2015 Oregon Highway Cost Allocation Study
Carbon Tax Issue Paper

**Northwest Economic Research Center**
March 13, 2015

Executive Summary

Countries, states, provinces, and cities around the world are considering and implementing a broad range of carbon emissions reduction programs in response to climate change. One of these methods is a carbon tax, which is a tax applied to fuels or activities based on their carbon content. Transportation activities are a major contributor to carbon emissions and would therefore be affected by a carbon tax. In light of the recent discussion in Oregon regarding carbon pricing, this issue paper estimates the impact on the demand for transportation fuels of a carbon tax at various carbon prices using two different estimation techniques

In 2013, the Northwest Economic Research Center (NERC) released *Carbon Tax and Shift: How to Make it Work for Oregon's Economy*. The report estimated the economic and emissions impacts of implementing a carbon tax in Oregon based on the British Columbia (BC) carbon tax. The BC carbon tax is revenue neutral- collected revenues are used to offset existing taxes and fees. In *Carbon Tax and Shift*, the revenues were modeled mainly as reductions in personal and corporate income tax rates.

The study utilized two models: The Carbon Tax Analysis Model (C-TAM) and IMPLAN, an input-output software. Figure 1 shows the expected decrease in transportation fuel consumption relative to a forecasted baseline for three different carbon prices.

Figure 1: Percent Change in Transportation Fuel Consumption from Baseline ($/ton CO_2e)
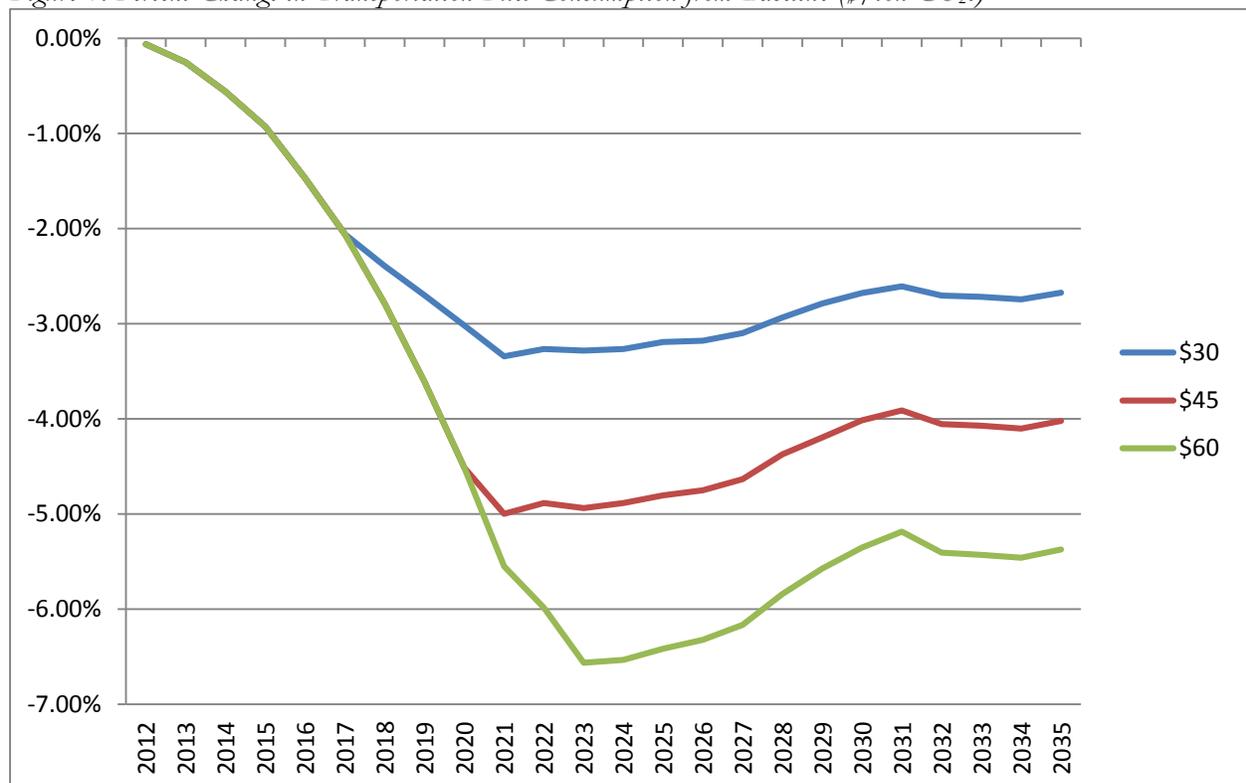
Two shortcomings of the study were the lack of dynamic feedback and tax incidence shifting, which would have an impact on final fuel consumption. In 2013, the Oregon Legislature passed SB306 which directed the Legislative Revenue Office (LRO) to conduct a study of the emissions and economic impacts of a clean air tax or fee in Oregon. LRO contracted with NERC to conduct the analysis, which addressed both of these issues.

For the SB306 analysis, NERC and the study team created a new Oregon emissions model and combined its results with those of REMI, an economic simulation software model. The new estimation methodology allowed for the incorporation of dynamic feedback and a broader range of carbon prices and modeled revenue uses. Figure 2 shows the expected decrease in household motor fuel demand relative to a forecasted baseline for the SB306 study.

Figure 2: Percent Change in Household Motor Fuel Demand ($/ton CO$_2$e)
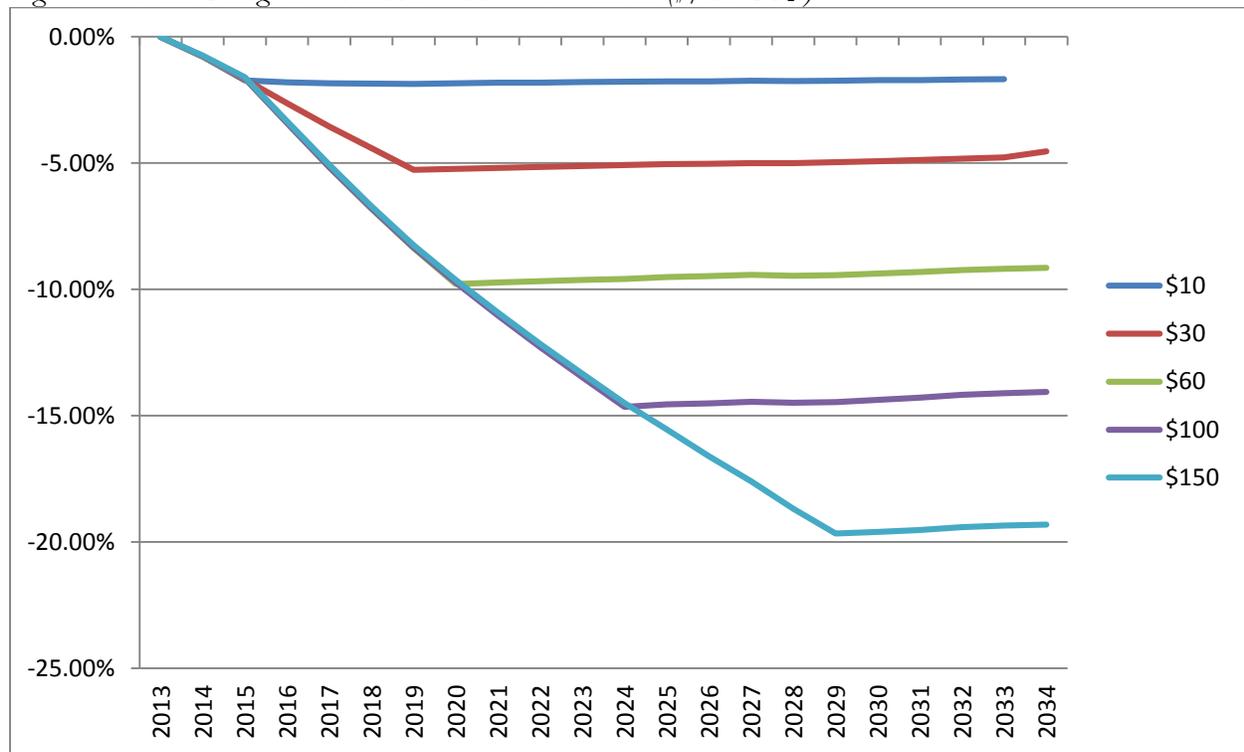
Other results from the SB306 study can be found in the REMI Model Results section (pg. 16).

While a carbon tax would almost certainly reduce demand for transportation fuels (relative to a baseline with no carbon pricing), this reduction in demand would not necessarily be tied to decreases in economic activity. Revenues could be used to reduce business expenses or increase household income and could stimulate economic activity. Carbon pricing schemes in other parts of the world have been successful at reducing carbon emissions while creating minimal economic impact.

Introduction

Innovative approaches to emissions reduction, such as carbon pricing, have received increased attention amidst rising public concern about climate change and the early successes of similar programs around the world. As Oregon policymakers weigh the economic and environmental costs and benefits of pollution reduction, a state carbon tax has been proposed to address each. Individual cities, states/provinces, and countries have already implemented a carbon tax, including British Columbia, numerous countries in Europe, Asia, and the US metro areas of Boulder, CO and San Francisco, CA. The impacts of such a tax on these regions are a useful tool when determining possible implications of such a policy in Oregon. While the overall impacts on the economy are distributed broadly, certain sectors will be affected more than others. This issue paper will investigate the literature covering the impacts of a carbon tax on the transportation sector and report on estimated changes to transportation fuel use due to a carbon tax.

The Northwest Economic Research Center (NERC) conducted a study analyzing how a British Columbia-style carbon tax would affect the Oregon economy.[1] NERC's report used baseline scenarios in which funds collected via the carbon tax were repatriated through reductions in personal or corporate income taxes, with a portion reinvested into targeted sectors and programs. NERC's report consistently showed the transportation sector experiencing disproportionately negative effects. The study estimated transportation employment losses near 3%, despite overall employment increases in the entire economy, in each scenario considered. Thus, the market efficiency gained by correcting a negative externality appeared to come in part from this sector's burden.

NERC has updated its economic and emission estimates as part of a study funded by the passage of SB306 in 2013. SB306 requires a new study which looks at geographic and industrial disparities of a tax in greater detail, and investigates other repatriation options. This new report was recently released in December 2014, and portions of the modeling related to fuel demand are used in this paper. These newer fuel demand estimates take into account industry price pass-throughs and dynamic reactions to energy price changes.

The implementation of a carbon tax would have an immediate effect on the retail price of gasoline. The amount of the increase would of course vary depending on the size of the tax, and studies have shown that an increase in the price of gasoline decreases demand. Furthermore, Davis and Kilian[2] (2009) find that consumer demand for gasoline is more sensitive to tax increases than to changes in the price of gas. Taking a price increase as given, one would expect consumer behavior to change; in the short run, consumers face a limited set of alternatives, eliciting the smallest change in fuel demand. In the longer term there are additional opportunities, including public transportation, carpooling, and fleet substitution to more fuel efficient vehicles.

The transportation and shipping industries may likewise experience an increase in fuel costs, and thus a reduction in revenue, illustrating how a carbon tax might negatively affect the transportation sector. However, if a portion of the tax revenue is reinvested in transportation infrastructure, there

---

[1] Liu, Jenny and Jeff Renfro (2013), *Carbon Tax and Shift.* Northwest Economic Research Center. Portland State University.

[2] Lucas W., Davis and Lutz Kilian (2009), *Estimating the Effect of a Gasoline Tax on Carbon Emissions*, working paper. Cambridge, MA: National Bureau of Economic Research.

could be significant public welfare gains. To the extent that the reinvested revenue funds public works projects which support less carbon intensive transportation, the tax can simultaneously address both climate change and infrastructure improvement. Parry and Williams[3] (forthcoming) examine the need for transportation policies which address negative externalities from carbon emissions, stating that revenue can be used to fund these policies.

The purpose of this paper is to estimate the changes in demand for transportation fuels due to a carbon tax. Changes in fuel demand from an expected baseline will have impacts on Highway Trust Fund revenues, which will alter the state's ability to fund maintenance and construction of roads. The previously mentioned *Carbon Tax and Shift* and the SB306 analysis includes estimates of impacts on emissions, income, employment, output, and state revenues and are resources for readers interested in the broader impacts of the policy.

The study team made an effort to suggest implementation methods which build on existing state programs or revenue collection methods, but differentiating between different types of road users would add a level of complexity to applying the carbon tax to commercial road users. The current method of imposing weight-mile fees on commercial road users takes into account the weight class of the vehicle. As the study team has envisioned it, a carbon tax would not differentiate between different weight classes. Following British Columbia, this study assumes that the tax is imposed at the wholesale level and is based on the calculated carbon content of combustion of the fuel, and the quantity of fuel purchased. If carbon tax collection was able to take advantage of current weight-mile fee collection mechanisms, a weight component could be incorporated into the collection of the tax. Experts could develop estimates of the carbon content produced by combusting the same quantity of fuel in different classes of vehicles. With this information, a weight-class specific carbon content per mile parameter could be developed. When commercial users report miles traveled in Oregon and pay the weight-mile fee, an additional fee could be added based on the estimated carbon produced by the vehicle during Oregon operation.

---

[3] Forthcoming in Ian Parry, Adele Morris and Roberton Williams, *Carbon Taxes and Fiscal Reform: Key Issues Facing US Policy Makers*. Routledge, forthcoming. The report we found was a draft paper titled *Implications of Carbon Taxes for Transportation Policies*. Ian Perry responded to a citation request, instructing that we cite as above.

Existing Carbon Pricing Policies

British Columbia Carbon Tax

Implemented in 2008, the British Columbia carbon tax provides an example of how such a measure might function in Oregon. Cultural and environmental similarities, as well as geographic proximity between British Columbia and Oregon make BC a particularly relevant case study. The tax was phased in over a 5 year time period, beginning at $10 per ton of carbon dioxide equivalent (CO_2e), and increasing by $5 per ton of CO_2e increments until it reached the level of $30 per ton of CO_2e in 2012. The key feature of the tax in BC is revenue neutrality - its proceeds are entirely repatriated into the provincial economy through reductions in other tax sources and direct rebates.

The results of the BC carbon tax have generally been considered favorable, though there are conflicting reports on its efficacy. The Pemba Institute[4] conducted confidential interviews across industry sectors, finding consensus on both the need for climate change mitigation and the public (as opposed to private) leadership needed to drive policy. The majority of interviewees considered the consequences of the carbon tax to be positive. Unfortunately, while the transportation organization field was represented in the interviews, freight businesses in particular were omitted, limiting the survey's applicability to this issue paper.

Rivers and Schaufele[5] researched the gasoline demand response associated with the BC carbon tax using econometric methods. They found that the demand response associated with a carbon tax is larger than that of price changes in gasoline in the absence of a carbon tax. As noted, implementing a tax creates significant short and long-run decreases in demand for gasoline. The River and Schaufele study does not specifically address the transportation sector, but its estimated demand changes for gasoline can be extended to the transportation industry, which relies heavily on the use of gasoline. Elgie and McClay of Sustainable Prosperity[6] confirmed the effectiveness of the BC carbon tax, illustrating significant reductions in the use of fossil fuels without adverse economic effects. Conversely, Rayne and Forest[7] concluded that pre-existing trends prior to the implementation of the carbon tax prevent accurate determination the tax's economic and environmental impacts.

---

[4] Horn, Matt, et al. (2012), *British Columbia's Carbon Tax: Exploring perspectives and seeking common ground*. Alberta: The Pemba Institute.

[5] Rivers, Nicholas and Brandon Schaufele (2012), *Carbon Tax Salience and Gasoline Demand,* working paper. Ottawa: University of Ottawa.

[6] Elgie, Dr. Stewart and Jessica McClay (2013), *BC's Carbon Tax Shift After Five Years: Results*. Ottawa: Sustainable Prosperity.

[7] Rayne, Sierra and Kaya Forest, *British Columbia's carbon tax: Greenhouse gas emission and economic trends since introduction.* Saskatchewan: Saskatchewan Institute of Applied Science and Technology.

Figure 3: British Columbia Motor Gasoline Sales[8]
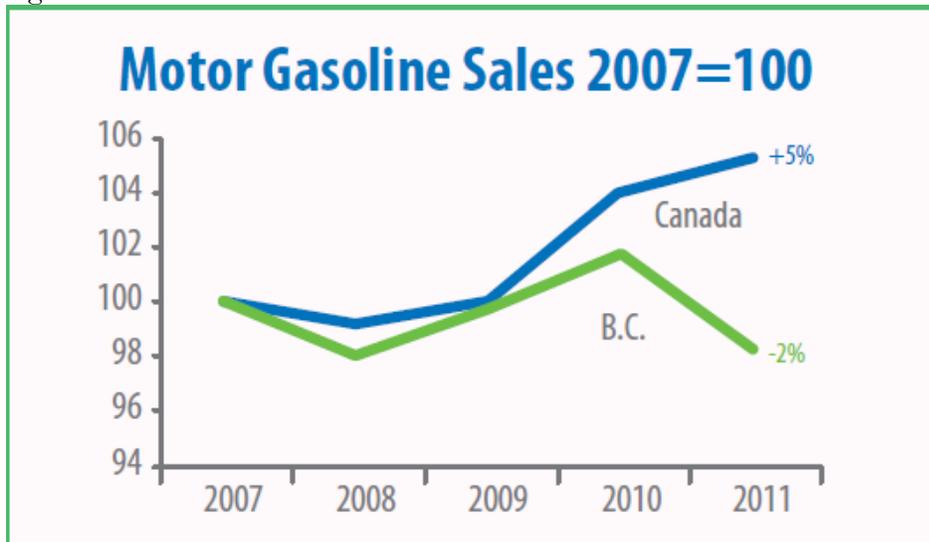
Despite an abundance of literature surrounding the BC carbon tax, most studies do not directly address the transportation industry. As the number of years of available data increases, there will be growing opportunities for research specifically addressing the transportation sector. Currently, much analysis relies on adapting aggregate results to an individual portion of the economy. The above figure shows the changes in motor gasoline sales in BC in the first four years of the carbon tax. Importantly, these results are not controlled for other fuel sale determinants, and the BC government implemented a suite of carbon reduction methods during this period.

Ireland's Carbon Tax

Ireland's carbon tax of €15 ($20.39)[9] per ton of CO_2e was implemented more recently than the BC tax, in 2010. The implementation of the tax consisted of three phases. The first phase applied to transportation fuels, such as automotive gasoline and diesel, followed by a tax on non-transportation fuels. Solid fuels, such as coal and peat, were introduced last, and at a lower rate.   The level of the tax has also incrementally risen to €20 ($27.19) per ton of CO_2e. Since the tax was first introduced on transportation fuels, short run effects on the industry should be expected, particularly with regards to fuel prices and demand.

Obtaining public support for the tax was largely tied to Ireland's financial crisis, a subject investigated by Convery, Dunne and Joyce.[10] At the time of implementation, Ireland experienced significant financial troubles, including large debt obligations. Revenues gained by the tax are thus intended in part to pay down these debt obligations. Much of the country's purported benefit of the carbon tax was the ability to address these fiscal issues without increasing the corporate income tax.

---

[8] Making Progress on B.C.'s Climate Action Plan 2012. Pg. 10

[9] Conversions based on 6/20/14 exchange rates.

[10] Convery, F. J., L. Dunne and D. Joyce (2013), *Ireland's Carbon Tax and the Fiscal Crisis: Issues in Fiscal Adjustment, Environmental Effectiveness, Competitiveness, Leakage and Equity Implications*, OECD Environment Working Papers, No. 59, OECD Publishing. http://dx.doi.org/10.1787/5k3z11j3w0bw-en

The report by Convery, Dunne and Joyce showed a reduction in CO_2 emissions in the transportation industry following the tax. However, because Ireland was experiencing a large-scale financial crisis, it is difficult to attribute changes in consumption with the implementation of the tax. Another complicating factor is that in 2008 the Irish government transformed the basis of taxation for the vehicle (VRT) and motor tax systems, making it even more challenging to disentangle the effect of the carbon tax. What is clear is that the carbon tax adds to the price of transport fuel paid by consumers. There is presumably a demand response to this change. As more years of data become available, allowing for proper statistical analysis, estimates of how the tax ultimately affects the transportation industry will become feasible.

Other Carbon Taxes Around the World

It should be noted that BC and Ireland are far from the only locations to have considered and/or implemented unit carbon taxes. Australia introduced a carbon tax in 2012 (which has since been repealed), and South Africa will implement its version of a carbon tax in 2016. Several European nations have already introduced carbon taxes, as well as some countries in Asia. Each is distinct in its specific coverage and magnitude; thus results cannot be compared directly across regions. However, important information can be gleaned from the experiences of these countries. As more research emerges on the results of carbon taxes in other regions, transportation-specific effects will be among the applicable lessons available.

Transportation Impacts from *Carbon Tax and Shift*

In the aforementioned "Carbon Tax and Shift" report, NERC used a program called The Carbon Tax Analysis Model (C-TAM) to estimate the emissions and fuel demand impact changes due to a carbon tax. C-TAM uses the Energy Information Administration (EIA) forecast for the Pacific Region as a basic input. The forecast is pro-rated for Oregon, and elasticities are used to estimate new fuel demand associated with a carbon tax. NERC estimated the change in transportation fuel demand under a variety of carbon prices.

CTAM Methodology[11]

The gold-standard for energy forecasting is the National Energy Modeling System (NEMS) run by the Energy Information Administration (EIA). NEMS includes sophisticated economic modeling modules as well as dynamic feedback. Simulation in this model requires extensive training and is expensive. In order to run estimates of the net impacts of an Oregon Carbon Tax, we combined two different modeling techniques that draw from this more complicated analysis.

The process began with the Carbon Tax Analysis Model (C-TAM)[12], originally created by Keibun Mori for the Washington State Department of Commerce. C-TAM incorporates NEMS energy forecasts and local economic projections, and features an interface appropriate for non-technical users. We adapted the Washington State model for use in Oregon.

C-TAM is a production-based model, meaning some sources of GHG emissions are not captured by the model. The emissions from fuel use in the production of cement, for example are captured, but the GHG given off by the materials are omitted. Likewise, emissions from tractors and trucks used on agricultural land are captured, but GHG given off by fertilized fields are not captured. We chose to use a production-based model because the BC Carbon Tax (our model) applies to fuels *combusted* in BC, and is not applied to non-production emissions sources. The model also ignores the emissions generated by using fuels purchased in another states but used in the Oregon's transportation sector.

C-TAM begins with the energy-usage forecast for the Pacific Region created using NEMS. This baseline forecast can be customized to include the effects of different carbon mitigation policies. We chose to use the Extended Policy forecast as the baseline. Extended Policy incorporates all laws and regulations currently on the books and assumes that energy efficiency and carbon mitigation regulations that are normally renewed will continue to be renewed, and that energy efficiency standards that are normally altered upon renewal will continue to be altered accordingly. This forecast also assumes full implementation of the new CAFE standards[13] and the Renewable Energy Portfolio Standard. It is important to note that the following results assume continued carbon mitigation efforts from policy-makers, and the ensuing changes in behavior by consumers and businesses.

---

[11] CTAM Methodology section is adapted from *Carbon Tax and Shift: How to Make it Work for Oregon's Economy*
[12] Mori, Keibun. (2012). *Modeling the Impact of a Carbon Tax: A Trial Analysis for Washington State.* Energy Policy, 48, 627-639.
[13] For full description of new CAFE Standards, see National Highway Traffic Safety Administration: http://www.nhtsa.gov/fuel-economy (Retrieved February 22, 2013)

This forecast is then pro-rated using historical Oregon energy-consumption data to create an Oregon energy-usage forecast. Tax revenue and population forecasts from the Oregon Office of Economic Analysis are also used as inputs. In order to estimate the effect of the Carbon Tax, we increase the price of fuels according to the price of carbon and the carbon content of each fuel. Change in usage is predicted based on elasticities drawn from multiple published papers. These elasticities are fuel-specific when possible; when an elasticity estimate has not been computed (or has not been computed recently); the fuel is assumed to have the same elasticity as a comparable fuel. This change in consumption is used to calculate the change in emissions, and the revenue generated by the tax. Figure 4 diagrams the C-TAM simulation process relevant to the transportation sector.

Figure 4: Transportation Sector - Outline of the simulation process in C-TAM
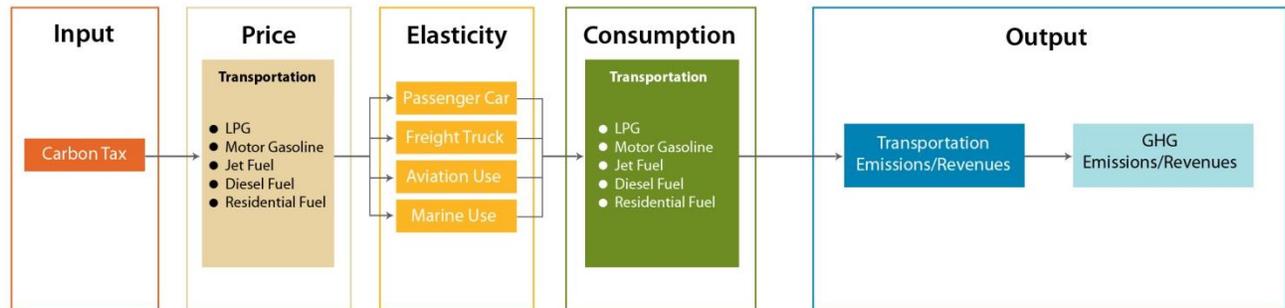
Model Results

A large portion of the transportation sector[14] relies on carbon-intensive fuels. This fact, and the high costs associated with developing and adopting less carbon intensive transportation energy sources, leads to a sector that is relatively unresponsive to changes in fuel price. Given this behavior the trend in fuel use forecasted by C-TAM should exhibit a sluggish decline in fuel use as a price on carbon is phased in. Such is the case for each of the three price scenarios visualized in Figure 5. As discussed immediately above, C-TAM relies on estimates of price elasticity of demand in order to model future fuel demand. These elasticity estimates as well as the NEMS fuel use forecast are key drivers of the forecasted fuel demand reported here.

The C-TAM model used for these three price scenarios assumes that a starting price of $10 per ton of CO_2e was introduced in 2012. This price then increases by $5 per year (or $10 per year in the case of the $60/ton cap) until the maximum price is reached. Interim year maxima are thus $30 in 2016, and $45 in 2019. Between 2016 and 2021, the price continuously increases for the $45 and $60 price scenarios, and forecasted fuel usage expectedly declines at a greater rate than in the $30 price scenario. The large initial decline in fuel use between 2017 and 2021 can mostly be attributed to a steady drop in demand for motor gasoline. The sharp *increase* in fuel use between 2023 and 2031 is similarly driven by a substantial rise in E85 fuel consumption. This increase in E85 use peaks in 2031 and slowly declines until it stabilizes in 2034. The only other notable trend through the forecasted period is that the growth in demand for distillate fuel (i.e., diesel fuel) remains positive and fairly steady. The relative unresponsiveness of diesel fuel demand is consistent with existing transportation systems and infrastructure. The current system is heavily dependent on ground and rail transport for freight movement, both of which consume large amounts of diesel fuel. C-TAM's

---

[14] In the C-TAM portion of this report, the transportation sector includes transportation of goods and freight, as well as private vehicle operation.

prediction that demand for diesel fuel will hold steady and grow seems plausible barring the development and adoption of a cost competitive alternative.

There are a few important caveats to discuss regarding the underlying mechanics and assumptions of C-TAM. First, while C-TAM's baseline fuel use forecast is derived using a dynamic model (i.e., National Energy Modeling System (NEMS)) the adjusted forecast, due to a price on carbon, is not dynamic. Prices on carbon will likely cause inter-industry burden shifting. For example the transportation sector may effectively shift much of its tax burden onto the industrial sector; these shifts are not reflected in C-TAM estimates. In the REMI section of the report, we report results which do include price shifting. This does alter our estimates of industry-specific employment impacts. Second, C-TAM does not take into account transportation policies that may be targeted at incentivizing development and adoption of less carbon intensive fuels and fuel efficiency technologies. Both of which could substantially influence the relative sensitivity to changes in fuel prices.

*Figure 5: Transportation Sector - Adjusted Fuel Consumption[15]*
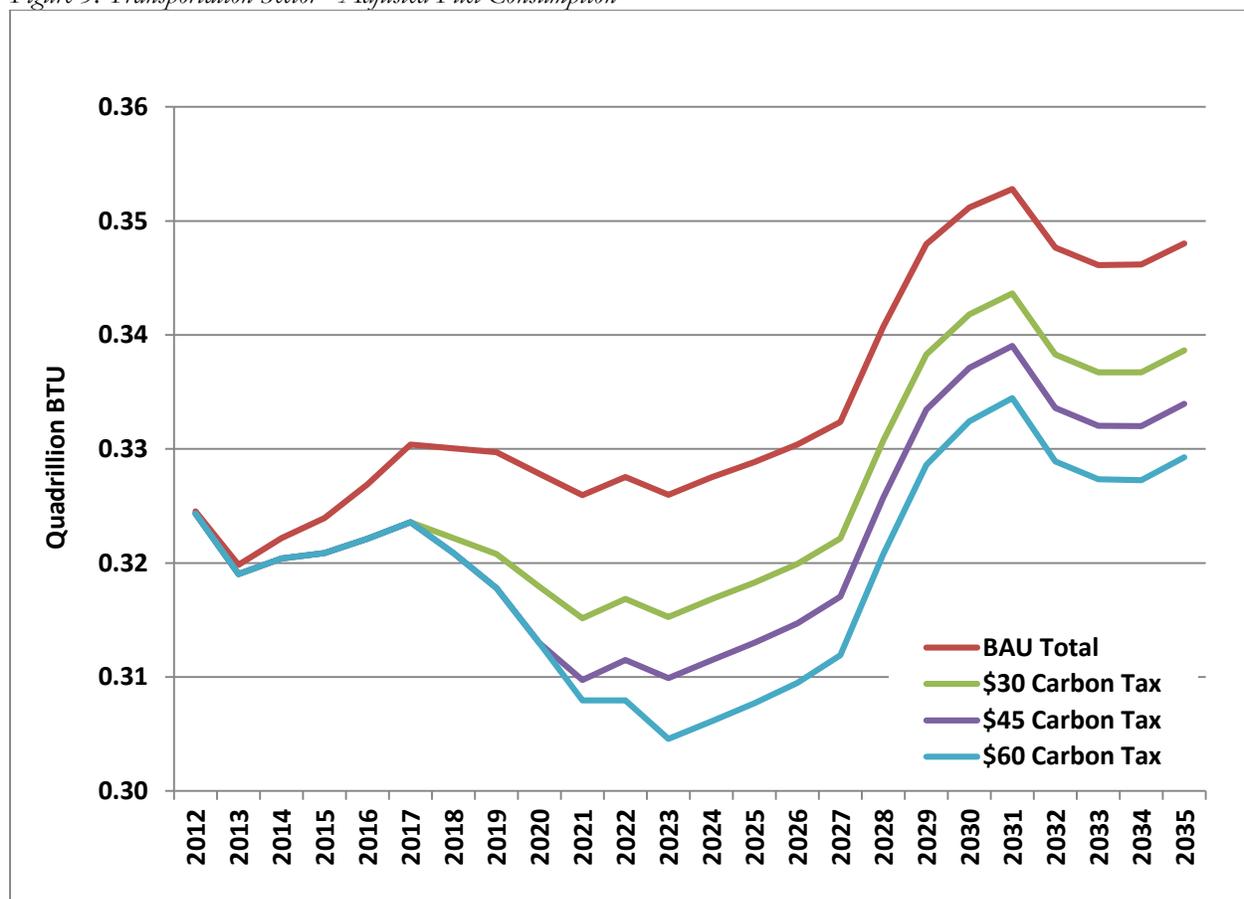
For this earlier study, transportation fuels are defined as any fuel used in the transportation goods, services, or people except for maritime and air transport. This differs from the fuel definitions used

---

[15] As a rule of thumb, a carbon price of $1/ton CO_2e corresponds to an increase in the price of gasoline by a little less than $0.01 per gallon. A carbon price of $30/ton CO_2e would increase prices at the gas pump by ~$0.29 per gallon.

later in the REMI portion of the study. Figure 6 shows the same information as Figure 5. It is reconfigured to show the percent reduction from the business as usual baseline.

Figure 6: Percent Change in Transportation Fuel Consumption from Baseline ($/ton CO_2e)
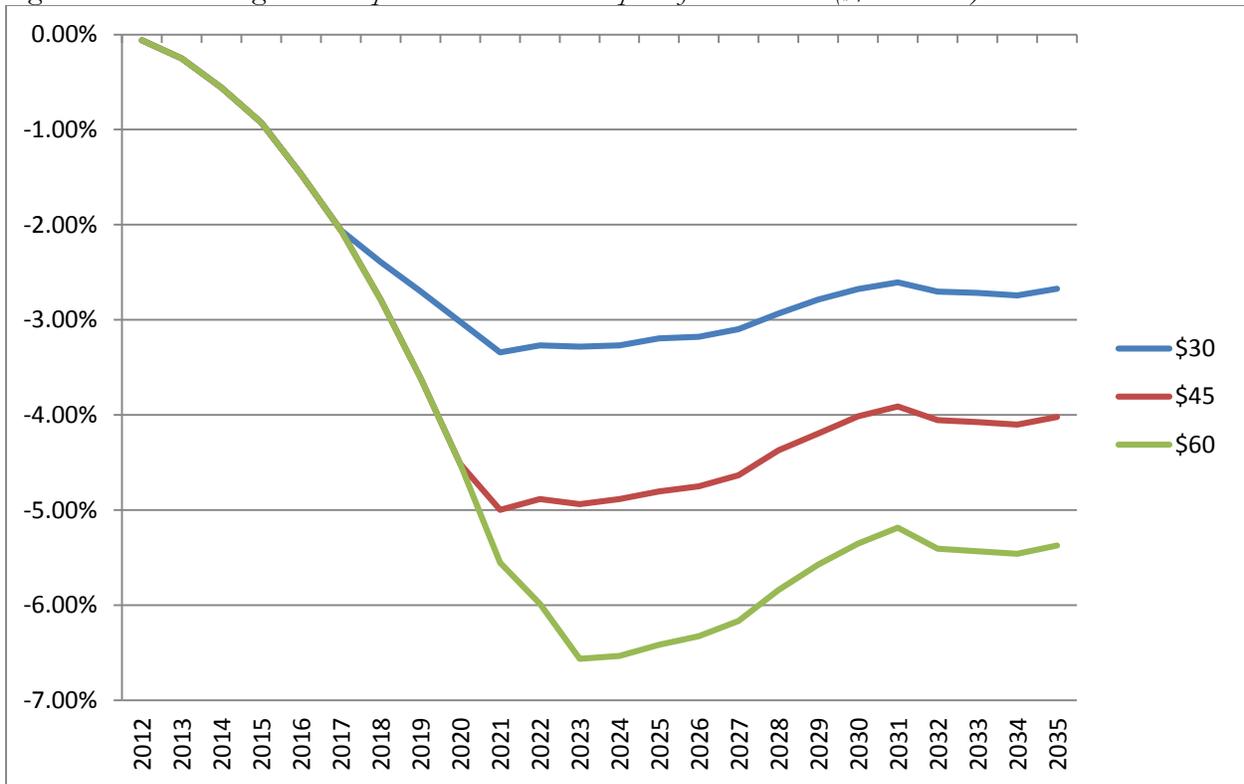
SB306 Estimates

In 2013, the Oregon Legislature passed SB306, which required the Legislative Revenue Office (LRO) to conduct a study of the economic and emissions impact of implementing a clean air tax or fee. LRO contracted with NERC to conduct the study. For this updated analysis, NERC used REMI (described below) and worked with two Portland State University physicists to create a custom Oregon emissions model. These two models in tandem provided greater modeling flexibility and capture dynamic effects of tax implementation.

The 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 the 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 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 workers 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, 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 in its production process. A supply or employment 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, resulting in constantly evolving variables. Household and population dynamics are similarly represented; households (like firms) respond according to standard economic theory to exogenous shocks. This means, for example, that workers in the model will 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 7 illustrates the basic structure of the model economy in REMI. The pictured schematic represents one given geographic region; equally complex links between regions including migration, inter-regional competition, and cross-border price effects are present in the model but not pictured.

*Figure 7: REMI Modeling Schematic*
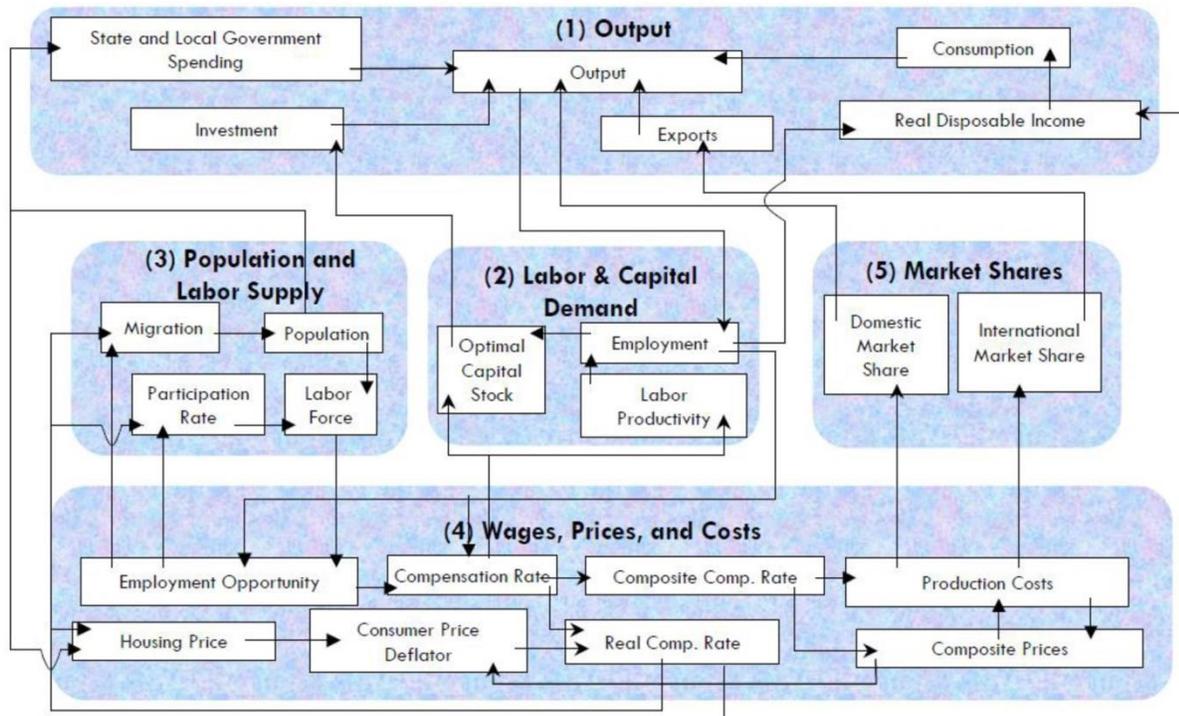
The magnitudes of supply-side and household effects (the arrows in Figure 7) depend on the responsiveness of numerous economic variables to signals and conditions. These elasticities and multipliers are estimated econometrically by REMI, using the observed data above to establish average and expected responses to simulated shocks in the economy. For our 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 propensity to consume different goods. In REMI, households of different income levels have appropriately diverse spending and saving habits. When repatriated carbon tax revenues are allocated to household income quintiles, it is thus possible to track the demand and output impacts across individual industries, which in turn interact with each other in accordance with each industry's estimated elasticity to input prices, interest rates, and so forth.

In essence, 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 8 is a map of the regional breakdown. NERC augmented the dynamic processes through which REMI equilibrates for our study to reflect the nexus of carbon emissions, emission 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 as a sizeable fund of revenues which are repatriated to the economy. Simply allowing REMI to reach a new equilibrium after this one-time change would conceptually omit an indirect channel of adjustment: if the tax, demand response, and revenue repatriation occurs in one year, the demand response and generated funds will evolve in the second year (fuel demand should be expected to have fallen, and revenues should be expected to

follow suit), the third year, and so on. NERC incorporated revenue feedback from our emissions model for each scenario in order to capture this effect; its impacts were essentially too small to measure at the lower tax levels, and became noticeable at tax levels higher than $100. [16]

Figure 8: Study Regions
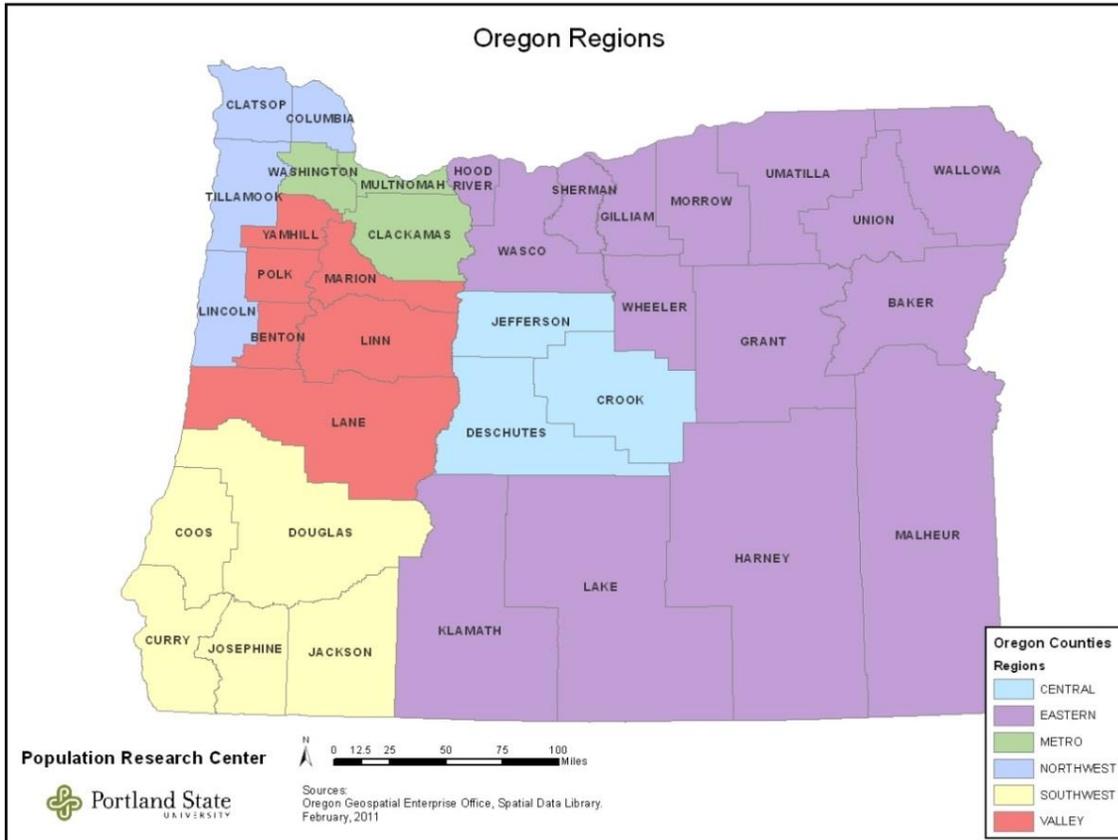
Establishing a Baseline

In order to establish a fuel demand baseline within the modeling, we calculated fuel demand by type using REMI's baseline forecast for Fuel Demand and Industry Output. Both measures are expressed in terms of dollars within REMI, requiring us to convert demand in dollars to demand for physical quantities of fuel. We used the EIA forecast for energy prices to make this conversion. Figure 9 shows the REMI-derived fuel demand forecast compared to the EIA/Oregon Department of Energy Forecast for fuel demand in Oregon. Our initial attempt at creating a baseline has the relative proportions of fuel demand correct, but overestimated the demand for electricity and residual fuels.

To solve this, we used the EIA/ODOE baseline numbers as a cap for the REMI baseline projections. The REMI model does not include explicit fuel prices; instead, it uses dynamic, econometrically-derived elasticities which output changes in fuel demand (expressed in dollars) from

---

[16] For a fuller explanation of the estimation methodology, see the Legislative Revenue Office/NERC report on a Clean Air Tax or Fee in response to SB306.

an expected baseline. By forcing the REMI energy usage forecast to match the EIA/ODOE forecast, we can use expected changes in fuel demand expressed in dollars and industrial output to derive expected changes in physical quantities of fuel demanded, relative to the EIA/ODOE baseline.

Figure 9: Fuel Demand Baseline
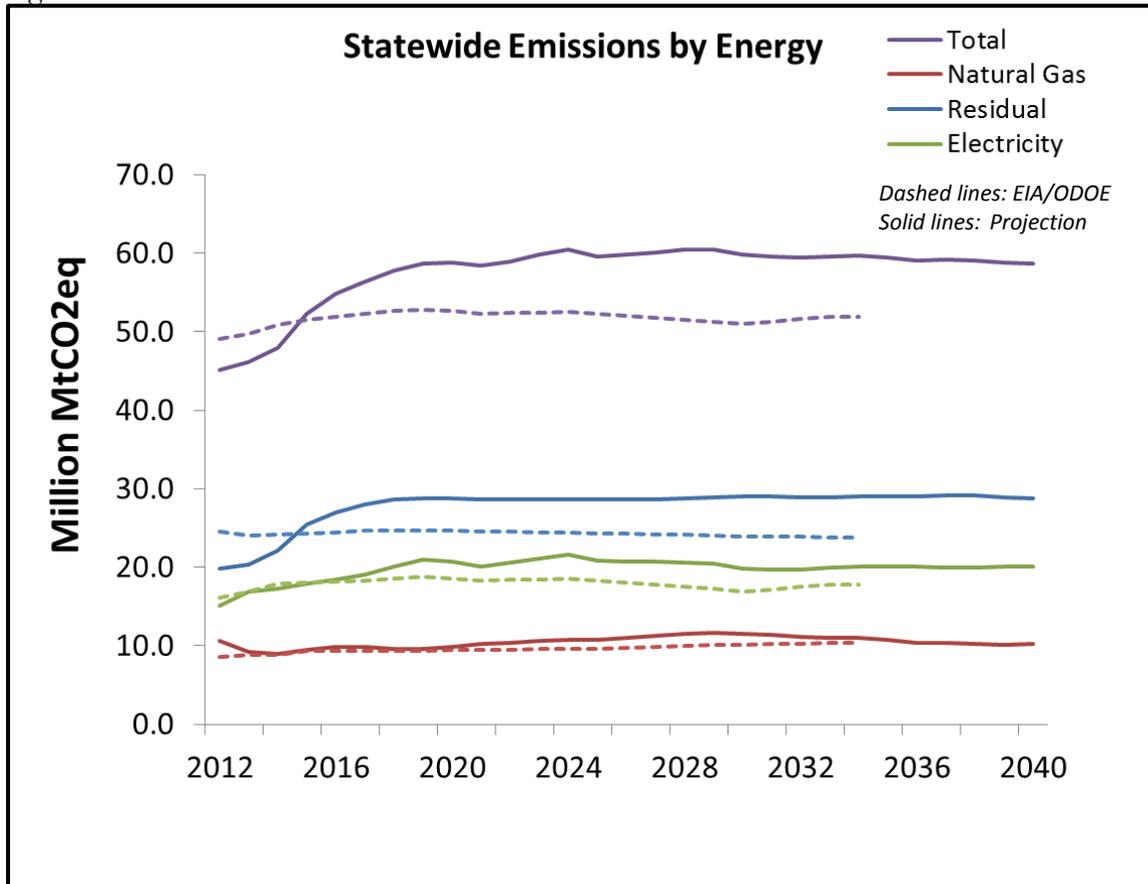
The modeling outputs related to energy demand are split into categories that do not directly correspond to how Oregonians talk about energy usage in their regular lives. For this study, there are two important definitions to keep in mind while reviewing results:

Residual Fuels: these fuels are best understood petroleum-based fuels. In Oregon, this is dominated by petroleum-based transportation fuels like gasoline and diesel.

Household Motor Gasoline: this is a subset of the overall residual fuels category. This is the portion of residual fuels which households purchase for transport in private cars. This represents a large portion of overall residual fuels and of the state's overall energy usage.

REMI Model Results

The first phase in the estimation process established an expected price change relative to the forecasted baseline for each fuel based on the assumed price of carbon. We started with the EIA's forecast of fuel prices, then added an additional cost to each fuel type based on its carbon content.

This portion of the estimation process was identical to the method used in the *Carbon Tax and Shift* report above (except for the estimation of electricity price changes). Figure 10 shows the expected percent price deviation from the baseline for motor gasoline for a range of carbon prices. Figure 11 shows the same percent price increase for residual fuels used in commercial and industrial processes. REMI uses a more aggregated fuel breakout than the EIA forecast. The residual fuel category is almost completely motor gasoline and diesel. The expected price change for each fuel type was therefore weighted and used to make an average price change for the residual fuels category.

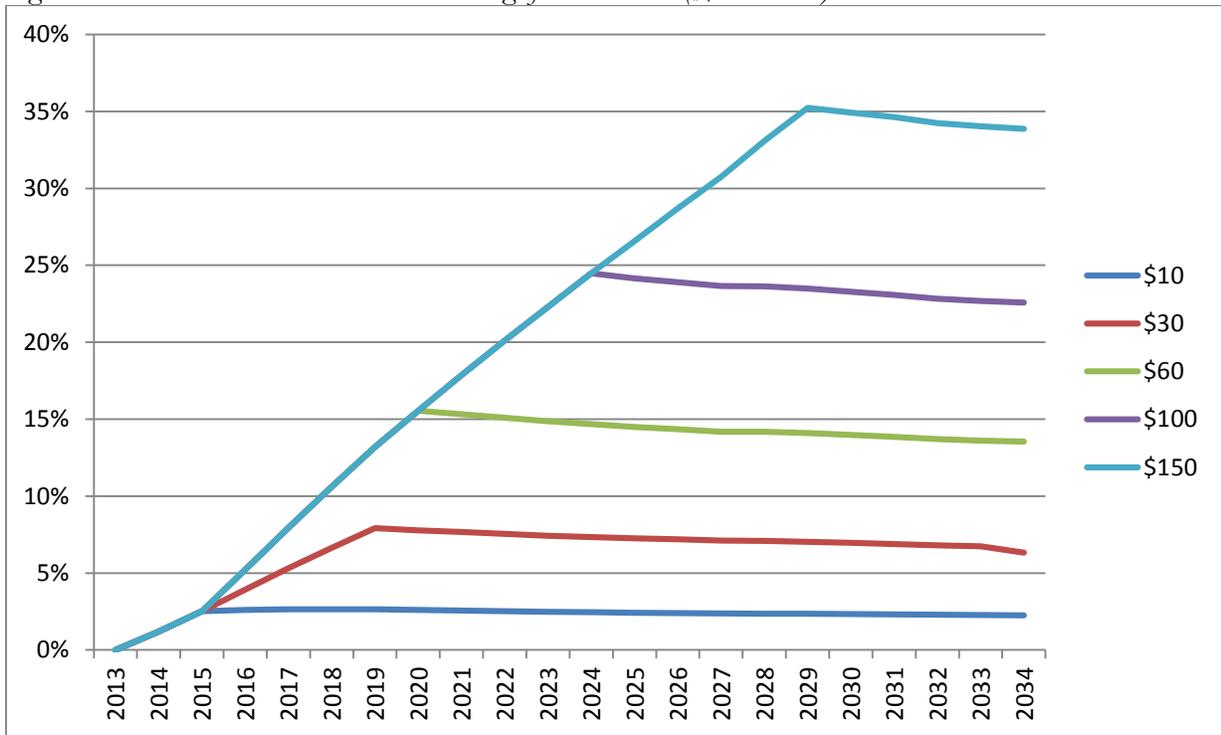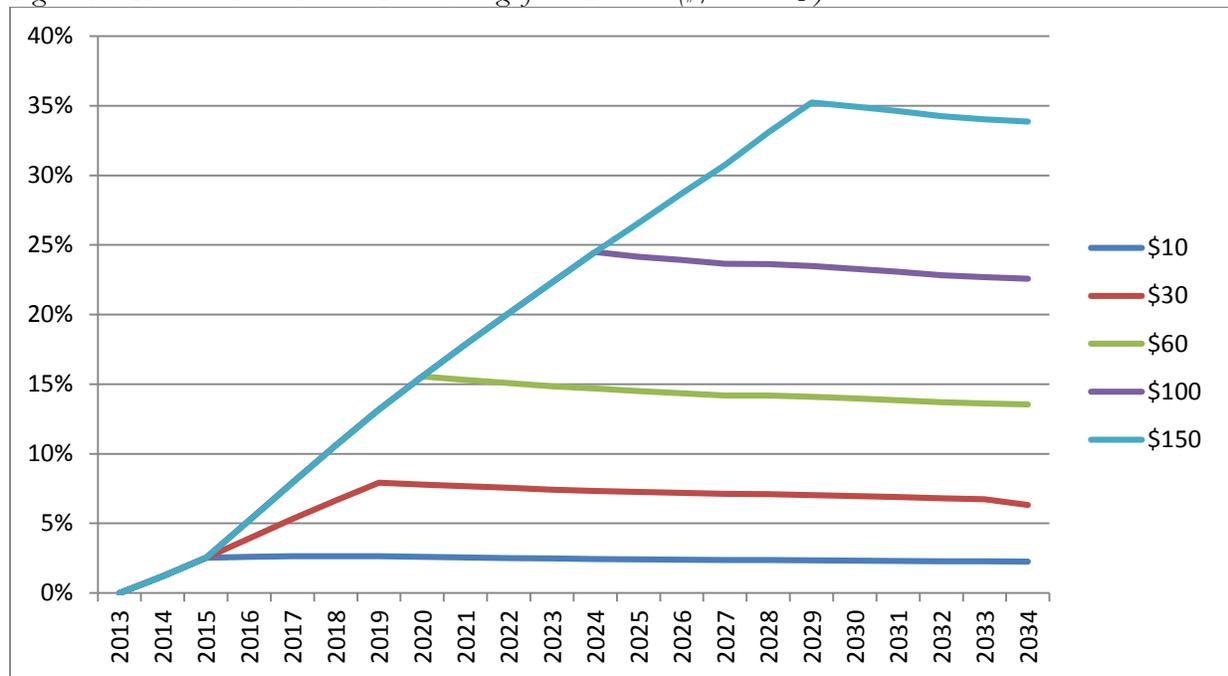*Figure 10: Motor Gasoline Percent Price Change from Baseline ($/ton CO_2e)*

Figure 11: Residual Fuels Percent Price Change from Baseline ($/ton CO₂e)

These price changes were used as inputs in REMI. Their overall impacts depend on how tax revenues are used. The following graphs assume that revenue derived from transportation fuels accrue to the state's highway fund, and that of the remaining revenue, 70% is applied to corporate income tax cuts and 30% is applied to personal income tax cuts. This breakdown is similar to the repatriation method employed in British Columbia.[17]

As part of the SB306 study process, NERC received mid- to long-term estimates of Highway Fund disbursements by study region from the Oregon Department of Transportation (ODOT). The formula is based on a weighted Vehicle Miles Traveled (VMT) formula, which applies greater weights to rural miles traveled. The disbursement of these funds, and the associated increase in construction jobs, has an impact on the region-specific economic outcomes. The scenarios reported on in this report all assume that highway funds are disbursed according to the weighted VMT. In the full SB306 study, scenarios are modeled in which the VMT formula is unweighted and the highway fund revenues are used for transportation investments beyond building and maintaining roads and highways.

After running scenarios which look at a variety of repatriation and expenditure methods at a variety of prices, we find that for carbon prices of $60/ton or lower, the repatriation method has a minimal to nonexistent impact on fuel demand. At prices of $100/ton or more, fuel demand does change based on repatriation method, but the impact is small relative to the overall fuel demand and economic activity in Oregon. For prices of $60/ton or less, the revenue generated by the policy is small relative to the overall level of economic output in the state. When this revenue is repatriated

---

[17] The full report which resulted from SB306 shares results for a broad range of scenarios. This scenario is presented here because it is similar to the program implemented in British Columbia, and features a combination of revenue uses seen in other jurisdictions. Overall economic results vary based on the use of the revenue, but the impacts on net changes in demand for transportation fuels are relatively stable.

or expended, the change in economic activity is also small relative to overall economic activity but the price signal created by the carbon tax is still in place.

The following results reflect the estimated net impact of fuel-specific price increases and the repatriation and expenditure method mentioned above. Results are reported for impacts on residual fuel demand, and the household motor gasoline subset of residual fuels.

Figure 12 shows the expected decrease in fuel demand for residual fuels due to the implementation of a carbon tax. In this case, residual fuel refers to all petroleum products combusted in Oregon, including motor gasoline for private cars. This category is dominated by transportation fuels for private, commercial, and industrial use. We assume that the price starts at $10/ton in 2014. For prices of $10/ton and $30/ton we assume a $5/ton annual increase. For all other prices, a $10/ton annual increase is used.

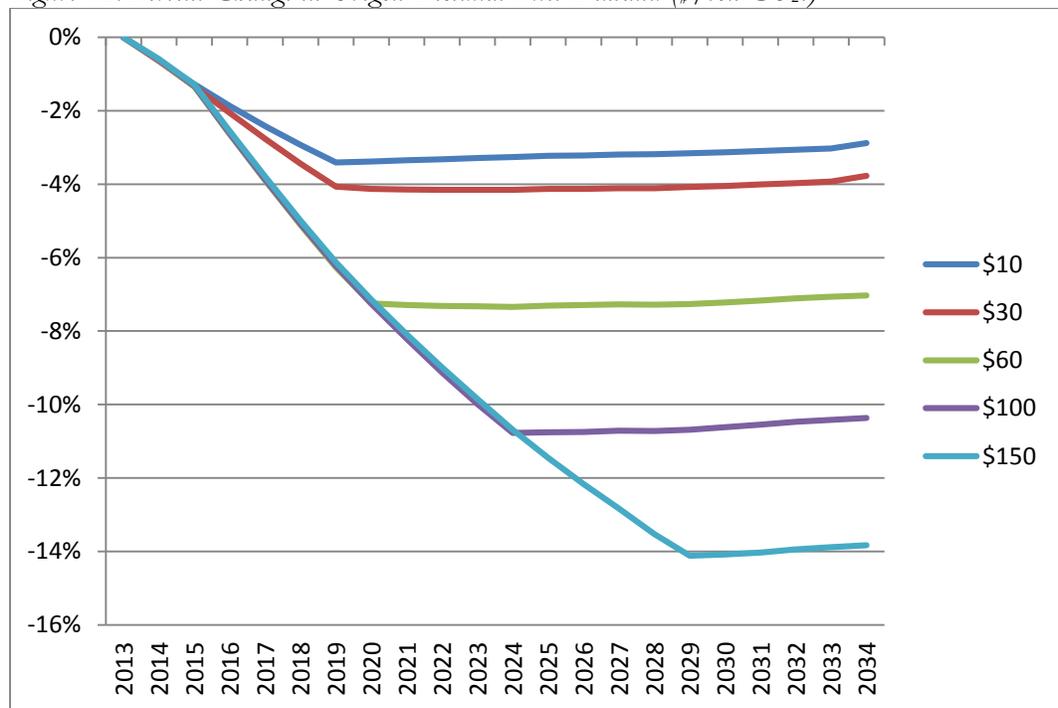*Figure 12: Percent Change in Oregon Residual Fuel Demand ($/ton CO₂e)*

Figure 13 shows the regional breakdown of the impact on residual fuel demand for the same scenario. The Metro area experiences the largest percentage decline, driven in part by the negative impact on industrial output in the area and the presence of alternative transportation options. Based on historical responses to price changes, the REMI model estimates larger elasticities (i.e. stronger responses to price changes) in the Metro region, relative to the rest of the state. If industrial impacts were proportionately equal across all regions, the expected changes Metro transportation fuel demand would still be greater.

Figure 13: Regional Percent Change in Residual Fuel Demand ($30/ton CO$_2$e)
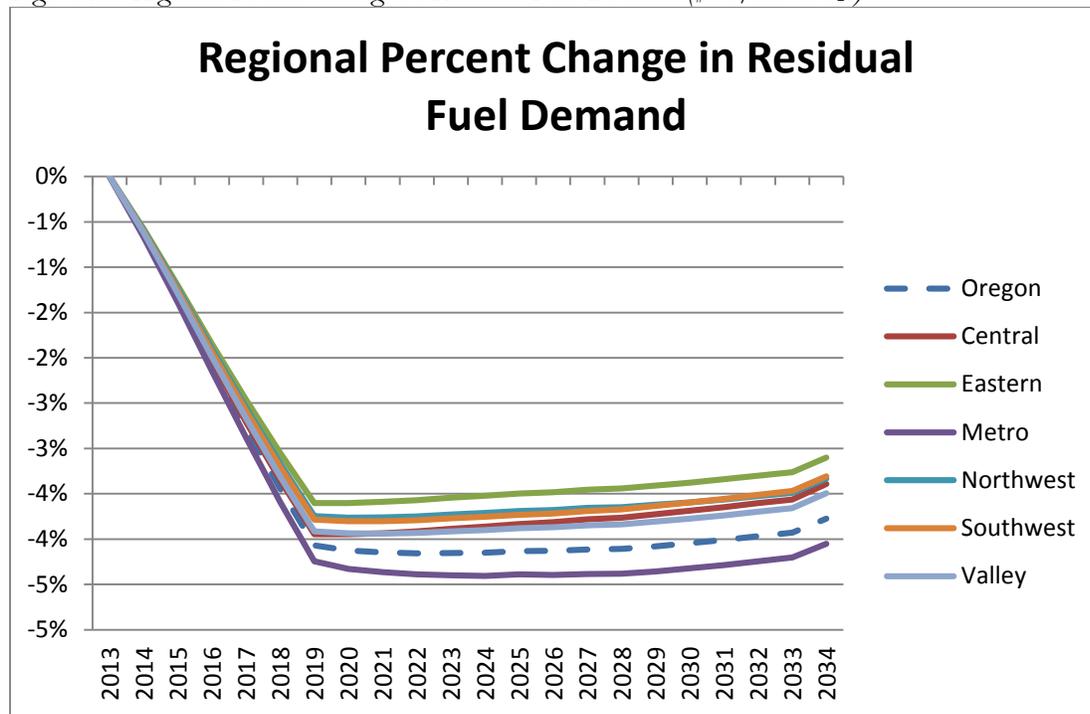

Figure 14 isolates the impact of the carbon tax on motor gasoline used by households for this scenario. This category represents a large portion of Oregon's fossil fuel usage. The magnitude of change for this category is greater than the overall residual fuel category, in part because some car drivers have alternatives to driving or can easily change driving patterns in response to higher prices. This effect is evident in Figure 15, which shows the regional breakdown of changes in household motor gasoline demand. The Metro region has the largest percentage decrease in motor fuel demand because residents in this area have better access to public transportation and other car substitutes. Rural areas like Eastern Oregon experience the smallest impact because residents have fewer alternatives and need to make budget adjustments in areas other than motor fuel costs.

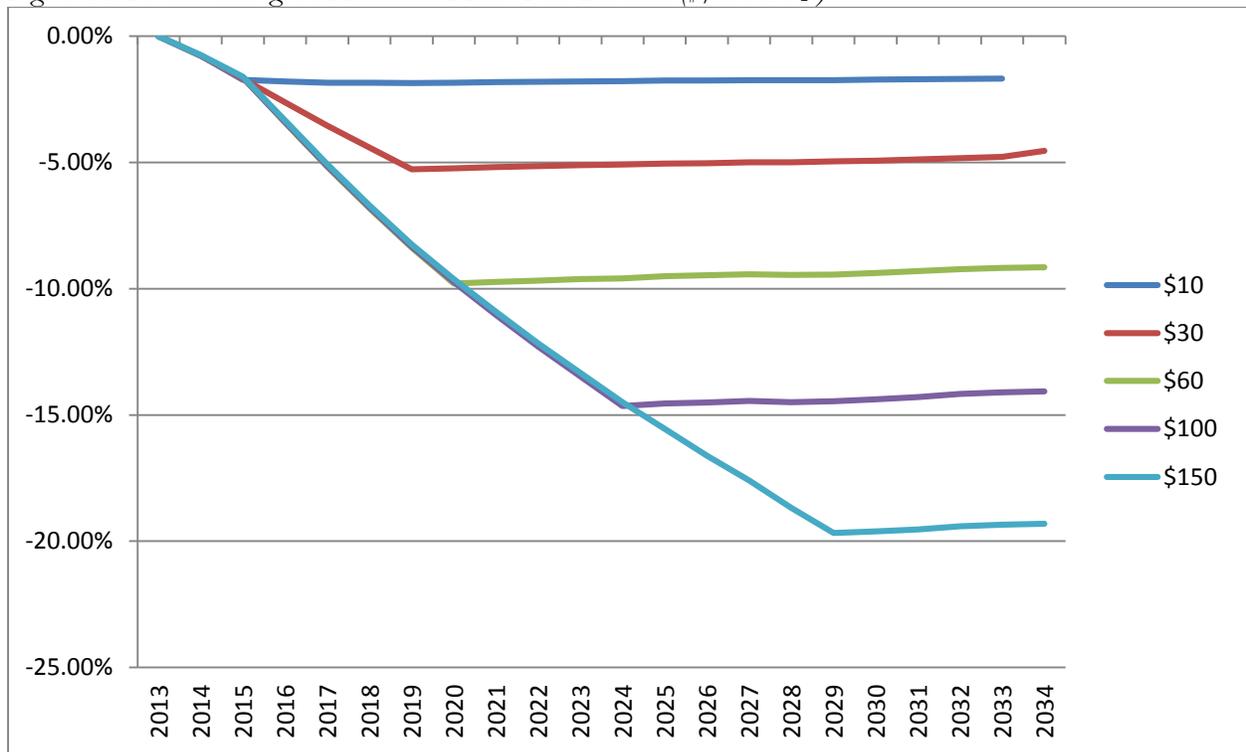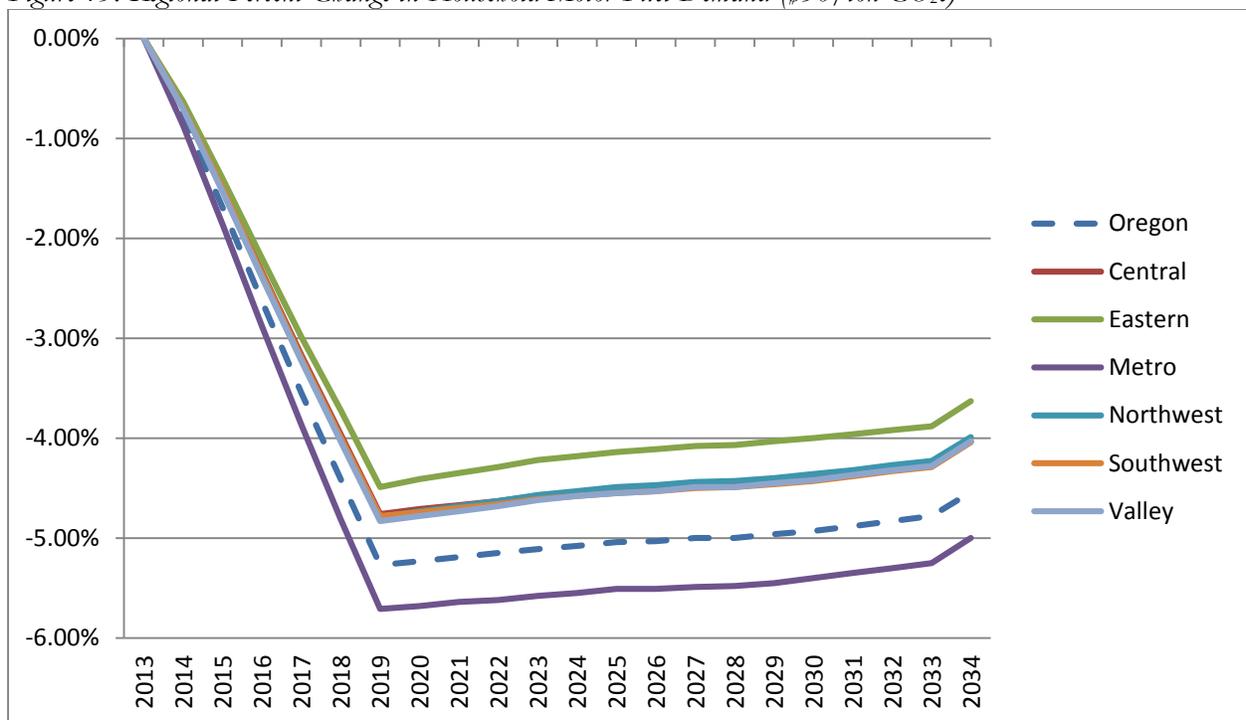*Figure 14: Percent Change in Household Motor Fuel Demand ($/ton CO₂e)*

Figure 15: Regional Percent Change in Household Motor Fuel Demand ($30/ton CO₂e)

Relevant to the remit of the Highway Cost Allocation Study panel is the impact of the carbon tax on the Oregon trucking industry. Given the high fuel-intensity of the industry, it would seem safe to

assume job losses. Our estimates actually show modest job gains, driven almost exclusively by the increase in the highway fund due to the tax. The increase in highway funding acts as a stimulus to the road construction and maintenance industries across the state. Because highway funds are disbursed according to a weighted distribution of VMTs, this stimulus is spread throughout the state. The trucking industry experiences a modest increase in employment to meet the demand of the industries working on Oregon highways.[18] REMI model parameters (based on historical data) reflect a strong link between construction and demand for road transportation services. Figure 16 shows percent change in employment relative to the forecasted levels of employment in the industry.

Figure 16: Percent Change in Oregon Truck Transportation Employment ($/ton CO$_2$e)
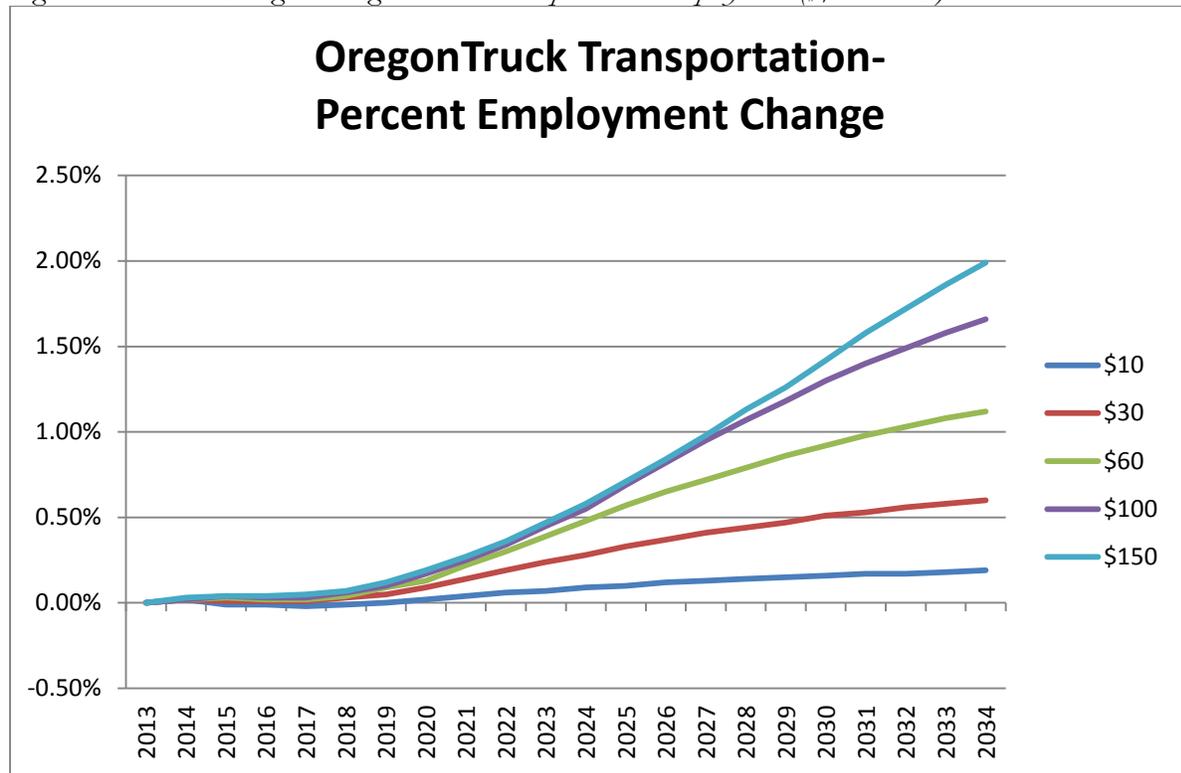

Figure 17 shows the regional impacts on the trucking industry. The Metro region sees the smallest impact for two main reasons: the formula for disbursement of highway funds, and the impact of the tax on the broader Metro economy. The highway funds are disbursed according to a weighted measure of VMTs. The Metro region receives the largest portion of highway funds, but it is slightly less than what would be expected based just on VMTs. This means that the increase in road construction and maintenance activity is slightly weaker in the Metro Area. There are also more industries in the area negatively affected by the tax, decreasing demand for trucking.

---

[18] Here, Truck Transportation employment refers to jobs with Oregon companies which transport goods by road.

Figure 17: Regional Percent Change in Truck Transportation Employment ($/ton CO₂e)
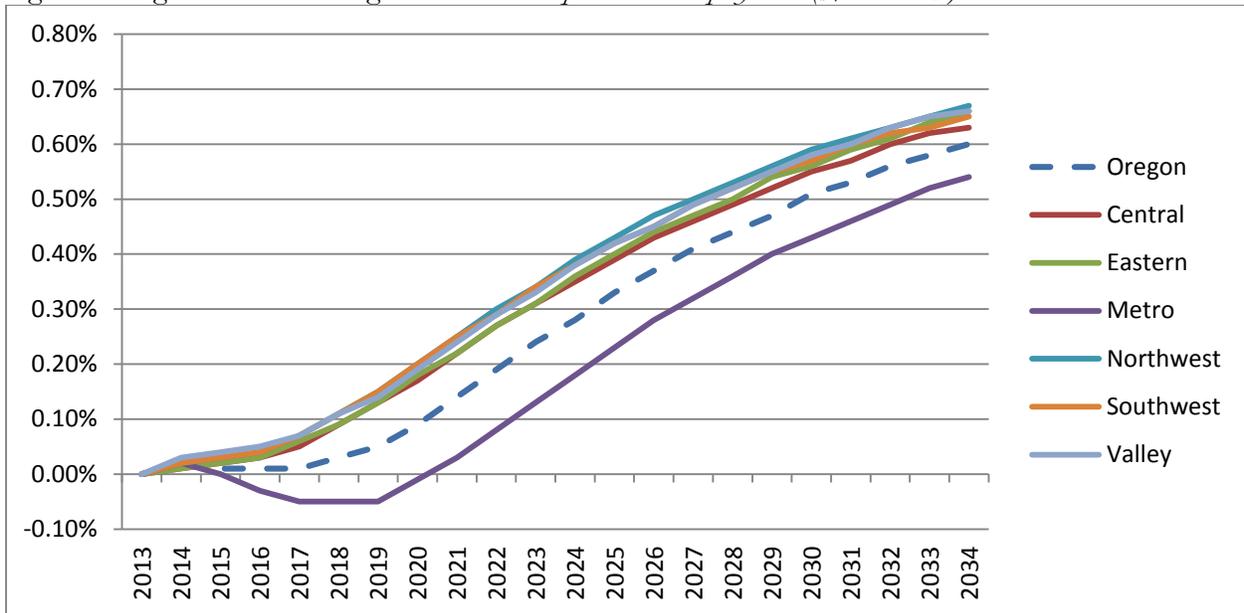
Conclusion

Initial data from British Columbia and the results of our forecasting in both studies agree that the implementation of a carbon tax would have significant impacts on the demand for transportation fuels. The higher energy prices due to the tax would incentivize behavioral change and fuel-reducing innovations, and increase demand for substitutes. While the use of carbon tax revenues would have an impact on the net effect of the tax, the existence of higher prices within the overall tax and repatriation scheme would ensure reductions in fuel demand.

The research team ensured that the underlying economic and emissions models matched the current levels of employment, output, and emissions in Oregon. The underlying analysis which produced the results in this paper was informed by meetings with relevant stakeholders from business associations, utilities, community groups, government agencies, and environmental experts. The process was also informed by meetings with the SB306 Technical Advisory Committee, made up of representatives from state agencies with a connection to energy policy.

Because expected energy price changes due to the carbon tax were a basic input of the modeling, care was taken to estimate region-specific fuel price changes. Several utilities provided data which allowed the study team to create electricity generation fuel mix profiles for each region. As a result of the customization and dynamic interactions within the models, and the general agreement with early results from actual carbon pricing programs, the study team has a high level of confidence in the results.

The basic insight behind carbon pricing is not new, and is based in mainstream economic theory. If market interactions are leading to the overuse of resources outside of the market, imposing a price on the overused resource will bring it into the market and increase efficiency. Currently, the negative impacts associated with the release of carbon through fossil fuel combustion is not incorporated into the market. By imposing a price on carbon, fossil fuel consumers are incentivized to reduce their fuel usage. This reduction in fuel demand is not necessarily associated with lower economic output. In fact, depending on the use of the revenue, a carbon tax might lead to net increases in employment and output. Because of Oregon's constitutional requirements related to transportation fuel tax revenues, a tax on carbon would significantly increase highway funding in the state. This increase in funding would akin to a public stimulus project which would reach every region in Oregon.