be significantly reduced if a coalition of states/provinces were to adopt the same standards.

Non-Combustion Emissions

Applying a carbon tax to fossil fuel greenhouse gas emissions from energy related activities similar to the British Columbia carbon tax necessarily limits the scope of taxable greenhouse gas emissions. For the year 2010, the Oregon Department of Environmental Quality estimates that non-energy based greenhouse gas emissions encompass ~17% of *in-boundary* emissions for Oregon (ODEQ, ODOE, ODOT, 2013). These emissions include: methane emissions from ruminant animal husbandry, municipal solid waste sent to landfills and wastewater treatment, agricultural residue burning; carbon dioxide process emissions from cement and other product manufacturing; nitrous oxide emissions from fertilizers and agricultural soil management, wastewater treatment and waste and agricultural residue burning; and high global warming potential gases (e.g., HFCs, PFCs, SF_6) used as refrigerants, propellants and in high-tech manufacturing processes. In principle, these non-energy sources of greenhouse gas emissions can be quantified and taxed based on their carbon dioxide equivalence.

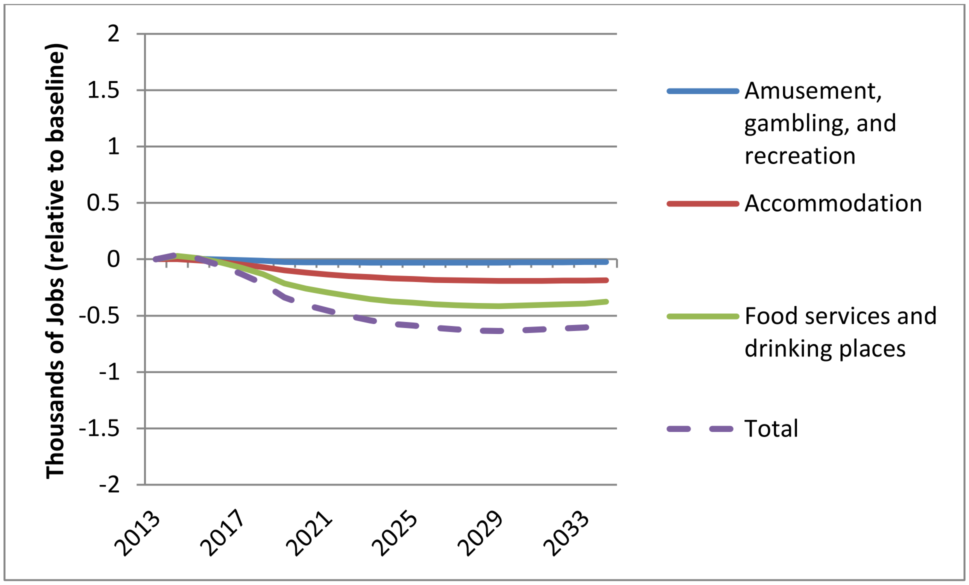
While annual totals for the state have been compiled, imposing tariffs on non-fossil fuel greenhouse gas emissions is problematic due to difficulty quantifying emissions related to the point of taxation. In many cases, emissions occur far upstream and vary widely within a sector as a result of differences in practices. For example, it is estimated that roughly half of non-fossil fuel greenhouse gas emissions in the state of Oregon are in the agricultural sector, primarily in the form of methane and nitrous oxide (ODEQ, ODOE, ODOT, 2013). One of Oregon's largest agricultural sources of greenhouse gases is methane emissions from enteric fermentation and manure management in beef and dairy cattle farming. However, methane emissions from cattle vary widely as a function of animal age, growth rate, feed quality and feed intake, and level of activity and productivity (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, EPA 430-R-14-0032014, US EPA, 2014). Similarly, nitrous oxide is produced in soils through microbial processes of nitrification and denitrification, emissions of which are typically enhanced through increasing soil mineral nitrogen by a variety of agricultural soil management practices including addition of fertilizers, application of livestock manure or other organic materials, and production of nitrogen fixing crops. Agricultural soil management emissions are estimated to be the largest source of nitrous oxide in the state of Oregon (ODEQ, ODOE, ODOT, 2013). Due to the variety of agricultural management processes including crop type, nitrogen input, soil type and irrigation, nitrous oxide emissions from agricultural soils vary widely (US EPA, 2014). In both cases of agricultural emissions (methane and nitrous oxide), the variety of factors which control greenhouse gas emissions make taxing these non-energy greenhouse gases problematic. However some process emissions (e.g., cement manufacturing) are easier to quantify due to stoichiometric calculations.

Through consultation with the Technical Advisory Committee, this study was limited to a carbon tax on energy-related greenhouse gas emissions. These represent more than 80% of statewide total greenhouse gas emissions, are the most straightforward to tax, and have been the target of carbon taxes elsewhere. For completeness, this study did investigate the indirect impact of an energy-related greenhouse gas carbon tax on non-energy greenhouse gas emissions (e.g., changes in emissions associated with sector-specific economic changes). Because these emissions are not directly modeled within the economic model, this was achieved by assuming that process emissions of non-energy greenhouse gases scale with the size of the sectors they are associated with (e.g., statewide nitrous oxide agricultural emissions increase or decrease with the estimated state economic output of the agriculture sector). Here, sector level economic output from REMI economic scenarios was used to produce emissions estimates for each scenario statewide. Results of this analysis showed that these secondary impacts were minor (<5%) in all carbon tax scenarios. This contrasts with the significant reductions in emissions directly resulting from a carbon tax on energy-related greenhouse gas emissions.

Impacts on Tourism

Although not an identified key industry, during the modeling process we were asked repeatedly about the impact of a carbon tax on the tourism industry. With some of the largest negative impacts concentrated in the service sector, it made sense to take a closer look at tourism impacts. These negative impacts are driven by the increase in the overall price level. As shown elsewhere in the report, this increase in price level is modest but would have an impact. Figure 51 highlights the expected employment impact on selected tourism-related sectors of a $30/ton carbon tax and repatriation structure that devoted transportation revenues to the Highway Trust Fund, and used 70% of the remaining revenue for corporate income tax cuts and 30% for personal income tax cuts (Scenario C.4.30).

Figure 51 - Tourism Employment Impact for Revenue Neutral (Excluding Transportation-based Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario C.4.30)



These impacts represent a reduction in employment below the expected baseline of half of one percent for the Accommodation industry, and a reduction of less than one quarter of one percent for the "Amusement, Gambling and Recreation" and "Food Services and Drinking Places" Industries.

Impacts on Government

Based on the relatively small estimated economic impacts, we expect the impact on state and local government to be small and in proportion to the impacts on employment and output. In most of the scenarios, wages, output, and business revenues change by a fraction of a percent from the estimated baseline.

Figure 52 and Figure 53 show the expected employment impacts for state and local governments, respectively. The negative employment impacts in later years are probably too large and are caused by our choice of modeling input. When dedicating revenues to road maintenance and construction, there is no "government road project" category to choose. Most of this revenue will actually be directed to road maintenance and construction firms around the state, and we modeled it as such. But it is likely that the expansion of the State Highway Fund will result in additional government administrative employment, which is not reflected here.

Figure 52 - State Government Employment Impact for Revenue Neutral (Excluding Transportation-based Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- (Scenario C.4)

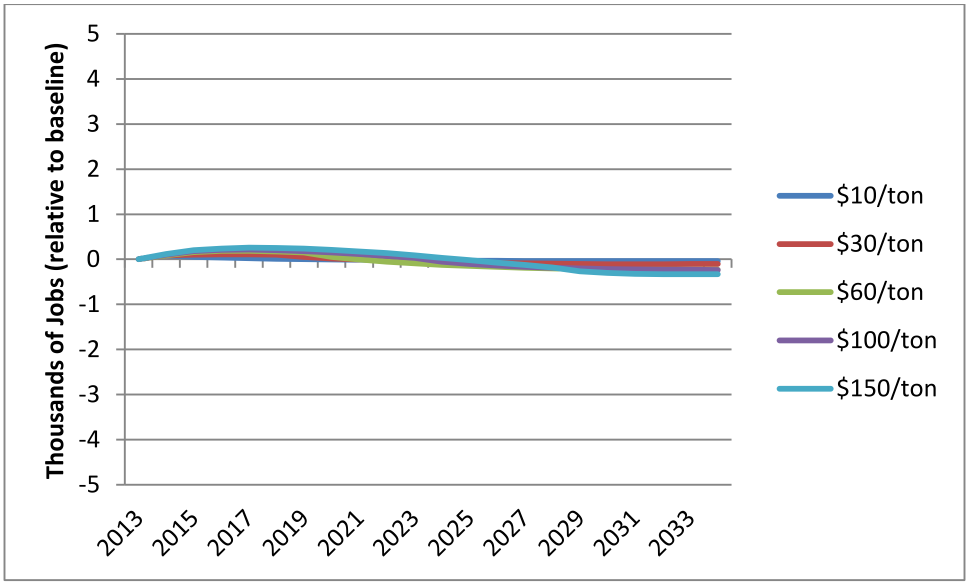
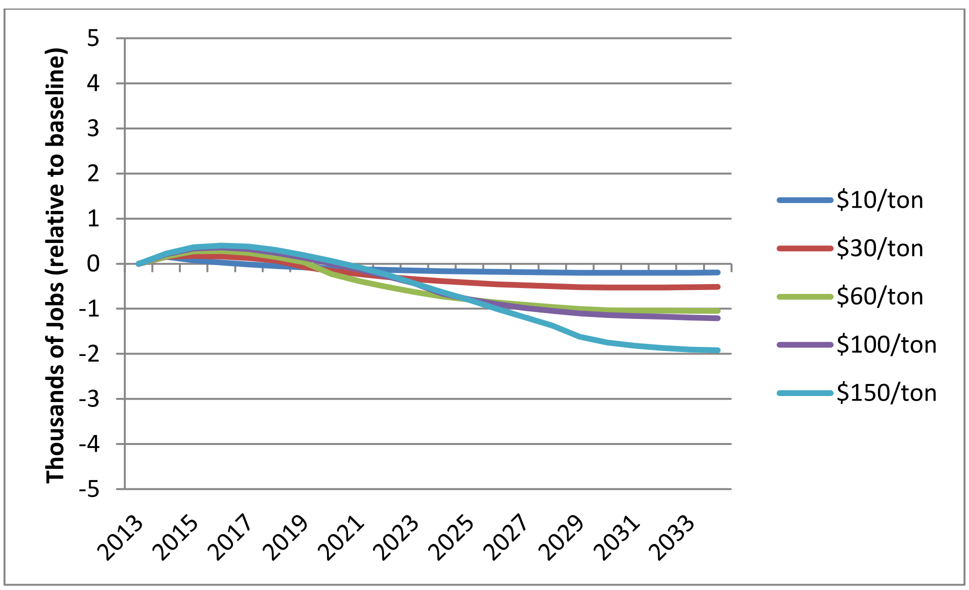


Figure 53 - Local Government Employment Impact for Revenue Neutral (Excluding Transportation-based Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- (Scenario C.4)



Evaluation of a Carbon Tax Relative to Existing Oregon Laws

Oregon has a relatively strong history of environmental protection among US states, and numerous existing laws and measures target the state's greenhouse gas emissions. Because these existing statutes can potentially interact with the proposed carbon tax, accurately measuring the utility of the proposed carbon tax thus requires consideration and analysis of its outcomes and cost effectiveness relative to those of the existing statutes. With an expansive "menu" of policy options and combinations to consider, and limited resources with which to implement those choices, the efficiency and cost-effectiveness of any new action will be proportional to its integration into the state's environmental and policy landscapes. Oregon SB 306 includes a requirement in Section J to evaluate the costs and benefits of a carbon tax relative to the state's existing laws that also result in greenhouse gas reductions.

> **(j) Evaluate the costs and benefits of a clean air fee or tax on greenhouse gas emission reductions relative to existing laws that result in greenhouse gas emissions, including ORS 468A.270, 468A.280, 469.501, 469.503, 469.504, 469.505, 469.507, 469A.005 to 469A.210, 469A.300, 646.910 to 646.923, 646.925, 757.365, 757.370, 757.375, 757.380, 757.385, 757.524, 757.528, 757.531, 757.533, 757.536 and 757.612;**

Therefore, the purpose of this chapter is to examine the proposed carbon tax in appropriate context alongside Oregon's existing efforts toward emissions reduction. We will proceed by introducing an analytical framework for comparing the costs and benefits of different measures. Next, the existing laws are categorized into three sections for ease of discussion and analysis: (i) laws regarding renewable portfolio standards, (ii) laws regarding low-carbon fuel standards and renewable fuel standards for transportation fuels, and (iii) other law concerning electric utilities.

Each of these sections provides a brief summary of the emissions measures established by the laws listed in SB 306, a discussion of each measure's associated costs and benefits, and analysis of each measure's effects and potential interactions relative to the proposed carbon tax. The tools available for comparison include an extensive body of literature addressing the costs and benefits of existing measures, the experiences of regions that have implemented them, and standard methods of economic analysis. Finally, the conclusion section integrates the above discussion and analysis into a summary table (Table 4).

Table 4 - Summary of Existing Laws and Possible Interaction with a Carbon Tax

	Existing Law	Purpose	Interaction with Carbon Tax
RPS	**Renewable Portfolio Standards (RPS)**	○ Promote renewable fuels in electric power sector through mandate/market mechanisms ○ **Goal**: 25% renewables by 2025	○ Likely complementary ○ Potential overlap under specific conditions
Motor Vehicle Emissions	**Low-Carbon Fuels Standards (Clean Fuels Program)**	○ Reduce life-cycle carbon intensity of transportation fuels through mandate/market mechanisms ○ **Goal**: 10% reduction in 10-year period	○ Potentially complementary or additive ○ Potential sector-specific overlap under certain conditions
	Renewable Fuels Standards (RFS)	○ Promote lower-pollution alternatives to gasoline and diesel ○ **Goal**: 10% ethanol and 5% biodiesel requirements for gasoline and diesel, respectively	○ Complementary ○ Minimal overlap
	Motor Vehicle Emissions Standards	○ Improve vehicle fuel economy ○ Reduce unnecessary transportation emissions	○ Complementary
Electric Utilities	**Emissions Reporting Requirements**	○ Measure GHG emissions from power sector	○ Complementary
	Electric Utility Facility Siting Requirements and Standards	○ Reduce GHG emissions from electricity generation through emissions caps ○ 0.675 lbs/kWh for baseload gas plants, 1100 lbs/MWh for all generation	○ Complementary under specific conditions ○ Potential sector-specific overlaps under certain conditions ○ Potential decrease in offsets

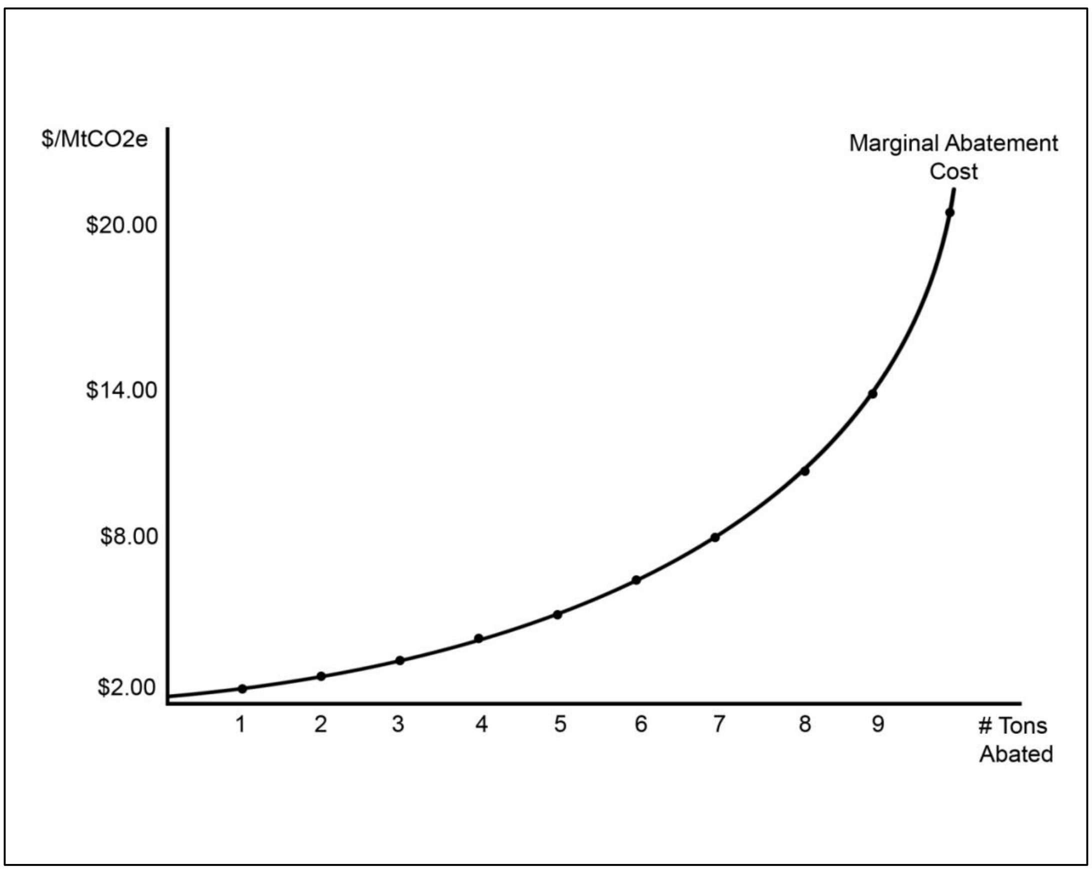
I. Analytical Framework

GHG Measures and Cost Effectiveness: the MAC Curve

Comparative analysis of greenhouse gas abatement, like other policy reviews, often focuses on the relative costs of such measures – that is, a dollar figure paid for each unit of a goal achieved. A good starting point for this comparison is a standard tool of economic analysis called a marginal cost curve. A marginal cost curve (or for our purpose, marginal *abatement* cost curve) offers a convenient way to organize and compare abatement options. The curve simply summarizes a schedule of discrete quantities of environmental degradation (e.g., tons of greenhouse gas emissions) avoided through abatement measures, and each marginal unit's cost, as seen in the hypothetical example in Figure 54 immediately below. The horizontal axis illustrates abated tons of CO_2 emissions from a hypothetical emission producer, and the vertical axis lists the cost corresponding to each unit of abatement.

Reducing zero tons of carbon costs this producer nothing. Moving to the right from zero, Figure 54 shows that for this hypothetical emitter, the first unit of carbon reduction is relatively cheap – approximately \$2.00. Cutting a second unit of CO_2 from its emissions costs this emitter \$2.50; a third will cost \$4.00, a fourth \$4.50, and so on.

Figure 54 - Hypothetical Marginal Abatement Cost Curve

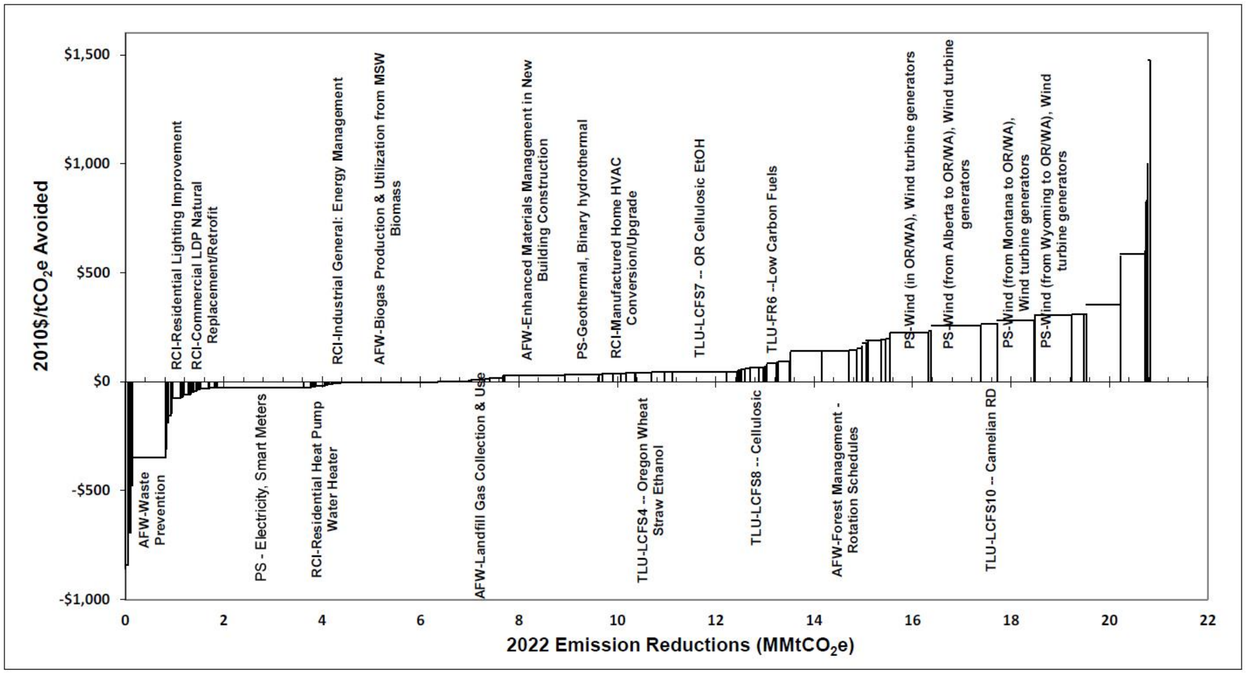


The generally upward slope of the curve is a useful and fairly intuitive feature. The interpretation is that, starting at unmitigated levels of pollution, the first few units of abatement should presumably be relatively easy and inexpensive – perhaps requiring only minor adjustments to an emitter's thermostat settings, installation of energy-efficient light bulbs, or powering down idle machines for part of the day. This "low-hanging" energy savings only goes so far for pollution reduction, however, and the next few units of reduction likely require a bit more investment and effort to achieve. To cut more and more carbon from its emissions, the emitter may need to institute a more stringent energy use management program or retool some portion of the plant with more efficient machines at a higher marginal cost per additional unit of carbon reduction. Continuing to the right along the horizontal axis, each additional unit of carbon emissions abated is associated with an incrementally higher cost. Presumably, once the emitter has cut its daily emissions by say, nine units, the last few units of carbon still escaping its exhaust stacks will be quite expensive to abate.

Essentially, the marginal abatement cost curve arranges units of pollution reduction (or equivalently, *methods* of pollution reduction) by cost from left to right, allowing for convenient analysis. Organized as such, an emitter's cost-minimizing bundle of abatement options is apparent: the cheapest route to an emissions reduction goal is to start with the cheapest measures at the far left and continue rightward until the desired amount of pollution is eliminated. Of course, such schedules are not limited to a single producer's options, and can be constructed for states, nations, or any other entity. In 2012, the Oregon Department of Energy commissioned a comprehensive study by the Center for Climate Strategies which constructed such a curve for the state of Oregon. The comprehensive report estimated the cost effectiveness of a multitude of greenhouse gas emissions strategies available to the state, disaggregated by economic sector, year and possible policy environment scenario. These estimates were then presented as marginal abatement cost curves, such as that in Figure 55 below.

Figure 55 (reproduced from ODOE and Center for Climate Strategies - 10-Year Energy Action Plan and Modeling, 2012) presents the abatement cost curve for the year 2022, given the most conservative policy environment considered (i.e. assuming continuation, but not expansion of, state and federal efforts towards greenhouse gas emissions reduction). As in Figure 54, the average per-ton (TCO_2e) abatement cost appears on the vertical axis, and the horizontal axis quantifies emissions reductions (in million metric tons of carbon dioxide equivalent, $mmTCO_2e$). Each column along the curve can be read like a bar graph, with its height illustrating the average per-unit cost and its width the total potential reductions for the indicated measure.

Figure 55 - Oregon Marginal Abatement Cost Curve for Carbon Emissions in 2022



(Source: Oregon Department of Energy and Center for Climate Studies, 2012)
AFW = Agriculture, Forestry and Waste sectors; PS = Power Supply; RCI = Residential, Commercial and Industrial; TLU = Transportation and Land Use)

In contrast to the hypothetical MAC curve in Figure 54, the first portion of Oregon's curve lies beneath the horizontal-axis because the marginal cost of many measures is effectively negative. For instance, the first labeled measure – Waste Prevention in the Agricultural, Forestry, and Waste Management (AFW) sector, is estimated to reduce approximately 0.7 MMtCO2e in 2022 for an average cost of -$442 per ton. The measure would aim to reduce food and packaging waste by 10% at the consumer and retail level by 2022. Because reductions to presumably excessive packaging are quite inexpensive, and the "upstream" pollution reductions are significant (i.e., pollution avoided by producing less *excess* plastic packaging), the savings to consumers and manufacturers outweigh the costs of implementing the measure, resulting in a negative cost effectiveness ratio. Approximately the first seven million metric tons of emissions are estimated to have negative or zero cost, at which point Oregon's curve crosses the horizontal axis and more closely follows the form of the curve for a hypothetical firm in Figure 55.

Several of the measures outlined in the laws listed in Section J of SB 306 were analyzed and placed along the marginal abatement cost curve developed by the ODOE-commissioned study. Others have closely related analogs considered by that study or other research, so that their performance and costs to the state can be compared. In either case, the Oregon MACC constructed by the ODOE-commissioned study presents both a framework through which the relative cost and effectiveness of the proposed carbon tax can be analyzed, and estimates for the costs and effectiveness of many of the regulations listed in SB 306 Section J.

Considering the tax alongside the cost effectiveness estimates of other measures requires strong caution; conceptually, the outcomes of the former are difficult to directly express in terms of cost. It is important to note that under most scenarios, the proposal in question is effectively a tax shift*,* rather than an additional liability to tax payers. Because payments for carbon use will be offset by reductions to Corporate and Personal Income taxes, the correct cost for the measure's cost-effectiveness ratio cannot be calculated in the same manner as measures with a new and distinct cost. As presented, the tax would generate an estimated $1-4.5B in revenues depending on price, and the repatriation and expenditure of those revenues may be distributed in ways that might be considered a cost to individual parties (e.g., when individual tax reductions are not equal to individual tax liabilities). Still, repatriated tax receipts, regardless of revenue-use scheme, are generally not comparable to the costs of other carbon reduction measures.

Additionally, the magnitude of estimated emissions reduction due to a carbon tax is significantly larger than those of most measures analyzed by the ODOE study. The 1.79 MMtCO2e emissions reduction attributable to a carbon tax in 2022 would be represented in Figure 55 by a column width comparable only to Smart Metering in the power generating sector (estimated to reduce 1.76 MMtCO2e). Estimated cumulative reductions due to the carbon tax for the period 2013 – 2022 are 11.1 MMtCO2e, which exceeds any measure considered in the ODOE report. For comparison, emissions estimated to be avoided during the first 10 years of a carbon tax are comparable to all of the included residential, commercial, and industrial (RCI) measures combined (12.535 $MMtCO_2e$).

This motivates another bit of necessary caution while comparing any of the measures appearing in the Oregon MACC study or any of those examined below in terms of cost effectiveness. Simply sorting the measures by the magnitude of their cost effectiveness (as is done along a marginal abatement cost curve) may appear to imply that those measures with the highest cost-effectiveness are qualitatively "better" than those with lower cost-effectiveness. It does not; any measure with benefits that exceed its cost *is* cost-effective.

II. The Carbon Tax in Context

This section will briefly describe each of the Oregon laws named in Section J of SB 306, which together address the state's renewable portfolio standards (RPS), low-carbon fuel standards (LCFS) and renewable fuel standards (RFS) for transportation fuels, and specific guidelines for electricity generation and other economic activities. The extensive amount of analysis that has been dedicated to emissions reduction measures within and outside the state allows for comparison between Oregon's existing laws and proposed legislation in terms of both costs and benefits. An analysis and discussion of the costs, performance measures and interactions with the carbon tax follow each set of regulations.

1. Laws Regarding Renewable Portfolio Standards

A. Description

The provisions of ORS 469A establish the framework for Oregon's renewable portfolio standards (RPS) and associated renewable energy certificate program. The objective of the RPS is to stimulate new renewable resource development beyond existing development. The standards for renewable energy as a share of total energy supplied began in 2011 at 5% for Oregon's largest utilities[33], and will progress to 25% of power portfolios in 2025 (with several interim targets). Smaller utilities are subject to lower standards, which will reach 10% and 5% for the state's small and smallest utilities, respectively, in 2025[34]. Qualifying renewable energy includes biomass, geothermal, hydropower, marine, solar, hydrogen gas, solid waste, and wind sources.

Definitions and Qualifying Fuels - Sections 469A.010 and 469A.020, and 469A.025 define electricity generation qualifying as "renewable" for the purposes of the program. Qualifying fuels are named, and specific rules are established for many fuels. For example, new hydropower capacity can only be used to comply with RPS if the source is outside any protected rivers and streams. Additionally, woody biomass which has been chemically treated does not qualify. Importantly, the statute was designed so that much of the state's renewable capacity (primarily large-scale hydroelectric generation) predating 1995 does not qualify for compliance, establishing one of the program's key incentives to promote the growth of *new* renewable generation.

Standards, Compliance, and Exemptions - Sections 469A.050 to 469A.075 define and set specific standards for large utilities, small utilities, and electricity service suppliers (ESS). The standards for electricity service providers mirror those of the utilities that service the territories they operate in.

Regulated utilities may meet requirements by adding new renewable generation capacity, purchasing unbundled Renewable Energy Certificates (RECs)[35] from other generators, or

[33]Pacificorp, Portland General Electric (PGE), Idaho Power Company, and Eugene Water and Electric Board
[34]Small utilities are those with retail electricity sales between 1.5 and 3% of state retail electricity sales. Smaller utilities are those with sales below 1.5% of state retail electricity sales.
[35] One REC is issued for each MWh of energy generated from a renewable resource

paying an "alternative compliance payment", but exemptions are made when compliance would require a utility to purchase electricity beyond its projected load requirement, substitute qualifying electricity sources for anything other than fossil fuels, reduce hydropower purchases from BPA or some hydropower facilities in Washington State, or if the incremental cost of compliance is above 4% of the utility's revenue requirement in a given year. Section 469A.170 mandates that investor-owned utilities[36] and ESSs must submit an annual compliance report to the Oregon Public Utilities Commission (OPUC) detailing how they have met RPS requirements: through added generation, purchased RECs, or alternative compliance payments.

Cost Containment: RECs, Alternative Compliance Payments, and Limits - Sections 469A.130 to 469A.150 establish rules for the transfer and banking of RECs, which utilities may use to comply with RPS. Purchased RECs used to meet generation quotas may be "bundled" with electricity – that is, a utility purchases the power associated with renewable generation along with the REC – or "unbundled" from their source, although the latter form cannot exceed 20%[37] of all RECs used to comply. The ability to meet RPS through REC purchases or trading is a key feature of the program, allowing utilities flexibility in choosing the least-cost option towards compliance.

Alternative compliance payments, described in ORS 469A.180 and 469A.185, likewise offer regulated entities the option of meeting requirements by directly paying a rate set for each entity by the OPUC. Utilities opting to pay alternative compliance payments can channel these fees toward the construction of new renewable capacity in the future, and the funds are held in holding accounts that accrue an approved interest rate (ODOE, 2014).

ORS 469A.100 sets upper bounds on incremental compliance costs for large and small utilities and electric service suppliers (ESSs) based on annual revenue requirements. Utilities do not have to comply with the standard to the extent that the cost of compliance is above 4% of revenue requirements. The cost cap is calculated as the sum of the incremental renewable electricity cost, REC costs, and alternative compliance payments. Consumer-owned utilities can additionally include the research and development costs associated with requirements in the incremental costs of compliance. Once again, the upper bound for an ESS is synced to the utilities serving the territories where it operates.

Resource-Specific Goals and Carve-outs - Oregon's RPS includes specific goals for certain renewable energy sources. The program's 8% goal for small scale community-based renewable projects, including marine renewable resources, is specified in ORS 469A. Sections of ORS 757 establish a quota for solar generation capacity. Solar generation capacity requirements for individual utilities are set in a nominally more complicated

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[36]Pacificorp, Portland General Electric (PGE) and Idaho Power Company.

[37] Small utilities can use 100% unbundled RECs to meet the standard. Consumer owned utilities that are in the largest category can use 50% unbundled RECs until 2020. Utilities that transition from the small utilities class to the large have an extended compliance period to use a greater share of unbundled RECs. Those transitioning utilities can use 100% unbundled RECs at the 5% compliance level, 75% unbundled RECs at the 15 and 20% compliance level, and 20% unbundled RECs when they reach the 25% compliance level.

manner than a simple portfolio share – minimum capacity is calculated by multiplying 20 megawatts by the company's share of all Oregon retail electricity sales[38], and qualifying systems that are online before January 2016 earn double credit toward compliance. Options for purchasing credits from qualified solar generators and alternative compliance fees parallel those of the larger RPS program.

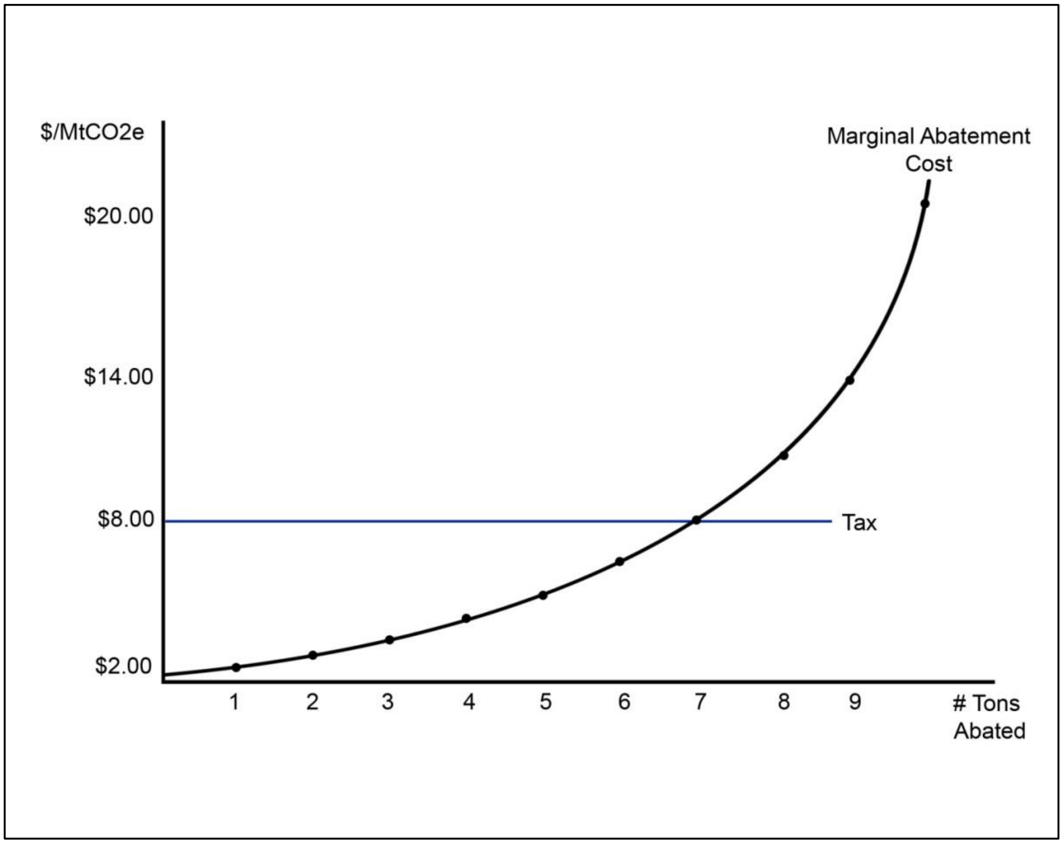
B. Costs, Performance and Interactions with Carbon Tax

RPS and emissions taxes are sometimes presented as alternatives to one another. Under specific circumstances, they needn't necessarily be mutually exclusive. A common method of analysis of the effects of a carbon tax on individual producers sets the tax to a level such that firms will choose to eliminate the desired amount of pollution rather than pay the tax, essentially incorporating the social cost of their carbon output into cost-minimizing production decisions. This is illustrated in Figure 56, where the marginal abatement cost curve for the hypothetical firm previously discussed intersects the per-unit tax imposed for emitting pollution. Say the firm initially does not abate any emissions and faces no tax or fee for emissions. In this stylized scenario, policy makers set a level of tax that achieves their policy objectives of 7 tons of abatement. When this $8/ton tax is imposed on the firm which starts out at 10 tons of emissions, it will naturally react in a manner that minimizes its costs of production. Thus, for the first ton, its choice is between taking action to eliminate that ton at a cost of $2.00 or emitting it and paying $8. The profit-maximizing firm will choose to eliminate that ton because it is cheaper to do so, as it is with all subsequent tons until the eighth, where it becomes cheaper to pay the fee than to abate additional tons. In this example, the policy objective of 7 tons of emissions abatement is achieved, and the firm now emits 3 tons and pays a tax of $8 per ton.

Renewable portfolio standards have an indirect effect of emissions reduction through substitution of renewable fuels for carbon-intense fuels. In contrast to the market price signal approach of emissions taxes that seeks to elicit emissions abatement which might otherwise include renewable energy without explicitly requiring any specific action be taken by firms. From an individual emissions-producing firm's perspective, the RPS and the proposed carbon tax would appear similar if both the standard and tax level were set to the same emissions reduction goal. Figure 57 adds an RPS requirement to the marginal abatement cost curve from Figure 56. As illustrated, a portfolio standard sets a minimum requirement along the horizontal axis, and a tax effectively alters the cost along the vertical axis; if both policy signals are designed and transmitted efficiently, the same outcome of 7 tons of abatement is achieved.

[38]Qualifying systems must be between 500 kW and 5 MW in capacity.

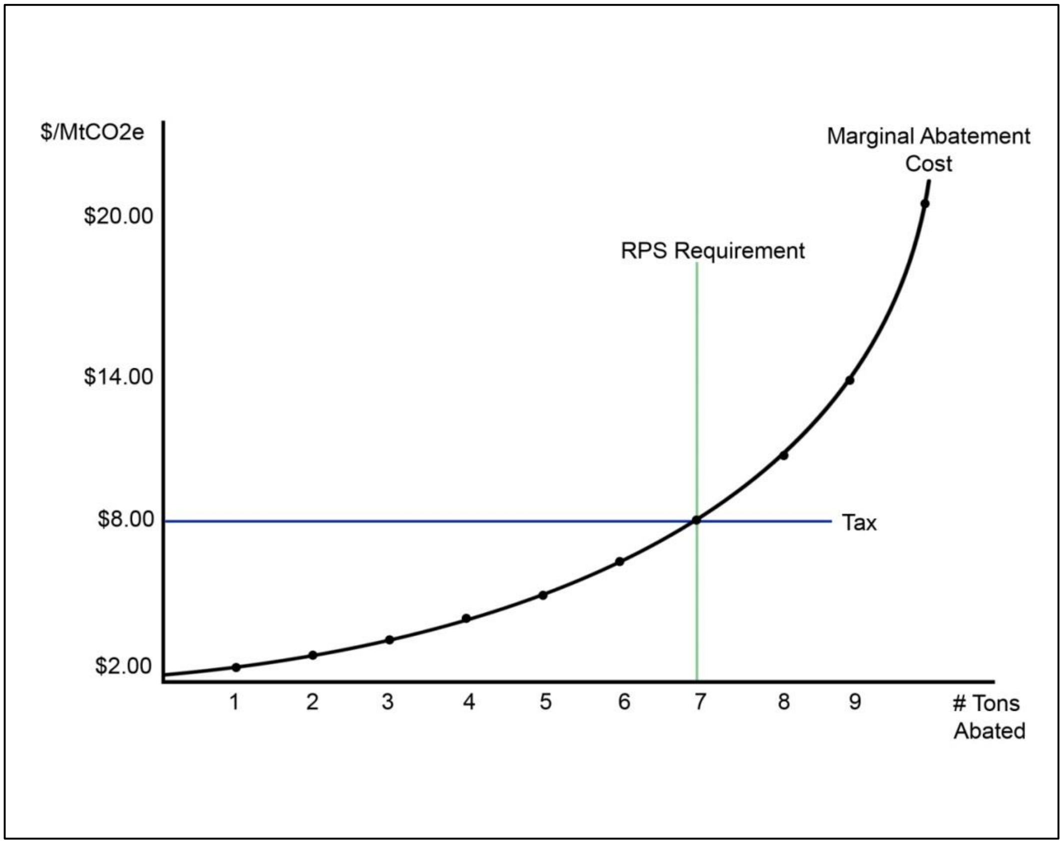
Figure 56 - Marginal Abatement Cost Curve with Tax



Non-compliance fees (established in ORS 469A.200) for power producers that fail to meet renewable standards in their fuel mixes minimally complicate this comparison: such a fee serves as both a cost containment mechanism for regulated firms and a minimum [indirect] price signal. Set to the desired level of compliance, it will appear similar to an emissions tax.

From a practical perspective, however, there are important distinctions and interactions between portfolio standards and emissions pricing schemes that are not characterized in the stylized example above.

Figure 57 - Marginal Abatement Cost Curve with RPS



The first distinction relates to economic efficiency – that is, the maximization of aggregate net benefits to the economy. While both approaches may lead to similar emissions reductions, the RPS requires actions by companies charged with meeting portfolio acquisition goals even in the presence of emissions reducing options. Carbon pricing, on the other hand, allows for maximum flexibility to firms in meeting emissions reduction goals; firms choose their own least-cost way to eliminate pollution (including options unrelated to electricity resource mix), which potentially leads to the same outcome at lower cost. This presents a second distinction: a trade-off between flexibility and certainty of specific outcomes. While both carbon tax and renewable portfolio standard approaches may lead to similar changes to emissions (as noted, this outcome is secondary for the RPS program), the former establishes an ex-ante price on emissions intended to elicit the desired response from firms, requiring neither specific method nor specific level of abatement from any individual entity. The RPS mandates a minimum response, thus guaranteeing an environmental outcome by perhaps sacrificing some flexibility for regulated parties.

Another distinction between the RPS program and the carbon tax as proposed arises after costs are levied on regulated entities, pertaining to how program revenues are used after collection. With the RPS program, compliance costs for utilities and their customers are not directly offset. Instead, funds generated from alternative compliance payments must be used toward capacity and efficiency investments, and state integrated resource planning

(IRP) guidelines require that resources implemented for RPS compliance must best balance cost and risk among available alternatives. Both of these uses should reduce or minimize costs, but the net costs associated with compliance are absorbed by utilities and their customers. In contrast, carbon tax revenue repatriation and expenditure schemes considered may directly offset the increase in costs through reductions in personal income and/or corporate income tax burden.

It should also be noted that carbon pricing applies to a much broader swath of the economy; the RPS apply only to utilities, whereas the impacts of carbon taxes are spread across all consumption sectors (including transportation, which is not subject to RPS). Finally, it should be noted that renewable portfolio standards directly serve socioeconomic goals beyond pollution reduction through support for the state's renewable energy infrastructure and a long-term permanent shift away from fossil fuels. Similar support stemming from a carbon tax is indirect through price incentives to producers and consumers, with no guarantee of any level of desired investment.

Given the distinctions above, the addition of a carbon tax may be seen as complementary to the RPS – the measures serve different, but related goals. A carbon tax does not directly target renewable capacity, and it is certainly possible that the tax may not spur the desired level of investment in renewable energy resources if the public merely responds to the price signal with near-term fuel shifting conservation efforts. Similarly, portfolio standards do not directly target emissions, and further treat all non-renewable sources equally, regardless of carbon content. If either measure is insufficient to achieve the goals of the other, then they may be considered complementary, in which case one measure may perform as a backstop to the other in terms of their respective purposes.

Twenty-nine states and several countries have implemented binding portfolio standards and REC schemes, providing good examples of their costs and performance. Oregon's RPS was enacted in 2007, and went into effect in 2011 for the state's largest utilities. There are at least two approaches to interpreting the price of carbon associated with the RPS program. The most common derives the *net* cost per ton avoided from the program's compliance costs and the cost savings spurred by responses such as investment and REC market activity. Oregon's incremental (i.e., net) compliance cost per MWh over its first two years has been estimated to be slightly negative (although some savings were attributable to strategic REC purchases), to slightly positive (Barbose et al., 2014). The ODOE/CCS (2012) study estimates a broad range of per-ton costs for resources that qualify for RPS compliance, but the program's 4% cost cap would limit maximum potential compliance costs to roughly $40 (2012 USD) per ton in 2025[39]. Thus far, RPS costs in Oregon have been on the low end of US states[40]. Elsewhere, incremental compliance costs of RPS schemes have been similarly low, with average incremental compliance costs of 0.9% to 1.2% of electricity costs for US states. Studies of California's particularly ambitious 33% standard have estimated the highest incremental cost among US states (6.5% of retail electricity

[39] Estimate based on current new gas-fired generation costs and CO_2 content of 118 lbs per MMBtu for natural gas.
[40] Compliance costs for PacifiCorp and PGE were very small in 2012; see Compliance Reports for 2012.

rates) as well as the lowest (a 3.5% savings), and a 2009 California Public Utility Commission report estimated that compliance to the 33% RPS goal would result in a 10.2% increase in cost over a hypothetical all natural-gas base case. At least two studies have estimated costs near 2% to 4% of electricity rates for foreign countries with relatively older programs. The Australian Energy Market Commission's 2013 report on the price impacts of renewables standards states that new renewables capacity results in retail prices that are lower than they would be without the standards (Australian Energy Market Commission, 2013).

The second view of the cost of carbon implicit in the RPS program considers the maximum cost per ton of abatement determined by regulators – the alternative compliance payment option available to utilities that do not cover their requirements through added generation or REC purchases. Because firms would never choose to spend more on compliance than this alternative, it effectively sets an upper bound on per ton abatement costs. This bound is inflated – it includes a penalty intended to incentivize program compliance. Still, if that the rate bears some relationship with the public's social costs and benefits associated with carbon reduction, then it can be interpreted familiarly as the maximum the state is willing to give up to reduce a ton of emissions. OPUC Order 12-375 sets the alternative compliance payment rate for 2014 and 2015 at $110 per MWh, increasing from a rate of $50 per MWh in 2013 (OPUC, 2012).

2. Laws Regarding Motor Vehicle Emissions

Low-Carbon Fuel Standards, Renewable Fuel Standards and other Motor Vehicle Emission Standards

A. Description of Low-Carbon Fuel Standards and Renewable Fuel Standards

Low-Carbon Fuel Standards - The provisions of OR 468A.270 provide the Environmental Quality Commission with the authority to establish several motor vehicle related pollution control measures, most notably Oregon's Clean Fuels Program for transportation fuels. The law's language describes greenhouse gas-reducing standards (and exemptions to those standards) specific to motor vehicles, including requirements for routine tire maintenance and prohibition of pollution control system tampering. It also sanctions restrictions on engine idling for commercial ships at port.

Oregon HB 2186 added provisions[41] to ORS 468A that establish Oregon's low carbon fuel standards (LCFS, named the Clean Fuels Program) for gasoline, diesel, and related substitutes with a goal of reducing GHG emissions by 10% over a 10-year period. This includes content and reporting standards for fuels throughout their life cycles, rather than strictly for end-use consumption. Proposed DEQ rules for the program will also apply to Oregon importers of transportation fuels, who will be required to submit reports that document program compliance. Providers of low-carbon fuels will be allowed to generate and sell credits for the fuels they provide in Oregon[42], and the proposed rules include several deferral mechanisms for cost containment including deferrals due to forecasted supply problems, emergency deferrals due to unanticipated supply shortages, and deferrals due to Oregon fuel prices diverging from those of neighboring states.

Renewable Fuel Standards - ORS 646.910 to 646.920 establish detailed rules regarding specific motor vehicle fuel additives used to meet Oregon's Renewable Fuels Standards. Specifically, ORS 646.910 and 646.911 prohibit sales of motor fuels with oxygenating additives such as MTBE or ethanol unless the fuel's contents meet the EPA's quality and clean air requirements, essentially syncing Oregon's ethanol requirements to the upper bound of federal statute, and set a maximum on the content of several other oxygenates, including MTBE. ORS 646.912 to 646.923 set Oregon's Renewable Fuels standards: a minimum ethanol content of 10% for retail gasoline and 5% minimum biodiesel content for diesel sales, specific quality and labeling requirements, and exemptions for sales for use in aviation, recreational vehicles, and antique vehicles. OR 646.923 and 646.924 directs the State Department of Agriculture to set, test for, and enforce each of these standards.

[41] The Environmental Quality Commission's (EQC) current authority to implement the low carbon fuel standards will sunset on December 31, 2015.

[42] Importers of less than 250,000 gallons per year will be required to register with DEQ, but will not be required to submit compliance reports.

B. Costs, Performance and Interactions with Carbon Tax

At the time of the writing of this report, Oregon's Clean Fuels Program remains in its administrative phase, but the Department of Environmental Quality has been directed to move forward with its carbon reduction phase. The future of the program is still uncertain pending legislation in 2015 to remove its statutory sunset on December 31, 2015. Program costs have been estimated, although a full macroeconomic analysis has not been completed. A preliminary 2010 Oregon DEQ-commissioned macroeconomic impact study estimated the possible effects of an LCFS program in the state under several policy scenarios defined by levels of federal and state action and assumed market responses. In all but one potential scenario, overall fuel expenditure was estimated to decrease due to the lower costs associated with alternative fuels between 2012 and 2022, and nearly all of the scenarios modeled resulted in a net economic gain in Oregon (the investment necessary for compliance was modeled as boosting output in the state) (Jack Faucett Associates, Inc., 2011). A 2014 update to the scenarios considered by the original report added new information regarding Oregon's vehicle fleet and the projected availability of lower carbon-intensity fuels. The update estimated GHG emissions reductions of close to 3% compared to the baseline[43] from 2016 to 2025, corresponding with annual reductions of approximately 1 million metric tons at the end of the period (ICF International, 2014).

A DEQ Notice of Proposed Rulemaking for the Clean Fuels Program cites potential costs to reduce carbon based on a range of assumed credit costs. (Oregon Department of Environmental Quality, 2014). Potential per-gallon fuel price impacts of carbon reduction were estimated at between $0.03 and $0.11 for credit prices ranging from $35 and $150 per metric ton. The full costs of the program, however, will depend on administrative costs, the actual costs of alternative biofuel feedstocks as they become available, and indirect costs to regulated companies and consumers as well as the market price of credits.

The ODOE-commissioned marginal abatement cost curve study cited above includes an analysis of several potential compliance scenarios considered in OR DEQ's 2010 macroeconomic study. The report estimates the per-ton costs of abatement over the 2012-2022 time horizon for several scenarios representing different combinations of alternative fuels (including ethanol and biodiesel from various feedstocks)[44]. Variation in the estimated per-ton abatement costs across scenarios resulted from the assumed phase-in schedule and availability of biofuels, the broad range of carbon-intensities and costs of feedstocks assumed to be used for compliance, and the assumed market penetration of electric vehicles (ODOE and Center for Climate Strategies 2012; Jack Faucett Associates, Inc., 2010). Cost containment measures currently proposed for the Clean Fuels Program were not considered as part of this ODOE study.

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[43] The baseline scenario included the ZEV program and increased light-duty fuel economy standards.

[44] The report estimates the average cost effectiveness of individual fuel types used for compliance to range from $42/tCO2e (2008$) for CNG from biogas, imported cellulosic ethanol or Oregon wheat straw ethanol to $597/tCO2e for MW corn ethanol or OR corn ethanol. Several scenarios that simulate substitution of gasoline and diesel to combinations of ethanol and biodiesel were estimated in this study, but they do not incorporate cost containments measures that are proposed as part of the Clean Fuels Program.

The ODOE-commissioned study illustrates the wide variation of per-ton abatement costs for individual feedstocks; compliance scenarios in the underlying study assumed the use of fuels corresponding to relatively low cost per ton of CO_2e avoided as well as those with very high per-ton abatement costs, which increases the total cost of scenarios that include them. As with any of the measures discussed in this section, the costs involved in the Clean Fuels Program are accompanied by economic benefits; the macroeconomic analysis commissioned by DEQ projected positive net economic impacts across nearly all the compliance scenarios it considered (ICF International, 2014).

A 2011 study commissioned by the Washington State Department of Ecology considered the impacts in that state of compliance to a 10% carbon intensity reduction requirement for gasoline and diesel. Over a range of compliance scenarios, that study projected similar patterns in overall fuel expenditure between 2013 and 2023 as the Oregon analyses, with higher projected incremental emissions reductions (roughly 10% at the end of the period). The Washington study also included estimates of the costs associated with alternative fuels infrastructure required to implement the LCFS. However, as with the Oregon DEQ's studies, these estimates ranged widely – from more than $2 billion to as low as $300 million between 2013 and 2023 - with scenario assumptions regarding electric vehicle penetration, the origin of feedstock used for alternative fuels, and location of biofuel production (Pont and Rosenfeld, 2011).

The costs and performance of California's nascent LCFS program have been intensely scrutinized. Several sources have estimated insignificant per-unit compliance costs (Yeh et al., 2013), though many analyses point to potentially rising incremental costs as fuel carbon intensity targets fall over time. Addressing high levels of uncertainty surrounding the availability of low-carbon alternative fuels necessary to meet LCFS requirements, the program includes cost containment mechanisms – most notably credit tradability which allows regulated entities to purchase allowances from other generators to cover their obligations. As of August 2014, the market credit price remained modest at $28/ton CO_2 due largely to a steady net surplus of credits generated since the program's inception (California Air Resources Board, 2014 (1)).

In 2012, California's LCFS program was estimated to have displaced 1.06 billion gallons of gasoline and 45 million gasoline equivalent gallons of diesel fuel, with an average compliance cost of $13/MT of carbon avoided if compliance was achieved purely through purchasing California LCFS credits (this was estimated to have raised California's cost of production of gasoline 0.10 cents per gallon). Cumulative emissions credits (measured in metric tons of carbon) were estimated at about 2.8 MMTCO2e in that same year (Yeh et al., 2013). By March of 2014, 6.6 million credits had been generated, and the average compliance cost had significantly fluctuated from an annual low of $20 to as high as $80 per ton. This variation is undesirable to firms required to incorporate compliance in their financial planning, and the California Air Resources Board has considered cost containment mechanisms including a credit window from which the state may sell credits outright, setting an upper bound on compliance costs (California Air Resources Board, 2014 (2)).

Oregon's Clean Fuels program targets greenhouse gas reduction by 10% over a 10-year period, which reflects the goals of the proposed carbon tax, and includes an administrative infrastructure for fuel testing and monitoring that would likely complement the efforts of tax enforcement. Requirements for the evaluation of GHG reductions in terms of public and environmental health, safety, and cost-effectiveness would similarly overlap with the exploratory phase of the carbon tax's development. Both LCFS and the specific fuel content requirements of the RFS internalize external costs associated with fossil fuel consumption by addressing carbon intensity from agricultural feedstock production to combustion.

However, the Clean Fuels program is distinct from the Renewable Fuels program in both goal and approach. While the former targets greenhouse gas emissions reduction, any such reduction from the content requirements of the latter is indirect. Further, while the provisions of the Clean Fuels Program are in some ways analogous to portfolio standards for electricity generators (producers and importers are held to performance, rather than technological standards), the ethanol and biodiesel content requirements of the latter present a relatively inflexible requirement for producers and importers. The total effective carbon content embedded in any combusted fuel includes the energy used in producing the fuel, as in extraction, refinery operation, or transport alongside the physical carbon contained in the fuel. Left to individually decide the mix of strategies to reduce the lifecycle carbon intensity of produced fuel, firms will likely choose to address each of these in a proportion that minimizes costs. Required to choose *specific* strategies (as in renewable content requirements), it would be more challenging for firms to minimize compliance costs. It should be noted however that these restrictions are often motivated by the environmental impacts of known alternatives, such as MTBE's tendency to accumulate in water supplies, or indirect goals such as developing markets for specific products.

The ethanol mandate from Oregon's Renewable Fuels Standards went into effect in late 2009[45], followed by biodiesel content requirements in 2009 and 2011[46]. Detailed studies comparable to those of other measures considered in this section are currently not available for the RFS program. The Oregon Department of Agriculture provided a summary of the administrative costs of the program to the state legislature in May 2014. In 2009 and 2011, the costs to implement and enforce the standards were $277,000 and $248,000, respectively, and $163,000 in 2013 (the early figures were relatively high due to the startup costs of the rulemaking process and equipment purchases). These totals do not include the costs (or avoided costs) associated with production and fuel expenditures, and estimates of the emissions reduction attributable to the program are not available at this time.

Once again, the distinctions between the Clean Fuels Program, Renewable Fuels Standards, and proposed carbon tax present a tradeoff between flexibility and certainty. The tighter a regulation's constraints on the choices available to regulated parties, the less flexibility available to minimize the costs of achieving a goal. As proposed, an emissions tax may sacrifice less efficiency than either LCFS or RFS; however, the behavioral response of end

[45] The mandate was passed by the legislature in 2007.
[46] These were 2% and 5%, respectively, triggered by state production capacity thresholds being passed.

users depends directly on the transmitted price signal. Set (or transmitted) too weakly, the tax is not guaranteed to have the desired results. Direct regulations such as fuel standards legally guarantee the environmental outcomes they address.

As with renewable portfolio standards, interactions between a carbon tax, the Clean Fuels program, and the state's renewable fuels standards depend on the outcomes of collaborative political processes and economic behavior. LCFS and specific content requirements both reduce the emissions intensity of vehicle fuels. The former requires that environmentally advantageous steps be taken at any point in the lifecycle of fuel. The carbon tax would limit its focus to the point of combustion – that is, the amount of carbon emitted while a unit of fuel burns – and would lack the *direct* incentive for upstream improvements that the Clean Fuels program features (although the carbon tax may affect upstream indirectly). On the other hand, the Clean Fuels program sets targets for carbon-*intensity* reduction with no absolute emission reduction targets (in contrast to the carbon tax). Here, the two measures would complement each other. Additionally, a harmonious interaction may arise when the cost burden of the carbon tax – based on the carbon emitted at the point of combustion – eases as the physical carbon content of fuels falls due to fuel standards over time.

C. Other Motor Vehicle Emissions Standards – Costs, Performance and Interactions with Carbon Tax

Regarding to the individual statutes of ORS 468A.270 that do not specifically relate to low-carbon or renewable fuel standards, several US EPA studies have looked at the environmental, social, and economic outcomes of vehicle emissions and pollution reduction. Twin studies from 2010 and 2011 examined parallel efforts by the EPA and National Highway Traffic Safety Administration to reduce the GHG emissions and fuel economy of motor vehicles. Per-ton reduction cost estimates were significantly negative for the first of these studies (concerned with medium and heavy-duty vehicles), as fuel efficiency more than offset incremental compliance costs (US EPA, 2011). The second study, concerned with light-duty fleets, estimated unit costs of reduction between $28 and $356, depending on the technology package installed. This projected reduction will be achieved through credits and charges associated with vehicle technology standards, such as engine efficiency and air conditioning improvements. It should be noted that both of these studies considered technology improvements far beyond those mentioned in the Oregon law.

California's Air Resource Board estimated the cost effectiveness of that state's "Check and Inflate" regulations, which are very similar to those mentioned in ORS 468A.270. Total annual costs between 2010 and 2022 were estimated to be approximately $180 million, for a $292 cost per ton of CO_2 reduced. The Oregon DOE-commissioned marginal abatement curve study estimated costs from idle reduction strategies such as adding shorepower availability to Oregon ports (as referenced in ORS 468A.270) ranging from $142 to $213 per tCO_2e, depending on levels of state and federal policy assumed.

As noted above, policies that address different (albeit related) goals can be viewed as complementary to each other. The standards for motor vehicles established by ORS 468A.270 generally address technological efficiency which, like the carbon intensity reductions of Oregon's clean fuels and renewable fuels standards would tend to reduce the burden of a tax on carbon emissions. Further, the carbon tax would also apply to sectors of the economy that are not subject to transportation fuels regulations, but it would not guarantee that any specific outcome (such as those listed in ORS 468A.270) be achieved.

3. Other Laws Regarding Electric Utilities

Additional existing Oregon laws that pertain to electric utilities and their greenhouse gas emissions include emissions reporting requirements (ORS 468A.280), and electric utility facility siting requirements and standards: energy facility siting requirements (ORS469.501 through ORS 469.507), the Oregon CO_2 Standard (ORS 468A.280) and emissions limits on new power plants and contracts (ORS 757.524, 757.528, 757.531, 757.533 and 757.536). The following paragraphs summarize these statutes and discuss their interactions with the proposed carbon tax.

A. Emissions Reporting Requirements – Description & Costs, Performance and Interactions with Carbon Tax

Description - ORS 468A.280 describes greenhouse gas emissions reporting requirements for any firm importing, selling, allocating or distributing electricity in the state. Language most relevant to the discussion of a carbon tax explicitly notes that reporting requirements extend to power imported from other states as well as consumer-owned utilities, including the fuel contents of purchased power, and that reports include detailed up and down-stream information about any power that changes hands in Oregon. The law also directs the Environmental Quality Commission to minimize reporting burdens by allowing, among other conveniences, concurrent reporting to other state agencies.

Costs, Performance, and Interactions - Reporting requirements naturally relate to efforts to price carbon emissions; as such, 468A.280 codifies the informational infrastructure needed to formulate carbon tax liabilities for Oregon's power sector. Importantly, it details the treatment of multijurisdictional energy commerce, allows for efficiencies in the reporting process, and explicitly discusses the differential carbon content of various fossil fuels. Each of these items would clearly support the implementation of the carbon tax, and the tax, if implemented, would not add to the reporting burden of firms already subject to emissions standards.

As reporting alone does not lead to direct emissions reductions per se, requirements such as those in 468A.280 should not be assigned a comparable cost-effectiveness ratio as are others discussed here. The benefits of such reporting come in the form of more comprehensive information and transparency, rather than abatement, and costs are considered to be relatively low. 2009 and 2010 EPA studies estimated the average unit costs of federal reporting requirements to be between \$0.35 and \$0.03 per ton of carbon equivalent reported depending on threshold requirements. A similar 2010 analysis of Washington's Department of Ecology GHG reporting requirements generally concurs, with total annualized estimated reporting costs of roughly \$1 million to \$2.7 million for reporters (State of Washington Department of Ecology 2010).

B. Electric Utility Facility Siting Requirements and Standards – Descriptions & Costs, Performance and Interactions with Carbon Tax

Description of Energy Siting Requirements and the Oregon CO_2 Standard - ORS469.501 through ORS 469.507 established the state's energy siting standards enforced by Oregon's Energy Facility Siting Council (EFSC). In addition to meeting other EFSC standards (i.e., limits on local community impacts), proposed new facilities that use fossil fuels must provide evidence of compliance with emissions standards (referred to as the Oregon Carbon Dioxide Standard) and reporting statutes (see ORS 468A.280 above). The OR CO_2 Standard sets an explicit CO_2 emissions cap of 0.675 pounds/kWh for both baseload and non-baseload plants (ODOE Energy Citing Standards, 2014). This statute allows utilities some flexibility in meeting the standard: firms may meet it by energy efficiency improvements, use of alternative fuel sources, or offsets including a "monetary path" to compliance amounting to $1.27 per short ton in excess of the standard. The funds collected from monetary offsets are disbursed to qualifying organizations [currently, only the Climate Trust fills this role] which in turn use them to implement greenhouse gas mitigation measures.

Description of Emissions Limits on New Power Plants and Contracts - ORS 757.524, 757.528, 757.531, 757.533 and 757.536 establish a maximum of 1,100 pounds per MWh of *all* generated power for the state's electric companies and electric service suppliers (as opposed to the limits for base load gas plants described in OR 469). Utilities may not operate - or enter long-term contracts with facilities that operate – above this standard. Exemptions to the rule mirror those for base load gas plants; facilities exclusively utilizing renewable fuels, operating cogeneration processes, or capturing and recycling waste heat from natural gas combustion are not subject to the 1,100 pound cap, nor are regulated parties meeting certain other criteria. Although non-compliance fees are not explicitly outlined in the law's text, a clear penalty is: the OPUC may not consider new costs incurred by utilities stemming from generation that exceeds the standard for the purposes of cost recovery.

Costs, Performance, and Interactions - Once again, the implicit goal of emissions standards matches that of the proposed carbon tax; the complete list of goals set forth for the EFSC could very well be a summary of the benefits of a unit emissions tax, balancing environmental goals with economic feasibility for power suppliers, as well as resource reliability. However, this set of laws diverges from both RPS and carbon pricing in specific terms, and as with the non-compliance fee of an RPS scheme, the proposed tax and the EFSC's "monetary path" would be redundant in specific cases. The carbon tax is proposed to apply to the carbon content of power delivered to Oregon customers, regardless of where that power is generated. Conversely, the EFSC standard applies to power plants built in Oregon, regardless of where their power is delivered.

Offsets preserve flexibility on the part of producers making decisions to meet the CO_2 standard. Since the structure of the statute prevents any facility from meeting requirements by efficiency improvements (the standard is pegged to 17% *below* that of the most efficient gas plant operating in the US), credits "purchased" from offset projects present an alternative means of compliance that should encourage both efficiency improvements and improvements in abatement measures. However, ORS 469 implicitly prohibits the sale or trade of offset credits, the prominent feature of the RPS program ensuring that environmental outcomes in the aggregate are met without excessive loss of efficiency. Of course, unit pricing for carbon maximizes flexibility (and thus overall efficiency) by allowing producers to choose between alternatives that include simply paying an all-inclusive price for production inputs in order to minimize compliance costs. The EFSC rule for monetary compliance offers a similar option, but the current noncompliance fee of $1.27 per ton is well below any estimate of the value of emissions reduction used at the federal level, typical permit price in trading markets, or any of the tax levels considered by NERC's study.

The relationship between reporting requirements and a carbon tax based on carbon emissions is clearly harmonious. Potential interactions between the emissions caps set for companies in the power sector and a carbon tax are nominally more nuanced, and in contrast to the interactions discussed for other measures, both the tax and emissions caps have the same explicit goals (although the latter apply only to the power sector). Here, the characteristics specific to Oregon's law prevent the oft-cited clash between cap-and-trade schemes and emissions taxes. When an emissions cap is set for the entire sector and allowances for emission are tradable, trades will undermine the emissions goals of a corrective tax; carbon price-induced reductions by one firm allow increased emissions elsewhere. However, limits in Oregon are set at the generator level – no source is allowed to *individually* exceed its cap, and offset credits are non-transferable. Potential overlap between the proposed tax and the EFSC standard would be confined to new power plants built in Oregon that serve Oregon retail customers.

III. Conclusion

Oregon will likely continue to pursue its environmental goals through a dynamic web of interacting regulations. Analyzing the "fit" of a carbon tax in such a policy landscape is both complicated and highly dependent of the exogenously determined bundle of policies in force over time. It is clear, however, that any additional environmental policy should be compared to existing efforts in terms of purpose, cost-effectiveness, and practical outcome. Table 4 at the beginning of this section summarizes our analysis for those laws listed in SB 306 Section J.

Further Research and Applications

As with all studies of this scope and complexity, there are extensions and applications that could improve the estimates or extend the research into related fields.

- **Energy Efficiency Feedback:** As mentioned in the body of the report, the modeling features many dynamic elements but one area in which we were unable to fully build scenario feedbacks into the modeling was in the energy efficiency scenarios. The industries within the model alter energy intensity in response to energy price changes, but the impacts of investments specifically designed to increase energy efficiency does not feed into this. By directly incorporating the impact of these investments, we would improve our emissions estimates, as well as our revenue estimates
- **More Data Detail:** Budget and data availability limited the number of study regions in the model. Even with an unlimited budget, energy use data is not publicly-available at the municipal level. In this study, the differences in regional impacts were relatively small but it would be interesting to analyze impacts for different types of cities. Greater data detail would also allow us to perform the analysis based on utility service areas.
- **Implementation:** The taxing jurisdictions mentioned in the Introduction have released reports on the impacts of their carbon pricing policies, but not enough work has been done on best practices in implementing the tax. For this study, wherever possible we assumed an expansion of existing government activities rather than the creation of new agencies or departments. Before implementation, more research should be done on practical issues related to implementation. Interviews with responsible parties in other tax jurisdictions could provide useful guidance.
- **Health Impacts:** A goal of any carbon pricing policy is to incorporate a broader definition of costs into the fossil-fuel-use decision-making process, and reduce carbon emissions into the atmosphere. By reducing fossil fuel intensity in the economy, other byproducts of combustion would also be reduced. This should have positive health impacts and by extension, impacts of health spending. It is beyond the scope of this project (and outside of our area of expertise) but health impacts could be estimated using our estimates on changes in fossil fuel use.
- **Emissions Feedbacks:** The dynamic REMI and emissions model developed for this work does include a number of feedbacks on emissions from repatriation and expenditure of carbon tax revenue in revenue-neutral scenarios. The feedback of different revenue-use scenarios was studied and found to have a small effect on overall statewide emissions as mentioned above. However, additional feedbacks on emissions were considered outside the scope of the current study which focused explicitly on a carbon-tax. These include, notably: changes in petroleum fuel mix by region as a result of regional or state-level clean-fuel programs, e.g., low-carbon fuel standards and renewable fuel standards (see above), which have a synergistic effect on emissions reductions through changing emissions factors; changes in electrical

utility fuel mix supplied to Oregon consumers by investor and customer owned utilities in direct response to a carbon tax or other levy on carbon emissions, the current study was limited to information provided to the Oregon DOE by utilities in their IRPs; response of state energy policy to the Environmental Protection Energy proposed guidelines to address greenhouse gas emissions from fossil-fuel based electrical power plants (i.e., under Section 111 (d) of the Clean Air Act).

Conclusion

The estimates reported in this study are generally in line with preliminary results from jurisdictions that have imposed some form of carbon pricing. Concerns about change to the economy or employment levels appear to be minimal. Rather, the difficulty for policymakers will be to balance competing objectives in implementation.

Benefits and costs of a carbon tax will vary across geographic regions, income levels, and industries. Negative impacts can be offset, but this necessarily takes resources away from achieving other goals. Investing funds in additional energy efficiency efforts will further reduce emissions, but will leave less revenue to offset negative economic impacts in other places. Exemptions or targeted business investment will offset negative impacts in key industries but will create a subsidy to those industries paid for by the rest of the economy.

If the starting point of a discussion on climate policy is that economic actors are not taking into account the total costs of carbon emissions and are producing an inefficient quantity of those emissions, then internalizing those costs through a carbon price is well within the economic mainstream. The basic insight of market-based carbon pricing is to internalize external costs into the decision-making process, and let individual households and firms decide how to respond. A broad-based, consistently-applied price will keep the incentive (price signal) strong and reduce distortions in the economy. By weakening the price signal or introducing exemptions, the possibility of outcomes counter to the stated goals of the policy is introduced. When any exemption or special revenue allocation is considered, the positive economic effects must be weighed against the potential impacts on emissions and the broader economic impacts in the rest of the state.

Our intent in this report was not to suggest one particular course of action, but to demonstrate the tradeoffs between different policy options. We know that imposing a price on carbon will reduce carbon emissions relative to the expected baseline. We also know that decisions about revenue repatriation and expenditure will be key to ensuring that economic impacts are positive. By reducing income taxes and creating a revenue collection mechanism that is tied to individual and firm decisions about fossil fuel usage, the state could lower the net cost of living and doing business for firms and households that reduce carbon emissions relative to their peers. If the national and global economies are moving in the direction of greater energy efficiency, incentivizing that behavior in Oregon early on could be an effective economic development strategy.

Appendix I - Detailed Description of Modeling Methodology

Emissions Modeling

Emissions were calculated by applying fuel-specific emissions factors (EFs) to fuel demand by economic sector across the six Oregon geographical regions in REMI (Central, Eastern, Metro, Northwest, Southwest, Valley, see map in Figure 6). A sector-level national input-output (IO) table was applied to the REMI economic output to estimate dollar fuel purchases in three energy categories: natural gas, electricity, and petroleum fuels. The petroleum fuel category is defined in REMI to be all energy purchases other than natural gas and electricity but primarily consists of liquid fuels such as motor gasoline and fuel oil. The petroleum fuel category also includes renewable energy and biofuels. The equations for these calculations are provided below.

Emissions factors for natural gas and petroleum fuels were taken from the US Department of Energy, Energy Information Administration (US DOE, 2014; EIA, 2014). The emissions factor for natural gas is constant throughout the study period. The emissions factor for petroleum fuels changes however during the study period as the relative consumption of fuels that comprise this category evolves annually. The EIA National Energy Modeling System (NEMS) estimates consumption of petroleum fuels on a regional basis. Oregon-specific consumption data were calculated by pro-rating the NEMS Pacific Region baseline forecast based on Oregon's relative consumption of fuels in the Pacific Region during recent years (CTAM, 2014).

The emissions factor for electricity consumption varies by region in Oregon as each region is served by a different mix of electrical utilities that each use different fuel mixes for electricity production. The carbon intensity of electricity delivered by consumer-owned utilities is low for example because it is largely sourced from the hydropower dams operated by the Bonneville Power Administration, while the carbon intensity of electricity produced by Portland General Electric and PacifiCorp is higher as these utilities rely more on natural gas and coal for electricity production.

We calculated electricity emissions factors for each region using a weighted average of the emissions factors of the utilities that serve a given region:

$$EF_r = \sum_{u=1}^{N_{u,r}} \alpha_{u,r} EF_u$$

Here EF_r is the weighted emissions factor for region *r*, $N_{u,r}$ is the number of utilities *u* that serve region *r*, $\alpha_{u,r}$ is the fraction of region *r*'s electricity served by utility *u*, and EF_u is the emissions factor for utility *u*. The utility emissions factors were based on utility data provided to NERC by the Oregon DEQ for years 2012-2013 and from the utility Integrated Resource Plans for forecast years. Utilities also provided to NERC, through a special data request, regional retail sales data for 2010-2012 that were used to determine the $\alpha_{u,r}$. For those utilities that did not report data at the regional level, but included districts in more than one region, we assumed that regional electricity sales were proportional to the regional population within the utilities' service district determined using GIS data and methods. Emission factors for all energy categories are provided in Table 5.

Table 5 - Average emissions factors for energy categories included in emissions modeling over the 2012–2034 modeled period

Energy Category	Emissions Factor ($kg\ CO_2\ e$ /million BTU)				
	2012–2015	2016–2020	2021–2025	2026–2030	2031–2034
Petroleum fuels	71.6	71.0	69.9	69.2	68.8
Natural Gas	53.1	53.1	53.1	53.1	53.1
Electricity (statewide average)	112.8	113.5	105.2	97.2	94.9
Central	134.4	134.0	130.9	117.3	112.6
Eastern	86.9	89.7	89.0	83.5	82.4
Metro	132.5	132.2	116.0	108.0	105.6
Northwest	47.1	49.0	49.3	47.7	48.2
Southwest	87.5	90.1	84.6	79.2	78.1
Valley	165.7	163.4	158.9	141.1	134.5

Baseline Scenario

Baseline emissions were estimated using the baseline REMI modeling forecast with the carbon tax set to zero. As described above, fuel dollar purchases were calculated by multiplying REMI economic output in each sector by a national IO table:

$$\text{Fuel Purchases}_{f,s,r,y} = \text{Economic Output}_{s,r,y} \text{x } \text{IO}_{f,s,y}$$

Here *f* is the fuel category, i.e. natural gas, electricity, or petroleum fuels, *s* is the economic sector, *r* is geographical region, and *y* is the year of the forecast. The economic output is provided by REMI in units of inflation-adjusted 2012 dollars. Emissions are calculated from fuel purchases using fuel emissions intensities. The emissions intensity is the quantity of emissions emitted per dollar of fuel consumed and is based on both the fuel price and the emission factor of the fuel. Fuel prices are taken from the EIA NEMS (US DOE, 2014; EIA, 2014)

$$\text{Emissions}_{f,s,r,y} = \text{Fuel Purchase}_{f,s,r,y} \times \text{Emission Intensity}_{f,y}$$

Because REMI does not have internal absolute fuel pricing, we expected the baseline fuel demand determined by this method to be close to but not exactly match the fuel demand forecasts by the EIA and ODOE (for electricity) which we consider to be the best available. Therefore we calibrated the fuel demand forecasts by forcing the state-level aggregated demand by fuel type to equal the demand estimated by the EIA and ODOE. In practice, this was equivalent to scaling the “bottom-up” REMI-derived fuel demand by the ratio

$$R_{f,y} = \frac{EIA\ \&\ ODOE\ State\ Fuel\ Demand_{f,y}}{Bottom{-}up\ State\ Fuel\ Demand_{f,y}}$$

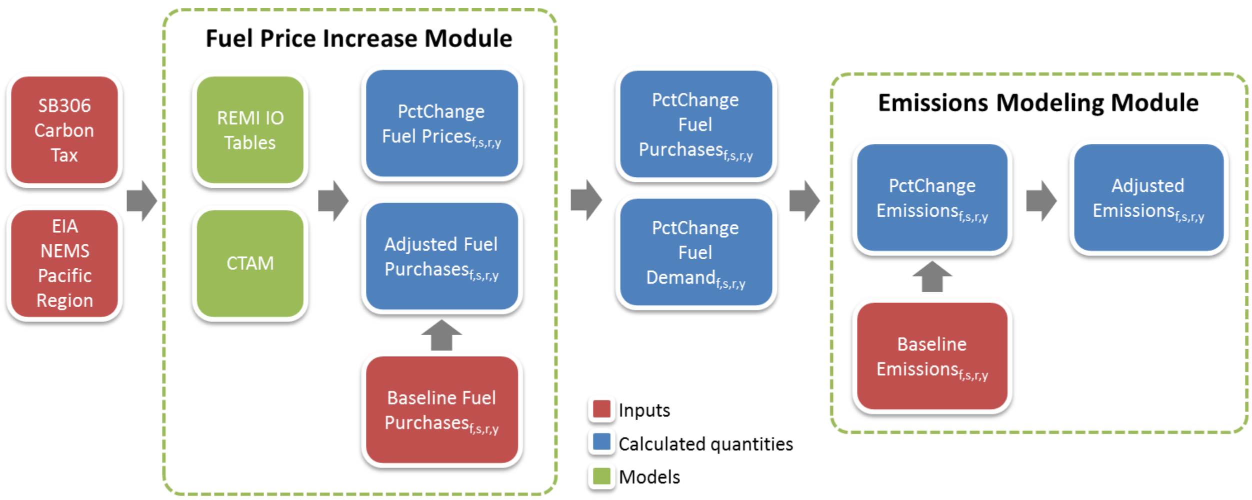
for each fuel category *f* and year *y*. Adjustments were less than 20% for all fuels and years.

This method produces a baseline emissions forecast that is consistent with the best available fuel demand data from the EIA and ODOE at the state level, but with emissions allocated to sectors and regions based on REMI modeling.

Carbon Tax Scenarios

Since the implementation of the carbon tax in REMI alters fuel purchases and demand relative to the baseline scenario, the emissions forecast for each carbon tax scenario was determined by perturbing or adjusting the baseline emissions forecast that was described above. A schematic of how the adjustment is calculated is shown in Figure 58.

Figure 58 - Schematic of Procedure to Calculate the Adjusted Emissions under the Carbon Tax Scenarios



The CTAM model was used to determine the change in fuel prices on an annual basis upon implementation of a carbon tax (CTAM, 2014). A number of carbon tax scenarios were investigated with maximum tax rates ranging from \$10 to \$150 per metric ton of CO_2-equivalent emissions. All scenarios began in year 2014 with a carbon tax of \$10/ton. At the lower tax rates (\$10, \$30, \$45/ton) the carbon tax was increased annually by \$5/ton until the maximum rate was reached and was held constant at the maximum rate for the remainder of the forecasting period (2034). For the higher rates (\$60, \$100, \$125, \$150/ton) the annual increase was \$10/ton. The tax-adjusted fuel prices were passed on to REMI to produce updated economic activity forecasts to reflect the higher fuel prices. Adjusted fuel purchases were then calculated from these forecasts using the same method as described above for the baseline scenario and with this the percent change relative to the baseline fuel purchases was determined by

$$\mathrm{PctChangeFuelPurchase}_{f,s,r,y} = \frac{(\mathrm{AdjustedFuelPurchase}_{f,s,r,y} - \mathrm{BaselineFuelPurchase}_{f,s,r,y})}{\mathrm{BaselineFuelPurchase}_{f,s,r,y}},$$

where the subscripts *f,s,r*, and *y* are the same as defined above. Since fuel demand is given by

$$\text{Fuel Demand}_{f,s,r,y} = \frac{\text{Fuel Purchase}_{\text{f,s,r,y}}}{\text{Fuel Price}_{\text{f,s,r,y}}},$$

the percent change in fuel demand relative to the baseline scenario was found using the percent change in fuel purchases and the percent change in fuel price by

$$\text{PctChangeFuelDemand}_{f,s,r,y} = \frac{(\text{PctChangeFuelPurchase}_{f,s,r,y} - \text{PctChangeFuelPrice}_{f,s,r,y})}{1+\text{PctChangeFuelPrice}_{f,s,r,y}}.$$

For this equation we used the changes in fuel prices that were determined by CTAM and used as input to REMI. The percent change in emissions for any fuel, sector, region, and year is then equal to the respective percent change in fuel demand with the assumption that the emissions factors do not change relative to the baseline scenario. From this, the final adjusted emissions for a given tax scenario were determined by

$$\text{Adjusted Emissions}_{f,s,r,y} = \text{Baseline Emissions}_{f,s,r,y}\ (1 + \text{PctChangeEmissions}_{f,s,r,y}).$$

The adjusted emissions were aggregated across fuel categories, sectors, and regions to arrive at state-level emissions.

Annual tax revenue for each scenario was calculated by multiplying emissions by annual carbon tax schedule as described above.

Economic Modeling (REMI PI+ Model)

NERC utilized Regional Economic Models, Inc.'s PI+ model (Version 3) for its analysis of the clean air emissions tax scenarios discussed in this report. REMI is a comprehensive model of the regional economy comprised of thousands of mathematical equations, econometric estimates, standard theoretical assumptions, and historical data. Versions of the model are commonly used by local, state, and national governments, universities, and consulting firms to analyze the economic and demographic effects of policy changes over time. It is a dynamic forecasting tool that projects baseline conditions based on historic trends and expected economic and demographic changes, and scenario outcomes that incorporate the effects of policy changes that work through the entire economy over time. NERC used a customized version of REMI that models Oregon's economy as 6 interdependent regions – Northwest, Eastern, Central, South/Southeast, Valley, and Metro – that interact economically and demographically with each other and the rest of the world economy.

This appendix provides a technical summary of the relevant aspects of each component. It is necessarily abridged; the full technical details of the model fill several volumes available from REMI[47]. The discussion that follows first describes the basic economic assumptions that inform the model's form. It then summarizes the major data sources it draws from, and finally explains the quantitative mechanics at its core.

[47] http://www.remi.com/products/pi

Assumptions
REMI utilizes standard assumptions from economic theory in its projections. These include the assumption that the multiple markets that make up the economy "clear" after a policy change – that is, prices adjust to equilibrate supply and demand in the factor and output markets in each location. Households are assumed to maximize their expected utility, responding to prices, real income, and employment variables across locations. Firms in each in industry are similarly assumed to be profit-maximizing. They are thus expected to optimize their production decisions based on the relative prices of inputs (labor, capital, and fuel) and output prices.

Labor force participation rates are allowed to vary with age, gender, and education level. Birth, death, and survival rates likewise vary with demographic characteristics. "New economic geography" assumptions are a notable characteristic of the REMI model. Firms and households are assumed to benefit from the relative variety of inputs and consumption goods and services available in urban areas, and are assumed to be negatively affected by congestion and high land prices therein. This effectively incorporates detailed spatial dynamics in the multiple region model used by NERC.

Data Sources
Historical data underlying the REMI model include output, personal income, employment, and population at each geographic level from numerous sources, including the Bureau of Economic Analysis, Bureau of Labor Statistics, and US Census Bureau. Employment, personal income and wage data at the county level are drawn from the BEA and BLS for each industry and sector of the economy (REMI adjusts and incorporates non-covered employment data from multiple secondary sources to account for the well-known gap in employment counts). Income data that appear in the model are highly detailed; components include (but are not limited to) wages and salaries, supplements, contributions to pensions and insurance plans, government transfer receipts, and rental and interest income. Detailed population data, including geographically-specific birth, death, and migration rates, are drawn from Census Bureau estimates.

State-level energy prices and expenditures for electricity, natural gas, and residual fuels (here defined as "all other" fuels) are estimated by the Energy Information Administration (EIA) for the residential, commercial, and industrial sectors. Numerous other secondary data appear in the model. These include state and local taxes, business conditions (cost of capital, investment credits, collections, and estimated profits), housing prices, and commuter information from several sources.

REMI uses the Bureau of Labor Statistics' Economic Outlook to develop its baseline output forecast. The model's input/output tables reflect the benchmark tables prepared by the BEA, incorporating information gathered by the BLS, IRS, and Census Bureau. Employment and population projections are from the BLS Current Employment Survey, the Census Bureau's Current Population Survey, and unemployment insurance programs.

Abridged Model Structure
The economy's output in the REMI model is represented mathematically by an input-output (I/O) structure. Input-output matrices capture the numerous links between industries as well as

final demand across geographic areas. Examination of a truncated set of equations behind these matrices provides a simplified example of the model's mechanics.

Output for an industry (industry *i*) in a single area (area *k*) is given by:

$$Q_i^k = [\sum_{l=1}^{m} s_i^{k,l} * DD_i^l] + [sx_i^{k,row} * X_i^u]$$

where
Q_i^k = Output of industry i in area k
$s_i^{k,l}$ = Area k's share of industry i in market area l
DD_i^l = Domestic demand for industry i from area l
$sx_i^{k,row}$ = area k's share of domestic exports of industry i to the rest of the world (row)
X_i^u = Domestic exports of industry i from the nation

In simpler terms, this equation states that the total output of an industry in one area, say manufacturing in the Oregon metro, is the sum of metro-area manufacturers' shares of demand in other areas of the US and demand in other areas outside the US. Notation aside, it is a familiar "supply equals demand" statement.

The domestic demand term (the first right hand side term in brackets) is given by:

$$DD_i^l = \left(\sum_{j=1}^{n} a_{ij,t}^l\, Q_j^l + \sum_{j=1}^{n+c} a_{ij}^u\, C_j^l + \sum_{j=1}^{n+c+inv} a_{ij}^u\, I_j^l + \sum_{j=1}^{n+c+inv+g} a_{ij}^u\, G_j^l\right) * sd_{i,t}^l$$

where
DD_i^l = Domestic demand for industry i in area l
a_{ij}^u = The average i purchased per dollar spent on j in the nation over the period
$a_{ij,t}^l$ = The average i purchased per dollar spent on producing j in region l in period t
$sd_{i,t}^l$ = The share of area l's demand for good i in period t
Q_j^l = The output of industry j in area l
C_j^l = Consumption category j in area l
I_j^l = Investment category j in area l
G_j^l = Government spending type j in area l

Again, in simpler terms, this equation states that the domestic demand for Oregon metro-area manufacturers' output [continuing with the previous example] is the sum of its output demanded by other industries (e.g., the share of manufactured goods used by the construction industry in each region of the state), consumer demand for those outputs, investment demand for those outputs, and government expenditures on those outputs.

Together, these two equations comprise the I/O core structure of REMI, with the familiar a_{ij}^l parameters representing the system's technical coefficients.

Employment in each industry and location depends on similarly complex dependencies represented by numerous individual equations. Truncated for simplicity, the subset of employment equations that is most helpful in interpreting the results of the NERC carbon tax study describe relative labor intensities across industries, the demand for labor in those industries, and the evolution of the employment mix in a region. Production in an industry is represented with a Cobb-Douglas functional form with capital, labor, and fuel inputs. REMI assumes that firms are profit-maximizing, and thus choose to hire the optimal number of employees, which depends on the relative costs of substitute inputs, labor productivity, and the firm's installed capacity (physical capital). Demand for labor in each industry and location is thus a function of labor costs relative other production costs. Overall production costs are given by:

$$\Omega_i^l = [\left(\frac{CADJ_i^l}{CR_i^u}\right)^{b_{ji}} * \prod_{j=2}^{6}\left(\frac{FC_j^l}{FC_j^u}\right)^{b_{ji}} * \sum_{j=1}^{6} a_{j,i}^u + \sum_{j=7}^{n} a_{j,i}^l * CP_{i,T}^l(\frac{CIFP_{i,t}^l}{CIFP_{i,T}})] * LAMONG_{i,T}^l$$

where
$\Omega_i^l =$ Composite cost of production
$CADJ_i^l =$ Productivity adjusted compenstation rate in area $\mathrm{l}\mathrm{CR}_\mathrm{i}^\mathrm{u}$
$=$ Compensation in industry i in the nation
$b_{ji} =$ [relative] Contribution of factor j to value added output in industry i
$FC_j^l =$ factor prices in l (j = structures, equipment, and fuels)
$a_{j,i}^l =$ proportion of input j in intermediate inputs[1]
$CP_{i,T}^l =$ The composite input cost[2]
$CIFP_{i,t}^l =$ Delivered average price of industry i in area l
$CIFP_{i,t}^u = D$elivered average price of industry i in the nation

$LAMONG_{i,T}^l =$ an adjustment for aggregation and normalization in the last year T

Note 1: inputs modified by an industry access effect of material input productivity. See complete REMI methodology.
Note 2: Calculated at the smallest geographic level available.

In general, the function says that an industry's costs are a function of the costs of each of its inputs. The relative productivities, prices, and representation in final demand and in the production of each of the intermediate inputs embedded in the final product determine the total costs of operation. This equation illustrates the demand side of the labor market in each industry and area that ultimately determines the income of workers. The carbon tax applied in NERC's scenarios enters the model through the fuel cost term FC_j^l. The tax [as modeled] raises the prices of residual fuels, electricity, and natural gas for firms assumed to minimize total production costs.

The labor intensity in an industry is then given by:

$$L_{i,t}^{l} = L_{i,t-1}^{l} + \left(\frac{I_{nrs,t}^{l}}{K_{nrs,t}^{l}}\right) * (h_{i,t}^{l} - L_{i,t-1}^{l})$$

Where:

$L_{i,t}^{l}$ = Labor intensity in industry i in region l and time period t

$L_{i,t-1}^{l}$ = Labor intensity in industry i in region l in time period $t-1$

$I_{nrs,t}^{l}$ = Nonresidential investment in region l

$K_{nrs,t}^{l}$ = Nonresidential capital stock in region l

$h_{i,t}^{l}$ = Optimal labor intensity in industry i, region l, period t

And:

$$EPV_{i,t}^{l} = \left(\frac{L_{i,t}^{l}}{L_{i,T}^{l}}\right) * \left(\frac{E_{i,T}^{l}}{Q_{i,T}^{l}} * \frac{\frac{E_{i,t}^{u}}{Q_{i,t}^{u}}}{\frac{E_{i,T}^{u}}{Q_{i,T}^{u}}}\right) * \left(Fl_{i,t}^{l}\right)^{-\alpha} * epvindx_{i,t}$$

Where:

$EPV_{i,t}^{l}$ = Employees per dollar of output in industry i, region l, time t

$L_{i,T}^{l}$ = Labor intensity in industry i, region l in the last history year T

$\frac{E_{i,t}^{u}}{Q_{i,t}^{u}}$ = Employees per dollar of output in industry i in the nation (u) in time t

$\frac{E_{i,T}^{u}}{Q_{i,T}^{u}}$ = Employees per dollar of output in industry i in the nation (u) in the last year T

$\frac{E_{i,T}^{l}}{Q_{i,T}^{l}}$ = Employees per dollar of output in industry i in region l in time t

$Fl_{i,t}^{l}$ = Labor productivity in industry i, region l, time period t

$epvindx_{i,t}$ = Change in region's industry mix relative to the nation since $t-1$

Together, these two equations link employment in a region's industries to the I/O matrix described above. Depending on the relative cost, productivity, and intensity of labor in an industry and region, changes in output are reflected directly in changes in employment. The labor intensity equation in turn illustrates that firms faced with rising costs for a non-labor input, say increased fuel prices due to environmental regulation, will substitute by increasing capital (perhaps by retooling with efficient equipment) and/or labor inputs.

The magnitude of changes in regional employment is directly tied to demand for each industry's output:

$$E_i = EPV_i * (QLI_i + QLC_i + QLG_i + QLINV_i + QXRMA_i + QXROU_i + QROW_i)$$

Employment in industry i ultimately depends on that industry's employees-per-dollar of output ratio and aggregate demand for that output: local intermediate demand (QLI_i), local consumer demand (QLC_i), local government demand (QLG_i), local inventory demand ($QLINV_i$), and demand in other regions of the model, nation, and world, respectively. Continuing the example, several factors can affect employment in the metro area's durable goods manufacturing industry. The relative cost and productivity of labor in that industry and location determine the number of employees per dollar of output; and demand in the model's six regions, domestic demand outside the state, and export demand determine the level of output.

Of course, employment conditions in one industry and location affect demand for other industries' output, as employment partially determines the income of households comprising much of each region's aggregate demand. As with the "blocks" of the REMI model that describe output and employment, income is modeled with numerous mathematical relationships. For the purposes of this report, this block can be summarized by focusing on the two most familiar equations that determine industry wages and production costs. Together, these equations complete the three-sided (output-employment-income) core of the model's economy.

Compensation in industry i and region l is given by:

$$CR_{i,t}^{l} = \left[\left(1 + \Delta CRD_{i,t}^{l}\right)\left(1 + k_t^u\right)\right] * CR_{i,t-1}^{l}$$

Where:
$\Delta CRD_{i,t}^{l}$ = The predicted change in the compensation rate in industry *i* due to changes in industry *i*'s labor market conditions.
k_t^u = The change in the national compensation rate that is not explained by changes in the national average compensation rate across industries, which are result from changes in supply and demand conditions and industry mix in the nation.

$\Delta CRD_{i,t}^{l}$ – a predicted input – is estimated econometrically using historical labor market data, and summarizes the complex forces of supply and demand for employees in a given region. k_t^u is calculated using the estimated value of $\Delta CRD_{i,t}^{l}$, and reflects the determinants of compensation changes at the national level – legislation, bargaining power, cost of living adjustments, etc. - that are not due to sectoral shifts and supply and demand conditions in the national labor market. Combined, the two arguments and the lagged compensation rate for the industry reflect fairly standard microeconomic wage theory. Wages in any industry depend on supply and demand for labor in that industry as well as in all other industries as workers optimize their choice of occupation. Factors other than these market forces such as legislation and bargaining power naturally play a role in wage setting. And wages are to some degree inflexible – an industry's wage this period tends to follow its momentum from previous periods.

Disposable income in the model consists of labor income as well as non-compensation income – transfers, taxes, and social security payments - and appears in real terms throughout the model. The repatriation of carbon tax revenues in NERC's modeling appears as an increase in households' disposable income that offsets increase in the prices of motor fuels, electricity, heating oil, and natural gas.

Given that households in the model respond to the output, employment, and income dynamics described thus far, REMI's labor force and population "block" closes the intuitive firm-household circular flow relevant to interpretation of this report's results. This block can be summarized by three main equations, the first of which is a "cohort-component" model of population change:

$$Pop_t^l = Pop_{t-1}^l + Births_t^l - Deaths_t^l + RTMIG_t^l + ECMIG_t^l + IntMIG_t^l$$

Where:

Pop_t^l = The population in region *l* and time *t*
$Births_t^l$ = The number of births during the time period *t-1* to t in region *l*
$Deaths_t^l$ = The number of deaths during the time period *t* to *t-1* in region *l*
$RTMIG_t^l$ = the net inflow of interregional retired migrants to region *l* during the time period *t-1* to *t*
$ECMIG_t^l$ = The net inflow of interregional economic migrants to region l during time period *t-1* to *t*
$IntMIG_t^l$ = The net inflow of international migrants to region *l* during the time period *t-1* to *t*

Each of these terms is represented by its own time series or estimated equation. For instance, births are determined by historical age-specific fertility rates, and deaths are a function of the age distribution and mortality rates in a region. For our purposes, the most relevant argument in the population function represents economic migration. In turn, economic migration is driven by the basic assumptions previously discussed: households weigh the relative cost of living in a region, availability and prices of the housing, goods, and services they consume, employment opportunity, and relative "attractiveness" of an area in their location choice:

$$ECMG_t^l = [\lambda^l + \beta_1 ln(REO_t^l) + \beta_2 ln(RWR_t^l) + \beta_3 ln(MIGPROD_t^l) * LF_{t-1}^l$$

Where:

$ECMG_t^l$ = Net economic migrants (all migrants less than 65 years of age) in area *l*
LF_{t-1}^l= The labor force last period in area *l*
REO_t^l = The relative employment opportunity in area *l* in period *t* (adjusted employment rate relative to all other regions).
$RWR_t^l =$ The relative real compensation rate in area *l* in period *t* (regional price-adjusted compensation relative to all other regions)
$MIGPROD_t^l$ = The consumption access index in area *l* at time *t*
λ^l = A fixed effect that captures the relative attractiveness of area *l*
β_i = Estimated coefficients

This equation means that, all else held constant, the relatively high cost of living in Oregon's metro region is reflected in (and affected by) workers' behavior as output and employment changes ripple through the economy and the mobile labor force migrates toward employment opportunities and higher wages. This movement is also informed by the often significant differences in compensation across regions. REMI incorporates the concepts of "new economic geography" here with the consumption access index, which measures the relative variety of goods and services available to households in different regions (and is presumably higher in urban areas).

Finally, the portion of the population in the labor force in an area is tied directly to the compensation, population, and migration equations already discussed:

$$LF^l = \sum_{i=l}^{n} PR_i^l * COH_i^l$$

$$PR_i^l = \beta_i^l * (REA^l)^{\beta_2} * (RWR^l)^{\beta_3} * PR_i^u$$

Where:

LF^l = The labor force in area *l*
PR_i^l= The participation rate of age-cohort *i* in area *l*
COH_i^l = The number of people in age cohort *i* in area *l*
REA^l= A term representing relative employment changes in area *l*
β_i^k= Estimated parameters, by age cohort, gender, and racial/ethnic group

Econometric Estimates
As noted, several of the relationships present in REMI's projections must be estimated econometrically. For instance, logic dictates that a shock to the price of fuel in Oregon due to a carbon tax will ripple through markets for fuel, labor, capital, and final products. But the *magnitude* of those ripples is to some extent unpredictable. REMI estimates each market's sensitivity to price changes using statistical methods and historical data, applying those sensitivities in the dynamic forecasts it generates. The importance of these details can be seen in the projected demand for a particular durable manufactured good after a price increase. The response of a household to increased prices for goods and services is sensitive to its real income. But if a single propensity to consume (i.e., the fraction of income that is spent on consumption rather than saved) is assumed for all households, the projected response will be biased. Thus, consumption responses are adjusted for income level as well as age and region.

Similarly, the results in this report include some projected migration between Oregon regions as infrastructure investments and changes to cost of living are spurred by the proposed policies. The extent to which say, workers in Central Oregon respond to changes in prices and the cost of living there (and compensation levels available elsewhere) depends on elasticities that are estimated from historical data.

Projected demographic changes can also be estimated this way; historical population trends interact with economic conditions as they evolve. In cases where data availability is limited (for instance, tax, profits, and industry data at the local level), statistical estimation is required.

Other Model Components
Output, employment, and income represent the model's core, but the relationships described above represent only a fraction of REMI's structure. The detailed dynamics of numerous markets that affect (and are affected by) these three endogenous variables are present in the

model but not discussed at length here. These include the shares of local, domestic, and export markets appearing in the equations above, each evolving over time based on historical data and the model simulations. Demographic changes across geographic areas affect the labor force, demand for goods and services, and government expenditure. On a smaller geographic scale, commuting patterns shift the distribution of output, employment, and income between localities. A full treatment of these dynamics is not relevant to the purposes of this appendix, but is available in detailed, equation-by-equation form from REMI.

Appendix II –Detailed Revenue-Usage Scenario Schematic and Results

Figure S.1 - Carbon Tax Scenario Overview

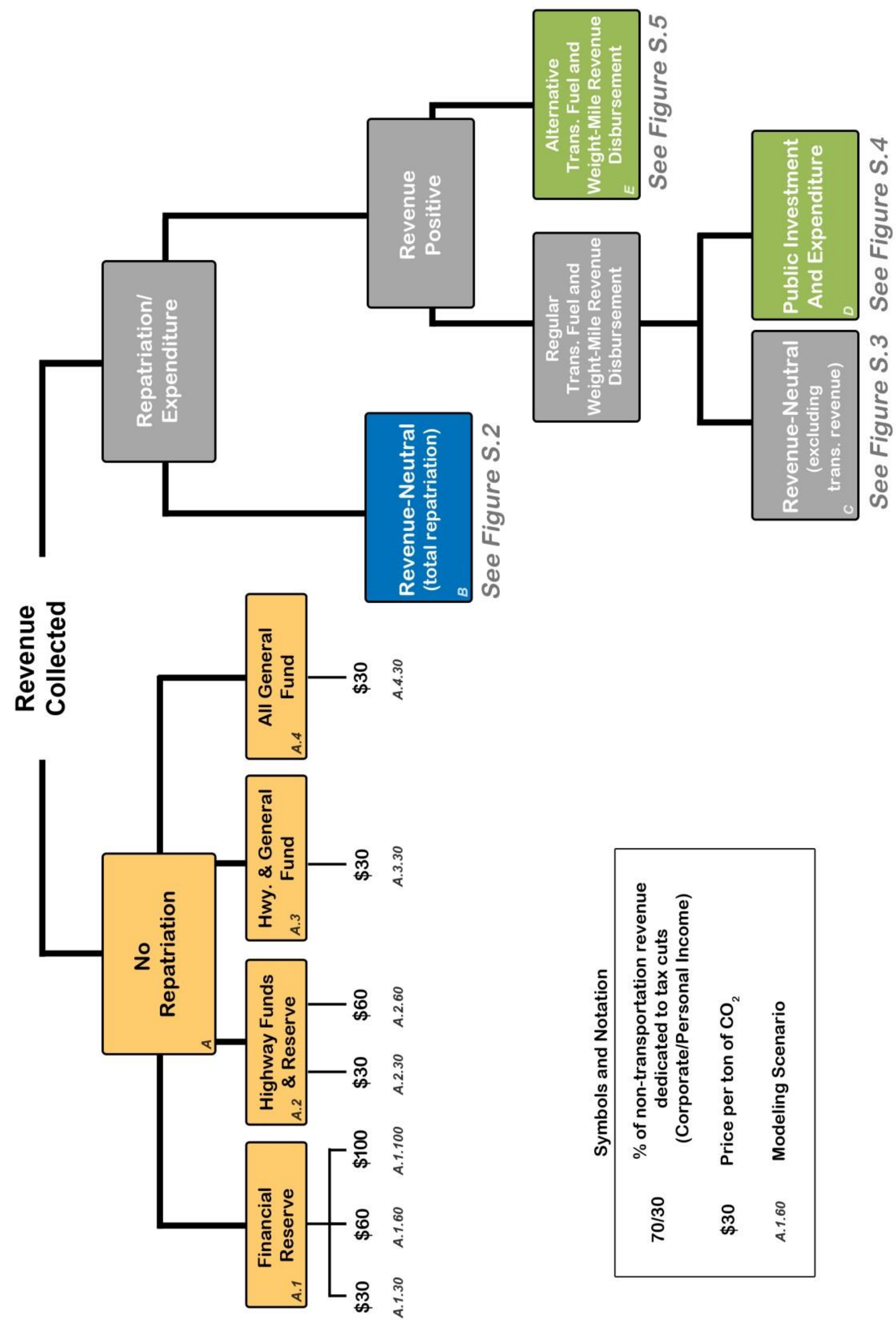
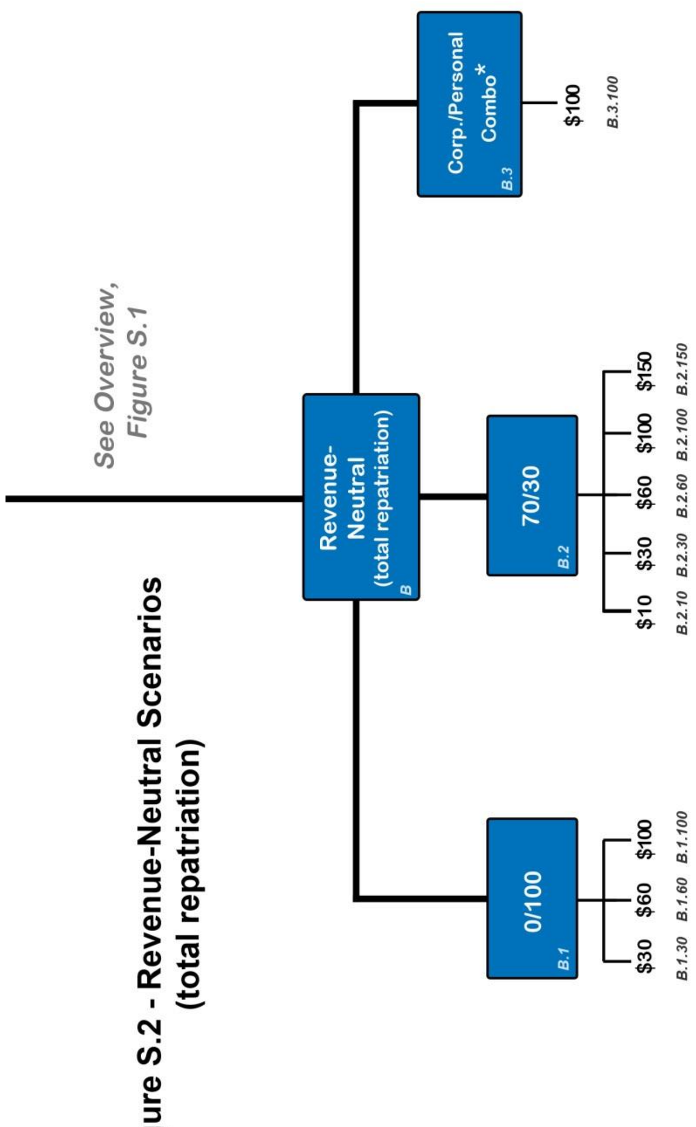
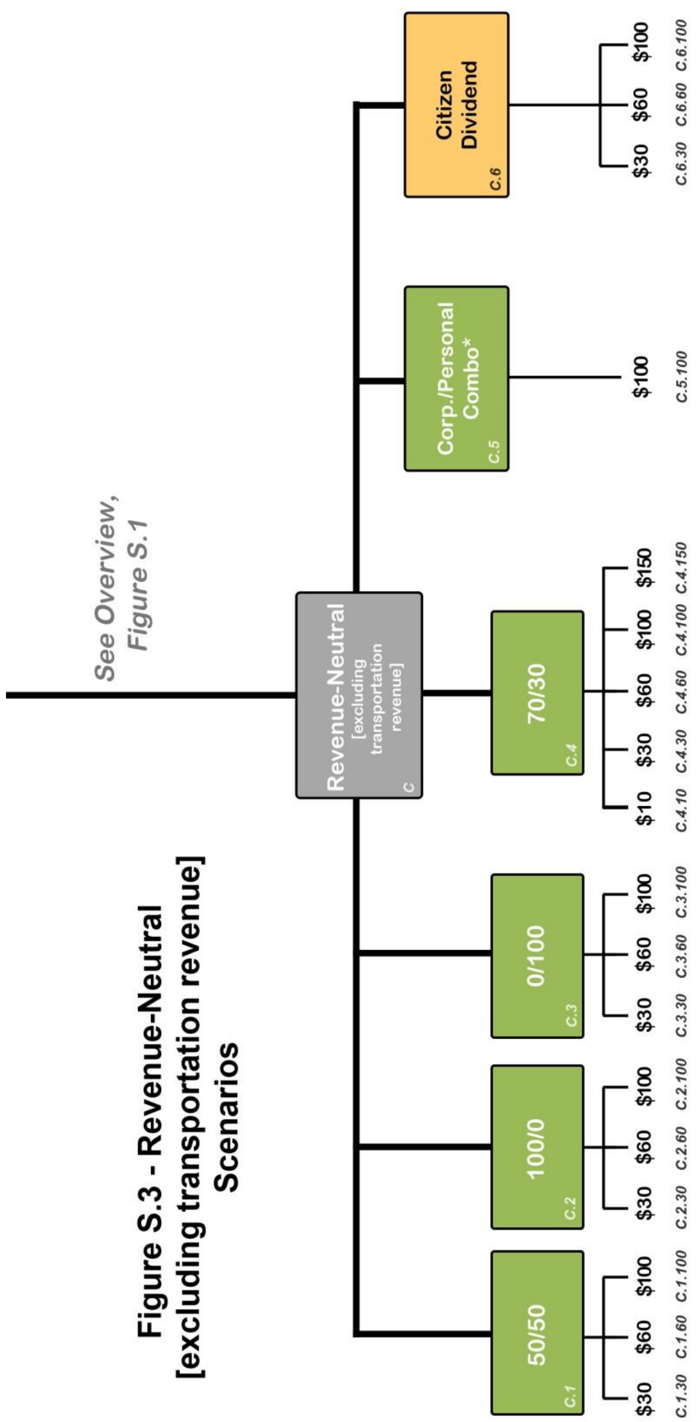


Figure S.2 - Revenue-Neutral Scenarios (total repatriation)



*Revenue used to eliminate corporate tax; remainder used to reduce personal income tax

Figure S.3 - Revenue-Neutral [excluding transportation revenue] Scenarios



*Revenue used to eliminate corporate tax; remainder used to reduce personal income tax

Figure S.4 Public Investment and Expenditure Scenarios

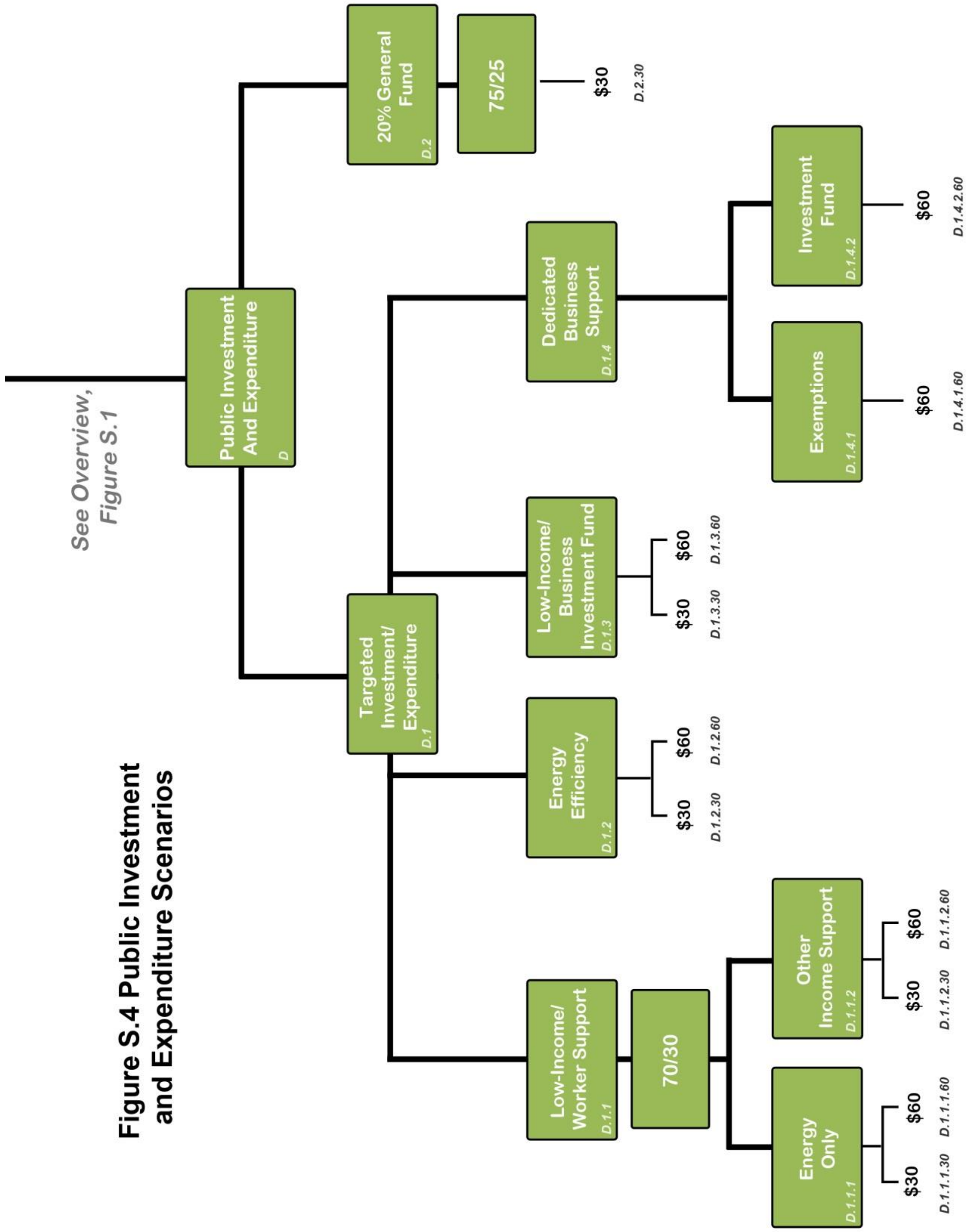
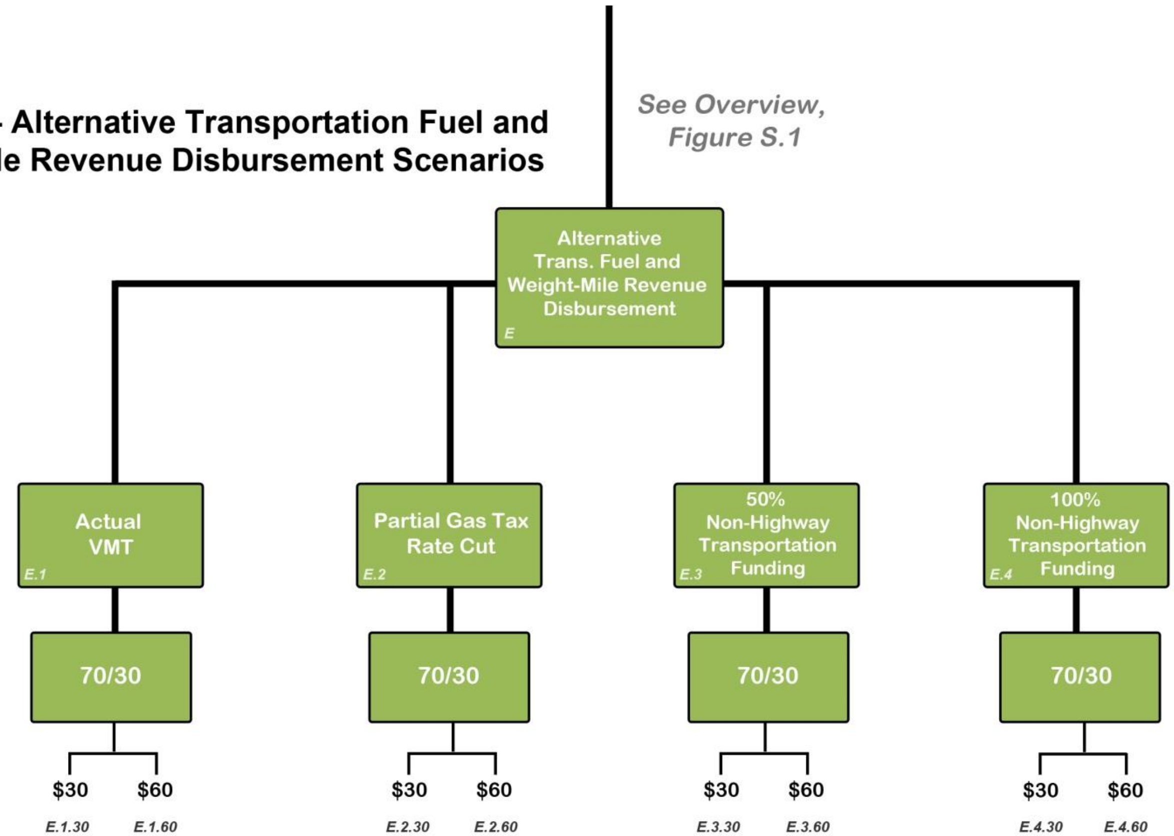


Figure S.5 - Alternative Transportation Fuel and Weight-Mile Revenue Disbursement Scenarios



Scenario A. 1 - Impacts for Financial Reserve Scenarios

Figure 59 - Impacts for Financial Reserve Scenarios (Scenario A.1) Employment

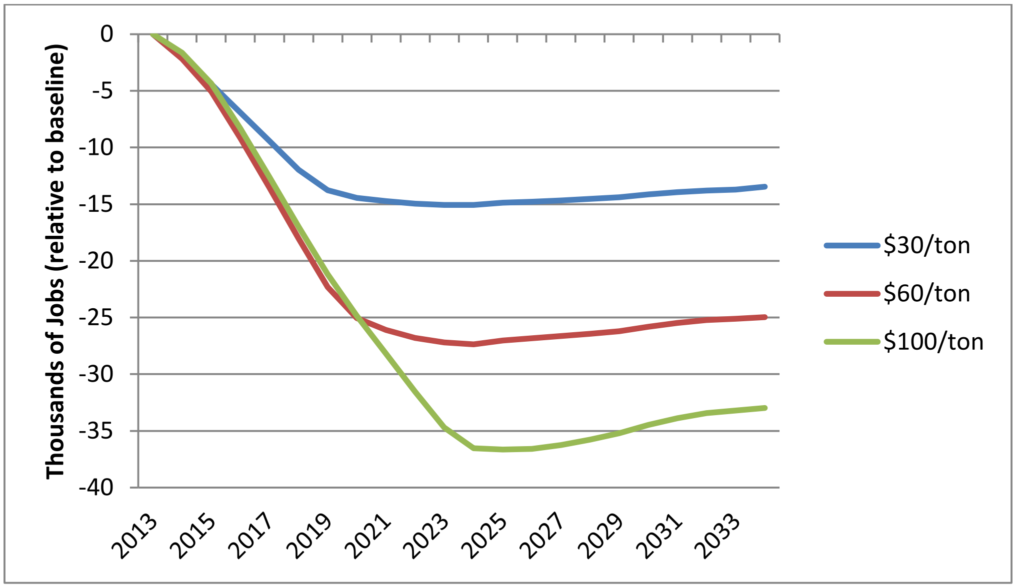


Figure 60 - Impacts for Financial Reserve Scenarios (Scenario A.1) Output

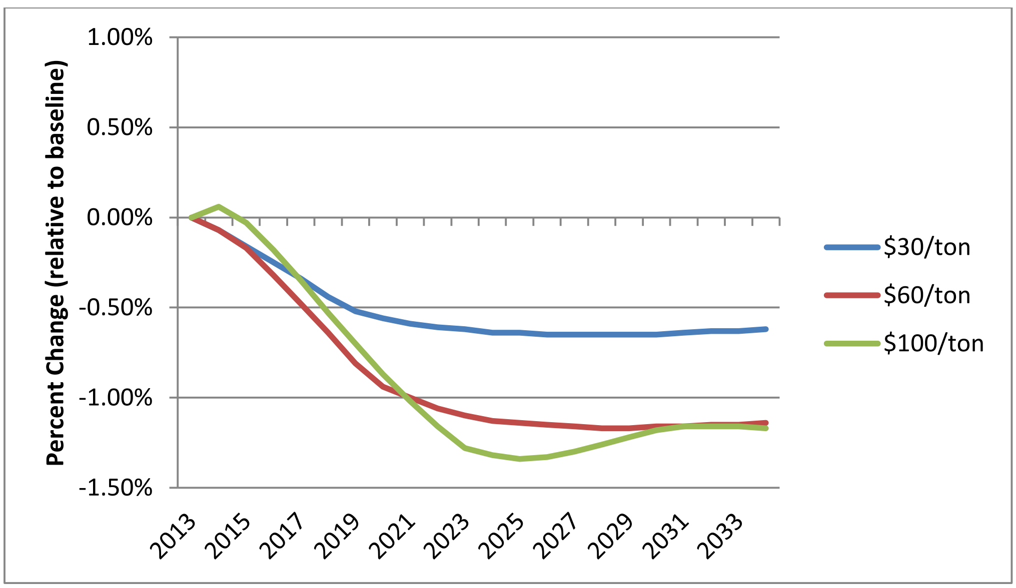


Figure 61 - Impacts for Financial Reserve Scenarios (Scenario A.1) Compensation

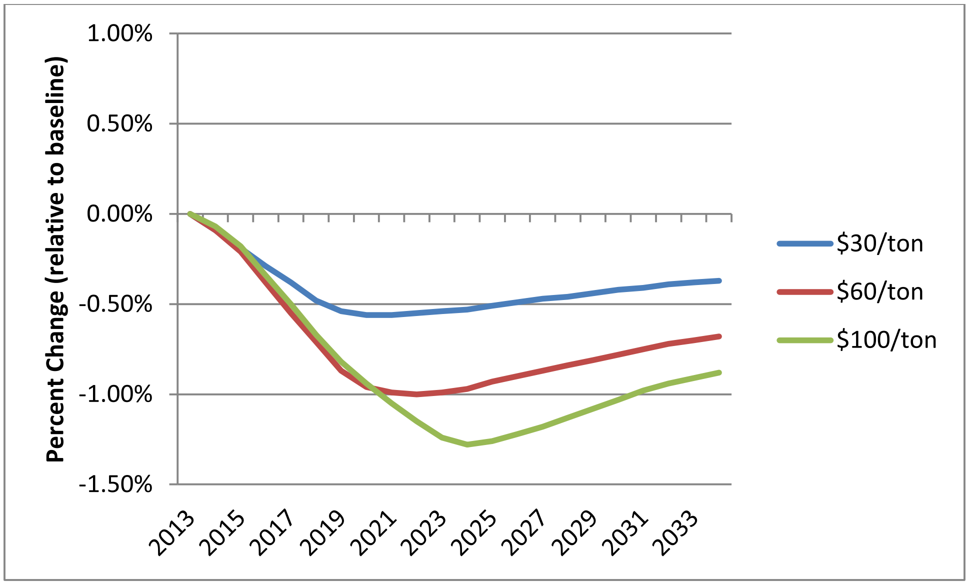
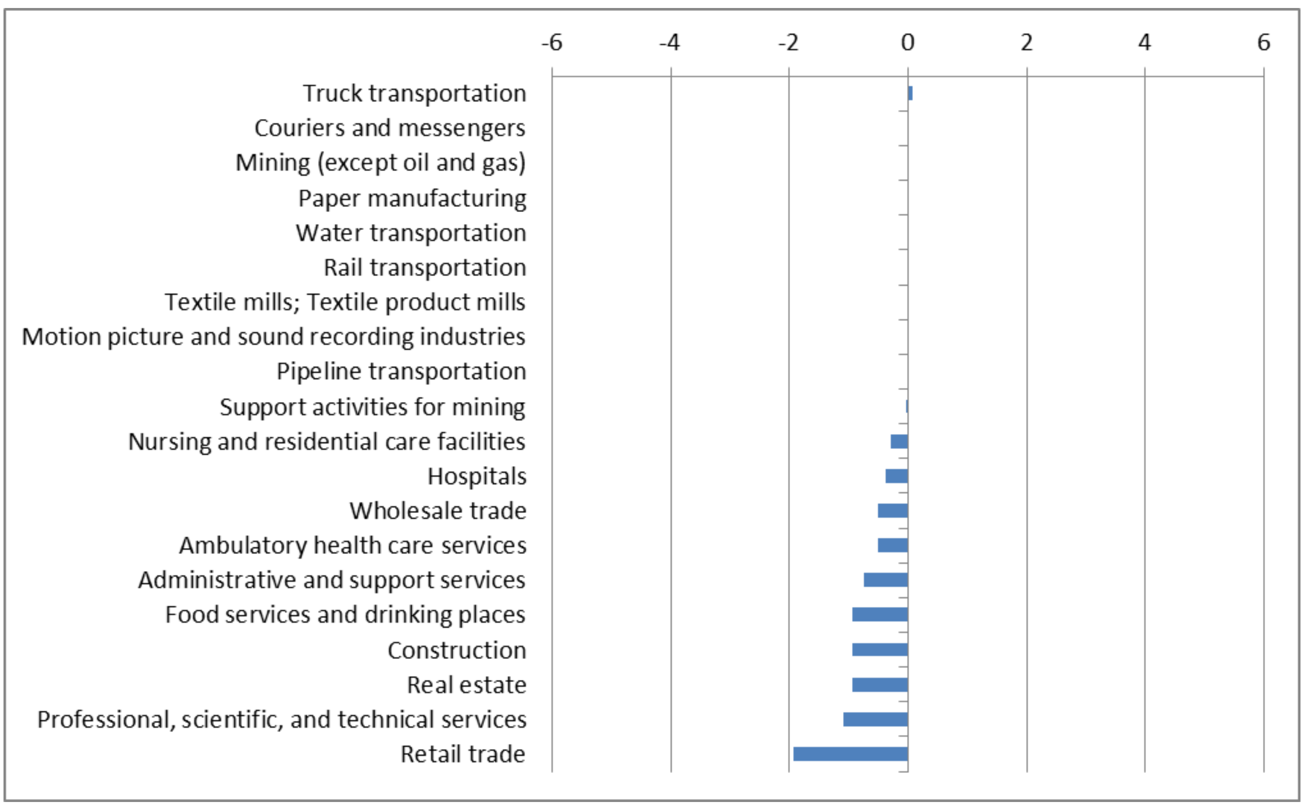


Figure 62 - Impacts for Financial Reserve Scenarios (Scenario A.1) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario A.2.30 - Impacts for Highway Funds and Reserve

Figure 63 - Impacts for Highway Funds and Reserve- $30/ton (Scenario A.2.30) Employment

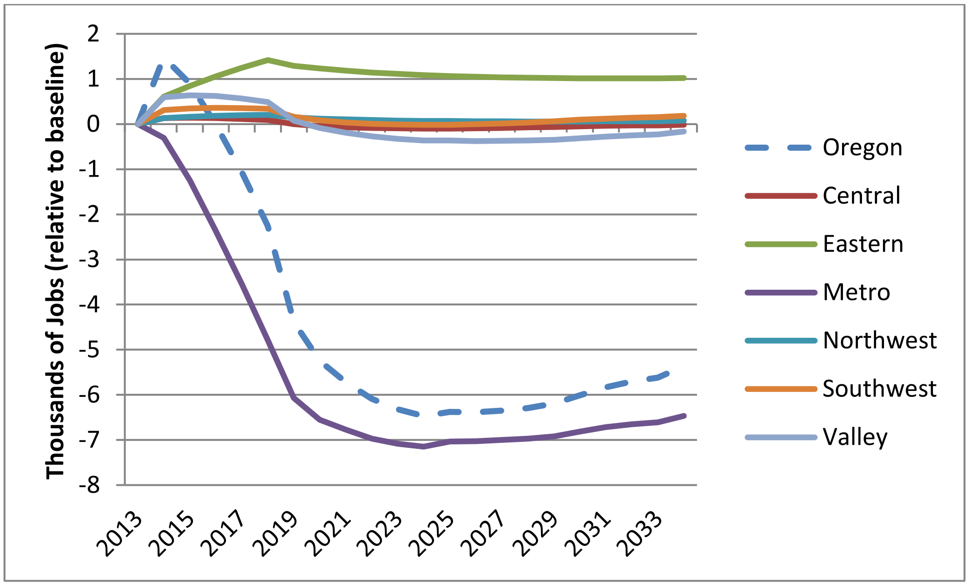


Figure 64 - Impacts for Highway Funds and Reserve- $30/ton (Scenario A.2.30) Output

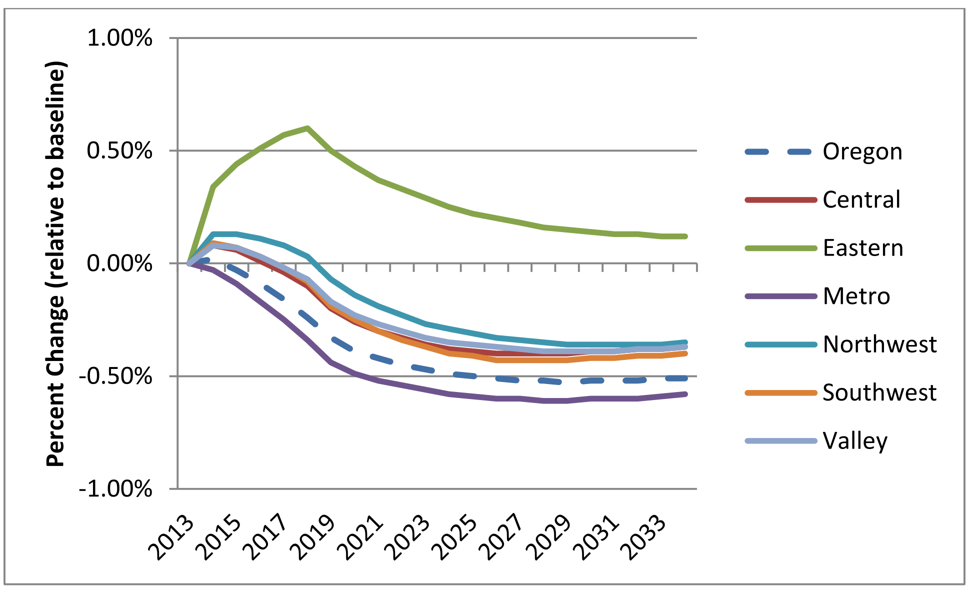
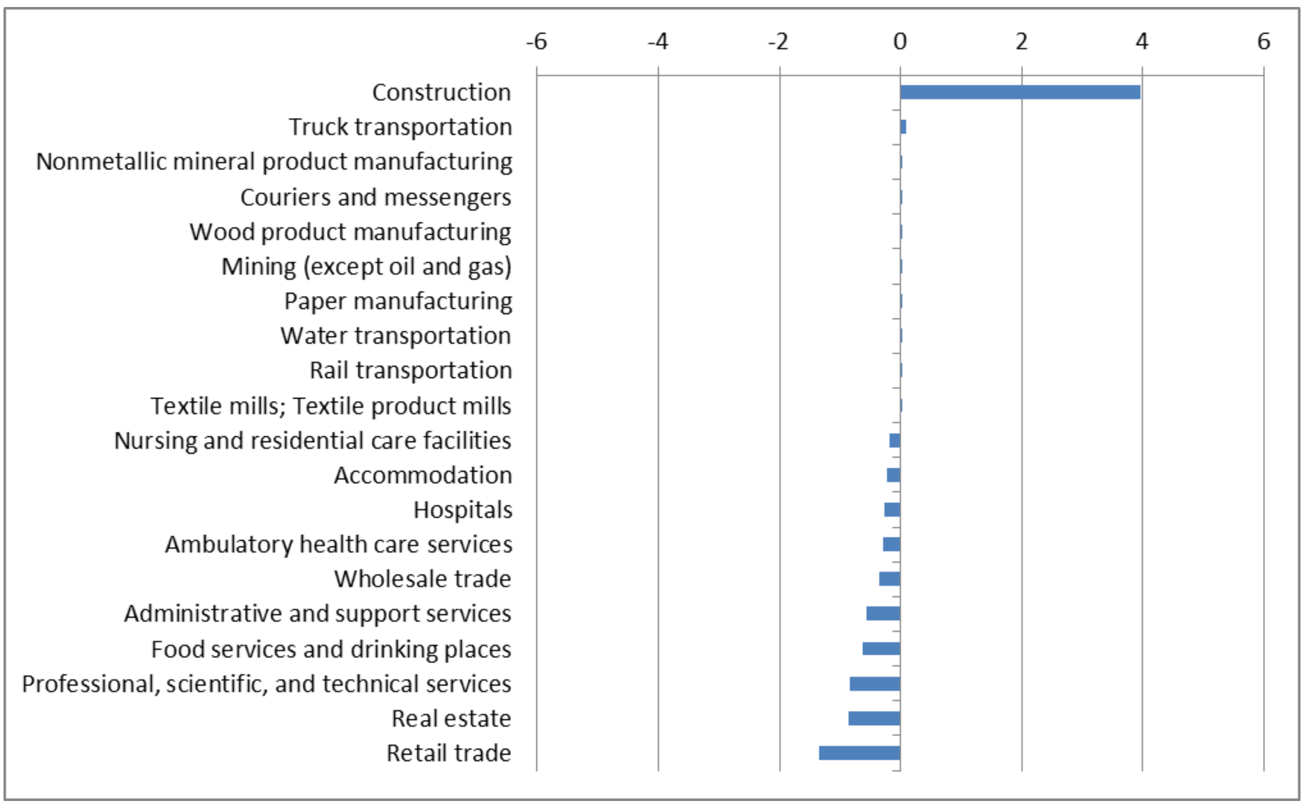


Figure 65 - Impacts for Highway Funds and Reserve- $30/ton (Scenario A.2.30) Compensation

Figure 66 - Impacts for Highway Funds and Reserve- $30/ton (Scenario A.2.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario A.4.30 - Impacts for All General Fund Scenario- $30/ton

Figure 67 - Impacts for All General Fund Scenario- $30/ton (Scenario A.4.30) Employment

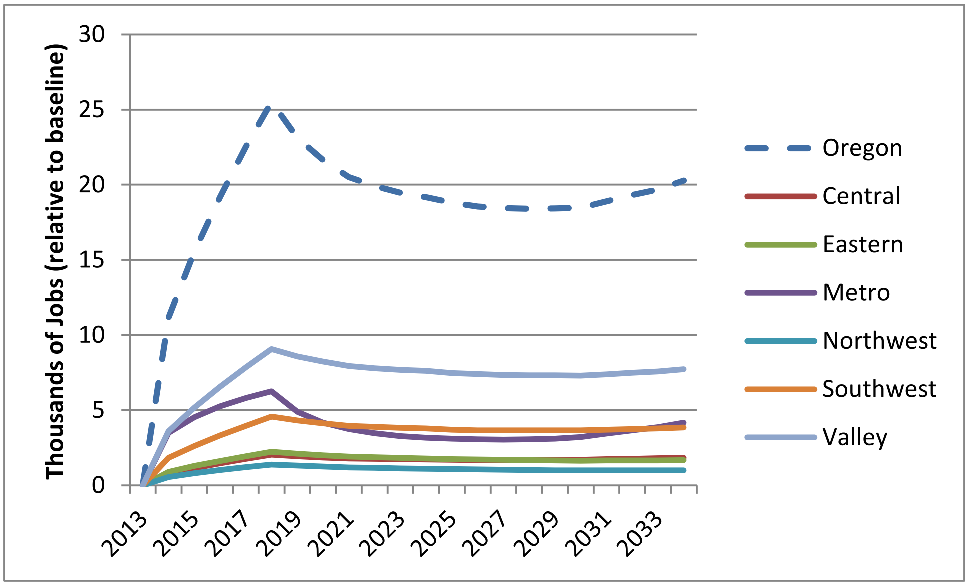


Figure 68 - Impacts for All General Fund Scenario- $30/ton (Scenario A.4.30) Output

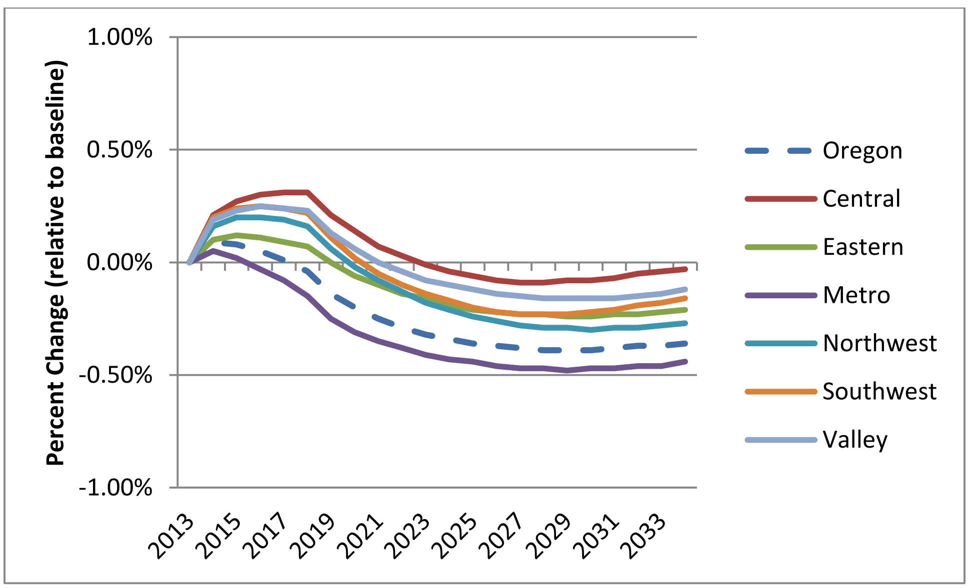


Figure 69 - Impacts for All General Fund Scenario- $30/ton (Scenario A.4.30) Compensation

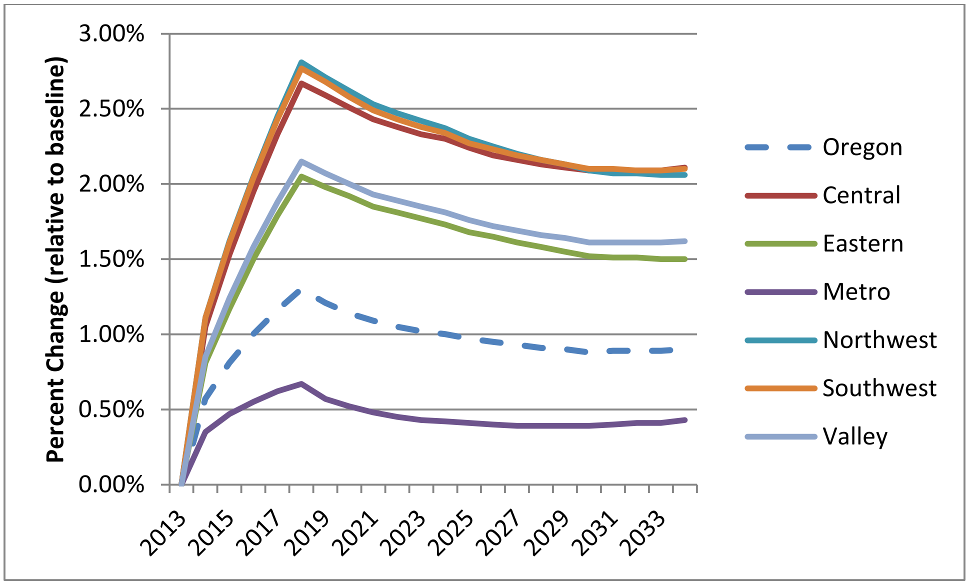
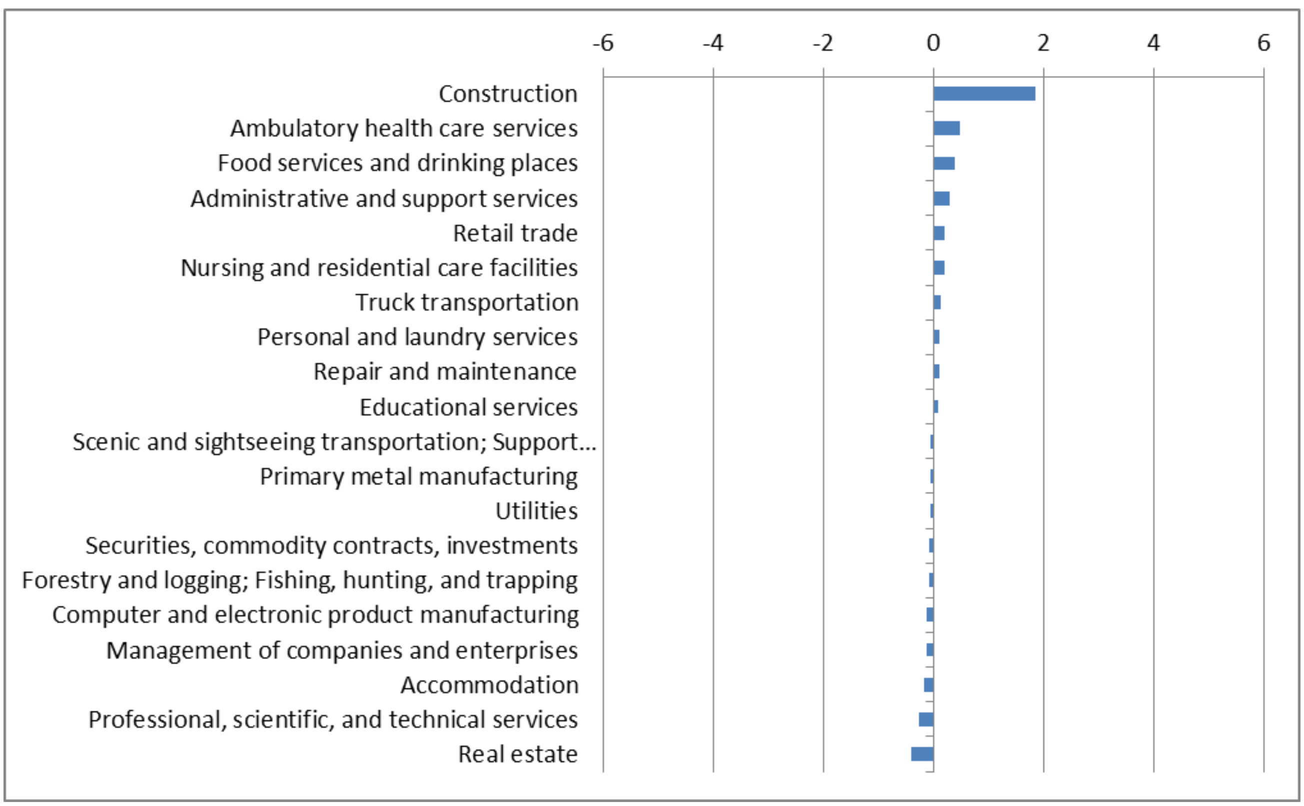


Figure 70 - Impacts for All General Fund Scenario- $30/ton (Scenario A.4.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario B.1.30 - Impacts for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax- $30/ton

Figure 71 - Impacts for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax- $30/ton (Scenario B.1.30) Employment

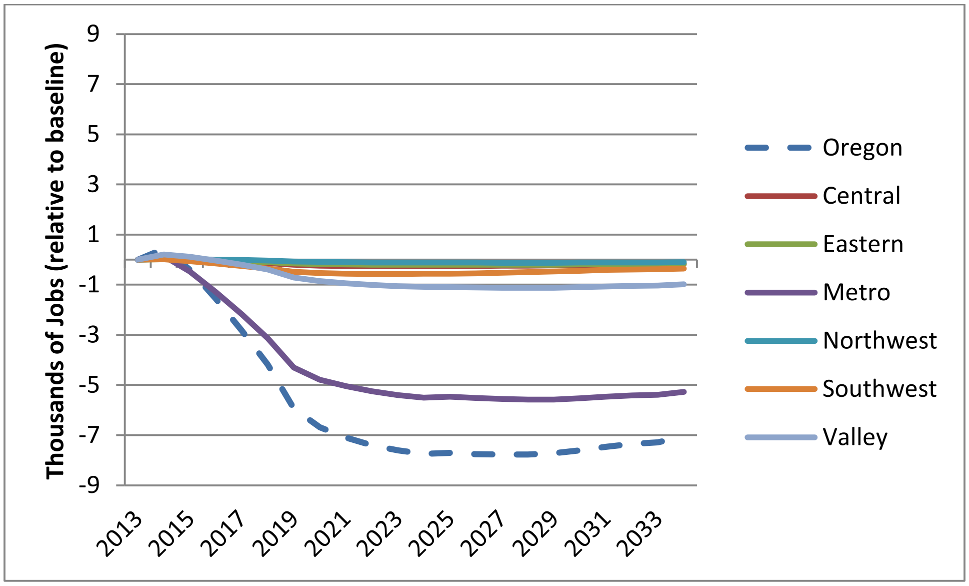


Figure 72 - Impacts for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax- $30/ton (Scenario B.1.30) Output

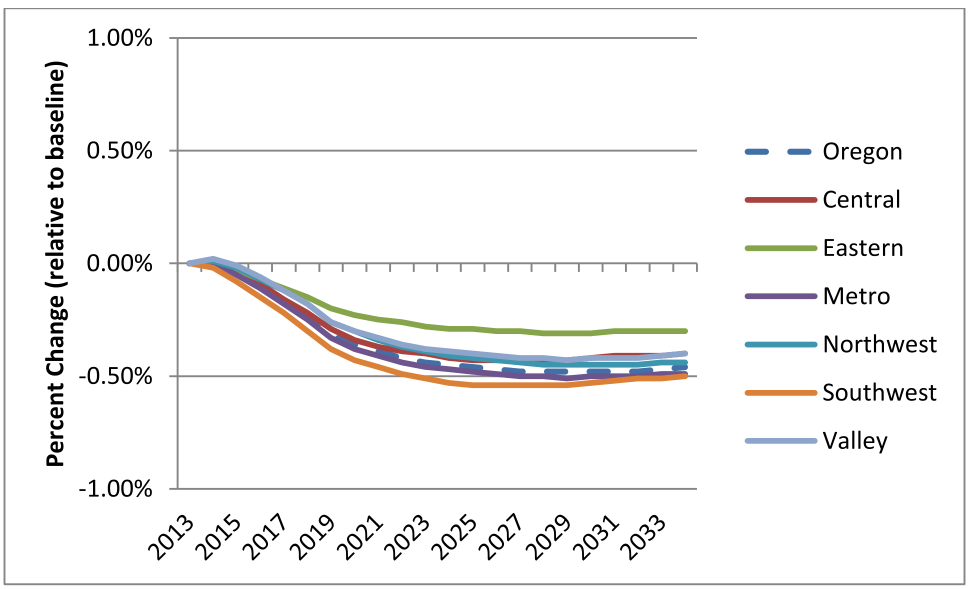


Figure 73 - Impacts for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax- $30/ton (Scenario B.1.30) Compensation

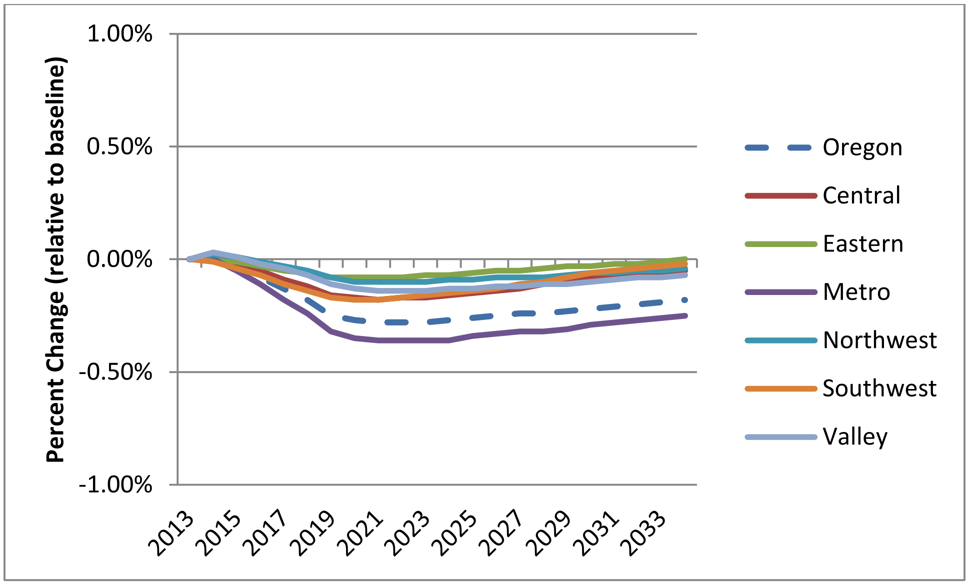
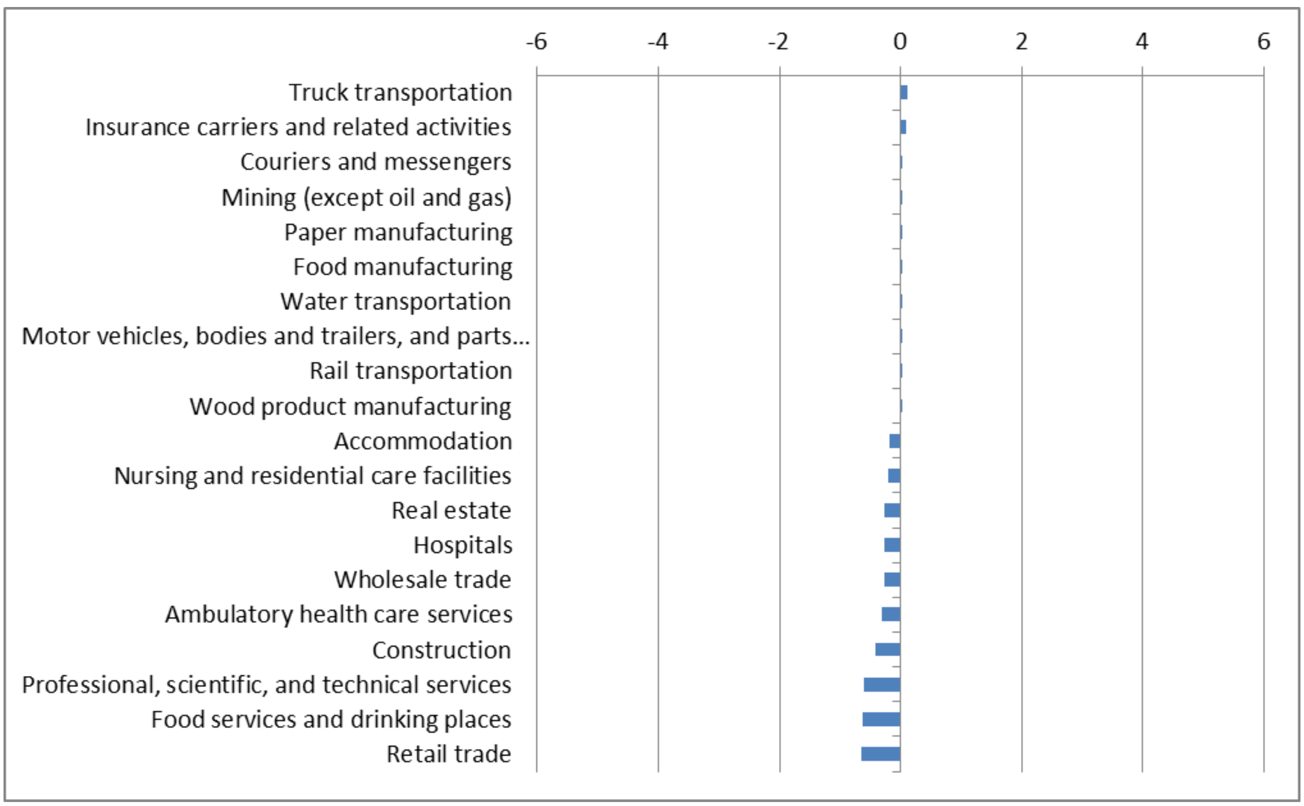


Figure 74 - Impacts for Revenue Neutral with Non-Transportation Revenues Reducing Personal Income Tax- $30/ton (Scenario B.1.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario B.2 - Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts

Figure 75 - Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2) Employment

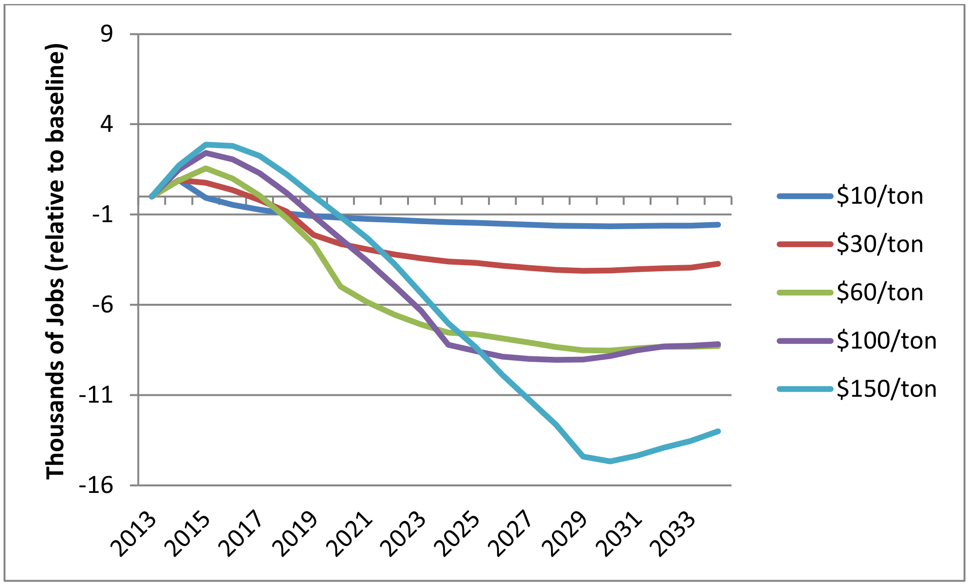


Figure 76 - Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2) Output

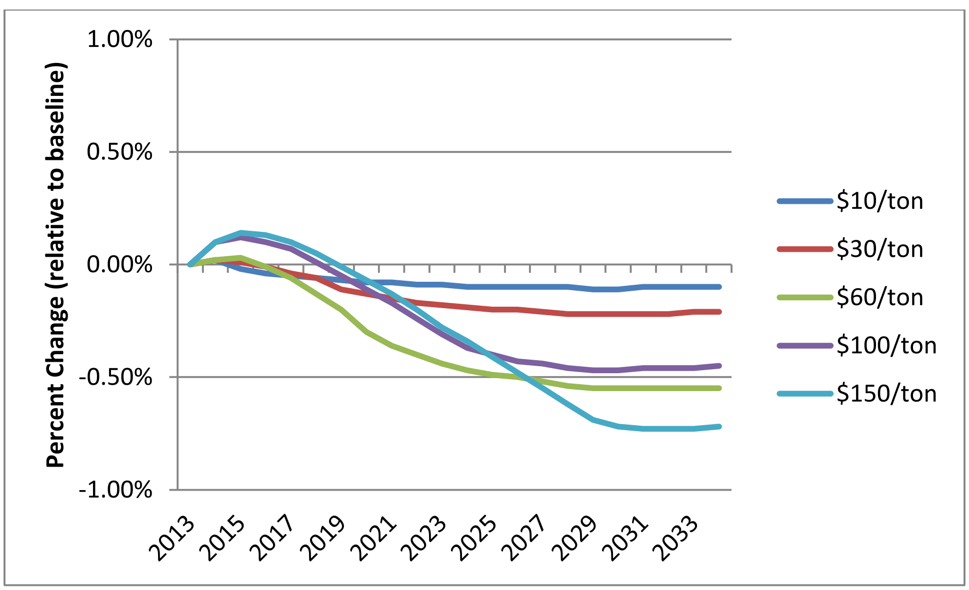


Figure 77 - Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2) Compensation

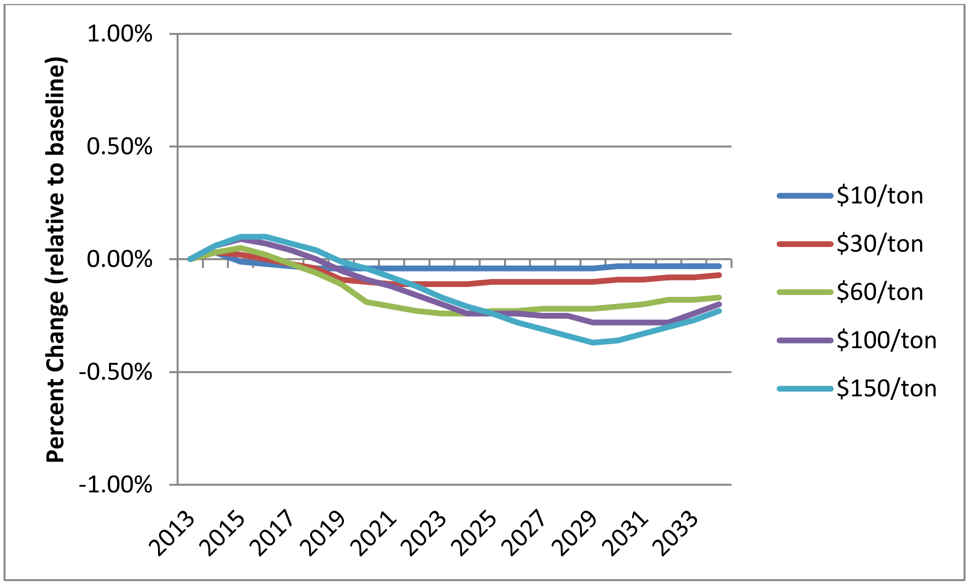
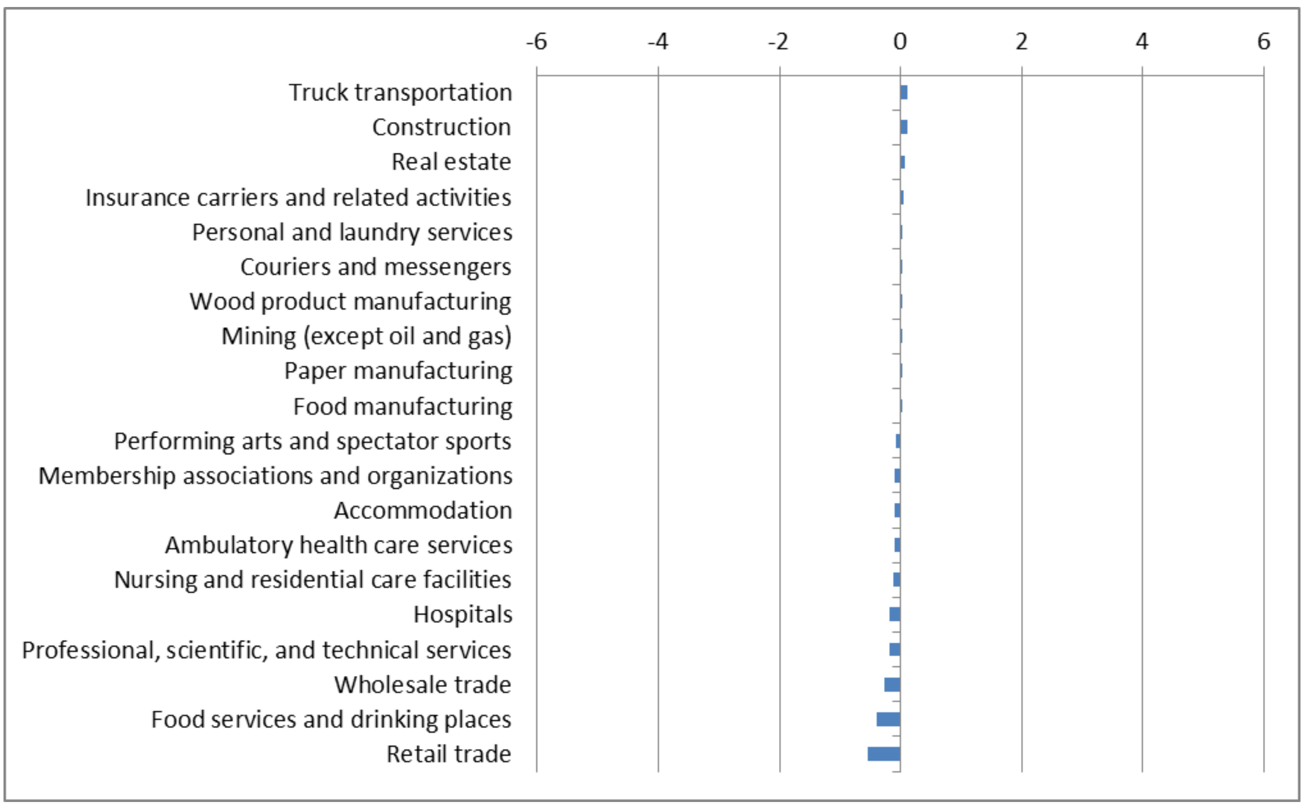


Figure 78 - Impact for Revenue Neutral with Non-Transportation Revenue Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario B.2) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario B.3.100 - Impacts for Revenue Neutral with Non-Transportation Revenue Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton

Figure 79 - Impacts for Revenue Neutral with Non-Transportation Revenue Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario B.3.100) Employment

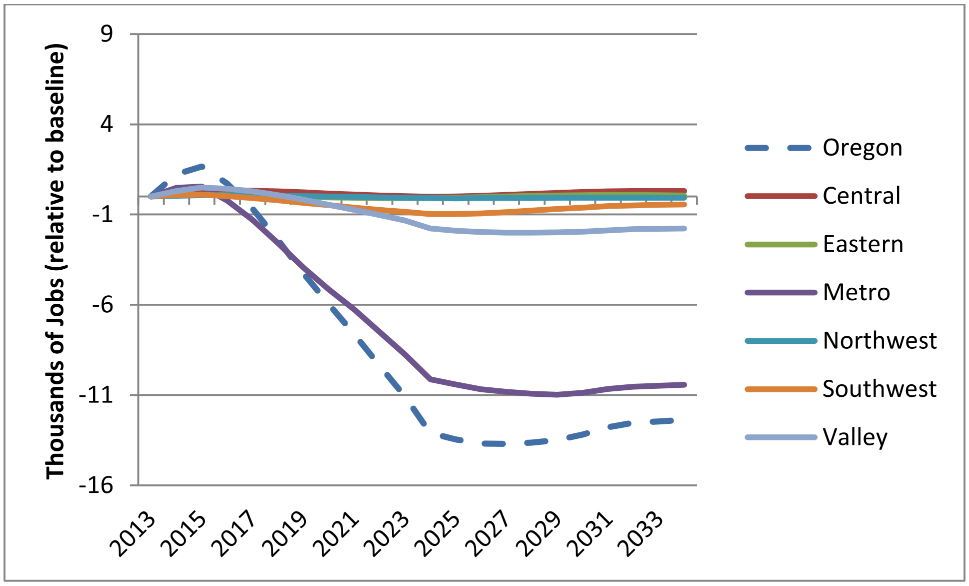


Figure 80 - Impacts for Revenue Neutral with Non-Transportation Revenue Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario B.3.100) Output

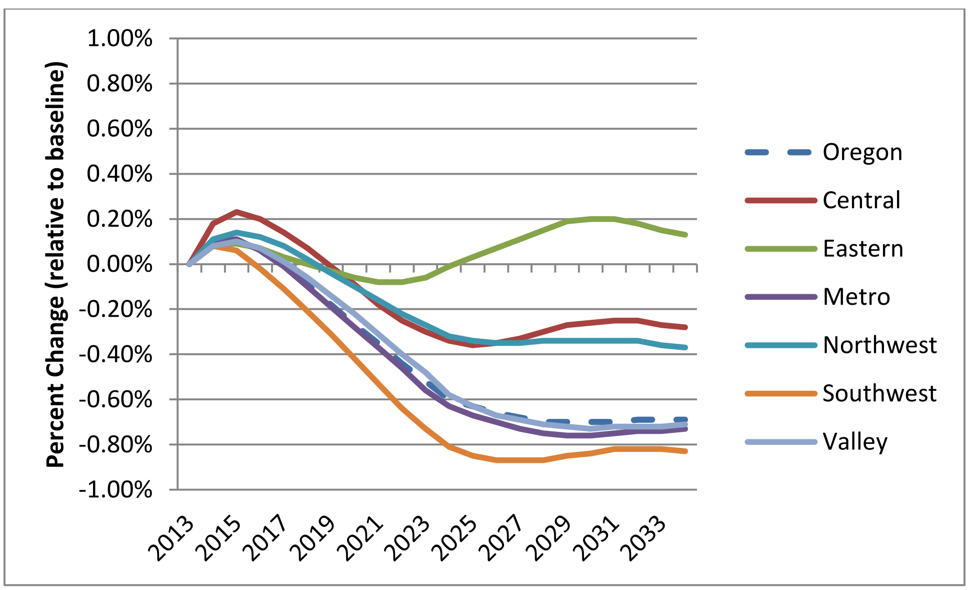


Figure 81 - Impacts for Revenue Neutral with Non-Transportation Revenue Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario B.3.100) Compensation

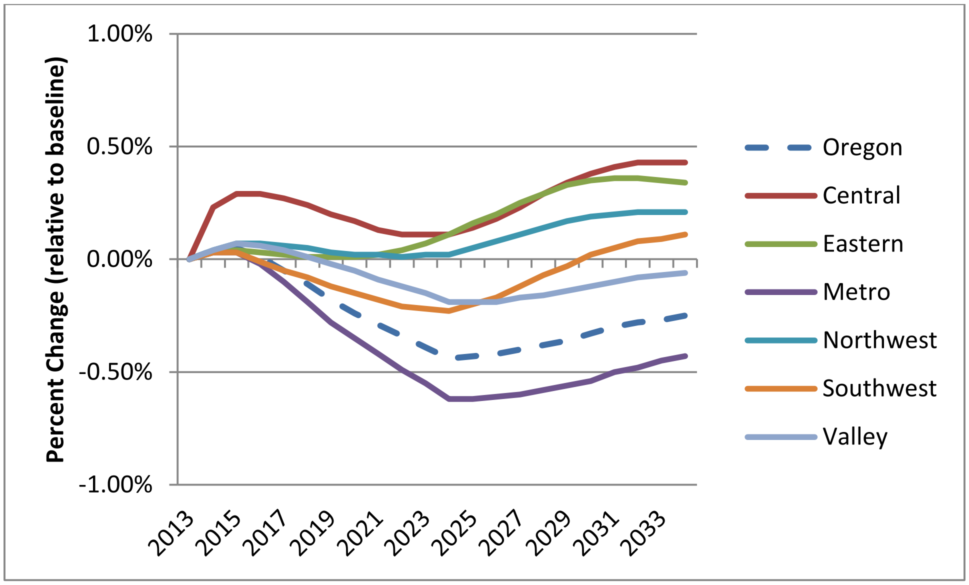
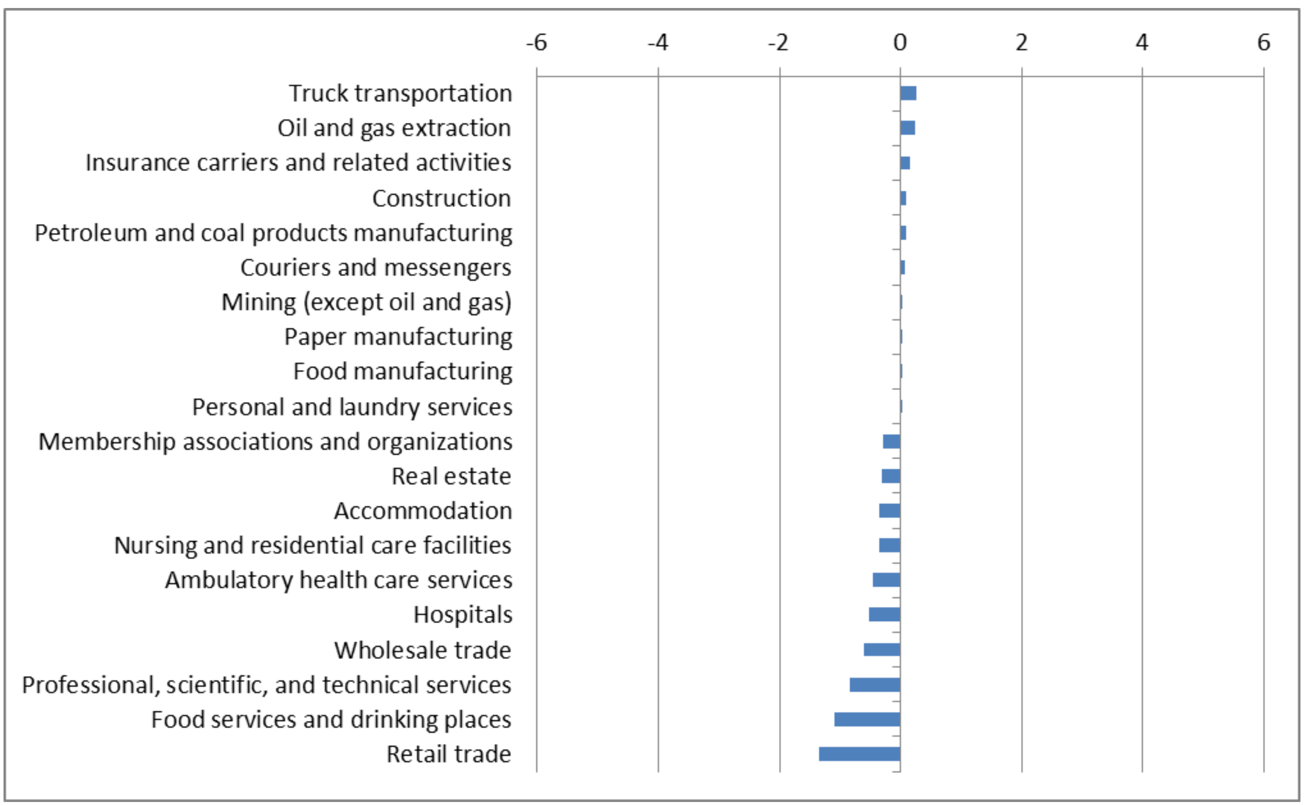


Figure 82 - Impacts for Revenue Neutral with Non-Transportation Revenue Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario B.3.100) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario C.2 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction

Figure 83 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction- (Scenario C.2) Employment

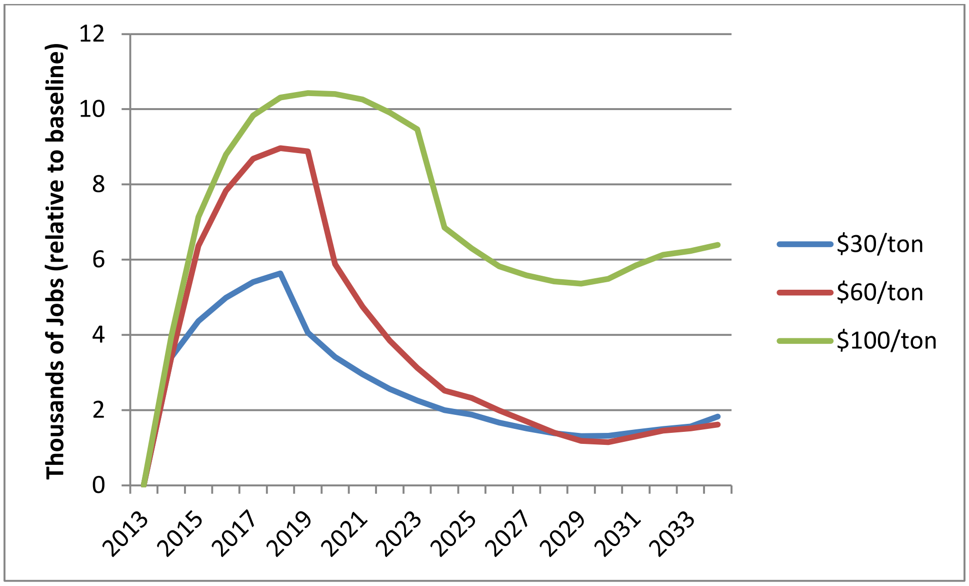


Figure 84 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction- (Scenario C.2) Output

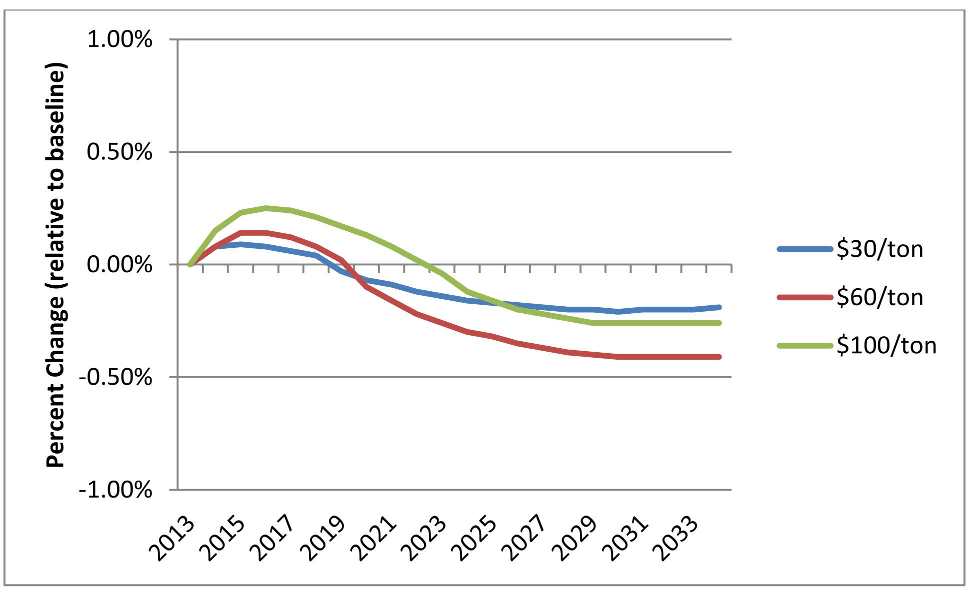


Figure 85 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction- (Scenario C.2) Compensation

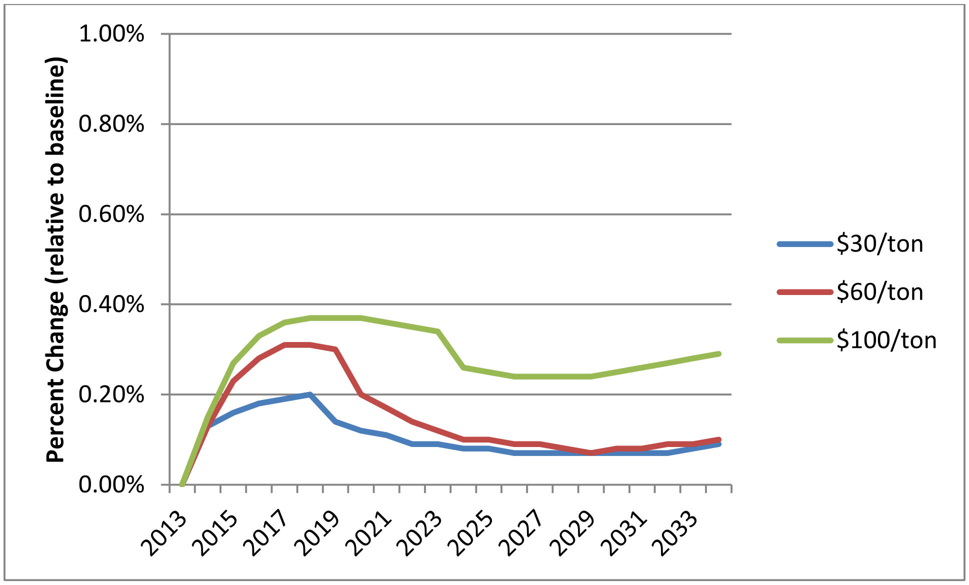
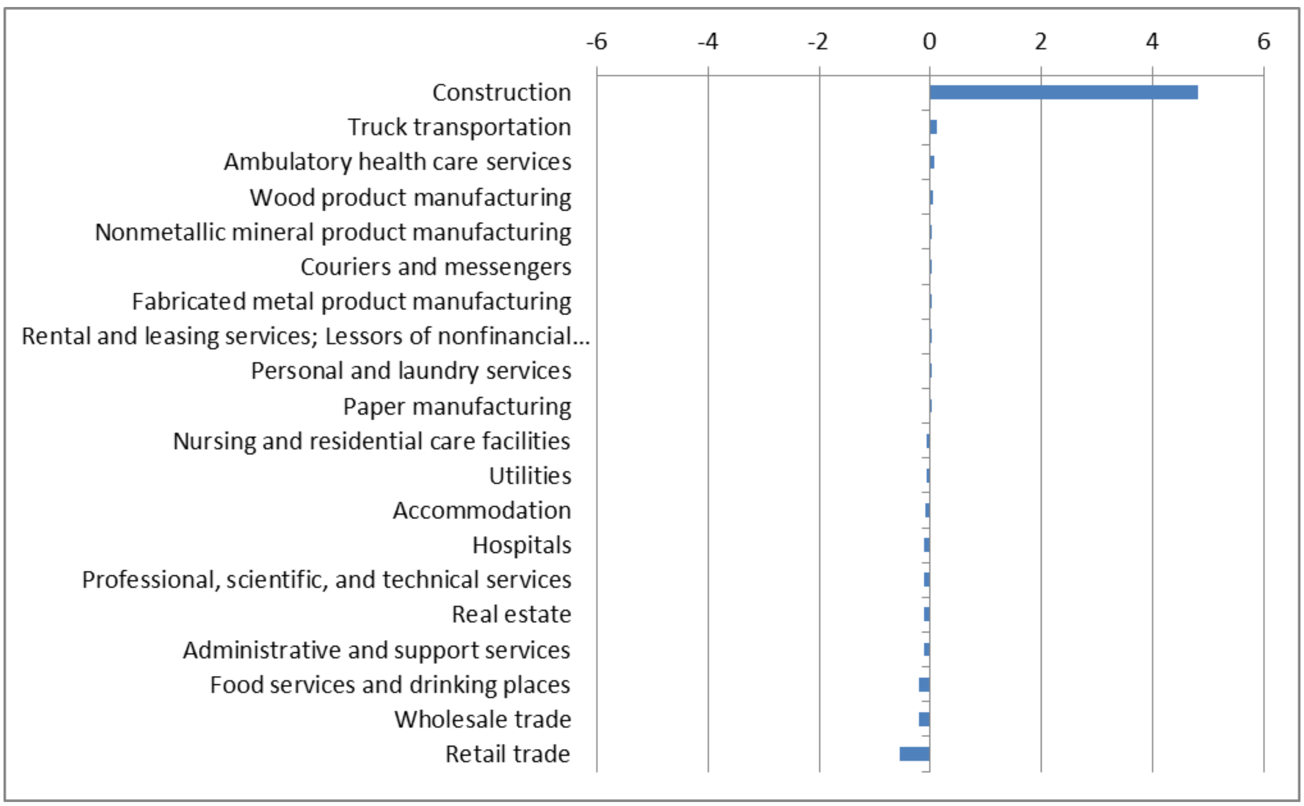


Figure 86 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Corporate Income Tax Reduction- (Scenario C.2) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3)

Figure 87 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3) Employment

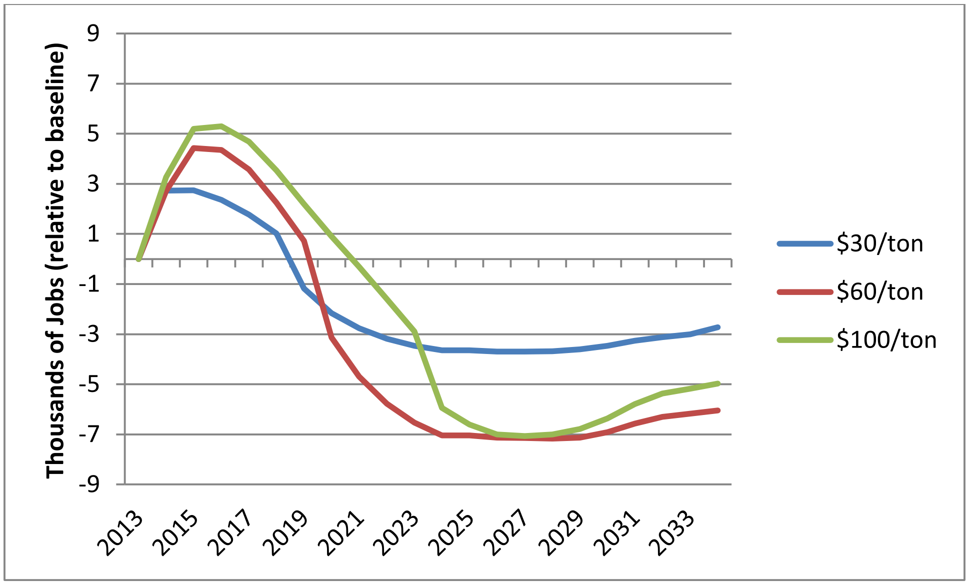


Figure 88 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3) Output

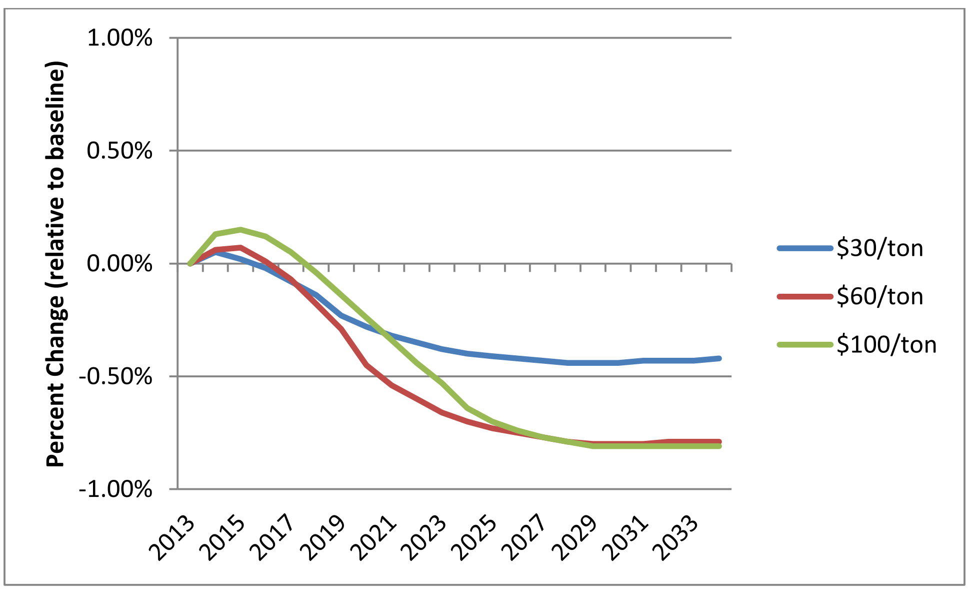


Figure 89 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3) Compensation

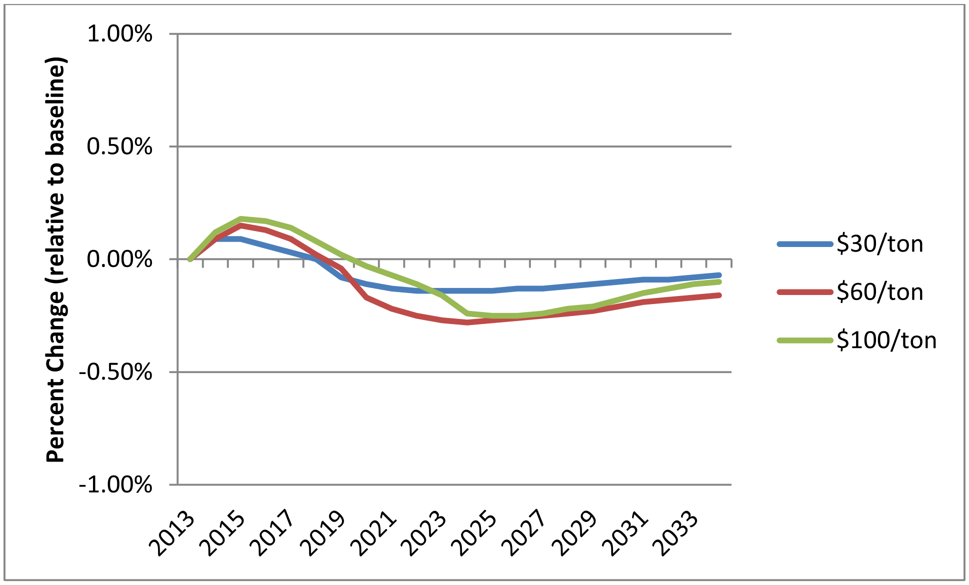
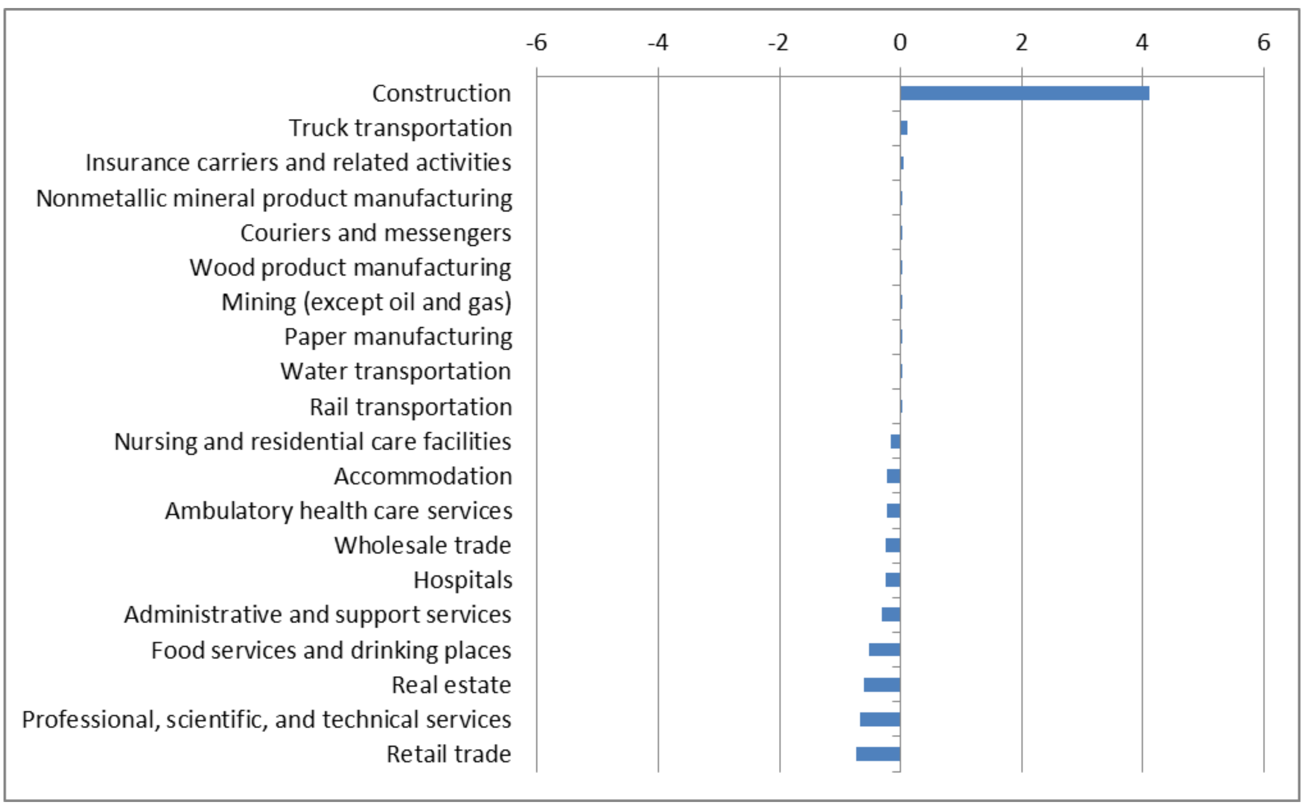


Figure 90 - Impacts Revenue Neutral (Excluding Transportation Revenue) All Personal Income Tax Reduction (Scenario C.3) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario C.4 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts

Figure 91 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario C.4) Employment

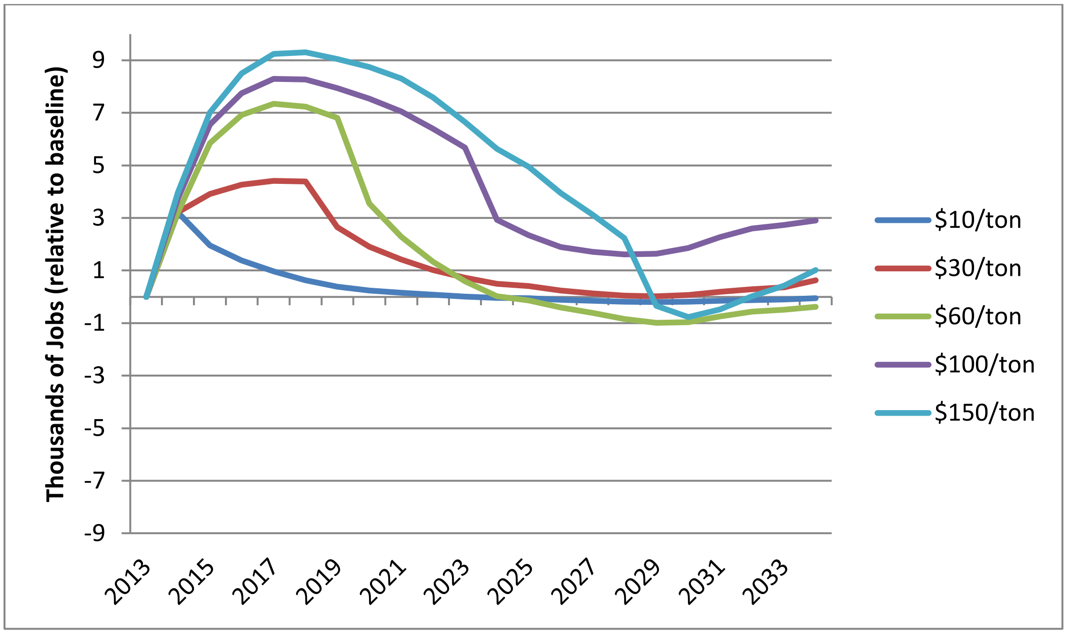


Figure 92 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario C.4) Output

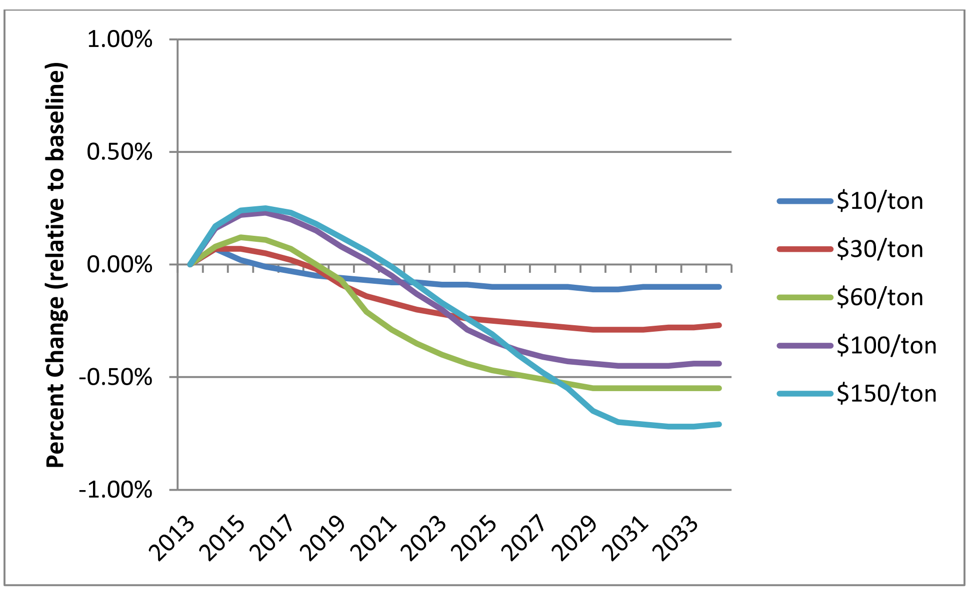


Figure 93 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario C.4) Compensation

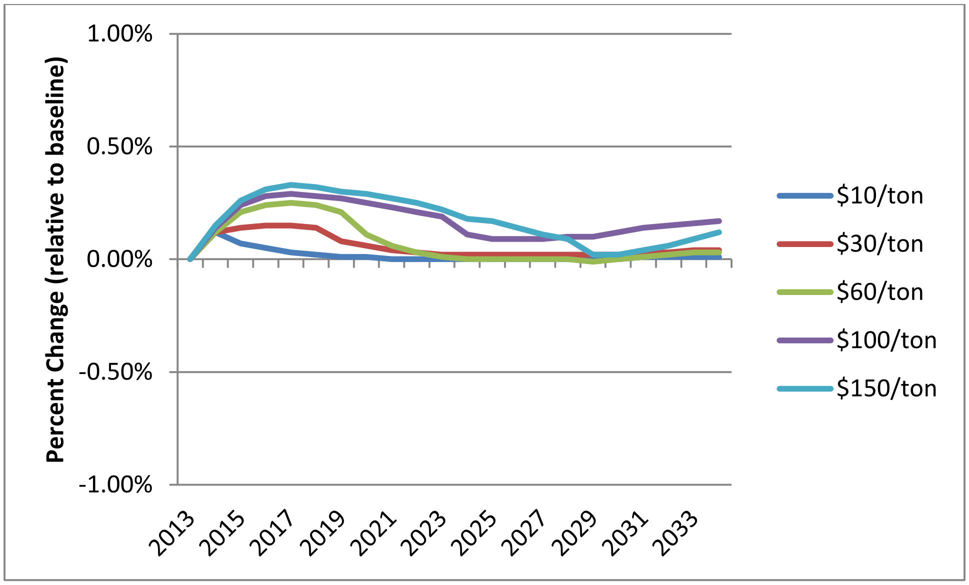
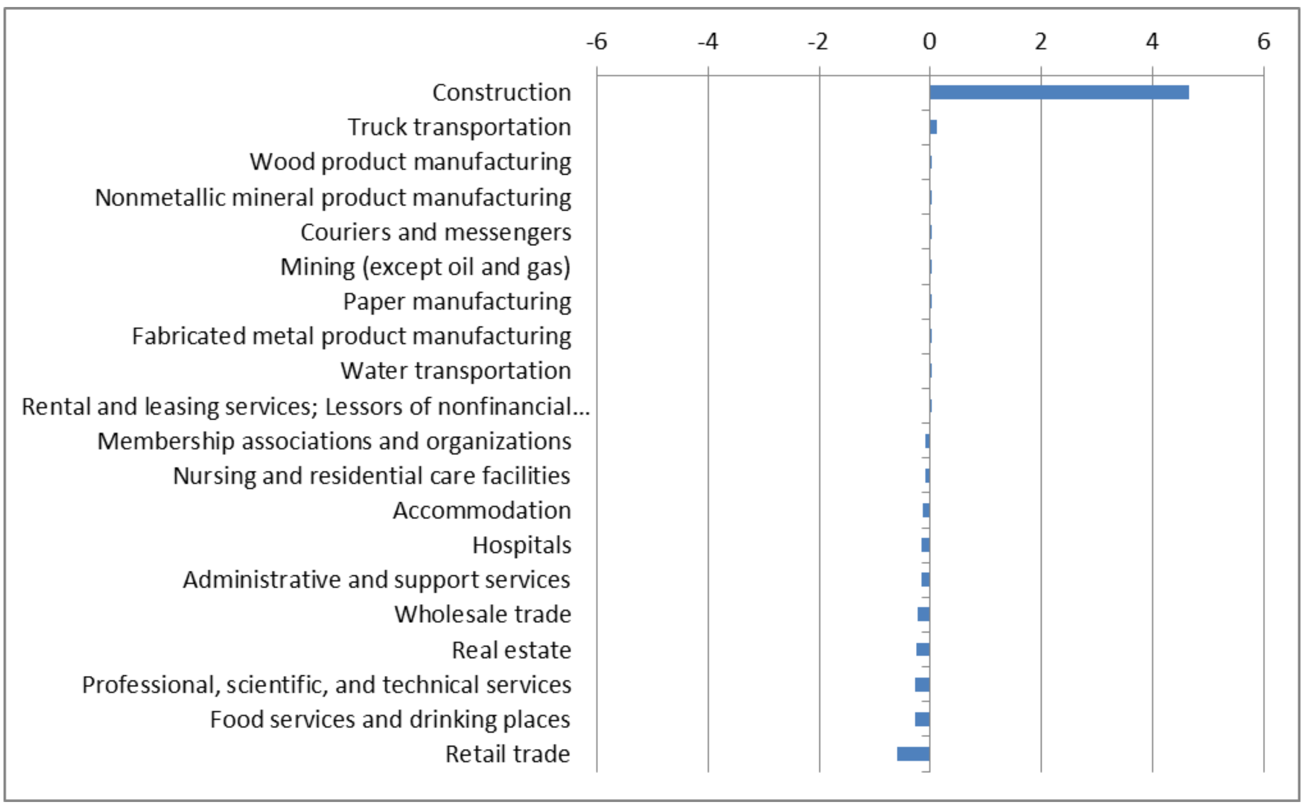


Figure 94 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts (Scenario C.4) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario C.5.100 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton

Figure 95 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario C.5.100) Employment

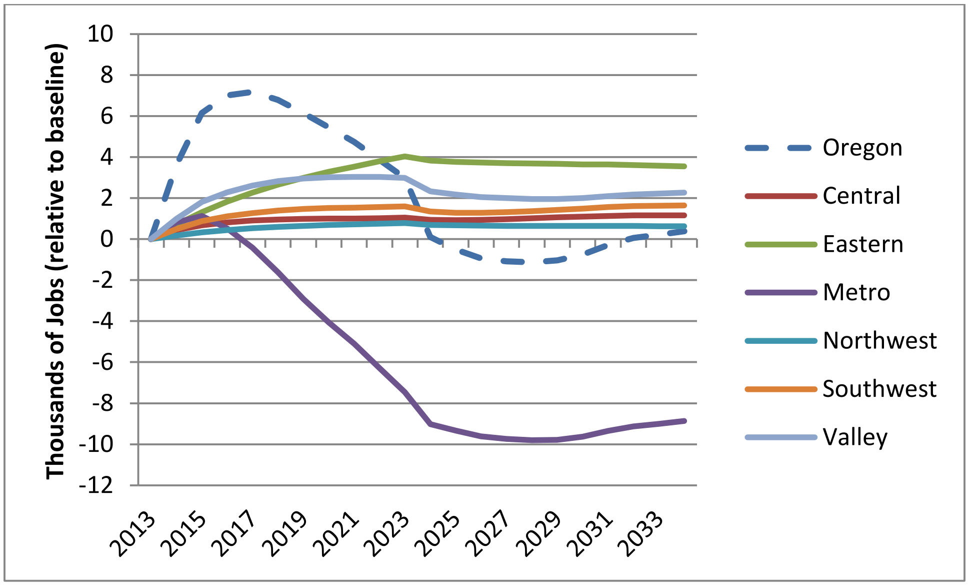


Figure 96 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario C.5.100) Output

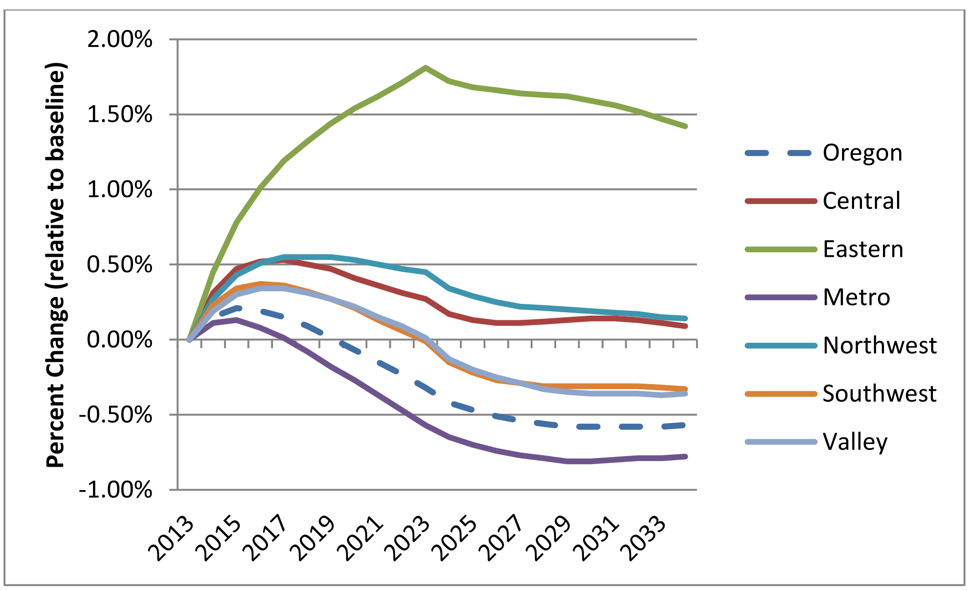


Figure 97 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario C.5.100) Compensation

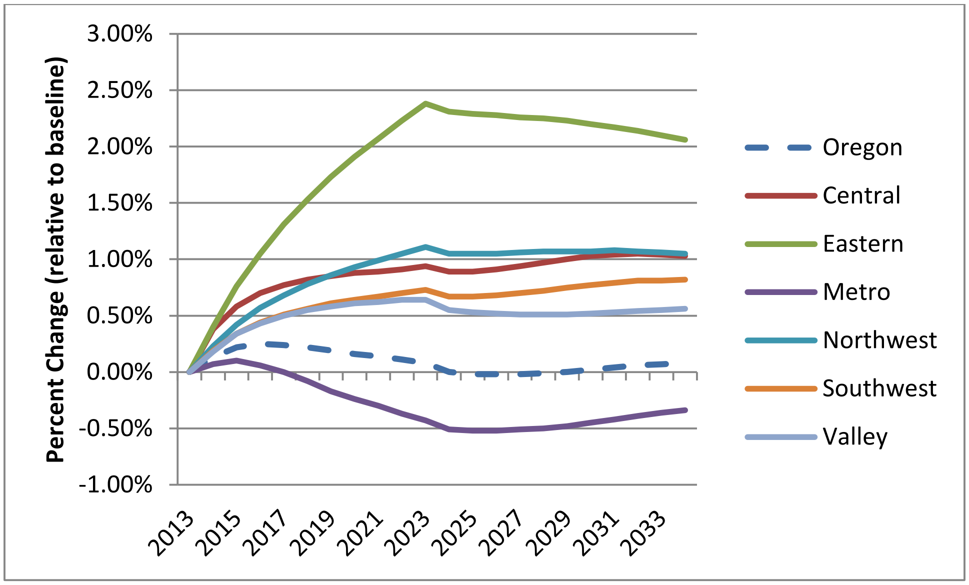
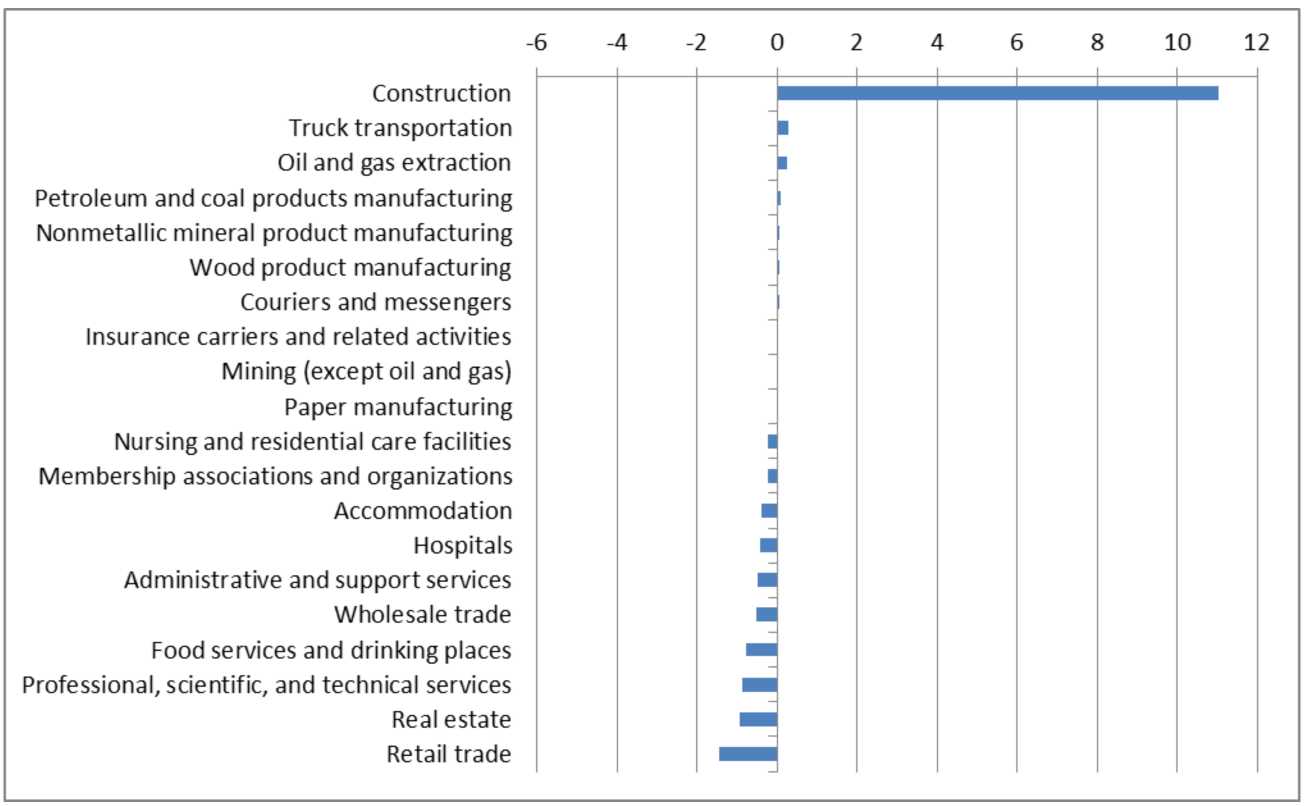


Figure 98 - Impacts for Revenue Neutral (Excluding Transportation Revenue) Eliminating Corporate Income Taxes and the Remainder Reducing Personal Income Taxes- $100/ton (Scenario C.5.100) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario C.6 - Impacts for Citizen Dividend (Excluding Transportation Revenues)

Figure 99 - Impacts for Citizen Dividend (Excluding Transportation Revenues) (Scenario C.6) Employment

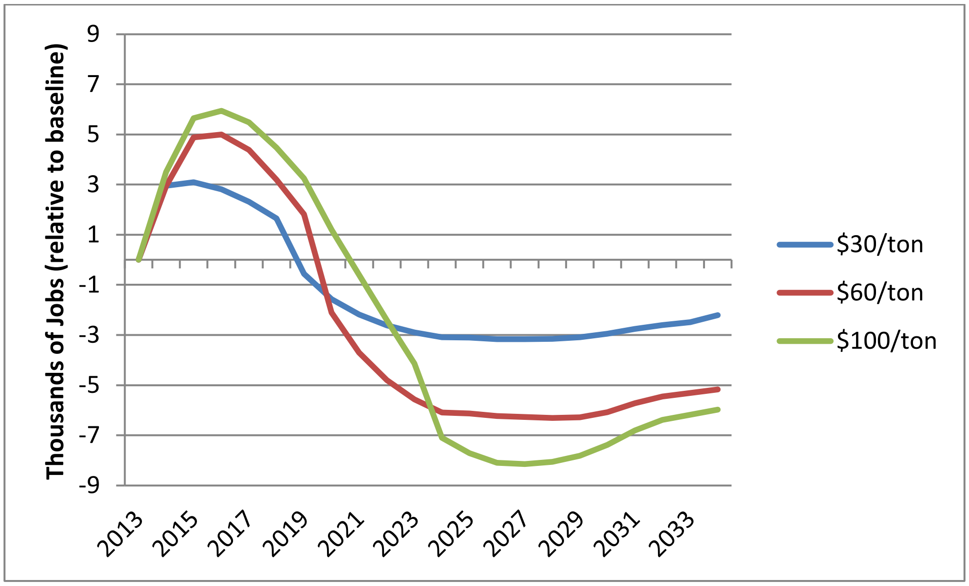


Figure 100 - Impacts for Citizen Dividend (Excluding Transportation Revenues) (Scenario C.6) Output

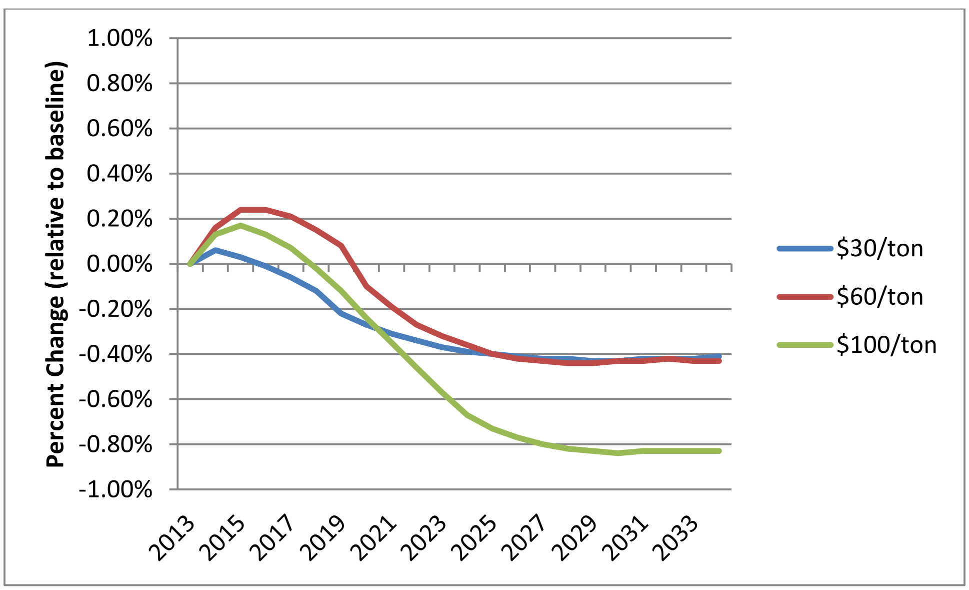


Figure 101 - Impacts for Citizen Dividend (Excluding Transportation Revenues) (Scenario C.6) Compensation

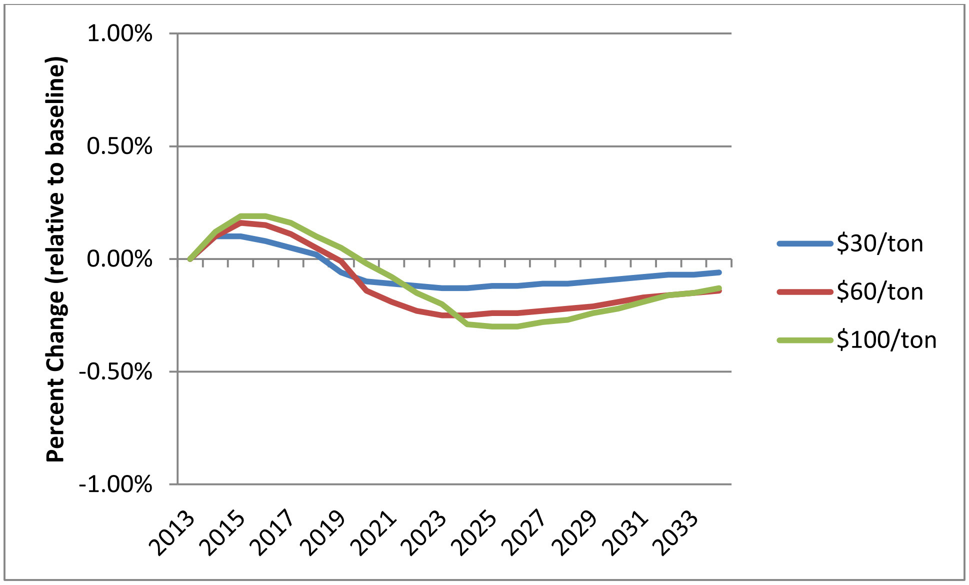
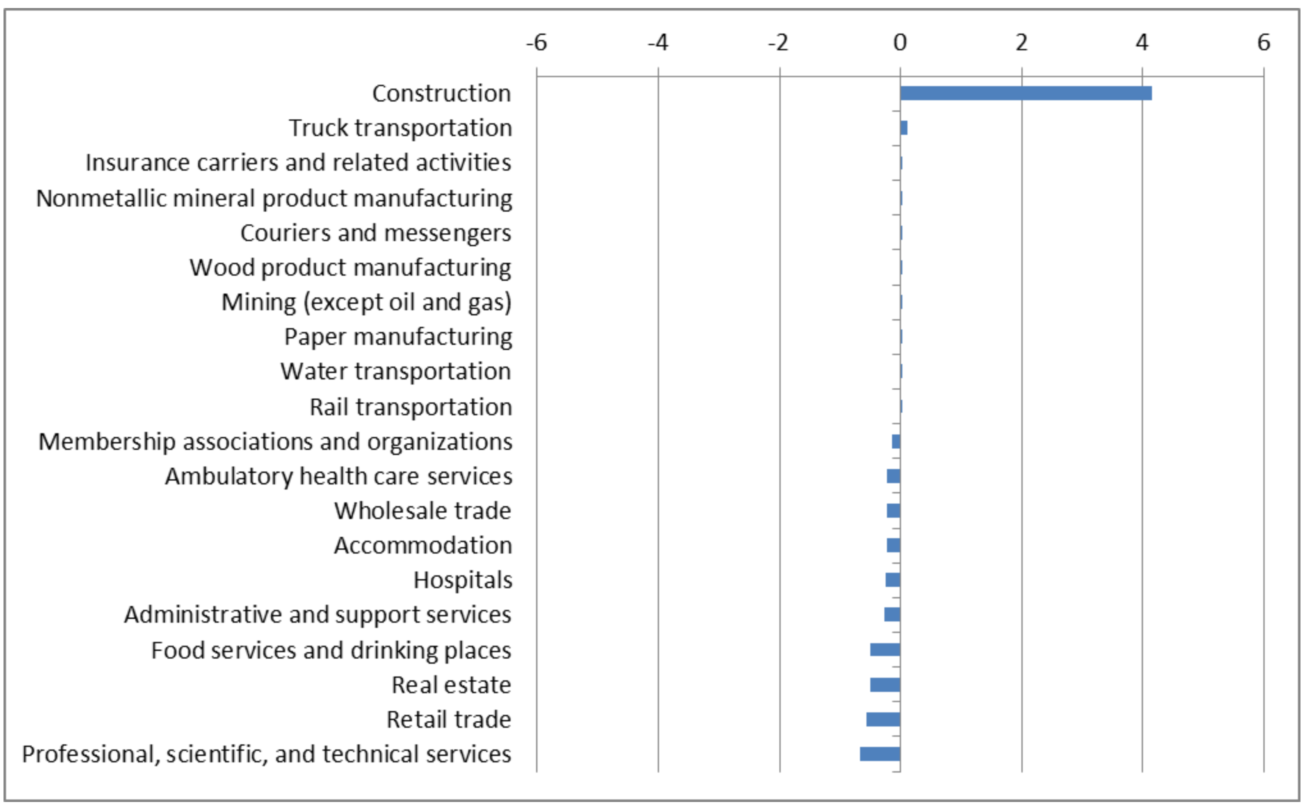


Figure 102 - Impacts for Citizen Dividend (Excluding Transportation Revenues) (Scenario C.6) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario D.1.1.1.30 - Impacts for Low-Income Assistance Scenario- $30/ton

Figure 103 - Impacts for Low-Income Assistance Scenario- $30/ton (Scenario D.1.1.1.30) Employment

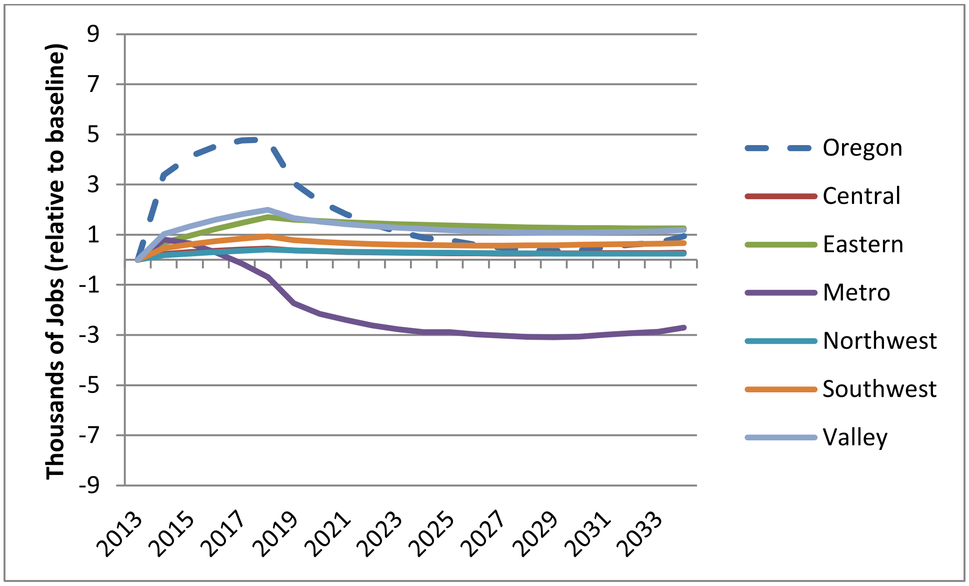


Figure 104 - Impacts for Low-Income Assistance Scenario- $30/ton (Scenario D.1.1.1.30) Output

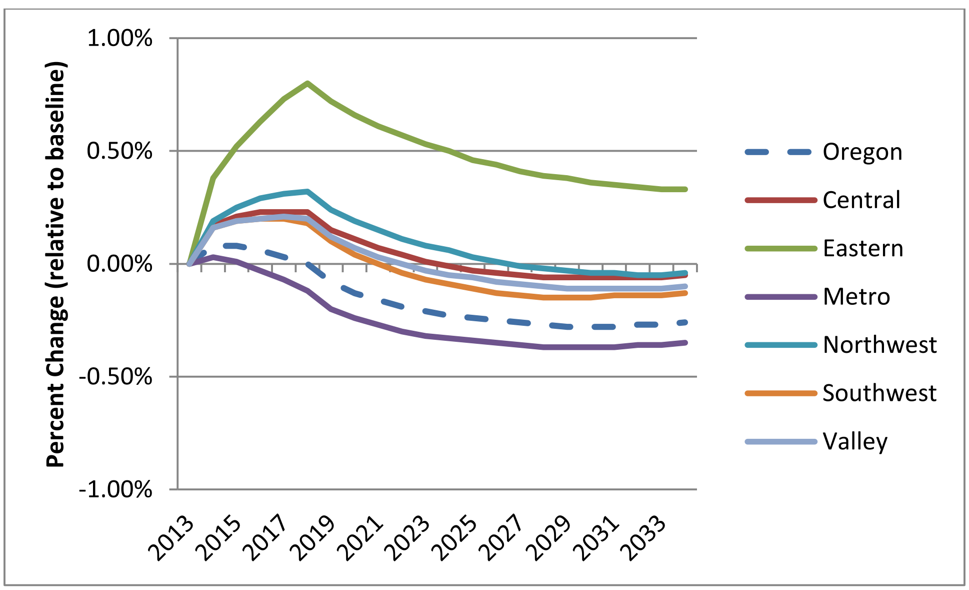


Figure 105 - Impacts for Low-Income Assistance Scenario- $30/ton (Scenario D.1.1.1.30) Compensation

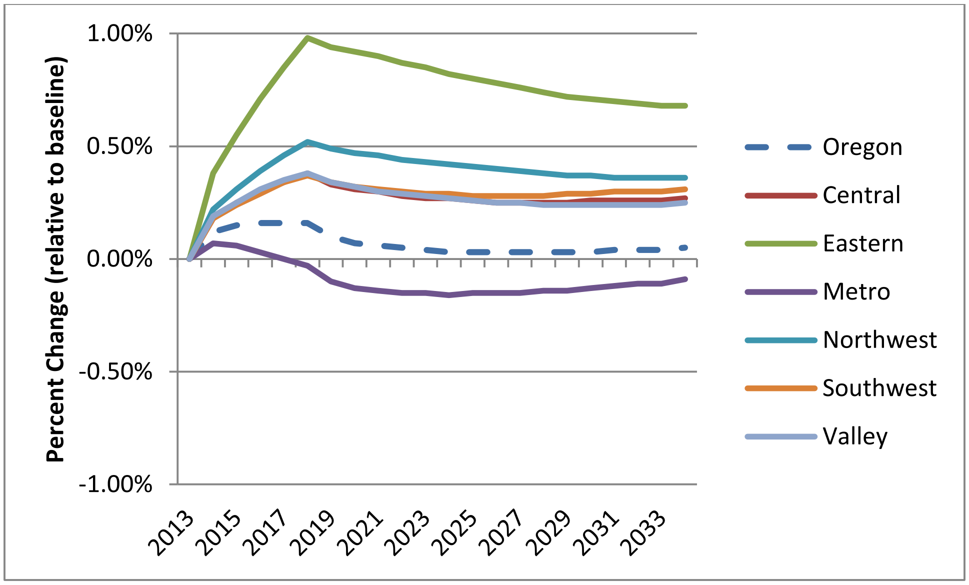
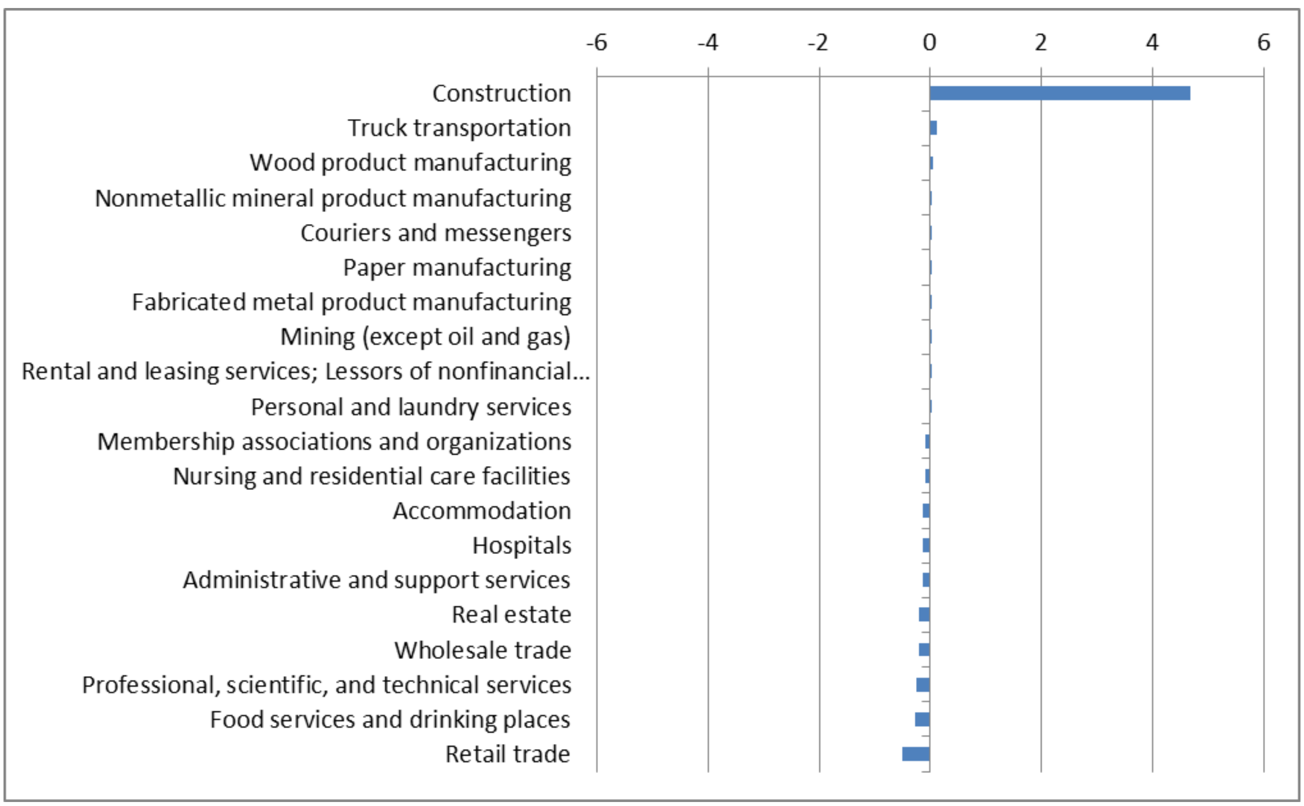


Figure 106 - Impacts for Low-Income Assistance Scenario- $30/ton (Scenario D.1.1.1.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario D.1.1.2.30 - Impacts for Low-Income Assistance and Targeted Income Support Scenario- $30/ton

Figure 107 - Impacts for Low-Income Assistance and Targeted Income Support Scenario- $30/ton (Scenario D.1.1.2.30) Employment

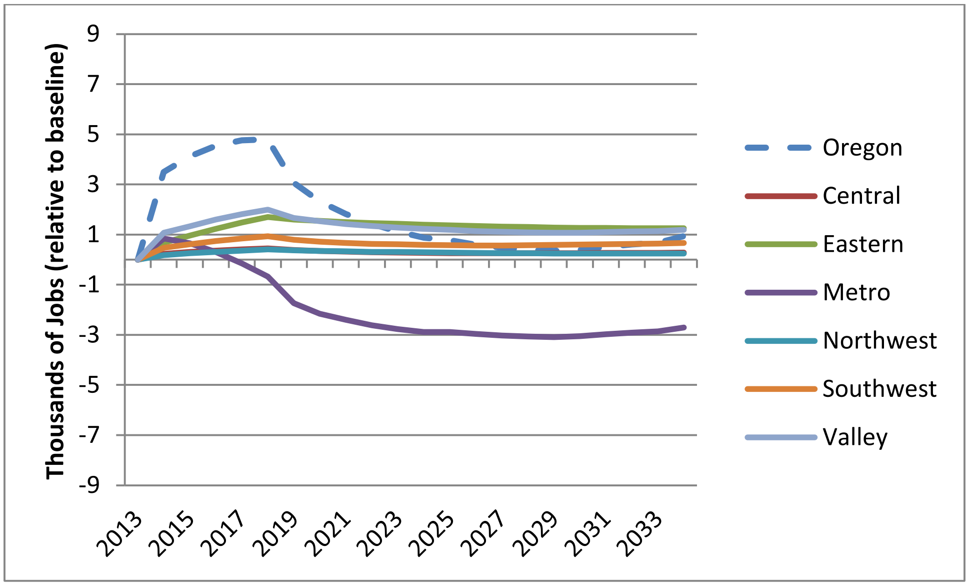


Figure 108 - Impacts for Low-Income Assistance and Targeted Income Support Scenario- $30/ton (Scenario D.1.1.2.30) Output

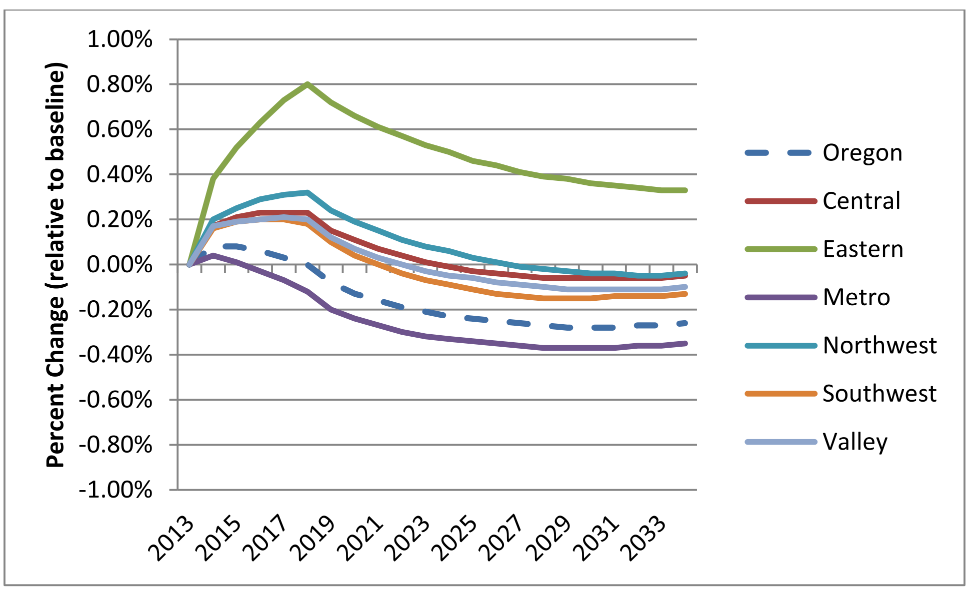


Figure 109 - Impacts for Low-Income Assistance and Targeted Income Support Scenario- $30/ton (Scenario D.1.1.2.30) Compensation

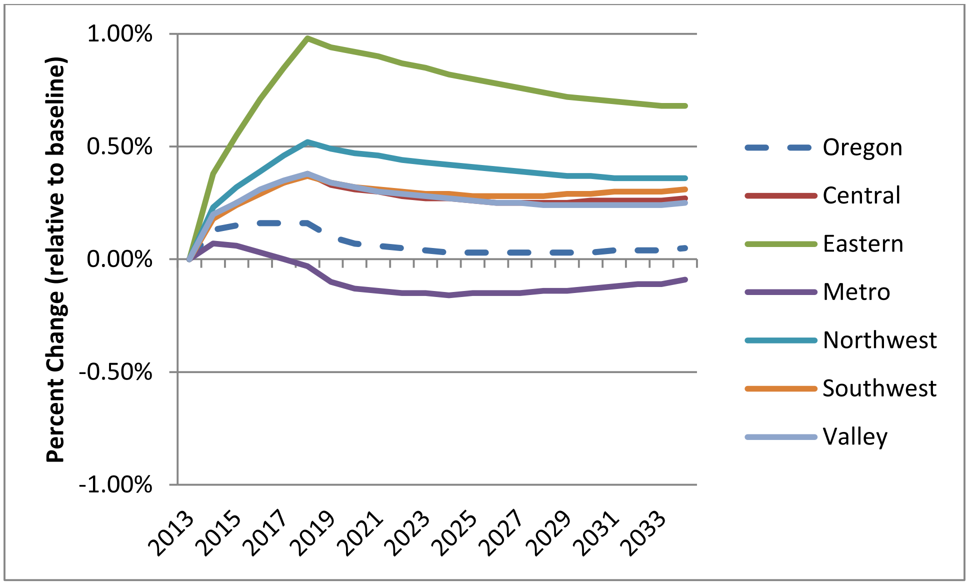
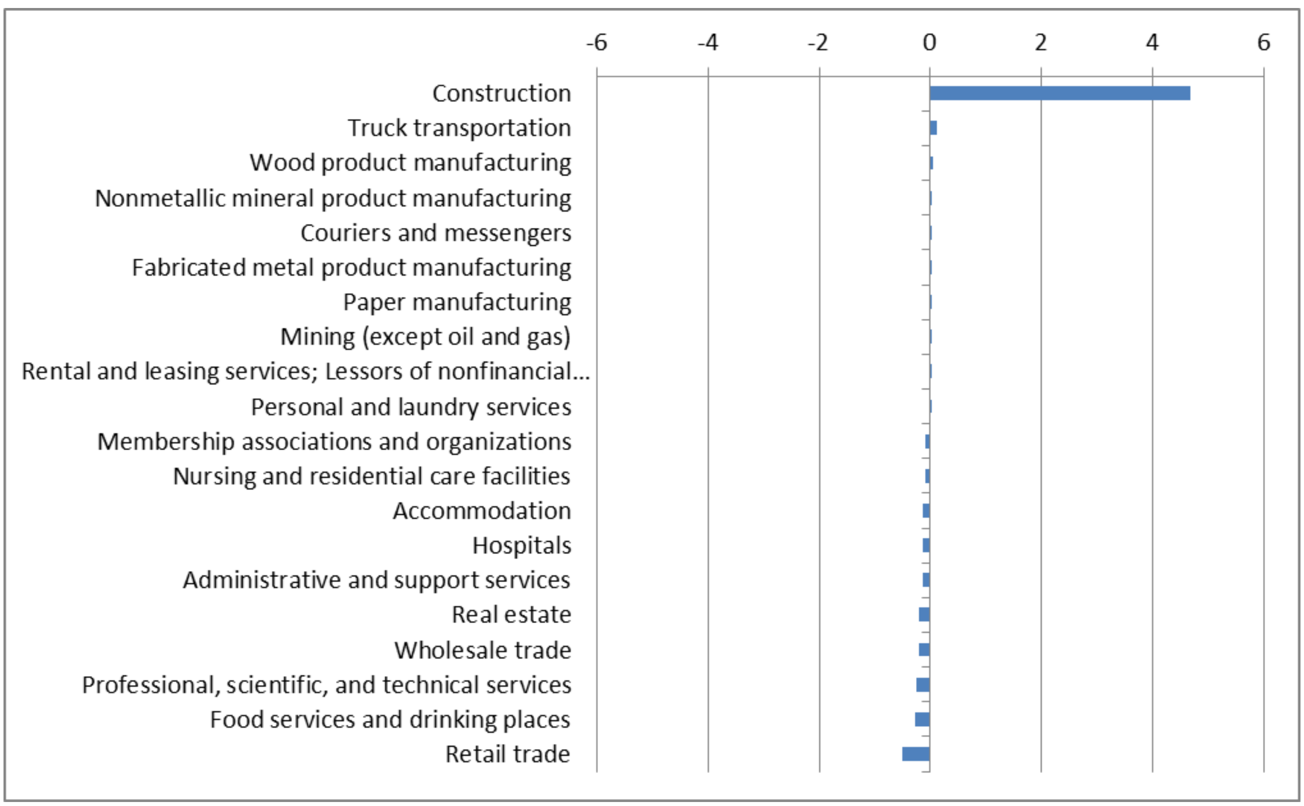


Figure 110 - Impacts for Low-Income Assistance and Targeted Income Support Scenario- $30/ton (Scenario D.1.1.2.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario D.1.2.30 - Impacts Energy Efficiency Investment- $30/ton

Figure 111 - Impacts Energy Efficiency Investment- $30/ton (Scenario D.1.2.30) Employment

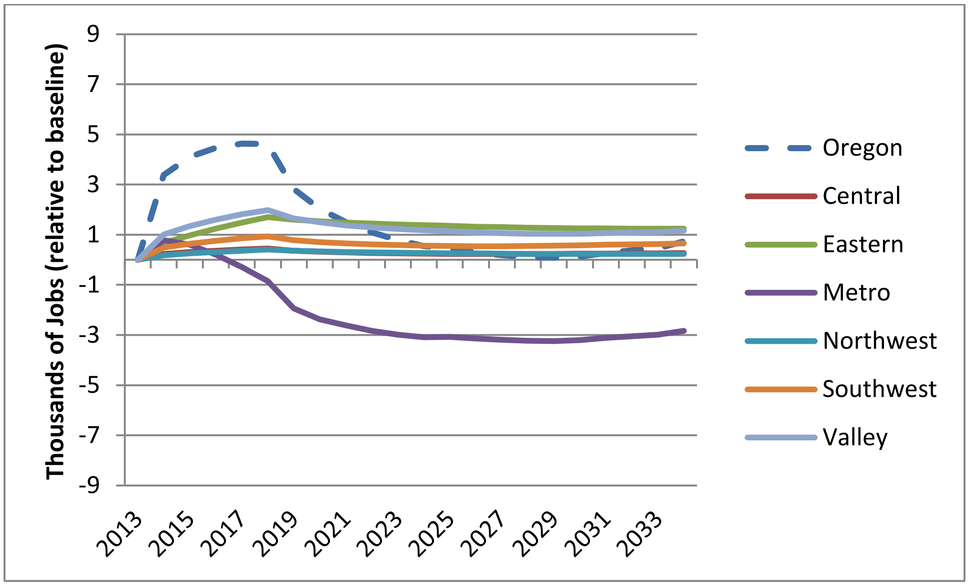


Figure 112 - Impacts Energy Efficiency Investment- $30/ton (Scenario D.1.2.30) Output

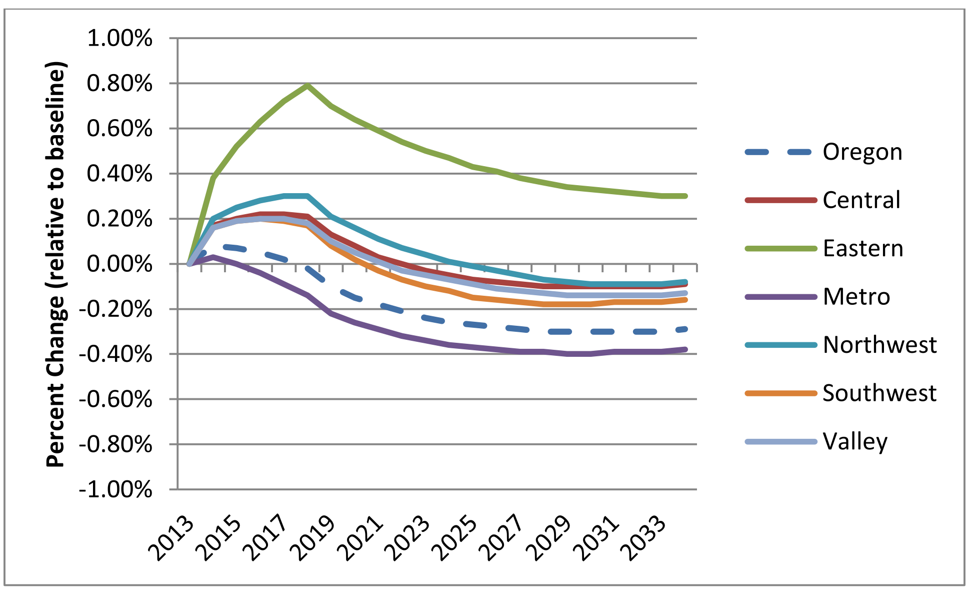


Figure 113 - Impacts Energy Efficiency Investment- $30/ton (Scenario D.1.2.30) Compensation

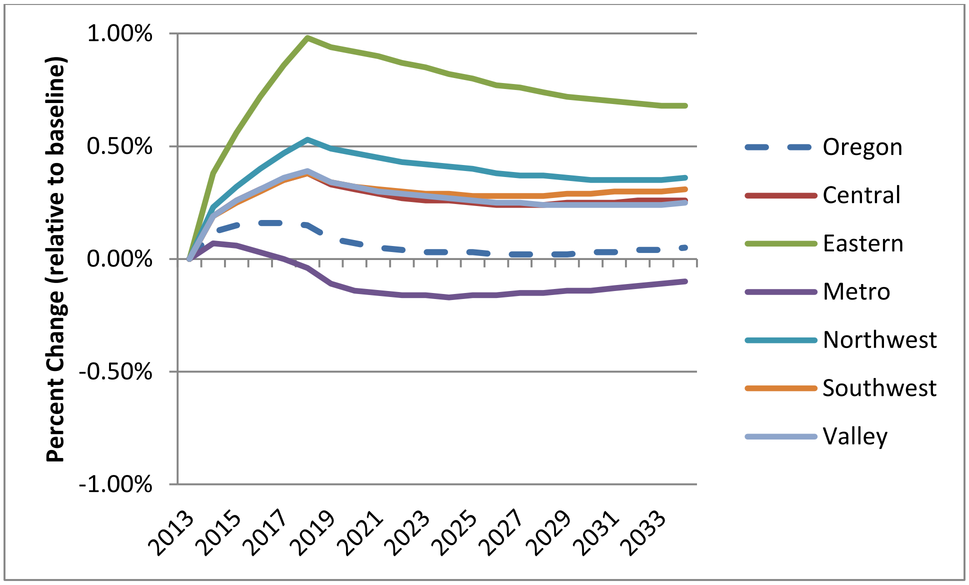
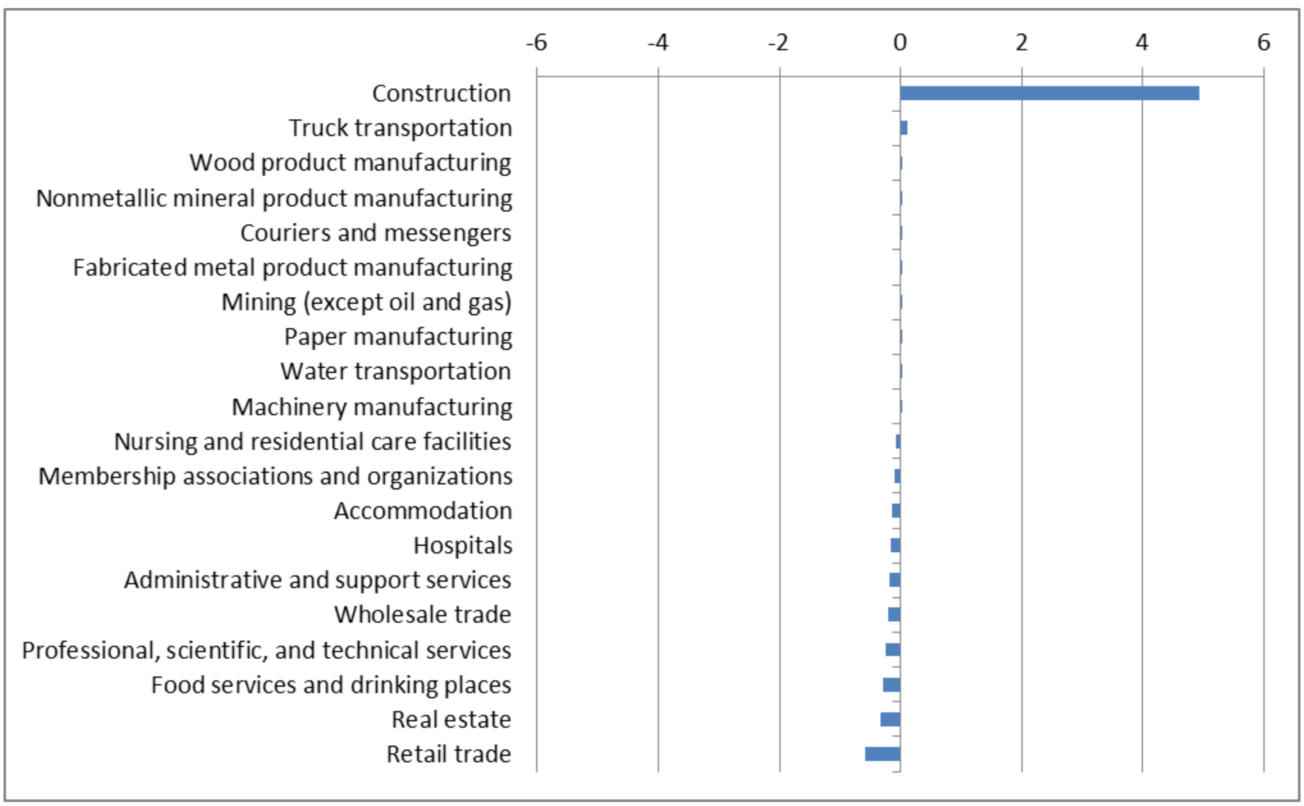


Figure 114 - Impacts Energy Efficiency Investment- $30/ton (Scenario D.1.2.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario D.1.4.1.60 - Business Carbon Tax Exemptions Impacts- $60/ton

Figure 115 - Business Carbon Tax Exemptions Impacts- $60/ton (Scenario D.1.4.1.60) Employment

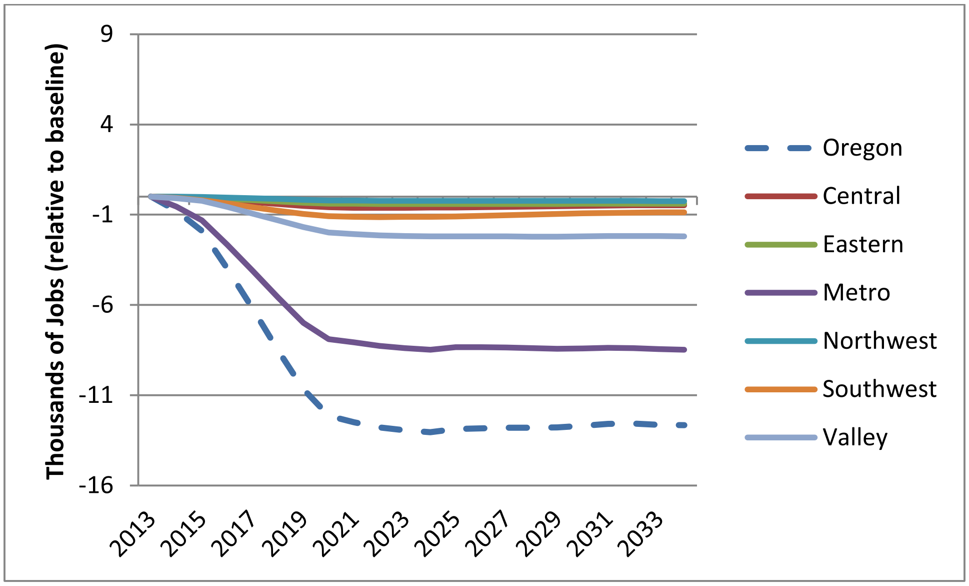


Figure 116 - Business Carbon Tax Exemptions Impacts- $60/ton (Scenario D.1.4.1.60) Output

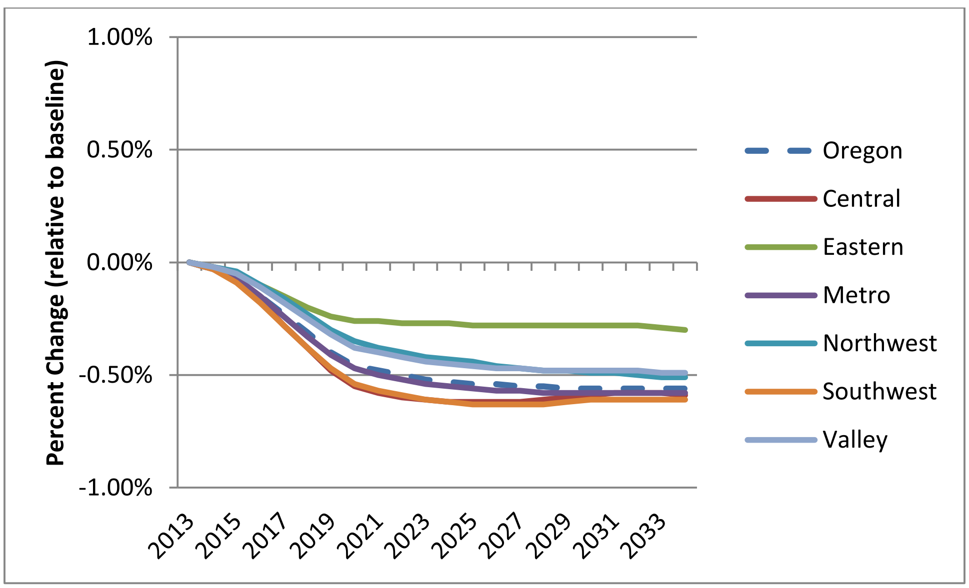


Figure 117 - Business Carbon Tax Exemptions Impacts- $60/ton (Scenario D.1.4.1.60) Compensation

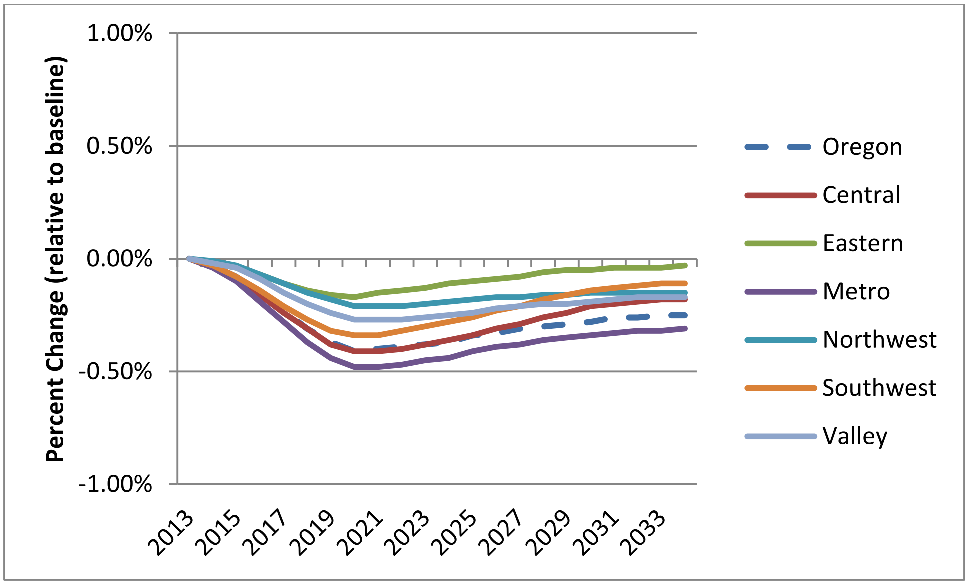
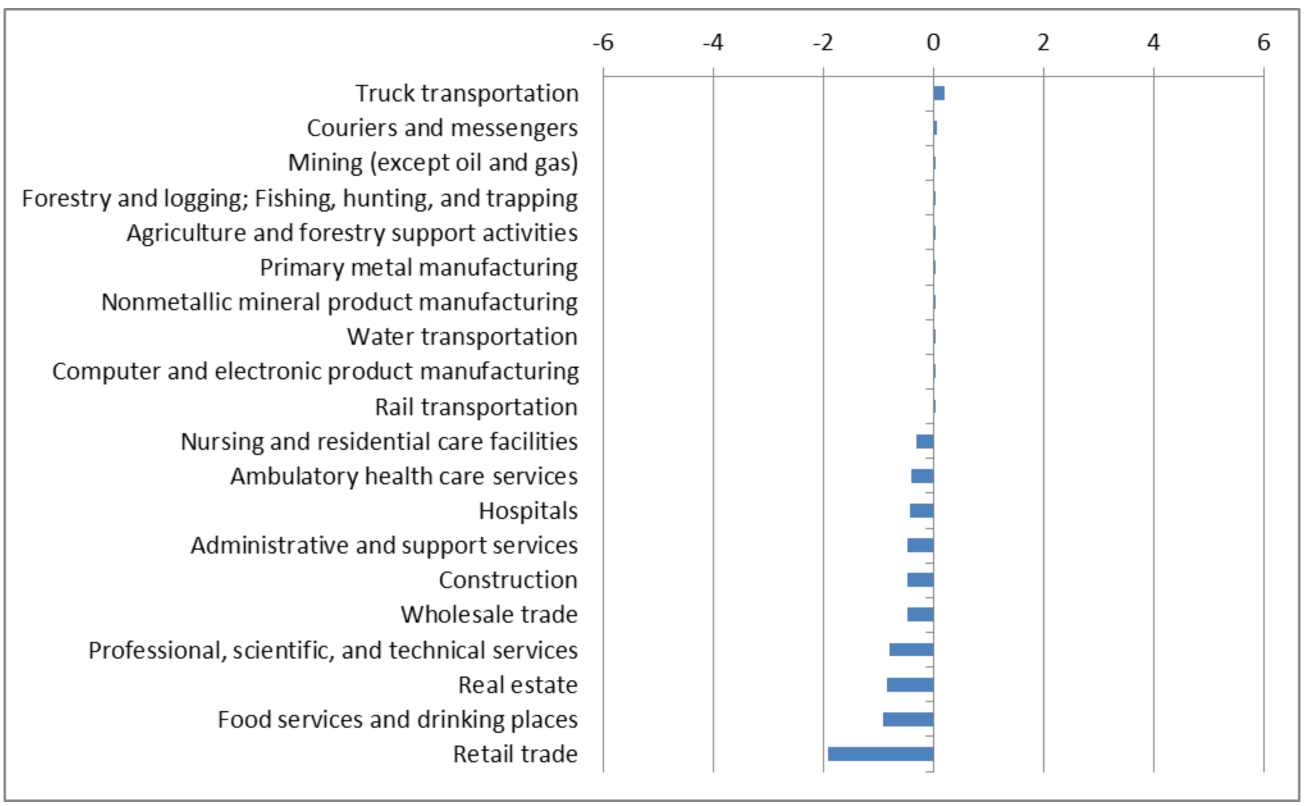


Figure 118 - Business Carbon Tax Exemptions Impacts- $60/ton (Scenario D.1.4.1.60) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario D.1.4.2.60 - Business Investment Fund Impacts- $60/ton

Figure 119 - Business Investment Fund Impacts- $60/ton (Scenario D.1.4.2.60) Employment

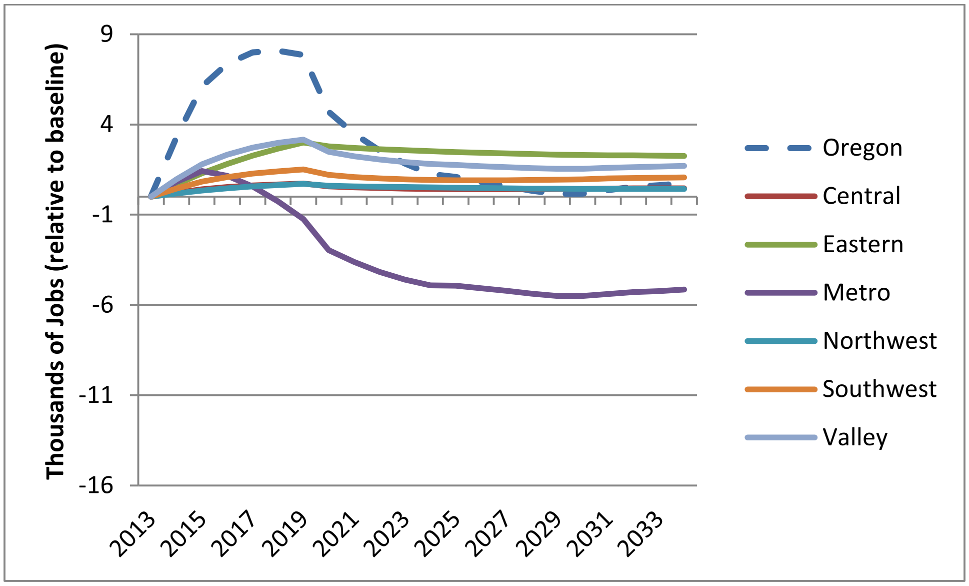


Figure 120 - Business Investment Fund Impacts- $60/ton (Scenario D.1.4.2.60) Output

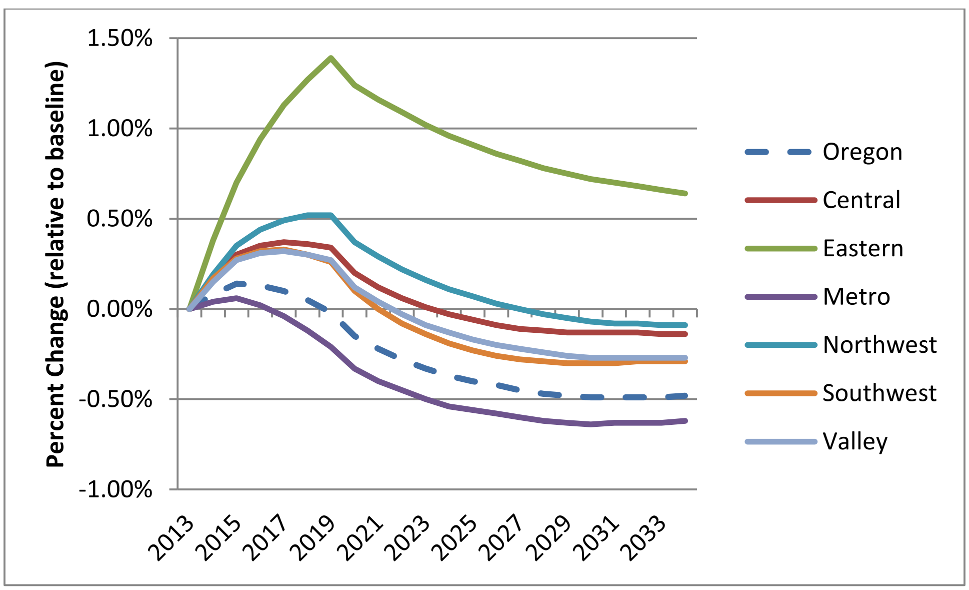


Figure 121 - Business Investment Fund Impacts- $60/ton (Scenario D.1.4.2.60) Compensation

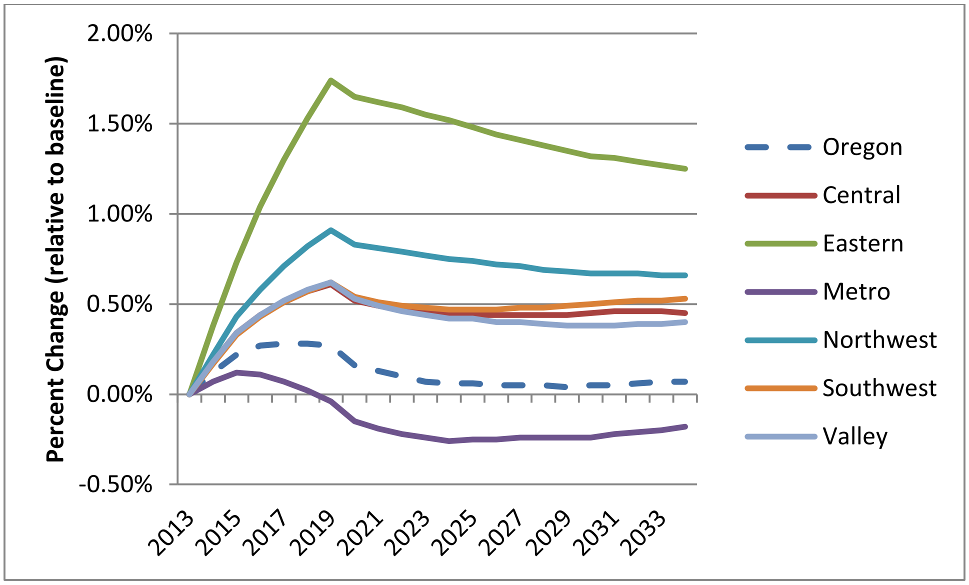
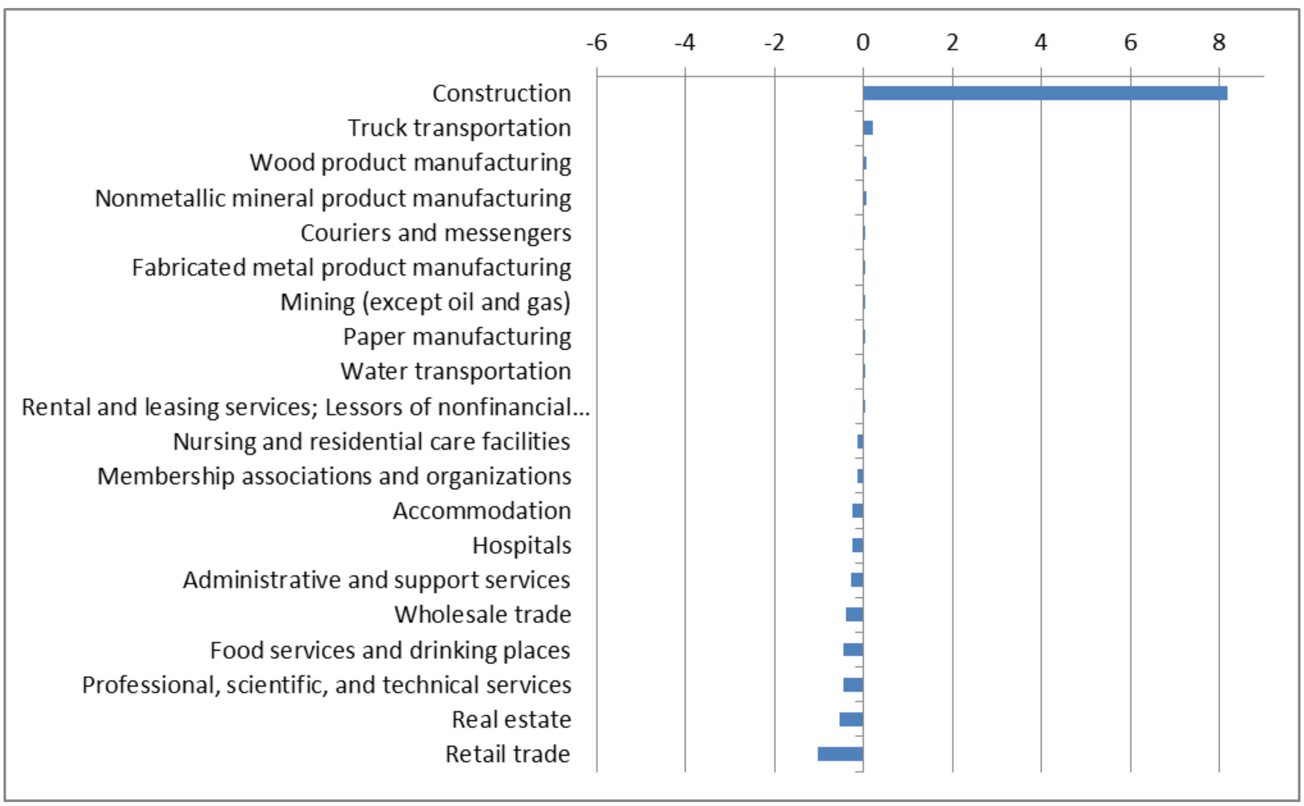


Figure 122 - Business Investment Fund Impacts- $60/ton (Scenario D.1.4.2.60) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario E.1.30 - Impacts for Unweighted VMT Disbursement- $30/ton

Figure 123 - Impacts for Unweighted VMT Disbursement- $30/ton (Scenario E.1.30) Employment

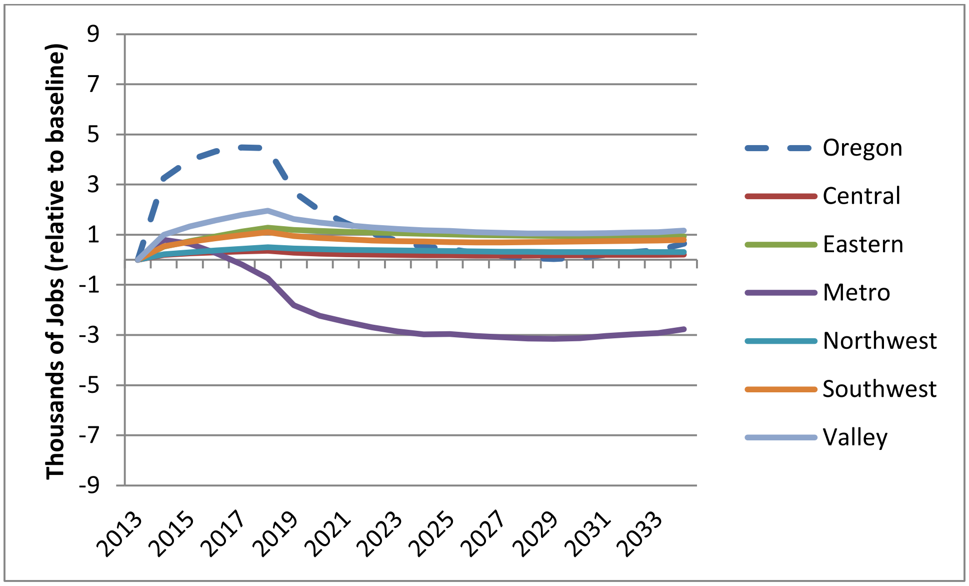


Figure 124 - Impacts for Unweighted VMT Disbursement- $30/ton (Scenario E.1.30) Output

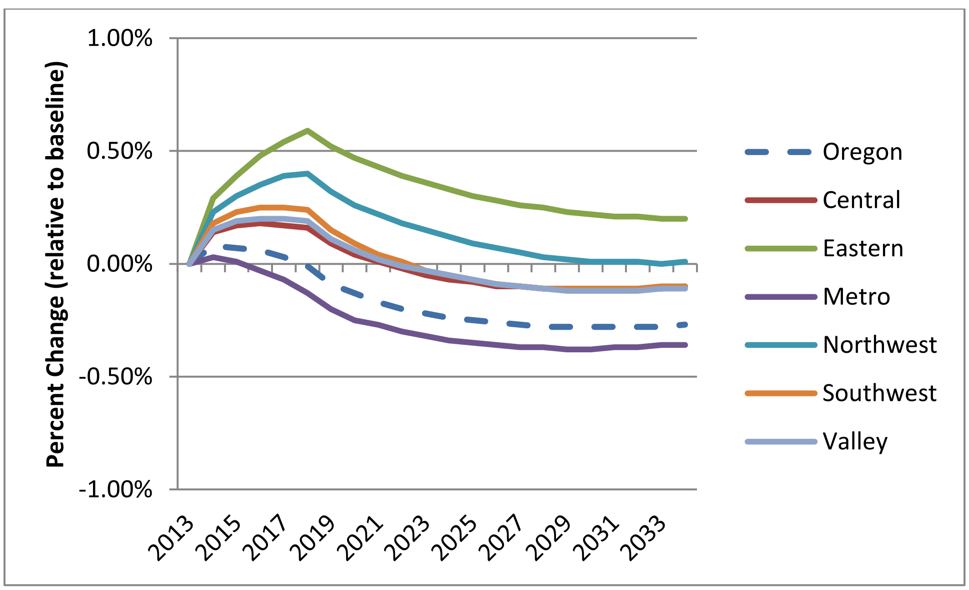


Figure 125 - Impacts for Unweighted VMT Disbursement- $30/ton (Scenario E.1.30) Compensation

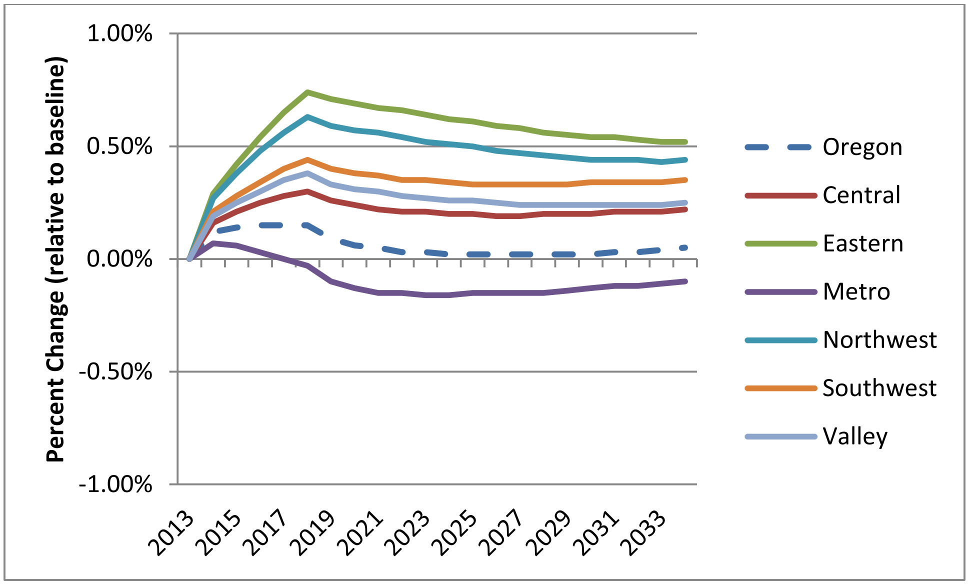
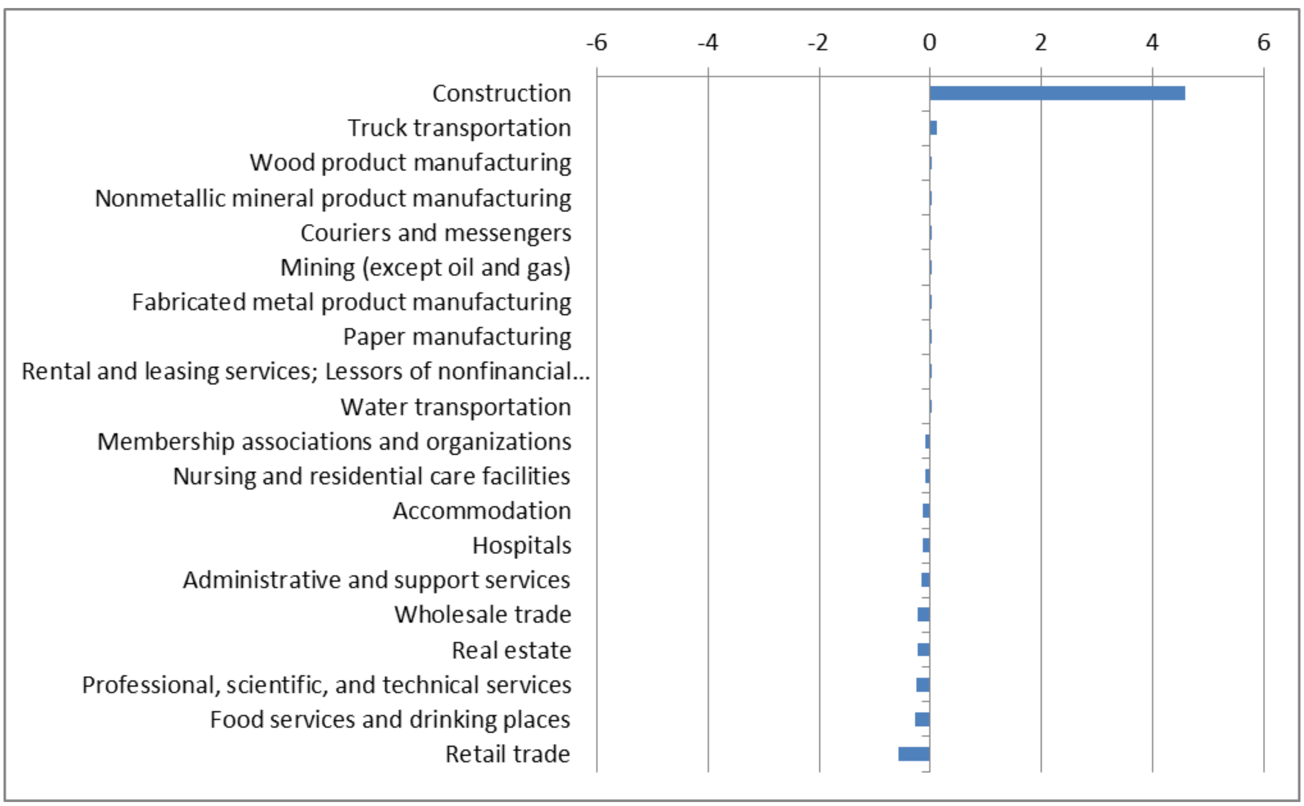


Figure 126 - Impacts for Unweighted VMT Disbursement- $30/ton (Scenario E.1.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario E.2.30 - Impacts for Revenue Neutral (Excluding Non-Residential Transportation-based Revenues) with 70% of Non-Transportation Revenues used for Corporate Income Tax Cuts and 30% of Non-Transportation Revenues for Personal Income Tax Cuts- $30/ton

Figure 127 - Impacts for Revenue Neutral (Excluding Non-Residential Transportation-based Revenues) with 70% of Non-Transportation Revenues used for Corporate Income Tax Cuts and 30% of Non-Transportation Revenues for Personal Income Tax Cuts- $30/ton (Scenario E.2.30) Employment

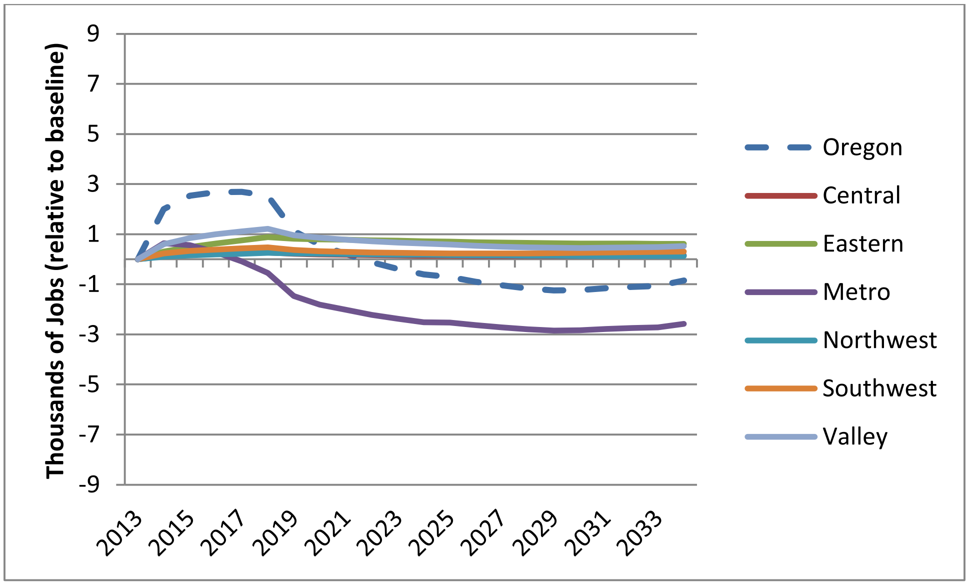


Figure 128 - Impacts for Revenue Neutral (Excluding Non-Residential Transportation-based Revenues) with 70% of Non-Transportation Revenues used for Corporate Income Tax Cuts and 30% of Non-Transportation Revenues for Personal Income Tax Cuts- $30/ton (Scenario E.2.30) Output

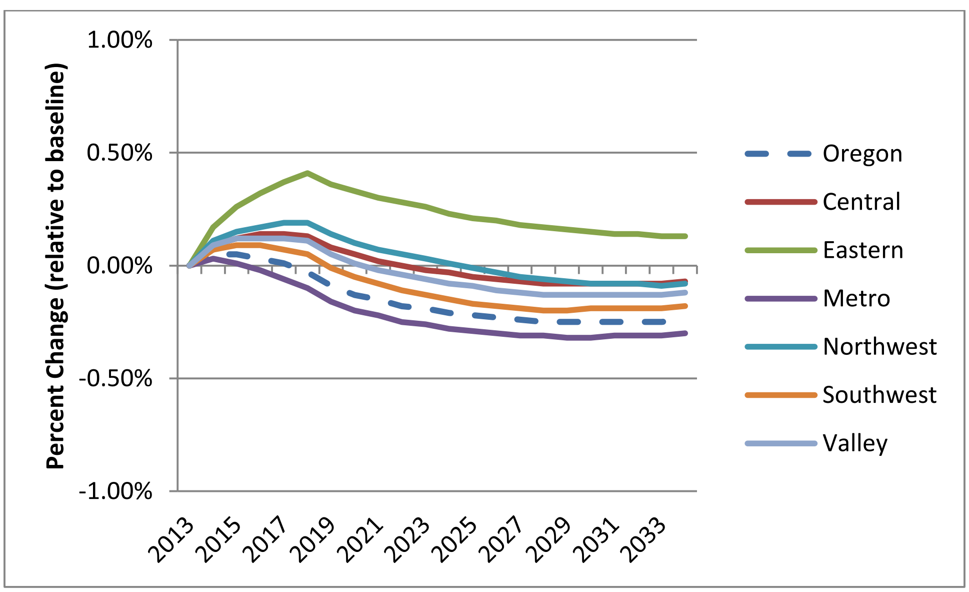


Figure 129 - Impacts for Revenue Neutral (Excluding Non-Residential Transportation-based Revenues) with 70% of Non-Transportation Revenues used for Corporate Income Tax Cuts and 30% of Non-Transportation Revenues for Personal Income Tax Cuts- $30/ton (Scenario E.2.30) Compensation

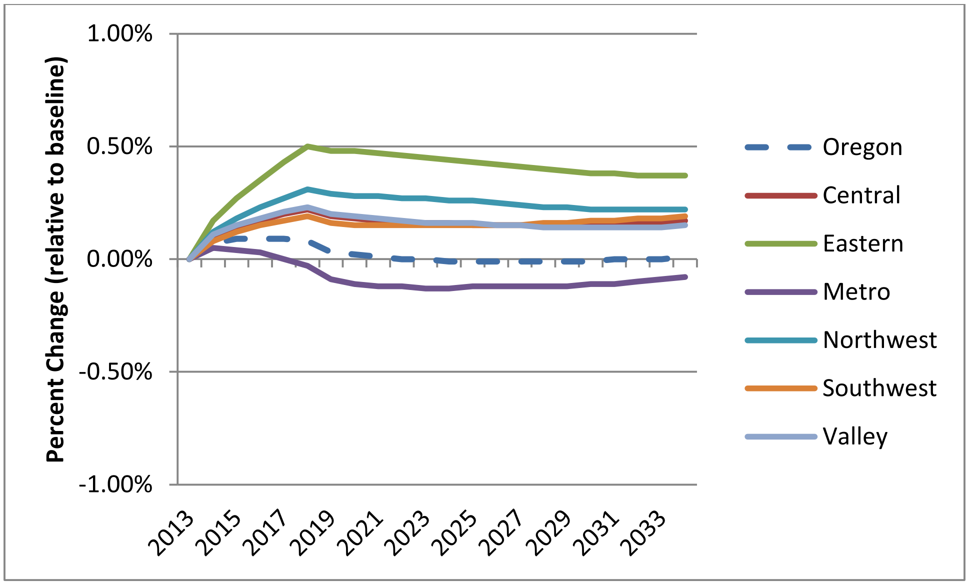
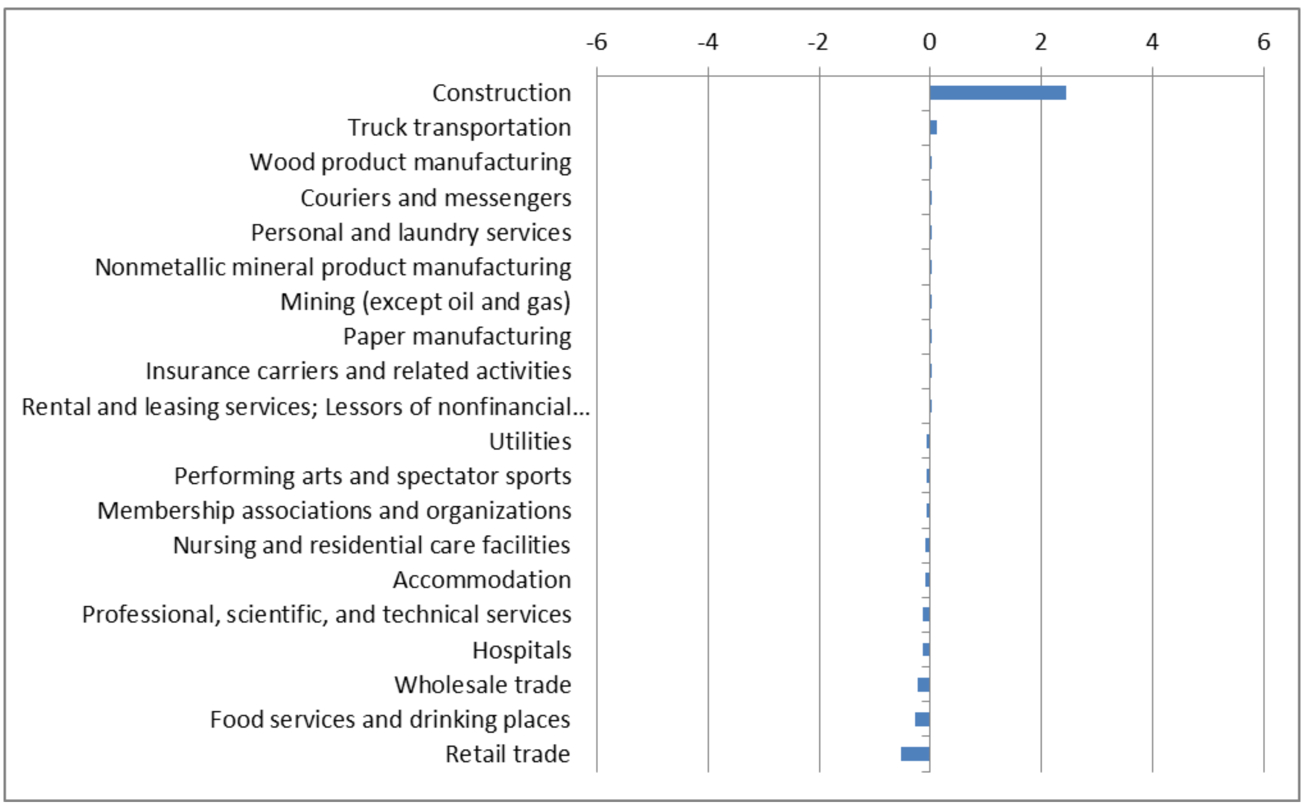


Figure 130 - Impacts for Revenue Neutral (Excluding Non-Residential Transportation-based Revenues) with 70% of Non-Transportation Revenues used for Corporate Income Tax Cuts and 30% of Non-Transportation Revenues for Personal Income Tax Cuts- $30/ton (Scenario E.2.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Scenario E.3.30 - Impacts for 50% of Transportation-based Revenues Dedicated to Non-Highway Transportation Projects with Remaining Revenues Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton

Figure 131 - Impacts for 50% of Transportation-based Revenues Dedicated to Non-Highway Transportation Projects with Remaining Revenues Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario E.3.30) Employment

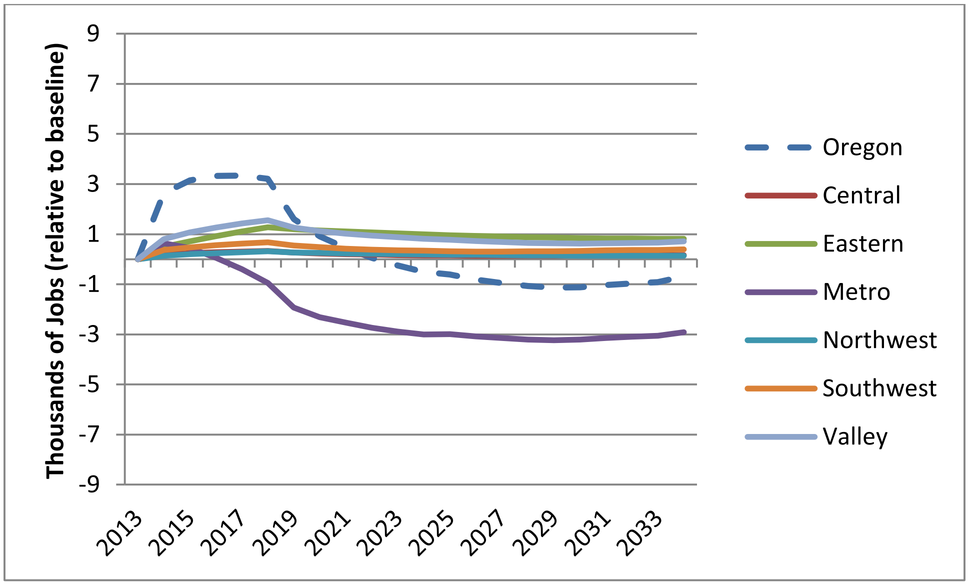


Figure 132 - Impacts for 50% of Transportation-based Revenues Dedicated to Non-Highway Transportation Projects with Remaining Revenues Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario E.3.30) Output

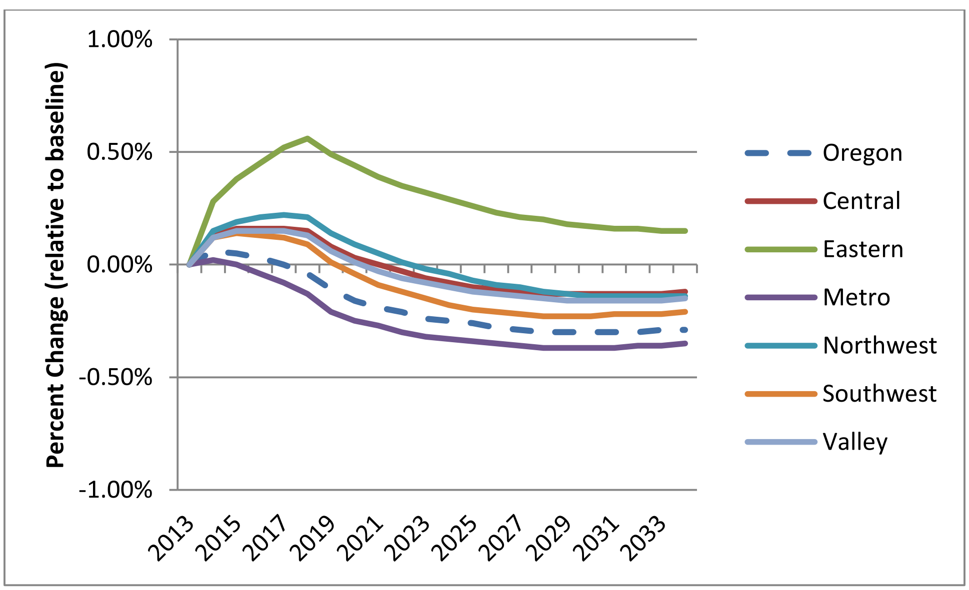


Figure 133 - Impacts for 50% of Transportation-based Revenues Dedicated to Non-Highway Transportation Projects with Remaining Revenues Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario E.3.30) Compensation

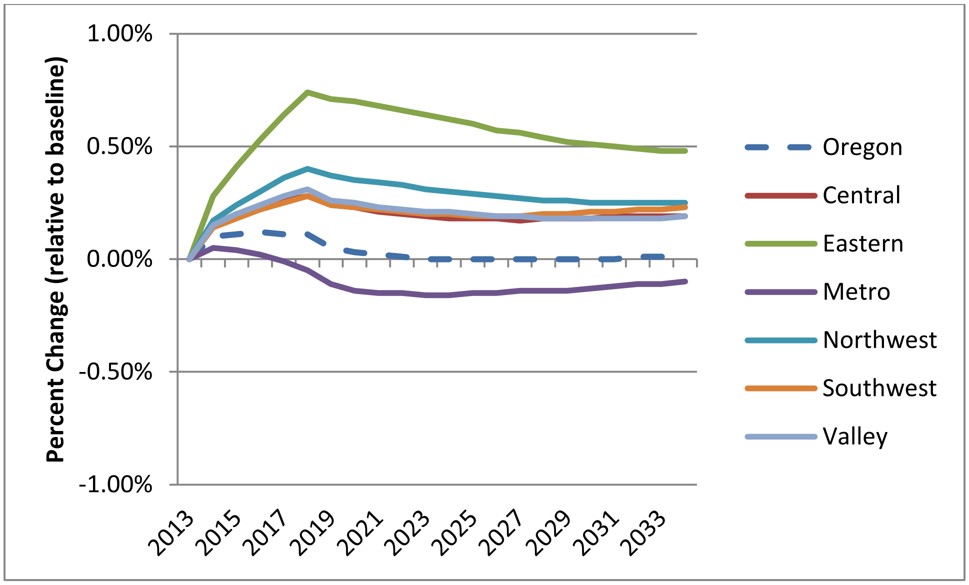
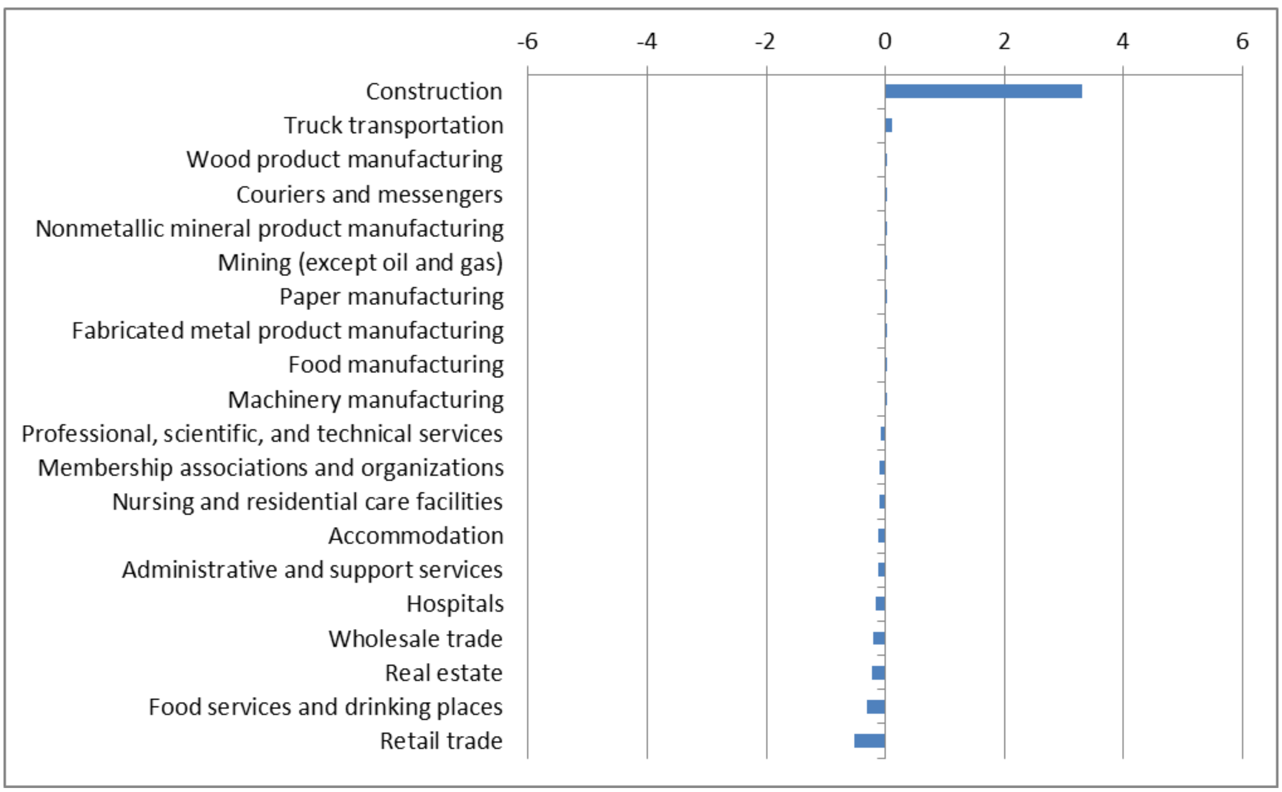


Figure 134 - Impacts for 50% of Transportation-based Revenues Dedicated to Non-Highway Transportation Projects with Remaining Revenues Split 70% to Corporate Income Tax Cuts and 30% to Personal Income Tax Cuts- $30/ton (Scenario E.3.30) Top 10/Bottom 10 Industry Sector Employment Impacts (1,000s of jobs)



Appendix III – Net Impacts by Income Quintile

This appendix breaks out the net effect of implementing a carbon tax and using the revenues for repatriation and expenditures by income quintile and region. The first quintile is comprised of the households with the lowest incomes, while the fifth quintile is households with the highest incomes. The numbers in the tables represent the net income change for each group in aggregate. Impacts change depending on the repatriation and expenditure options. These results are from Scenario C.3.30, in which transportation-related revenues are dedicated to the Highway Trust Fund and all remaining revenues are repatriated as personal income tax cuts. Other scenarios would produce different results but the relative effects for each quintile in each region would comparable.

Table 6 - Metro

Quintile	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1st	-$11,809,917	-$17,283,601	-$22,543,652	-$27,637,261	-$32,591,001	-$32,181,881	-$31,806,824	-$31,473,884	-$31,531,014	-$31,612,487	-$31,684,971
2nd	-$11,881,259	-$17,292,217	-$22,616,955	-$27,796,635	-$32,791,459	-$32,294,842	-$32,039,503	-$31,813,360	-$31,845,629	-$31,895,055	-$31,921,756
3rd	-$10,017,559	-$14,391,786	-$18,945,865	-$23,421,571	-$27,654,800	-$27,069,242	-$27,093,317	-$27,116,157	-$27,093,904	-$27,071,726	-$27,003,543
4th	-$3,770,741	-$4,975,337	-$6,841,388	-$8,781,225	-$10,426,147	-$9,813,480	-$10,385,298	-$10,895,872	-$10,771,210	-$10,612,745	-$10,373,847
5th	$65,025,779	$97,386,611	$125,584,982	$152,347,468	$179,364,013	$179,084,159	$174,188,806	$169,831,026	$170,730,423	$171,934,002	$173,405,517

Quintile	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1st	-$28,777,560	-$28,725,134	-$28,700,313	-$28,677,917	-$28,667,138	-$28,571,520	-$28,811,671	-$29,065,435	-$29,300,127	-$29,620,212
2nd	-$28,091,587	-$28,033,747	-$27,999,512	-$27,961,844	-$27,929,631	-$27,855,955	-$27,986,443	-$28,130,698	-$28,254,888	-$28,463,592
3rd	-$21,997,966	-$21,939,197	-$21,892,153	-$21,830,692	-$21,761,601	-$21,743,671	-$21,635,660	-$21,539,396	-$21,424,491	-$21,378,109
4th	-$4,313,693	-$4,268,056	-$4,207,609	-$4,114,645	-$3,990,055	-$4,087,198	-$3,533,936	-$2,985,423	-$2,425,844	-$1,885,629
5th	$178,399,601	$178,229,208	$178,307,493	$178,535,376	$178,971,834	$177,922,849	$181,823,185	$185,796,823	$189,685,821	$194,077,328

Table 7 - Valley

Quintile	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1st	-$12,332,596	-$7,212,446	-$9,407,187	-$11,532,376	-$13,599,399	-$13,429,064	-$13,272,016	-$13,132,601	-$13,156,553	-$13,190,695	-$13,221,148
2nd	-$15,310,792	-$7,514,109	-$9,823,567	-$12,068,490	-$14,236,227	-$14,026,531	-$13,907,194	-$13,801,449	-$13,817,211	-$13,840,932	-$13,855,738
3rd	-$18,171,481	-$6,195,010	-$8,150,689	-$10,071,026	-$11,890,349	-$11,644,826	-$11,646,216	-$11,648,042	-$11,640,326	-$11,633,181	-$11,607,260
4th	-$18,932,627	-$1,586,481	-$2,220,223	-$2,890,884	-$3,439,486	-$3,189,672	-$3,446,804	-$3,676,334	-$3,621,057	-$3,550,511	-$3,445,752
5th	-$359,279	$32,399,508	$41,739,633	$50,587,811	$59,550,314	$59,515,127	$57,806,940	$56,286,184	$56,601,917	$57,023,625	$57,543,583

Quintile	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1st	-$12,012,009	-$11,990,155	-$11,979,840	-$11,970,562	-$11,966,160	-$11,926,160	-$12,026,866	-$12,133,253	-$12,231,685	-$12,365,755
2nd	-$12,255,793	-$12,231,036	-$12,216,817	-$12,201,516	-$12,189,016	-$12,155,464	-$12,219,840	-$12,290,189	-$12,351,887	-$12,450,374
3rd	-$9,521,537	-$9,496,642	-$9,477,096	-$9,451,782	-$9,423,645	-$9,414,281	-$9,376,003	-$9,342,771	-$9,301,589	-$9,289,971
4th	-$938,643	-$920,730	-$895,590	-$856,427	-$803,332	-$848,026	-$603,125	-$359,831	-$112,394	$129,443
5th	$59,816,331	$59,763,217	$59,795,500	$59,881,439	$60,040,862	$59,677,286	$61,047,725	$62,442,454	$63,809,676	$65,344,689

Table 8 - Southwest

Quintile	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1st	-$1,985,386	-$2,906,431	-$3,790,414	-$4,646,217	-$5,478,899	-$5,410,880	-$5,346,740	-$5,289,799	-$5,299,628	-$5,313,615	-$5,326,212
2nd	-$2,161,655	-$3,152,261	-$4,118,923	-$5,057,757	-$5,965,791	-$5,880,892	-$5,826,610	-$5,778,485	-$5,785,973	-$5,797,053	-$5,804,877
3rd	-$1,980,641	-$2,861,645	-$3,756,516	-$4,632,119	-$5,467,219	-$5,365,775	-$5,349,976	-$5,336,153	-$5,336,001	-$5,337,100	-$5,331,410
4th	-$799,136	-$1,083,936	-$1,469,271	-$1,863,346	-$2,208,518	-$2,104,868	-$2,188,476	-$2,263,163	-$2,244,508	-$2,220,948	-$2,184,557
5th	$9,023,422	$13,534,325	$17,440,352	$21,142,383	$24,889,020	$24,868,197	$24,163,043	$23,535,278	$23,665,424	$23,839,334	$24,053,323

Quintile	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1st	-$4,845,516	-$4,836,748	-$4,832,657	-$4,829,027	-$4,827,406	-$4,811,131	-$4,852,494	-$4,896,145	-$4,936,598	-$4,991,418
2nd	-$5,166,098	-$5,155,901	-$5,150,267	-$5,144,385	-$5,139,895	-$5,125,046	-$5,155,916	-$5,189,285	-$5,219,061	-$5,264,302
3rd	-$4,494,284	-$4,483,524	-$4,475,784	-$4,466,183	-$4,456,124	-$4,448,784	-$4,446,155	-$4,445,837	-$4,441,982	-$4,451,909
4th	-$1,179,074	-$1,170,973	-$1,161,016	-$1,145,977	-$1,126,155	-$1,139,806	-$1,056,781	-$974,742	-$890,627	-$811,046
5th	$24,938,090	$24,915,525	$24,928,351	$24,963,180	$25,028,273	$24,877,938	$25,442,713	$26,017,645	$26,581,018	$27,214,418

Table 9 - Central

Quintile	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1st	-$1,083,857	-$1,586,671	-$2,069,253	-$2,536,451	-$2,991,026	-$2,953,893	-$2,918,879	-$2,887,793	-$2,893,159	-$2,900,795	-$2,907,672
2nd	-$1,185,339	-$1,728,679	-$2,258,697	-$2,773,421	-$3,271,322	-$3,224,896	-$3,194,947	-$3,168,395	-$3,172,539	-$3,178,663	-$3,183,023
3rd	-$1,081,368	-$1,562,373	-$2,050,943	-$2,528,992	-$2,984,931	-$2,929,549	-$2,920,918	-$2,913,367	-$2,913,285	-$2,913,886	-$2,910,781
4th	-$472,923	-$646,206	-$872,615	-$1,103,089	-$1,306,807	-$1,249,676	-$1,293,118	-$1,331,932	-$1,322,140	-$1,309,808	-$1,290,559
5th	$5,730,770	$8,584,206	$11,068,850	$13,426,609	$15,807,428	$15,784,054	$15,350,773	$14,965,069	$15,044,715	$15,151,281	$15,281,668

Quintile	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1st	-$2,645,250	-$2,640,463	-$2,638,231	-$2,636,249	-$2,635,364	-$2,626,479	-$2,649,059	-$2,672,889	-$2,694,973	-$2,724,900
2nd	-$2,834,110	-$2,828,527	-$2,825,451	-$2,822,248	-$2,819,818	-$2,811,642	-$2,828,736	-$2,847,201	-$2,863,697	-$2,888,675
3rd	-$2,453,774	-$2,447,899	-$2,443,674	-$2,438,433	-$2,432,942	-$2,428,933	-$2,427,503	-$2,427,334	-$2,425,233	-$2,430,658
4th	-$740,317	-$735,775	-$730,341	-$722,190	-$711,517	-$718,481	-$674,847	-$631,792	-$587,552	-$546,064
5th	$15,735,525	$15,720,586	$15,727,625	$15,747,938	$15,786,728	$15,693,939	$16,039,363	$16,391,246	$16,735,683	$17,124,428

Table 10 - Eastern

Quintile	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1st	-$1,209,389	-$1,769,900	-$2,308,560	-$2,830,179	-$3,337,466	-$3,295,554	-$3,257,170	-$3,223,096	-$3,228,942	-$3,237,279	-$3,244,693
2nd	-$1,301,357	-$1,896,558	-$2,478,906	-$3,044,772	-$3,591,560	-$3,539,419	-$3,508,219	-$3,480,566	-$3,484,769	-$3,491,045	-$3,495,194
3rd	-$1,117,819	-$1,610,397	-$2,117,030	-$2,613,872	-$3,085,719	-$3,024,352	-$3,021,338	-$3,018,802	-$3,017,497	-$3,016,543	-$3,011,095
4th	-$306,071	-$390,493	-$546,549	-$711,715	-$846,789	-$785,205	-$848,626	-$905,239	-$891,606	-$874,207	-$848,372
5th	$4,691,796	$7,050,307	$9,076,798	$10,994,172	$12,940,746	$12,941,488	$12,558,241	$12,217,025	$12,288,125	$12,382,978	$12,500,532

Quintile	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1st	-$2,946,787	-$2,941,417	-$2,938,874	-$2,936,577	-$2,935,469	-$2,925,682	-$2,950,253	-$2,976,218	-$3,000,230	-$3,032,987
2nd	-$3,099,662	-$3,093,461	-$3,089,957	-$3,086,232	-$3,083,270	-$3,074,604	-$3,091,841	-$3,110,583	-$3,127,152	-$3,153,014
3rd	-$2,494,843	-$2,488,523	-$2,483,707	-$2,477,556	-$2,470,845	-$2,467,792	-$2,460,932	-$2,455,379	-$2,447,787	-$2,447,907
4th	-$230,270	-$225,855	-$219,657	-$210,001	-$196,909	-$207,934	-$147,534	-$87,530	-$26,506	$33,141
5th	$13,083,734	$13,072,695	$13,080,624	$13,100,793	$13,137,546	$13,056,315	$13,365,092	$13,679,141	$13,987,298	$14,332,057

Table 11 - Northwest

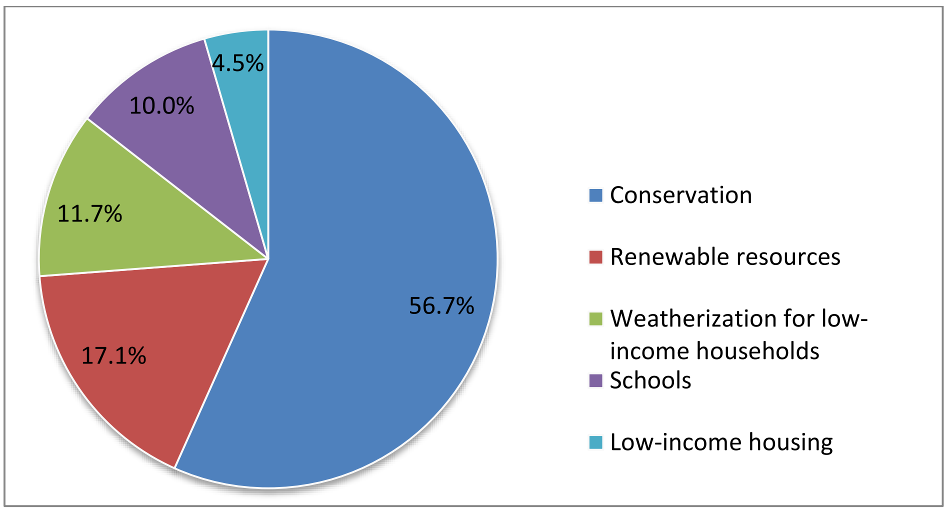
Quintile	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1st	-$683,011	-$999,494	-$1,303,729	-$1,598,357	-$1,884,859	-$1,861,127	-$1,839,538	-$1,820,374	-$1,823,657	-$1,828,342	-$1,832,495
2nd	-$698,072	-$1,016,209	-$1,328,982	-$1,633,182	-$1,926,622	-$1,897,640	-$1,882,356	-$1,868,817	-$1,870,772	-$1,873,751	-$1,875,426
3rd	-$531,949	-$761,753	-$1,004,432	-$1,243,527	-$1,468,607	-$1,435,316	-$1,439,746	-$1,443,770	-$1,441,937	-$1,439,919	-$1,435,104
4th	-$70,328	-$68,042	-$111,350	-$161,820	-$195,382	-$161,985	-$204,171	-$241,810	-$232,971	-$221,608	-$205,208
5th	$2,640,799	$3,968,656	$5,109,152	$6,188,149	$7,283,745	$7,284,480	$7,068,312	$6,875,851	$6,915,964	$6,969,474	$7,035,812

Quintile	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1st	-$1,663,594	-$1,660,557	-$1,659,114	-$1,657,806	-$1,657,165	-$1,651,654	-$1,665,450	-$1,680,034	-$1,693,513	-$1,711,930
2nd	-$1,652,482	-$1,649,096	-$1,647,106	-$1,644,927	-$1,643,084	-$1,638,703	-$1,646,627	-$1,655,359	-$1,662,915	-$1,675,439
3rd	-$1,145,917	-$1,142,664	-$1,139,927	-$1,136,272	-$1,132,051	-$1,131,681	-$1,123,075	-$1,115,095	-$1,106,102	-$1,100,712
4th	$141,724	$143,892	$147,413	$153,058	$160,904	$153,273	$192,304	$231,227	$270,585	$309,941
5th	$7,367,451	$7,361,256	$7,365,754	$7,377,163	$7,397,929	$7,352,123	$7,526,335	$7,703,513	$7,877,379	$8,071,851

Appendix IV – Public-Purpose Charge Background

Senate Bill 1149 was enacted in 1999, and required the investor-owned utilities of Oregon (Portland General Electric and Pacific Power) to start collecting a 3% public-purpose charge from its customers in March 2002 to "fund energy conservation and renewable energy programs and to help provide weatherization and other energy assistance to low-income households and public schools"[48] for 10 years. The statutory allocation of public-purpose charge revenues is detailed in Figure 135. Energy Trust of Oregon (ETO) administers the conservation and renewable resources portion of the charge, school districts within the investor-owned utility service areas administer the schools portion, and Oregon Housing and Community Services (OHCS) administers the weatherization for low-income households and low-income housing portions. Table 12 provides details on the expenditures by each of the administrators of the public charge funds. In 2007, Senate Bill 838 (Renewal Portfolio Standard) extended the authority for public-purpose charge collection to 2026 and allowed additional incremental funding for ETO from Portland General Electric and Pacific Power.

Figure 135 - Distribution of Oregon Public-Purpose Charge[49]



[48]http://www.puc.state.or.us/electric_restruc/purpose/FINAL13PPCSpendingReport.pdf
[49] Source: http://www.oregon.gov/energy/cons/pages/sb1149/business/ppcinvest.aspx

Table 12 - Oregon Public Purpose Charge Expenditure Distribution[50]

	2003 & 2004	2005 & 2006	2007 & 2008	2009 & 2010	2011 & 2012
ETO	$68,500,512	$65,174,397	$98,210,685	$128,273,516	$135,891,398
School Districts	$9,879,272	$11,160,022	$17,947,638	$20,159,346	$17,220,791
OHCS	$13,016,692	$14,962,655	$26,255,094	$28,292,385	$25,455,320
Total Expenditures	$91,396,476	$91,297,074	$142,413,417	$176,725,247	$178,567,509

I. Energy Trust of Oregon (ETO)

Beginning operations in March 2002, Energy Trust of Oregon, Inc. (ETO) is a nonprofit organization charged by the Oregon Public Utility Commission (OPUC) to help Oregon homes and businesses with energy efficiency and renewal energy solutions. It is overseen by a volunteer board of directors and two advisory councils (Conservation Advisory Council and Renewable Energy Advisory Council). ETO is funded by and directly benefits customers of Portland General Electric, Pacific Power, NW Natural and Cascade Natural Gas in Oregon through the public-purpose charge (73.8% of the total charge revenue is administered by ETO: 56.7% for conservation purposes and 17.1% for renewable resources). The table below details ETO's revenues, expenditures and outcomes of energy efficiency and renewable energy generation project. In the past 5 years, the average total expenditure by ETO is $128,200,635, resulting in an average annual savings of 47.10 MWa[51] for electricity, 4.82 million therms for natural gas and an annual average renewable energy generation of 3.07 MWa.

[50] Source: OPUC Public Purpose Expenditures Reports - http://www.puc.state.or.us/pages/electric_restruc/indices/ppindex.aspx

[51] Average Megawatts

Table 13 - Energy Trust of Oregon Annual Revenues, Expenditures and Results[52]

	2009	2010	2011	2012	2013
ETO Actual Revenue	$90,841,542	$124,715,769	$132,433,163	$144,844,553	$161,173,914
ETO Actual Expenditure					
Energy Efficiency	$80,145,759	$98,962,482	$116,572,388	$127,170,657	$116,979,428
Renewable Energy	$13,135,514	$19,145,851	$18,027,846	$21,817,901	$7,918,893
Administration	$3,666,524	$4,116,466	$3,976,898	$5,135,474	$4,231,092
Results					
Electricity Energy Efficiency Savings (aMW)	32.30	45.65	46.89	52.86	57.80
Gas Energy Efficiency Savings (Therms)	2,856,642	4,622,778	5,407,244	5,915,717	5,309,550
Renewal Energy Generation (aMW)	2.64	3.29	1.48	5.05	2.87

II. School District Energy Efficiency

Energy efficiency audits and investments for K-12 schools have been funded by the Oregon public-purpose charge since 2002. 10% of all public-purpose charge revenues are set aside for this specific purpose. In addition, the Governor's School Energy Audit Initiative provided additional funding from the American Recovery & Reinvestment Act in 2011. Oregon Department of Energy (ODOE) is currently leading a pilot Cool Schools program that expands financing mechanisms for public school energy efficiency investments and upgrades. ODOE school audits data provides information on potential energy efficiency measures[53] and operation & maintenance measures[54], costs associated with the measures, energy savings (electric, demand electric, natural gas, diesel, propane, #5 gas, kerosene and steam), and cost savings from lower energy usage. Although the school audits identified 834 potential measures costing $37,514,202 in 2011 and 2012, only a total of $15,667,374 was actually spent on installing 505 measures in these two years (OPUC 2013). The table below summarizes the audit results as well as actual installation results.

On the past 8 years, the average cost differential between the potential measures identified by the audits and the actual installed measures is $23,324,174 per year, translating to average annual cost savings of $925,068 from energy savings of 3,330,208 kWh from electricity, 293,476 therms from natural gas and 174,428 gallons of other fuels.

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[52] Source: Energy Trust of Oregon Annual Reports to the Oregon Public Utility Commission * Energy Trust Board of Directors http://energytrust.org/about/policy-and-reports/Reports.aspx

[53] Energy efficiency measures may include building envelope, controls, cooling, domestic hot water, electrical equipment, heating, kitchen equipment/systems, lighting, retrocommissioning and ventilation/distribution.

[54] Operation & maintenance measures apply to the same types of systems as above.

Table 14 - Oregon Department of Energy Schools Energy Efficiency Program[55]

	2005 & 2006	2007 & 2008	2009 & 2010	2011 & 2012
Audit Results				
Potential Measures	1143	2071	452	834
Cost of Potential Measures	$42,079,583	$95,412,276	$74,589,221	$37,514,202
Potential Annual Cost Savings	$2,123,099	$5,529,466	$2,747,843	$2,561,252
Potential Annual Energy Savings				
Electricity (kWh)	14,519,753	39,319,202	9,875,118	9,644,584
Natural Gas (therms)	379,439	2,142,810	693,598	974,085
Other fuels (gal)	535,821	655,100	397,418	276,766
Actual Installations				
Measures	429	604	469	505
Cost of Measures	$13,170,231	$15,754,289	$18,409,993	$15,667,374
Annual Cost Savings	$912,404	$1,803,538	$1,391,728	$1,453,447
Annual Energy Savings				
Electricity (kWh)	9,475,328	18,578,645	9,462,128	9,200,891
Natural Gas (therms)	333,962	598,349	433,633	476,183
Other fuels (gal)	54,588	140,631	136,657	137,803

III. Low-Income Assistance

Oregon Housing and Community Services (OHCS) administers the portions of the public-purpose charge for low-income housing (4.5% of all public-purpose charge revenues) and for low-income housing weatherization (11.7% of revenues). The scenarios being considered in this section pertain to energy efficiency specific investments, so we will focus on the low-income housing weatherization part of OHCS's programs. OHCS operates two programs within low-income housing weatherization: (i) Energy Conservation Helping Oregonians (ECHO) which contracts with local community action agencies to facilitate grants for low-income households to complete weatherization; and (ii) low-income weatherization program for affordable multi-family rental housing which provides grants to construct or rehabilitate affordable rental housing and each dollar invested must demonstrate one kWh of energy savings during its first year of operation.

During the past eight years, we see an average of $8,789,344 in annual expenditures in the ECHO program which weatherizes an average of 1921 homes and saves 8,070,747 kWh of electricity. In the affordable multi-family rental housing weatherization program, the average annual expenditure is equal to $2,147,570, and 609 units are constructed/rehabilitated for a total annual energy savings of 962,734 kWh.

[55] Source: OPUC

Table 15 - Oregon Housing and Community Services Low-Income Weatherization Programs[56]

	2005 & 2006	2007 & 2008	2009 & 2010	2011 & 2012
ECHO Program				
Expenditures	$16,545,941	$17,966,286	$19,523,570	$16,278,958
Number of Homes Weatherized	4123	3947	4287	3014
Annual Energy Savings (kWh)	16,830,086	15,785,703	12,769,713	19,180,472
Low-Income Weatherization (MFH)				
Expenditures	$2,557,425	$5,149,089	$5,196,731	$4,277,314
Number of Units Weatherized	1262	1640	904	1066
Annual Energy Savings (kWh)	1,572,770	1,928,235	2,128,386	2,072,480

[56] Source: OPUC

References and Bibliography

Ahearn, A. (2013) Talk of a Carbon Tax in the Northwest. *Oregon Public Broadcast*. Retrieved January 20, 2013, from http://earthfix.opb.org/energy/article/taxing-carbon-to-pay-for-transportation-infrastruc/.

Aldy, J. E., & Stavins, R. N. (2012). The Promise and Problems of Pricing Carbon Theory and Experience. *The Journal of Environment & Development, 21*(2), 152-180.

Aldy, J. E., Krupnick, A. J., Newell, R. G., Parry, I. W., & Pizer, W. A. (2009). *Designing climate mitigation policy* (No. w15022). National Bureau of Economic Research.

Amdur, D., Rabe, & B. G., Borick, C. (2014). Public Views on a Carbon Tax Depend on the Proposed Use of Revenue. *Issues in Energy and Environmental Policy (No. 13) http://closup.umich.edu/files/ieep-nsee-2014-spring-carbon-tax.pdf* .

American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress (2009). Retrieved 10/5/2014 from http://www.epa.govs/climatechange/Downloads/EPAactivities/HR2454_Analysis.pdf

Analysis Group (2011). *The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States.* Retrieved 11/25/2014 from http://www.analysisgroup.com/uploadedfiles/publishing/articles/economic_impact_rggi_report.pdf

Andersen, M. S., Barker, T., Christie, E., Ekins, P., Fitz Gerald, J., Jilkova, J., et al. (2007). *Competiveness Effects of Environmental Tax Reforms*. Denmark: National Environmental Research Institute.

Australian Energy Market Commission, 2013. 2013 Residential Electricity Price Trends Final Report. Sydney, South NSW: Australian Energy Market Commission.

Bansari, S., & Mazurek, J. (2013). *Modeling the Economic Impacts of AB 32 Auction Proceeds Investment Opportunities*. Retrieved 11/25/2014 from http://www.icfi.com/insights/reports/2013/modeling-economic-impacts-of-ab-32-auction-proceeds-investment-opportunities

Barbose, G., Heeter, J., Bird, L., Weaver, S., Flores-Espino, F. & Wiser, R. (2014). Costs and Benefits of Renewables Portfolio Standards in the United States, 2014. Berkeley, CA: Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory. Retrieved 10/2/2014 from http://www.usaee.org/usaee2014/submissions/OnlineProceedings/IAEE%20Conference%20Paper%20(Final).pdf

Beck, M., Rivers, N., Wigle, R., & Yonezawa, H. (2014, September 4). *Carbon Tax and Revenue Recycling: Impacts on Households in Britsih Columbia.* Retrieved 11/26/2014 from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2492766

Bell, R. G., & Callan, D. (2011). More than Meets the Eye: The Social Cost of Carbon in US Climate Policy. *Environmental Law*.

British Columbia Ministry of Finance. (2008). *Budget and Fiscal Plan*. Vancouver, BC: National Library of Canada Cataloguing in Publication Data.

British Columbia Ministry of Finance. (2009). *Budget and Fiscal Plan*. Vancouver, BC: National Library of Canada Cataloguing in Publication Data.

British Columbia Ministry of Finance. (2010). *Budget and Fiscal Plan*. Vancouver, BC: National Library of Canada Cataloguing in Publication Data.

British Columbia Ministry of Finance. (2011). *Budget and Fiscal Plan*. Vancouver , BC: National Library of Canada Cataloguing in Publication Data.

British Columbia Ministry of Finance. (2012*). Budget and Fiscal Plan*. Vancouver, BC: National Library of Canada Cataloguing in Publication Data.

Bureau of Labor Statistics. (2013). Consumer Expenditure Survey. *United States Department of Labor*. Washington, D.C. Retrieved February 22, 2013 from http://www.bls.gov/cex/.

California Air Resources Board (2014). *Low Carbon Fuel Standard Rulemaking: Cost Containment Provision.* Retrieved 11/26/2014 from http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040414_cost_containment_presentation_bw.pdf

California Air Resources Board (2014). *Monthly LCFS Credit Trading Activity Report for July 2014*. Retrieved 11/26/2014 from http://www.arb.ca.gov/fuels/lcfs/credit/20140812_julcreditreport.pdf

California Environmental Protection Agency Air Resources Board (2014). Monthly LCFS Credit Trading Activity Report for July 2014. Retrieved 10/2/2014 from http://www.arb.ca.gov/fuels/lcfs/credit/20140812_julcreditreport.pdf

California Environmental Protection Agency Air Resources Board (2014). Low Carbon Fuel Standard Rulemaking: Cost Containment Provision. Retrieved 10/2/2014 from http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040414_cost_containment_presentation_bw.pdf

Callan, T., Lyons, S., Scott, S., Tol, R. S., & Verde, S. (2009). The distributional implications of a carbon tax in Ireland. *Energy Policy, 37*(2), 407-412.

Climate Trust, The (2014). *An Evaluation of Potential Carbon Pricing Mechanisms for the State of Oregon*. Retrieved 11/25/2014 from http://climatetrust.org/wp-content/uploads/2014/07/An-Evaluation-of-Potential-Carbon-Pricing-Mechanisms-for-the-State-of-Oregon.pdf

Community Action Partnership of Oregon (2012). *CAPO: Energy Snapshot*. Retrieved November 25, 2015 from http://www.caporegon.org/resources/capo-publications/finish/90-energy-assistance-snapshots/406-energy-assistance-snapshot-2012

Convery, Frank. (2012). Budget 2013- Three Cheers for the Carbon Tax. *Public Policy Ireland. Dublin*. Retrieved December 21, 2012, from http://www.irishfiscalpolicyresearchcentre.com/budget-2013-three-cheers-for-the-carbon-tax/.

Cosbey, A. (2008). Border carbon adjustment. In IISD, *Background Paper for the Trade and Climate Change Seminar*, June, 18-20.

Department of Energy and Climate Change (UK) Updated 2013 (2013). Estimated impacts of energy and climate change policies on energy prices and bills. Originally published November 2011. Retrieved 10/2/2014 from https://www.gov.uk/government/publications/assessment-of-the-impact-of-energy-and-climate-change-policies-on-prices-and-bills

Dinan, Terry (2012). *Offsetting a Carbon Tax's Costs on Low-Income Households.* Retrieved 11/26/2014 from http://www.cbo.gov/sites/default/files/11-13LowIncomeOptions.pdf

Energy and Environmental Economics (2014). *Capital Cost Review of Power Generation Technologies*. Retrieved 11/25/2014 from https://www.wecc.biz/Reliability/2014_TEPPC_Generation_CapCost_Report_E3.pdf

Environment Oregon Research & Policy Center (2014). *Moving America Forward.* Retrieved 11/26/2014 from http://www.environmentoregon.org/sites/environment/files/reports/OR_Moving_Forward_scrn.pdf

Evergreen Economics (2013). *Report to Legislative Assembly on Public Purpose Expenditures January 2011- December 2012.* Retrieved 11/26/2014 from http://www.puc.state.or.us/electric_restruc/purpose/FINAL13PPCSpendingReport.pdf

Jack Faucett Associates, Inc. (2011). *Economic Impact Analysis of the Low-Carbon Fuel Standard Rule for the State of Oregon.* Retrieved 11/26/2014 from http://www.deq.state.or.us/aq/committees/docs/lcfs/appendixDeconimpact.pdf

Fischer, C., & Fox, A. (2011). *Comparing Policies to Combat Emissions Leakage: Border Carbon Adjustments versus Rebates*. Resources for the Future.

Fullerton, D., Karney, D., & Baylis, K. (2011). Negative Leakage. *Energy and Climate Economics*. Retrieved December 20, 2012, from http://www.econstor.eu/dspace/simple-search?query=negative+leakage.

Gordon, Kate (2014). A Climate Risk Assessment for the United States. *Risky Business, The Economic Risks of Climate Change in the United States*. Retrieved 11/26/2014 from http://riskybusiness.org/uploads/files/RiskyBusiness_Report_WEB_09_08_14.pdf

Grainger, Corbett A., & Kolstad, C. D. (2012). Who Pays the Price on Carbon?. *Environmental Resource Economics*, 359-376.

Green, D., Harrison, K., Richards, J., & Olewiler, N. (2008, June 24). We Shouldn't 'Axe' B.C.'S Carbon Tax; The Issue Should be Helping People Adjust to Higher Fuel Prices and Reduce their Dependence on Fossil Fuels. *The Vancouver Sun*, pp. A11.

Harrison, K. (2012). A Tale of Two Taxes: The Fate of Environmental Tax*. Review of Policy Research*, 392-393.

Hassett, Kevan A., Mathur Aparna, & Gilbert E. Metcalf. (2007). The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis. *The Energy Journal*.

ICF International (2014). *Task 3- Updated Compliance Scenarios.* Retrieved 11/26/2014 from http://www.oregon.gov/deq/RulesandRegulations/Documents/T3m3.pdf

Idaho Power (2013). *Integrated Resource Plan*. Retrieved 11/25/2014 from http://www.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/2013/2013IRP.pdf

Intergovernmental Panel on Climate Change (2014). Fifth Assessment Report Retrieved 11/25/2014 from http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf

James, C. (2008, June 20). NDP Leader Carole James Says Carbon Tax Hurts Average Families. *The Vancouver Province*, pp. A20.

Johnson, L. T., & Hope, C. (2012). The social cost of carbon in US regulatory impact analyses: an introduction and critique. *Journal of Environmental Studies and Sciences*, 1-17.

Kolstad, C. D. (1996). Learning and stock effects in environmental regulation: the case of greenhouse gas emissions. *Journal of Environmental Economics and Management, 31*(1), 1-18.

Kuik, O., & Hofkes, M. (2010). Border adjustment for European emissions trading: Competitiveness and carbon leakage*. Energy Policy, 38*(4), 1741-1748.

Lee, M. (2010). *By Our Own Emissions: The Distribution of GHGs in BC*. Vancouver, BC: Canadian Centre for Policy Alternatives.

Lee, M., & Sanger, T. (2008). *Is BC's Carbon Tax Fair? An Impact Analysis for Different Income Levels*. Vancouver, BC: Canadian Centre for Policy Alternatives.

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

Luckow, P., Stanton, E., Biewald, B., Fisher, J., Ackerman, F., & Hausman, E. (November 1, 2013). *2013 Carbon Dioxide Price Forecast.* Retrieved 11/26/2015 from http://www.synapse-energy.com/sites/default/files/SynapseReport.2013-11.0.2013-Carbon-Forecast.13-098.pdf

Martella, R., Visser, J. (2014, June 9). *EPA's Existing Source Performance Standard for Greenhouse Gases.* Retrieved 11/26/2014 from http://www.csg.org/aapca_site/events/documents/MARTELLA.pdf

Mazerov, Michael (2010). *Cutting State Corporate Income Taxes is Unlikely to Create Many Jobs*. Retrieved 11/25/2014 from http://www.cbpp.org/files/9-14-10sfp.pdf

McMullen, B. S., Zhang, L., & Hakahara, K. (2010). Distributional Impacts of Changing from a Gasoline Tax to a Vehicle-Mile Tax for Light Vehicles: A case Study of Oregon. *Transport Policy*, 359-366.

Metcalf, G. E. (2009). Designing a carbon tax to reduce US greenhouse gas emissions. *Review of Environmental Economics and Policy, 3*(1), 63-83.

Mori, K. (2012). Modeling the Impact of a Carbon Tax: A Trial Analysis for Washington State. *Energy Policy, 48*, 627-639.

Morris, D. F. and Munnings, C. (2013) *Designing a Fair Carbon Tax.* Resources for the Future, Washington, D.C.

Morris, D. F. and Munnings, C. (2013) *Progressing to a Fair Carbon Tax – Policy Design Options and Impacts to Households.* Issue Brief 13-03, Resources for the Future, Washington, D.C.

Nordhaus, W. D. (1994). *Managing the global commons: the economics of climate change*. Cambridge: The MIT Press.

Nordhaus, W. D. (2010). Economic aspects of global warming in a post-Copenhagen environment. *Proceedings of the National Academy of Sciences, 107*(26), 11721-11726.

Nordhaus, W. D. (2011). *Estimates of the social cost of carbon: background and results from the RICE- 2011 model* (No. w17540). National Bureau of Economic Research.

Northwest Power and Conservation Council (2008). *Marginal Carbon Dioxide Production Rates of the Northwest Power System*. Retrieved 11/ 25/2014 from http://www.nwcouncil.org/media/29611/2008_08.pdf

Nystrom, S. and Zaidi, A. (2013) *Modeling the Economic, Demographic, and Climate Impact of a Carbon Tax in Massachusetts*. Regional Economic Models, Inc. (REMI). Retrieved 7/20/2013 from http://www.remi.com/download/presentations/2013_energy_and_environment_series/MA%20Carbon%20Tax%20Paper.pdf.

Oregon Department of Environmental Quality, Oregon Department of Energy, Oregon Department of Transportation. 2013. Oregon's Greenhouse Gas Emissions Through 2010: In-Boundary, Consumption-Based, and Expanded Transportation Sector Inventories. Retrieved 12/2/2014 from http://www.oregon.gov/deq/AQ/Documents/OregonGHGinventory07_17_13FINAL.pdf

Oregon Department of Energy and Center for Climate Strategies (2012). *10-Year Energy Action Plan Modeling - Greenhouse Gas Marginal Abatement Cost Curve Development and Macroeconomic Foundational Modeling for Oregon*. Retrieved 10/2/2014 from http://www.oregon.gov/energy/GBLWRM/docs/Energy_Plan_GhG_MACC__Foundational_Modeling_Final_Report.pdf

Oregon Department of Energy, Revised 2010 (2010) Oregon's Carbon Dioxide Emissions Standards for New Energy Siting Facilities. Retrieved 10/5/2014 from http://www.oregon.gov/energy/Siting/docs/Reports/CO2Standard.pdf

Oregon Department of Energy (2014(1)). *Current Oregon Fuel Tax Rates*. Retrieved 11/26/2014 from http://www.oregon.gov/odot/cs/ftg/Pages/current_ft_rates.aspx

Oregon Department of Energy (2014(2)). *Highway Revenues Apportionment*. Retrieved 11/26/2014 from http://www.oregon.gov/ODOT/CS/FS/pages/hwy_rev.aspx

Oregon Department of Energy (2014(3)). *Energy Facility Siting Standards.* Retrieved 11/26/2014 from http://www.oregon.gov/energy/Siting/Pages/standards.aspx#Carbon_Dioxide_Emissions

Oregon Department of Energy (2014(4)). *Oregon's Electric Power Mix*. Retrieved 11/19/2014 from http://www.oregon.gov/energy/pages/oregons_electric_power_mix.aspx

Oregon Department of Energy (2014(5)). *Summary of Oregon's Renewable Portfolio Standard*. Retrieved 10/2/2014 from http://www.oregon.gov/energy/RENEW/docs/RPS_Long_Summary_January%202014.pdf

Oregon Department of Environmental Quality (2014). *Clean Fuels Program Phase 2 Rulemaking.* Retrieved 11/26/2014 from http://www.oregon.gov/deq/RulesandRegulations/Documents/cf2pubnotice.pdf

Oregon Department of Environmental Quality, Oregon Department of Energy, Oregon Department of Transportation (2013). *Oregon's Greenhouse Gas Emissions Through 2010.* Retrieved 11/26/2014 from http://www.oregon.gov/deq/AQ/Documents/OregonGHGinventory07_17_13FINAL.pdf

Oregon Environmental Council (2013). *Climate Conversations Postscript "Given what science tells us, isn't there more we should be doing?"*

Oregon Global Warming Commission (2013). *Report to the Legislature 2013* Retrieved 11/19/2014 from http://www.keeporegoncool.org/sites/default/files/ogwc-standard-documents/OGWC_2013_Rpt_Leg.pdf

Oregon Governor's Office (2012). Draft 10-Year Energy Plan. *State of Oregon. Salem, Oregon*. Retrieved February 22, 2013 from http://www.oregon.gov/energy/Pages/Ten_Year_Energy_Plan_Draft.aspx.

Oregon Governor's Office (2006). *Summary of the Median Proposal for an Oregon Carbon Allocation Standard*. Retrieved 11/25/2014 from http://www.oregon.gov/energy/GBLWRM/docs/CATF_Proposal.pdf

Oregon Public Utility Commission (2013). *2012 Oregon Utility Statistics.* Retrieved 11/26/2014 from http://www.puc.state.or.us/docs/statbook2012.pdf

Oregon Public Utility Commission (2012). *Establish the Alternative Compliance Payment Rate for 2014 Pursuant to ORS 469A.180* Retrieved 11/26/2014 http://apps.puc.state.or.us/orders/2012ords/12-375.pdf

Oregon Transportation Research and Education Consortium (2008). *The Techniques for Assessing the Socio-Economic Effects of Vehicle Mileage Fees.* Retrieved 11/25/2014 from http://www.oregon.gov/odot/td/tp_res/docs/reports/2008/odot-vmt_fee_impacts.pdf

Pacificorp (2013, April 30). *Integrated Resource Plan Volume 1*. Retrieved 11/26/2014 from http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2013IRP/PacifiCorp-2013IRP_Vol1-Main_4-30-13.pdf

Parry, I., & Williams, R. (2011). Moving US Climate Policy Forward: Are Carbon Taxes the Only Good Alternative?. *Resources for the Future Discussion Paper*, 11-02.

Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J., & Hanson, C. E. (2007). *Climate change 2007: impacts, adaptation and vulnerability*. Intergovernmental Panel on Climate Change.

Pearce, D. (1991). The role of carbon taxes in adjusting to global warming. The Economic Journal, 101(407), 938-948.

Pont, J., & Rosenfeld, J. (2011). *A Low Carbon Fuel Standard in Washington: Informing the Decision.* Retrieved 11/26/2014 from http://www.ecy.wa.gov/climatechange/docs/fuelstandards_finalreport_02182011.pdf

Province of British Colombia (2014). *Climate Action 2014 Progress Report.* Retrieved 11/25/2014 from http://www.env.gov.bc.ca/cas/pdfs/2014-Progress-to-Targets.pdf

Ramseur, J. L., & Parker, L. (2009). *Carbon Tax and Greenhouse Gas Control: Options and Considerations for Congress*. Congressional Research Service, Library of Congress.

Ramseur, J. L., Leggett, J. A., & Sherlock, M. F. (2012). *Carbon Tax: Deficit Reduction and Other Considerations.* Congressional Research Service, Library of Congress.

Rausch, Sebastian, Gilbert E. Metcalf, and John M. Reilly. (2011). Distributional Impacts of Carbon Pricing: A General Equilibrium Approach with Micro-Data for Households. *Energy Economics*.

Read, R. (2012). Evraz Portland Will Fire Up Oregon Steel Mill Closed in 2009, Hiring 200. *The Oregonian*. Retrieved December 21, 2012, from http://www.oregonlive.com/business/index.ssf/2012/10/evraz_oregon_steel_will_fire_u.html.

Regional Economic Models, Inc. (2013). *The Economic, Demographic, and Climate Impact of Environmental Tax Reform in Washington and King County.* Retrieved 11/25/2014 from http://www.cbuilding.org/sites/default/files/etr-wa-remi-dec-13-2013.pdf

Regional Economic Models, Inc. (2014(1)). *Environmental Tax Reform in California: Economics and Climate Impact of a Carbon Tax Swap.* Retrieved 11/25/2014 from http://citizensclimatelobby.org/wp-content/uploads/2014/03/Environmental-Tax-Reform-in-California-Economic-and-Climate-Impact-of...-1.pdf

Regional Economic Models, Inc. (2014(2)). *Products.* Retrieved 11/26/2014 from http://www.remi.com/products/pi

Reinaud, J. (2009). Trade, competitiveness and carbon leakage: challenges and opportunities. *Energy, Environment and Development Programme Paper, 9*(01).

Ripple, W. J., Smith, P., Haberl, H., Montzka, S. A., McAlpine, C., & Boucher, D. (2014). *Commentary: Ruminants, climate change and climate policy.* Retrieved 11/26/2014 from http://www.health.gov/dietaryguidelines/dga2015/comments/uploads/CID230_Ripple__2014_NatureClimateChange-Ruminants.pdf

Rivers, N. (2010). Impacts of climate policy on the competitiveness of Canadian industry: How big and how to mitigate?. *Energy Economics, 32*(5), 1092-1104.

Schaffrin, A. (2013). Who Pays for Climate Mitigation? An Empirical Investigation on the Distributional Effects of Climate Policy in the Housing Sector. *Energy and Buildings*. Forthcoming.

State of Washington Department of Ecology (2010). Final Cost-Benefit and Least Burdensome Alternative Analysis - Chapter 173-441 WAC Reporting of Emission of Greenhouse Gases.

Stern, N.H. (2006). *Stern Review: The economics of climate change. Vol. 30*. London: HM treasury.

Sustainable Prosperity (2012). *British Columbia's Carbon Tax Shift: The First Four Years*. Ottawa, Canada: University of Ottawa. Retrieved 11/19/2014 from http://www.sustainableprosperity.ca/dl1026&display

Sustainable Prosperity (2013). *British Columbia's Carbon Tax Shift after Five Years: Results*. Ottawa, Canada: University of Ottawa. Retrieved 11/26/2014 from http://www.sustainableprosperity.ca/dl1026&display

Tietenberg, T. H., & Lewis, L. (2004). Environmental economics and policy. Boston: Pearson Addison Wesley.

Tol, R. S. (2011). The social cost of carbon. *Annual Review of Resource Economics, 3*(1), 419-443.

Patora, K (2010) *Publication no. 10-02-037, December 2010*. Retrieved 10/5/2014 from https://fortress.wa.gov/ecy/publications/publications/1002037.pdf

University of California, Davis (2013). California Exceeds Low Carbon Fuel Standard Targets – For Now. Retrieved 10/2/2014 from http://news.ucdavis.edu/search/news_detail.lasso?id=10562

US Department of Energy (2014). Renewable Portfolio Standard Program Info. Retrieved 10/2/2014 from http://energy.gov/savings/renewable-portfolio-standard-3

US Energy Information Administration (2014). 2014 Annual Energy Outlook. Retrieved 12/2/2014 from http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf

US Energy Information Administration (2014). *Oregon State Energy Profile.* Retrieved 11/26/2014 from http://www.eia.gov/state/print.cfm?sid=OR

US Environmental Protection Agency (2007). *Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes.* Retrieved 11/26/2014 from http://www.epa.gov/sectors/pdf/energy/report.pdf

US Environmental Protection Agency; National Highway Traffic Safety Administration, 2011. Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency for Medium and Heavy-Duty Engines and Vehicles – Regulatory Impact Analysis.

US Government Accountability Office (2006). *Most Workers in Five Layoffs Received Services, but Better Outreach Needed on New Benefits.* Retrieved 11/25/2014 from http://www.gao.gov/assets/250/248989.pdf

U.S. Interagency Working Group on Social Cost of Carbon (2013). *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis*. Retrieved 11/19/2014 from http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

U.S. Interagency Working Group on Social Cost of Carbon (2010). *Technical support document: Social cost of carbon for regulatory impact analysis under executive order 12866*. Retrieved 11/26/2014 from http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf

Western State and Provincial (2014). *Western State and Provincial Meetings March 24-26, 2014* (Meeting minutes) Retrieved 11/25/2014 from http://www.westernenergyboard.org/wieb/meetings/crepcsprg2014/03-26-14EIM-CREPC-SPSC-WIRAB_agenda.pdf

Willcocks, P. (2008). Carbon Tax Opposition A Challenge For Liberals; The Opposition To The New Tax Is Stronger Than Expected And Coming From All Sides Which Is Not A Good Thing For Campbell With 11 Months Until An Election. *Nelson Daily News*, 6.

Williams III, R. C., Gordon, H., Burtraw, D., Carbone, J. C., & Morgenstern, R. D. (2014). *The Initial Incidence of a Carbon Tax across US States.* Retrieved 11/25/2014 from http://www.rff.org/RFF/Documents/RFF-DP-14-25.pdf

Williams III, R. C., Burtraw, D., Carbone, J. C., & Morgenstern, R. D. (2013). *Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts*. Retrieved 11/26/2014 from http://www.rff.org/RFF/Documents/RFF-Rpt-Carbone.etal.CarbonTaxes.pdf

Wooster, R. B., & Lehner, J. W. (2009). Reexamining the Border Tax Effect: A case Study of Washington State. *Contemporary Economic Policy*, 511-523.

World Bank Group (2014, May). *State and Trends of Carbon Pricing.* Retrieved 11/26/2014 from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/05/27/000456286_20140527095323/Rendered/PDF/882840AR0REPLA00EPI2102680Box385232.pdf

Yeh, S., Witcover, J., & Kessler, J. (2013) Status Review of California's Low Carbon Fuel Standard - Spring 2013 Issue (REVISED VERSION). Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-13-06. Retrieved 10/5/2014 from http://www.its.ucdavis.edu/research/publications/publication-detail/?pub_id=1861

Yeh, S., & Witcover, J. (2012). Status Review of California's Low Carbon Fuel Standard (LCFS) 2011-August 2012. Institute of Transportation Studies, University of California, Davis 2012. Retrieved 10/5/2014 from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2174817

Zabin, C., Buffa, A., & Scholl, L. (2009). *The Impact of Climate Change Policies on Carbon-Intensive Manufacturing Industries in Oregon*. Berkeley, CA: UC Berkeley Labor Center.

Zakreski, S. (2014). Oregon Carbon Dioxide Standard an Ideal Model under New EPA Regulation. Portland, OR: The Climate Trust, 2014. Retrieved 10/5/2014 from http://www.climatetrust.org/documents/OregonCarbonDioxideStandardanIdealModelUnderNewEPARegulationTheClimateTrust.pdf