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OREGON CAP-AND-TRADE –
An Economic Impact Analysis of SB 1574 (2016)

KEN DITZEL
SCOTT NYSTROM
EVAN KLEIN

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Executive Summary

Associated Oregon Industries ("AOI") retained FTI Consulting, Inc. to examine the economic impacts of implementing a greenhouse gas ("GHG") cap-and-trade program in Oregon. This report examines a program that follows the 2016 version of Oregon Senate Bill 1574,[1] hereinafter "SB 1574 (2016)."

SB 1574 (2016) proposed to limit or "cap" Oregon GHG emissions at 75 percent below 1990 emissions by 2050 and would apply to any entity with annual emissions greater than 25,000 metric tonnes of carbon dioxide equivalent ("CO_2e"). It would also cover emissions generated outside of Oregon if they are associated with electricity imports. For instance, emissions from out of state fossil fuel-fired generating plants would be covered if the electricity served Oregon demand.[2]

To assess the economic impacts of a cap-and-trade program in Oregon, FTI used a combination of detailed energy market and macroeconomic forecasting tools. These tools are "dynamic" and "integrated," covering all years of the cap from 2021 to 2050, and are linked together to determine the least-cost solution for compliance under the cap.

The FTI models are substantially more robust and detailed than the models in the analysis and report commissioned by the Oregon Department of Environmental Quality (the "DEQ Report"),[3] which resulted in different conclusions even though supporting assumptions were almost identical.

As shown in the table below, we found that the SB 1574 (2016) cap-and-trade program would result in lost state GDP opportunity (GDP that would otherwise exist) of $1.3 billion and $4.5 billion (2016 $'s) in 2035 and 2050, respectively. Additionally, the bill would result in 4,800 and 16,900 fewer jobs in 2035 and 2050, respectively. This contrasts with net economic gains shown in the DEQ Report.

Figure ES- 1: Summary of Macroeconomic Impacts to Oregon from SB 1574 (2016)

Results	2035		2050	
	% Change from Baseline	*Absolute Change*	*%Change from Baseline*	*Absolute Change*
GDP	-0.4%	-$1.3 billion	-0.9%	-$4.5 billion
Employment	-0.2%	-4,800	-0.6%	-16,900
Real Income	-0.8%	-$1.8 billion	-2.0%	-$6.1 billion
Population	-0.7%	-31,400	-1.3%	-67,500

Notably, Oregon's manufacturing sector would be highly impacted. This sector, which represents 16 percent of the Oregon economy and covers employers in the computers and electronics, primary metals, and food sub-sectors, would reduce its total output by $0.7 billion and would employ 400 fewer workers by 2035.

High forecasted GHG allowance prices are the principal driver of these economic losses. Based on our modeling, we forecast GHG allowance prices to start at $13 per metric tonne in 2021, rise to $84 per tonne in 2035, and end at $464 per tonne in 2050 (2016$'s). These prices result in correspondingly higher cost of living and doing business in Oregon. Relative to our baseline forecast for 2050, we project that retail electricity rates would increase 65 to 118 percent for the majority of consumers; average retail natural gas prices would jump 179 percent; and retail gasoline prices would increase to $7.60 per gallon (2016 $'s).

[1] https://olis.leg.state.or.us/liz/2016R1/Measures/Overview/SB1574
[2] Entities emitting more than 25,000 metric tonnes plus electricity imports amount to approximately 80 percent of Oregon's total GHG emissions. Sectors fully or near-fully covered include fuel wholesalers/retailers and natural gas utilities. Sectors mostly covered include electricity generators and manufacturers. Sectors generally not covered include agriculture, landfills, wastewater, and some industrial processes.
[3] "Considerations for Designing a Cap-and-Trade Program in Oregon," *Oregon Department of Environmental Quality*, February 14, 2017, https://www.oregon.gov/deq/FilterDocs/ghgmarketstudy.pdf, supplemented by https://www.oregon.gov/deq/FilterDocs/App2LitReview.pdf

Introduction

This report examines the economic impacts of a GHG cap-and-trade program in Oregon starting from 2021 and running through 2050. The analysis presented here closely follows the program design that was proposed in a 2016 version of Oregon SB 1574.[4] This proposal would "cap" Oregon GHG emissions at 75 percent below 1990 emissions by 2050 and would apply to any entity with annual emissions greater than 25,000 metric tonnes of CO_2e. According to data from DEQ, such entities would include most electricity generation units and manufacturers, practically all fuel wholesalers and retailers, and natural gas utilities.[5]

According to the DEQ Report, approximately 80 percent of emissions would fall under the cap. All emissions from fossil fuel combustion – coal, natural gas, petroleum – would be subject to the cap (assuming an entity's emissions are greater than 25,000 metric tonnes of CO_2e per year). This includes emissions from out of state fossil fuel-fired electricity generating plants if the electricity serves customers in Oregon.

The remaining 20 percent of emissions outside of the cap would include the agriculture, wastewater, and waste incineration sectors, as well as some industrial process emissions, high global warming potential gases ("HGWP"), and municipal solid waste ("MSW").

SB 1574 (2016) requires the following emissions reductions shown in Table 1:

Table 1: Cap Limitations under SB 1574 (2016)

Year	Reduction below 1990 Emissions
2021	Cap begins January 1
2025	20%
2035	45%
2050	75%

In modeling SB 1574 (2016), we developed two scenarios – a Baseline Scenario and a Cap-and-Trade Scenario. The Baseline Scenario assumes current law (see the Major Assumptions section) and has similar market, regulatory, and legislative assumptions to the "Reference Policy Scenario" outlined in the DEQ Report. FTI's Baseline emissions, however, were significantly lower than the projections in the DEQ Report.

FTI's Cap-and-Trade Scenario closely follows the program proposed in SB 1574 (2016) with the exception of offsets. Offsets are reductions in GHGs not covered under the cap. Examples include reductions in high global warming potential pollutants such as methane emissions, carbon dioxide sequestration through afforestation or reforestation, or energy efficiency improvements. In our Cap-and-Trade Scenario, we assumed that no offsets would be available, though we did conduct a sensitivity analysis to examine the change in allowance prices if 8 percent of the cap were to be met using offsets.

FTI used a combination of detailed, dynamic, and integrated forecasting tools to assess the market and macroeconomic responses to an Oregon cap-and-trade program. PLEXOS describes the electricity market, CTAM (the Carbon Tax Assessment Model, which can solve for allowance prices under a cap-and-trade or assume them with an explicit tax) describes other energy markets, and REMI PI+ handles macroeconomic impacts. Our analysis covered eight Oregon sub-regions and the state for every year. Demand responses to changes in energy and GHG allowance prices were an inherent part of our modeling package.

This report presents the findings from modeling SB 1574 (2016). The results include macroeconomic impacts to GDP, employment, real income, and population along with retail electricity, natural gas, and transportation fuel prices to final consumers at the state and regional levels.

[4] https://olis.leg.state.or.us/liz/2016R1/Measures/Overview/SB1574
[5] http://www.deq.state.or.us/aq/climate/docs/2014GHGfacilityEmissions.pdf

Major Assumptions

Baseline Scenario

For the Baseline Scenario, FTI made the following set of key assumptions:

- **Natural gas prices:** applied Annual Energy Outlook ("AEO") 2017 reference case
- **Oregon electricity demand (load):** applied the Northwest Power & Conservation Council ("NWPCC") assumptions (including conservation) for load growth, which is essentially flat
- **Oregon Renewable Portfolio Standard:** 20 percent by 2020 rising to 50 percent by 2040
- **Coal Plant Closures:** Boardman and Centralia Unit 1 in 2020; Colstrip Units 1 & 2 in 2022; Centralia Unit 2 in 2025
- **Oregon CO_2 Emissions Standard for New Gas-Fired Combined Cycle Plants:** assumed owners purchase the $1.27 per tonne offset, which is equivalent to approximately $0.05/MWh
- **Clean Power Plan:** in-state existing electric generators must reduce their CO_2 emissions to 8.8 million short tons by 2030; modeled as a mass-based requirement under the New Source Complement
- **Clean Fuels Program**: carbon-intensity of transportation fuels decline 10 percent by 2025
- **Oregon fuel consumption:** based on share of Pacific Region in the AEO 2017 forecast
- **GDP growth:** based on Oregon OEA employment forecast to 2026, REMI control forecast thereafter
- **Population growth:** REMI control forecast, averaged 0.6 percent per year from 2021 to 2050

Cap-and-Trade Scenario

For the Cap-and-Trade Scenario, FTI started from the Baseline Scenario and added the following assumptions:

- **Covered entities:** placed entities generating 25,000 tonnes CO_2e or more annually under the cap
- **Electricity imports:** placed fossil-based electricity imports into Oregon under the cap
- **Price response:** using the AEO 2017 and other third-party analyses, assumed a price elasticity of demand by sector and by fuel for the non-electric sectors
- **Administrative losses:** assumed 15 percent of auction revenues lost to administrative expenses

Our Cap-and-Trade Scenario assumptions were conservative for the following reasons:

- **State Electricity Demand Growth:** Oregon electricity demand essentially has remained flat over the past 10 to 20 years even though the state has experienced above average population growth relative to other states. We assumed load growth would continue to remain flat.
- **Electric Vehicle ("EV") Miles Traveled:** as GHG allowance prices increase and raise the cost of fossil-based transportation fuels, consumers likely would switch to EVs and thus increase electricity demand. We did not assume an EV-based increase in electricity demand in the Cap-and-Trade Scenario.
- **Electric Space Heating:** similar to EVs, electricity space heating would increase as consumers switch away from fossil fuels due to rising GHG allowance prices. We did not assume an increase in electricity demand in the Cap-and-Trade scenario due higher electricity-based space heating demand.

Higher-than-expected growth in the economy, population, EV miles, and electric space heating would increase electricity demand (load) growth beyond what was modeled and would place more pressure on the electric sector to comply with the cap. GHG allowance prices, therefore, could be higher than forecasted.

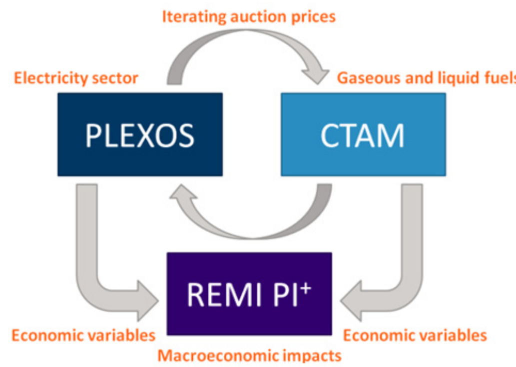
Two drivers for reducing costs were not modeled explicitly – offsets and combining an Oregon program with other states. Given it is unclear how much offsets would matter under SB 1574 (2016), we assumed none would be available. California allows only up to 8 percent; SB 1574 (2016) stated, "Offset credits may be used to account for no more than 50 percent of the greenhouse gas emissions reductions required."[6]

Combining an Oregon cap-and-trade program likely would allow covered entities to obtain reductions outside of Oregon, thus increasing the available supply of reductions and theoretically lowering compliance costs.

[6] Pg. 7 of draft legislation

Modeling Approach

To assess the economic impacts of a cap-and-trade program in Oregon, FTI used a combination of three detailed energy market and macroeconomic forecasting tools:



- **PLEXOS:** represents every electric generating unit and regional transmission constraints in the Western Interconnect.[7] The PLEXOS emissions results fed into CTAM and provided electricity rates, net investments in new assets, and fuel demand for REMI PI+.
- **CTAM:** represents demand, emissions, and prices for gaseous and liquid fuels, solves allowance prices under cap-and-trade, and provides variables regarding the same for REMI. CTAM generated the first estimates of GHG allowance prices before iterating with PLEXOS.[8]
- **REMI PI+:** a dynamic, computable general equilibrium ("CGE") model of a regional economy, including demand and supply, the labor market, demographics, commodity markets, and regional competitiveness. The results include changes to jobs, GDP, and real income.[9] The Oregon Legislative Revenue Office ("LRO") uses REMI for its analyses.[10]

Table 2 describes the key differences in modeling approaches between the DEQ Report and this research:

Table 2: FTI Modeling Approach Compared to the DEQ Report

Modeling approach	DEQ Report	FTI
Years	1 year: 2035	34 years: 2017-2050
Oregon regions	State-level only	State-level plus 8-regions
Electricity market	Unknown	Western Interconnect
Price effects	No	Yes
Macroeconomic model	Static (Input-Output)	Dynamic (Computable General Equilibrium)
CO_2 price	Fixed input	Solved by the models

As part of our modeling approach, we followed the allowance distributions outlined in SB 1574 (2016):

- **Direct allocation of allowances:** emissions-intensive, trade-exposed industries ("EITE")[11] would receive allowances to mitigate their cost of compliance. FTI assumed the amount of allowances to these industries would equal 2014 emissions starting in 2021 and would decline proportionally with the cap.
- **Consignment of allowances to utilities:** we assumed allowances would be consigned to utilities to help them compensate their low-income customers for higher energy costs. Electric and natural gas utilities would receive free allowances that would then have to be consigned to the auction; proceeds from the sale of these allowances would then benefit these customers (at the discretion of the PUC). Utilities would then have to participate in auctions or a secondary market to obtain allowances for compliance.
- **Allowance auctions:** remaining allowances after allocations would be auctioned and proceeds would be distributed to the Climate Investment Fund (85 percent of remaining funds) and the Just Transitions Fund (15 percent). We modeled the Climate Investment Fund as a collection of state infrastructure and efficiency improvements and the Just Transitions Fund as a transfer to low-income households.

[7] http://energyexemplar.com/software/plexos-desktop-edition/
[8] http://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/
[9] http://www.remi.com/
[10] See, for instance, https://olis.leg.state.or.us/liz/2015R1/Downloads/CommitteeMeetingDocument/61077
[11] According to the DEQ emissions inventory, EITE industries would include computers and electronics, primary metals, food processing, and pulp and paper subsectors.

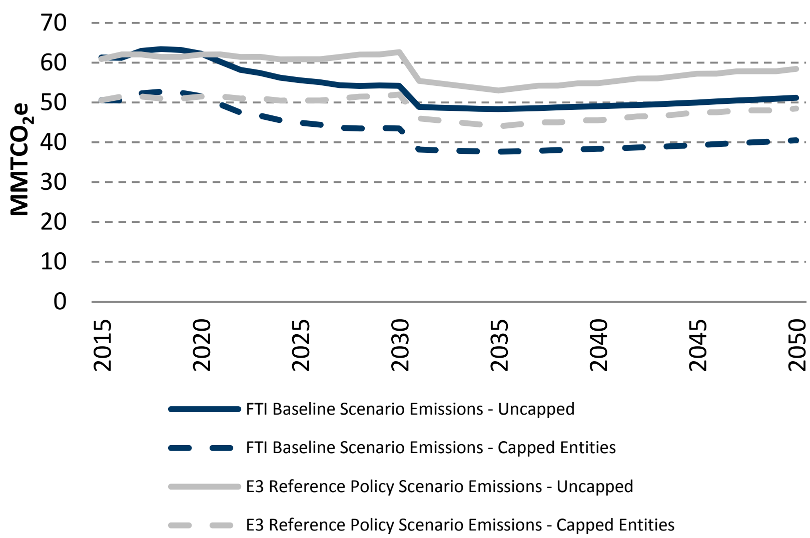
Macroeconomic Results and Findings

In this section, we discuss our modeling results and findings for the Baseline and Cap-and-Trade Scenarios. Our Baseline Scenario has similar assumptions to the Reference Policy Case in the DEQ Report. Both represent a "best estimate" of policies, future energy markets, economic growth, and technology going forward. They serve as a "baseline" for applying the cap-and-trade in order to estimate the economic impacts of the SB 1574 (2016) proposal. As with any "reference" case, future conditions can change, which could negatively or positively influence the net cost or net benefit of a policy.

Baseline Scenario

FTI's Baseline Scenario serves as a reference projection of future GHG emissions in Oregon without a cap-and-trade program. Figure 1 compares our Baseline Scenario emissions with those in the DEQ Report:

Figure 1: Baseline Scenario GHG Emissions for Oregon



The figure shows that forecasted GHG emissions in the Baseline Scenario decline about 7 $MMTCO_2e$ by 2030 or 12 percent from 2015 emissions levels of 61 $MMTCO_2e$. This is due to existing policies and actions as outlined in the Major Assumptions. The DEQ Report, on the other hand, assumes emissions remain flat through 2030. Both our forecast and the DEQ's show emissions start to rise again after 2030.[12]

In addition to a more robust modeling of the electric sector, another likely reason for the disparity between our emissions forecast and the DEQ's is that we used the more recent AEO 2017 forecast,[13] which has lower fuel consumption and emissions in the Pacific Region compared to AEO 2016 underlying the forecast in the DEQ Report.

Figure 2: Baseline Scenario GHG Emissions by Sector

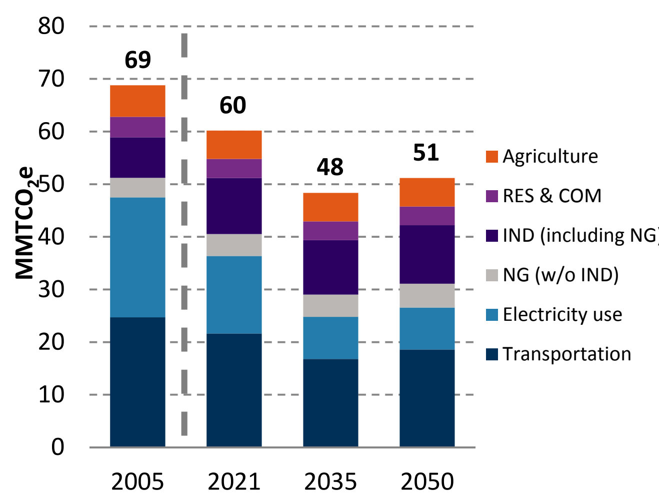


Figure 2 indicates that the electricity sector would produce most of the GHG reductions in the Baseline Scenario. This is due to the closure of Boardman and Centralia Unit 1 in 2020, closure of Colstrip Units 1 and 2 in 2022, the closure of Centralia Unit 2 in 2025, a ban on coal-based electricity imports after 2030, and the implementation of a higher renewable portfolio standard ("RPS") resulting from the passage of SB 1547 in 2016. The Clean Fuels Program ("CFP") also helps reduce transportation emissions by reducing average carbon-intensity of transportation fuels by 10 percent by 2025, but its effects are small relative to policies for electricity. These actions and policies thereby "complement" a GHG cap-and-trade program and furthermore help to make a cap-and-trade program appear less costly in earlier years.

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[12] Both studies adjusted emissions for capped entities only, with the remaining 20 percent of emissions, mostly from agriculture and landfills, remaining unchanged.
[13] https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf

Cap-and-Trade Scenario

Our Cap-and-Trade Scenario implements the matters outlined in the Major Assumptions section. As shown in Figure 3, capped entities under SB 1574 (2016) would need to reduce their emissions from ~50 $MMTCO_2e$ to almost 10 $MMTCO_2e$ by 2050. This is equivalent to achieving 1910s emissions.

Figure 3: Baseline and Cap-and-Trade Scenarios

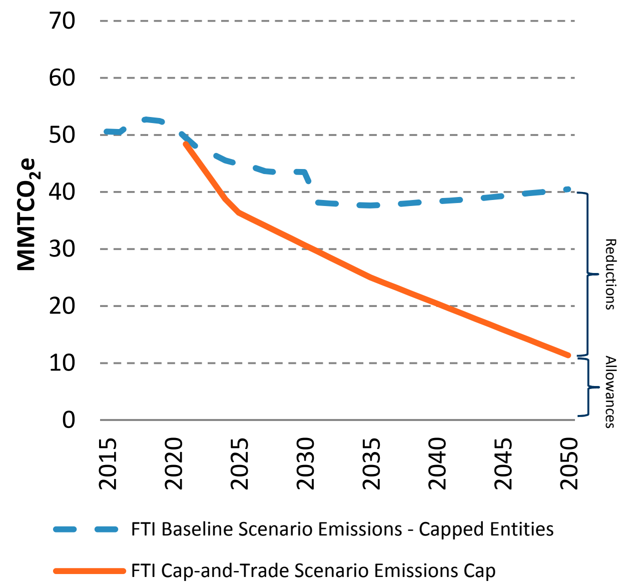
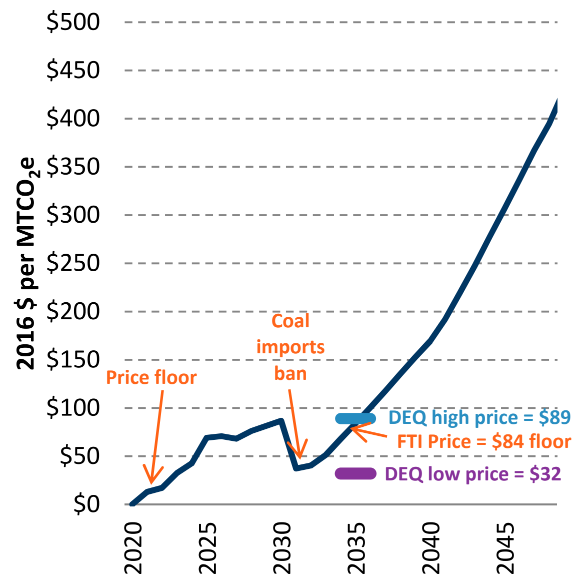
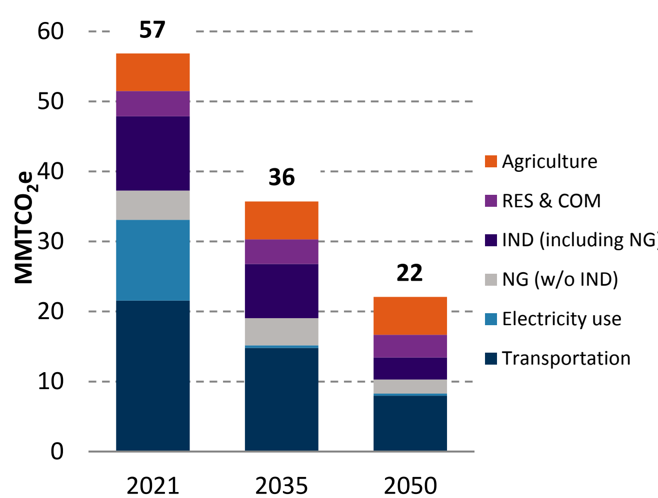


Figure 4: Forecasted GHG Allowance Prices



We forecast these deep GHG reductions would result in allowance prices reaching over $450 per tonne CO_2e by 2050. While we forecast high long-term GHG allowance prices, they are consistent with the modeling of other 2050 goals, such as the Waxman-Markey climate legislation. The National Association of Manufacturers estimated that a $1,000 per MT carbon tax (with similar CO_2e reductions) produced analogous results.[14]

Figure 5: Forecasted Cap-and-Trade Emissions by Sector



Emissions reductions concentrate in the power sector in the beginning years of both the Baseline and Cap-and-Trade Scenarios. This partially is due to significant complementary policies. It is also due to the electric sector being more "elastic" or responsive to price changes as there are more substitutes available (e.g., gas replacing coal or renewables replacing gas).

Other sectors, notably natural gas and transportation, behave in a more "inelastic" fashion.[15] These sectors are more diffuse than the power sector, with millions of emission sources and fewer substitutes available, and lack the extensive complementary policies of the power sector outside of the current CFP.

If we were to start from the DEQ Report's baseline emissions, our forecasted GHG allowance prices would be higher because complying with the cap would be more challenging with more elevated baseline emissions as a starting point. Our sensitivity analysis allowed up to 8 percent of the cap's limits to be met by inframarginal

[14] http://www.nam.org/Issues/Tax-and-Budget/Carbon-Tax/2013-Economic-Outcomes-of-a-US-Carbon-Tax-Full-Report.pdf

[15] We used an average of the price elasticity of demand for liquid and gaseous fuels between the Washington calibration of CTAM and the REMI consumption equation. The most crucial parameter, that for motor gasoline, was the average of -0.62 (Washington) and -0.66 (REMI) for -0.64 overall.

offsets.[16] The sensitively analysis showed that offsets of 8 percent could reduce allowance prices by up to 44 percent, on average, from 2021 to 2050. This is a conservative result as offsets can set the marginal price, which means smaller reductions in allowance prices.

Our modeling analysis, as shown in Figure 6, finds that the SB 1574 (2016) cap-and-trade program would produce a gross domestic product (or GDP) reduction of almost $1.3 billion in 2035 in Oregon relative to the Baseline Scenario GDP forecast. This finding is in contrast to the findings in the DEQ Report's Reference Policy Case Scenario #4, which shows a $282 million increase in GDP in 2035. Scenario #4 in the DEQ Report most closely aligns with our assumptions.

Figure 6: GDP Impacts in 2035 – DEQ v. FTI

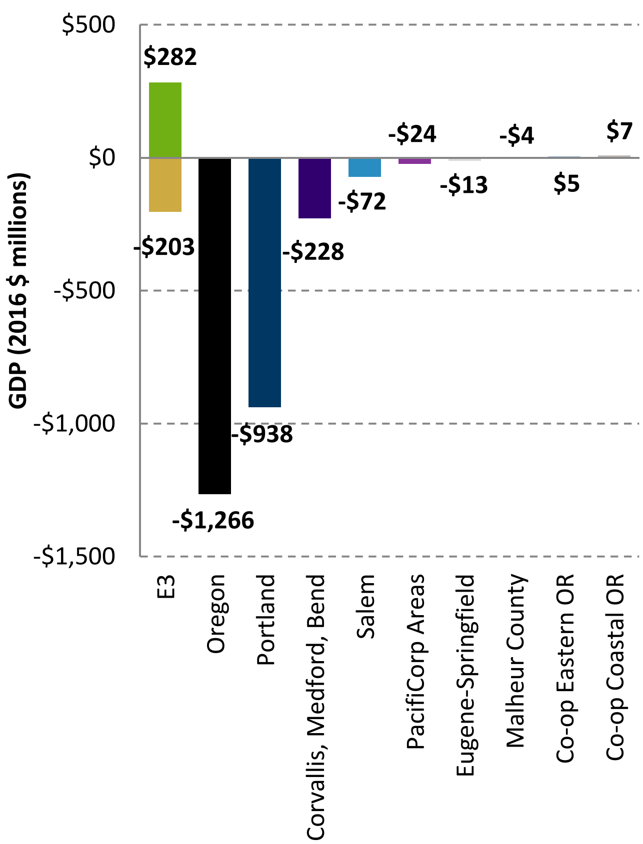
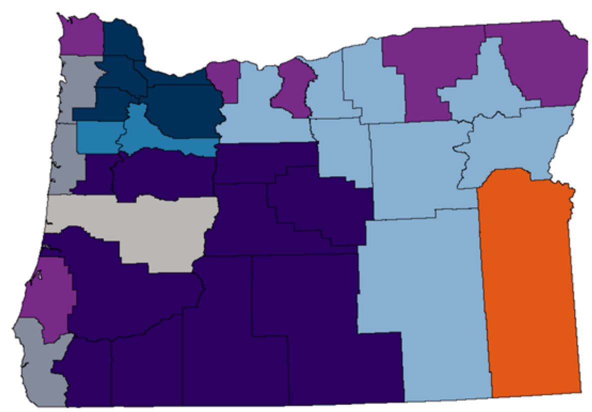


Figure 7: Regional Map of Oregon Macroeconomic Areas



Our modeling divided Oregon into the eight regions shown above. The eight regions are a collection of the thirty-six counties of Oregon, broken down based on sensible "economic regions" of the state centered on its metro areas and between the service territories of its three investor-owned utilities (IOUs). The colors on the map and the charts and graphs throughout this report are consistent. The Portland MSA dominates much of the results with 48 percent of state population and 61 percent of state GDP in 2016.

The Oregon economy continues to grow in both the Baseline Scenario and Cap-and-Trade Scenario, but state GDP in 2035 is 0.4 percent lower in the Cap-and-Trade Scenario relative to the Baseline Scenario.

The likely reason for the GDP difference with DEQ Report is that the static modeling underlying that report does not consider "price effects" – i.e., the influence of higher energy costs on competitiveness and real incomes of consumers in the regions of Oregon. FTI's dynamic modeling accounts for price effects. Higher energy prices force consumers to reallocate spending towards energy and away from goods and services possibly produced and supplied in Oregon, and puts business at a cost disadvantage relative to their competitors in other states and countries with different energy input prices.

The DEQ Report additionally does not consider demographics. Weaker job opportunity and higher costs of living discourage domestic migrants from living in Oregon and encourage current residents to leave or to

[16] Inframarginal offsets are offsets that shift the marginal abatement cost curve for GHG reductions but do not explicitly set the marginal price by intersecting with the required abatement quantity.

commute into the state instead. This removes their labor and their demand for housing and consumption from Oregon, decreasing the long-term potential size of state GDP.

The Oregon GDP impacts vary considerably across intrastate regions due to inherently different economic structures, relative levels of investment, and intensity of fossil fuel consumption. Figure 8 and Figure 9 show how net changes to GDP by region and for the state fluctuate with time, the cap, and prices.

Figure 8: Absolute Change in GDP by Region

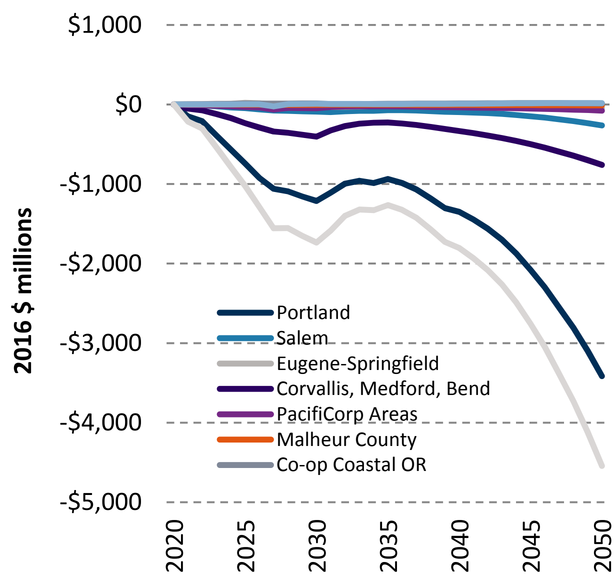
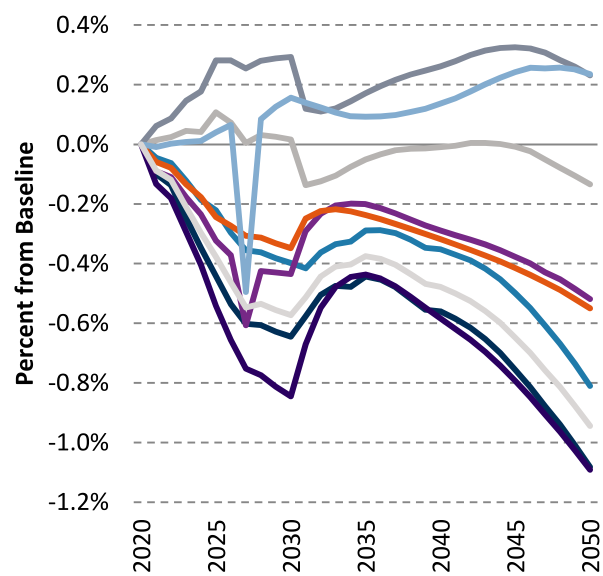


Figure 9: Percent Change in GDP by Region



From 2021 to 2030, higher energy prices under a cap-and-trade program place a drag on the economy relative to the baseline. Industries gradually become less competitive, and households must reallocate more of their spending to heating and transportation fuels, lowering their real income available for other goods and services. Allocating free allowances and redistributing revenues helps to mitigate these negative economic impacts, but they are not enough to overcome the burden of higher energy prices.

When coal imports end, starting in 2031, allowance prices drop considerably. The economy has a “snap back” before long-term increases in prices (in the 2030s and 2040s) push GDP down relative to baseline. One region, Co-op Eastern Oregon, experiences a decline in construction jobs in the late 2020s from reduced investment in power generating assets, though the impact may be more gradual than the pronounced, singular impact in Figure 9. The loss of hundreds of job opportunities in Co-op Eastern Oregon produces an acute result in such a rural region. These numbers are more easily obscured in urban areas.

Our results indicate an interesting divergence in economic impacts between rural and urban areas where rural areas – coastal and eastern Oregon save Malheur County –perform better, on average.

There are four reasons for this. First, while many rural areas in the U.S. are producers of fossil energy, rural Oregon is not.[17] Lower demand for fossil energy does not result in less fossil fuel extraction in Oregon.

Second, free allowances for EITE industries have a larger proportional benefit in rural economies while the benefit of these allowances is harder to see in the heftier economies of Portland, Salem, and Eugene.

Third, the investor owned utilities (“IOU”) serving the metropolitan areas have higher rate impacts, giving the rural areas a slight competitive advantage. Malheur County is the exception, where Ontario, its largest city, has electrical service with Idaho Power, whose generation profile is exposed to coal and natural gas.[18]

[17] http://www.eia.gov/state/seds/sep_prod/pdf/P1.pdf
[18] http://sightline.wpengine.netdna-cdn.com/wp-content/uploads/2015/04/Map-of-Oregon-Utilties-service-territory.png

Fourth, urban areas suffer when consumers' real incomes decline because their economies are more dependent on consumption and the service sector than that of the rural areas.

The particularities of the Oregon economy and its power sector combine to "reverse" the typical story about cap-and-trade and rural versus urban impacts that the DEQ Report attempts to argue.[19]

Trends in employment impacts are similar to those in GDP. Rural areas, except Malheur County, experience disproportionately fewer losses, or, in some cases, employment increases relative to urban areas. The Portland metropolitan statistical area ("MSA"), which produces approximately 61 percent of the Oregon economy, would see job losses relative to the baseline. Due to its initial size, Portland greatly influences the overall state results as shown in Figure 10, Figure 11, Figure 12, and Figure 13.

Figure 10: Absolute Change in Jobs by Region

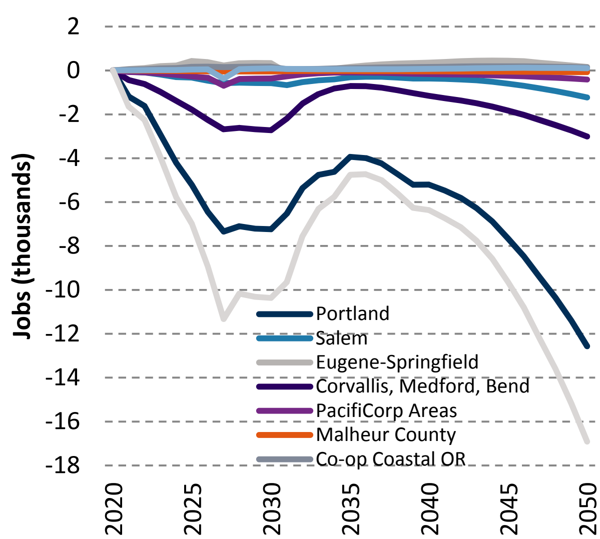


Figure 11: Change in Employment by Region

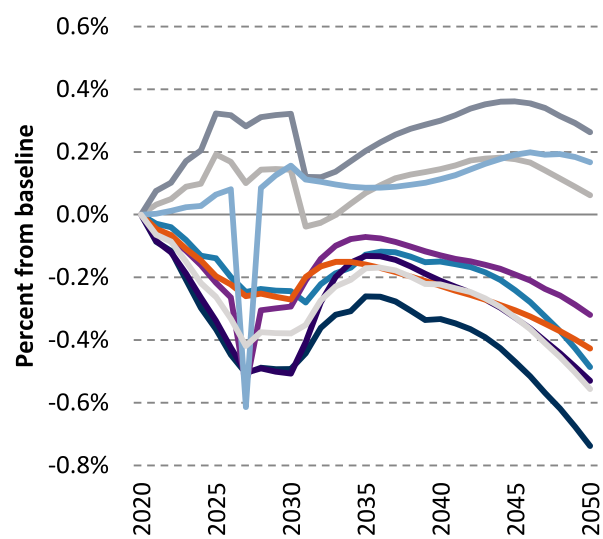
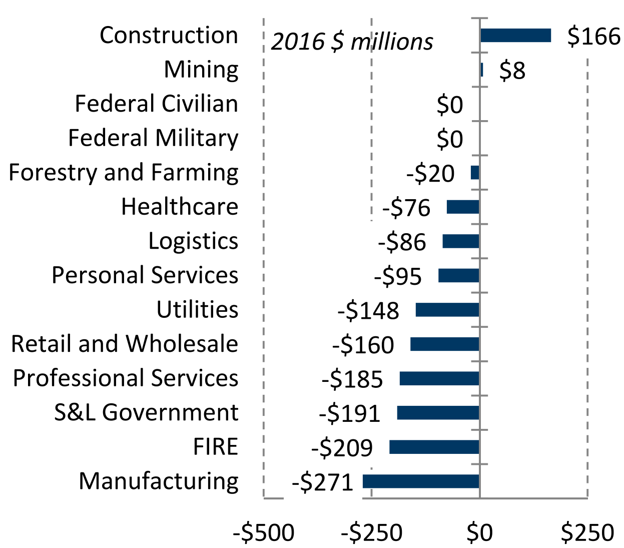
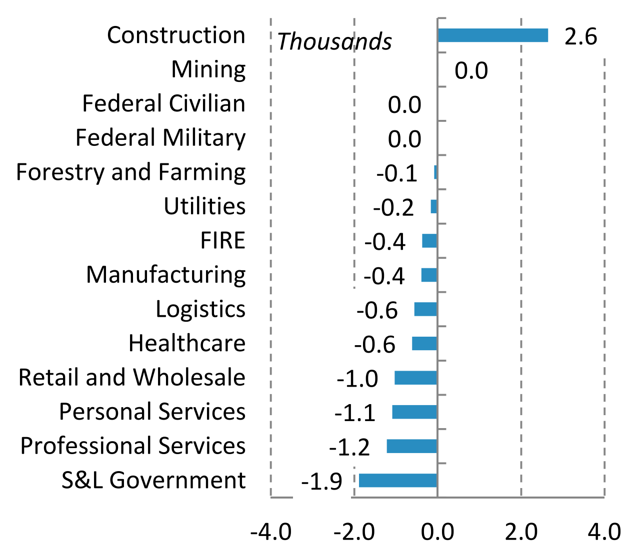


Figure 12: Change in GDP by Sector (2035)[20]



Net sum = -$1,266 million (-$1.3 billion)

Figure 13: Change in Employment by Sector (2035)



Net sum = -4.8 thousand (-4,800)

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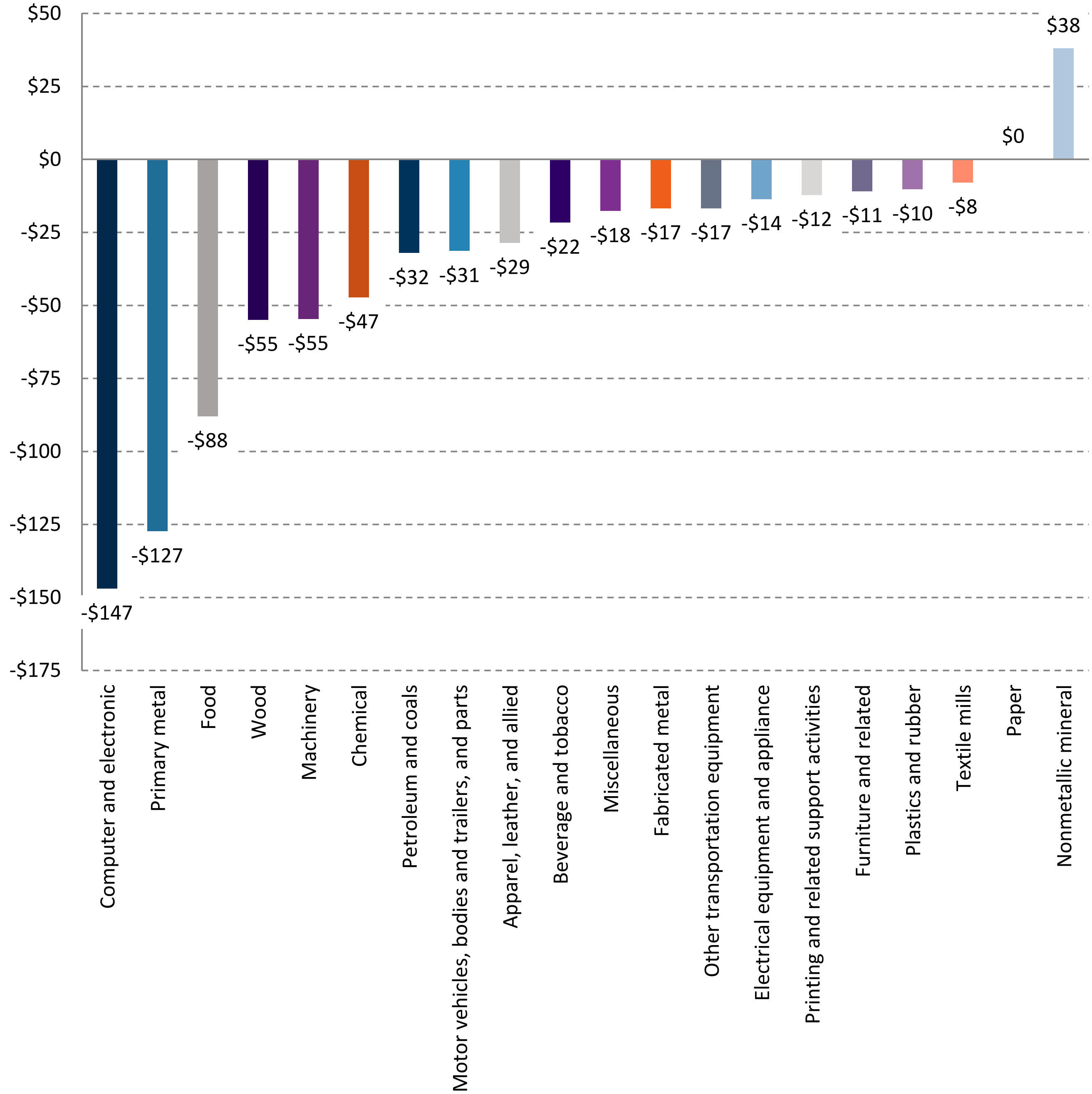
[19] Pg. 49 of presentation, https://tinyurl.com/oregondeq
[20] FIRE = Finance, Insurance, and Real Estate

Expending of revenues has economic benefits, particularly for construction. On the other hand, the other sectors face higher operating costs, degraded competitive positions relative to the baseline, and lower spending from households. These two factors associate to reduce the tax base available to state and local ("S&L") governments, reducing public employment and GDP contributions.

Figure 14: Change in Manufacturing Subsector Output in 2035



Most manufacturing sectors, despite free allowances, see their output decrease. Nonmetallic mineral product manufacturers, which feature industries such as glass, stone, concrete, and cement, may be an exception given their close association with construction, efficiency, and infrastructure. Paper manufacturing breaks even for being a particular target of free allowances for EITE industries, though barely. The other industries face higher costs themselves and throughout their supply chains, lower consumer demand from lowered real incomes, and increased competition from other regions and countries, which leads to declining output projections (relative to the baseline) for most other subsectors in 2035.

Energy Price Impacts

This section describes the estimated energy price impacts under SB 1574 (2016). Under such a program, utilities and fuel wholesalers would pass the cost of allowance purchases onto customers.

Figure 15 and Figure 16 show the estimated impact to residential and industrial electricity prices. Our analysis covers the three IOUs as well as the Eugene Water & Energy Board.[21]

For PGE, the rate increases generally follow the trend in GHG allowance prices under the cap-and-trade.

For PacifiCorp, coal units outside Oregon are tagged with Oregon's GHG allowance price based on PacifiCorp's Oregon load relative to its total load across the Western Interconnect. PacifiCorp's rate impact is pronounced through 2030 due to out-of-state coal production and then becomes more muted as coal imports discontinue after 2030.

Idaho Power follows a similar pattern as PacifiCorp because the majority of its generation is outside of Oregon and the largest proportion of its electricity generation capacity is fossil fuel-based.

EWEB experiences almost no rate impact. EWEB has an almost zero-carbon profile.

Figure 17 shows our price forecast for retail gasoline with and without SB 1574 (2016). Absent the cap-and-trade program, gasoline prices are stable in the long-term between $3.50 and $4.00 in the AEO 2017 forecast. However, adding the cost of allowances to the price of gasoline eventually leads to gasoline over $7.50 per gallon by 2050. These are higher than prices currently paid in Europe.

The residential natural gas prices featured in Figure 18 surge under cap-and-trade. Prices generally follow the path of allowance prices, slowly building up in the 2020s before dropping in 2031, and building again in the later decades. Natural gas prices for residential consumers double relative to the baseline by the early 2040s and nearly triple by the end of the analysis in 2050.

[21] For the IOUs, we calculate rate impacts by starting with each IOU's generation portfolio, generation costs, and market purchases to serve load. We then add a fixed cost charge for generation, transmission, and distribution based on the difference between 2015 retail rates and our cost build-up. This fixed charge cost is applied in future years. Finally, we add GHG allowance compliance costs for each IOU to determine the final impact on retail rates.

Figure 15: Residential Electricity Price Change from Baseline

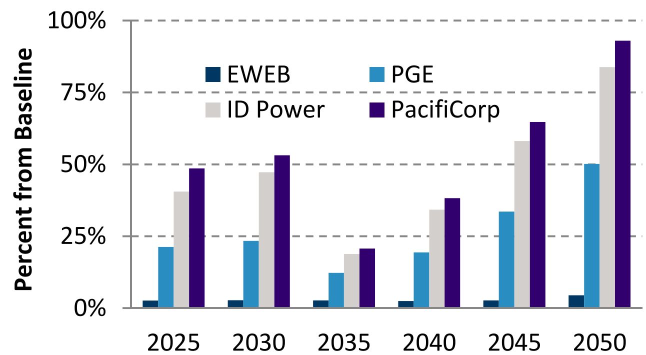


Figure 16: Industrial Electricity Price Change from Baseline

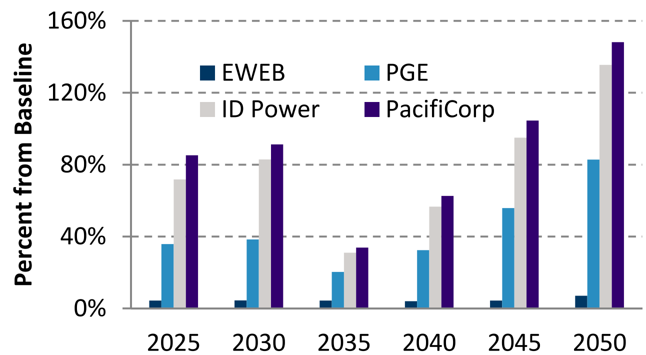


Figure 17: Retail Gasoline Prices

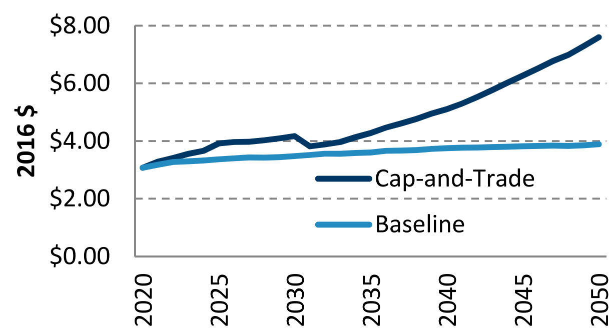
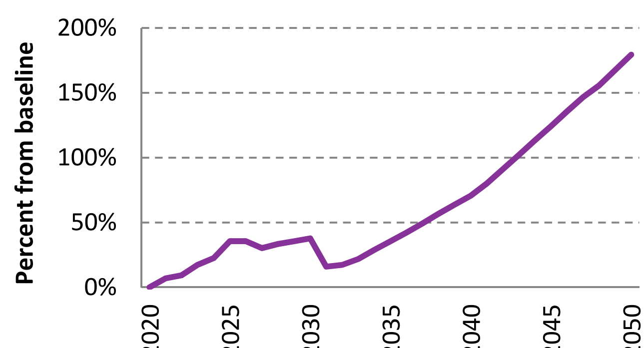


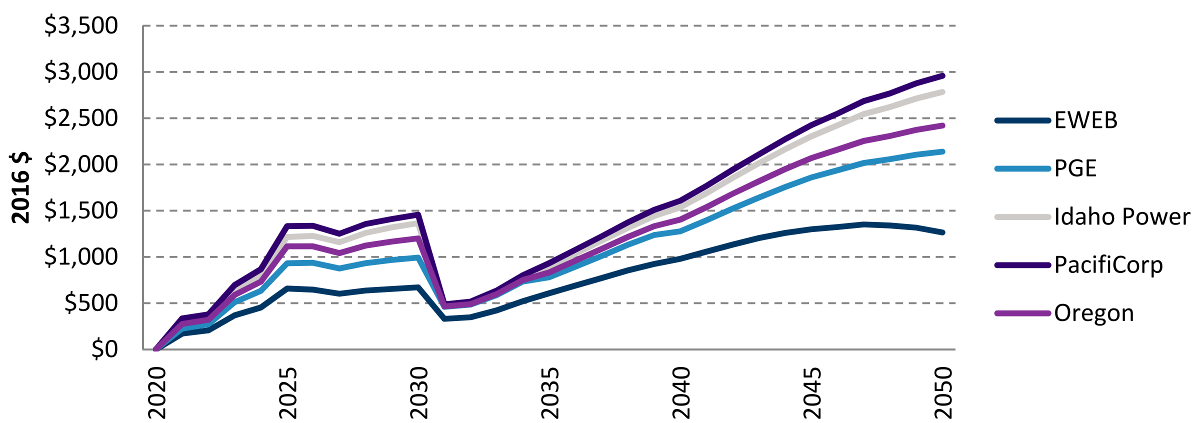
Figure 18: Residential Natural Gas Price Change from Baseline



Family-of-Four Cost-of-Living Impact Analysis

Oregon SB 1574 (2016) or similar bills that call for a 75 percent reduction from 1990 levels of emissions by 2050 would have significant direct costs for the average Oregon household. Using information from PLEXOS, CTAM, and REMI PI+, FTI calculated the estimated direct costs to the average household or "family-of-four."[22] The results vary with allowance prices and with the utility serving the family.

Figure 19: Average Annual Direct Cost-of-Living Impact per Family-of-Four by Year and Utility



The cost per family-of-four varies from $500 to $1,500 per year in the 2020s. This figure drops in 2031 with the suspension of coal-fired power imports, and, thereafter, costs per family escalate rapidly to $1,250 per year for EWEB customers and between $2,000 and $3,000 per family for PGE, Idaho Power, and PacifiCorp customers. These three IOUs serve the majority of Oregon's population base.

Figure 19 would mean significant increases in total energy expenditures by Oregon households. The typical family-of-four would spend 25 percent more on energy in the late 2020s, 18 percent more in 2035, over 40 percent more in the 2040s, and eventually 52 percent more by 2050.

Our methodology for the family-of-four cost-of-living impact analysis begins with creating a baseline projection of household energy expenditures. First, we start with U.S. Energy Information Administration data that shows residential consumers in Oregon spent $7 billion on electricity, natural gas, and petroleum products in 2014.[23] We then forecast this amount forward using CTAM. Next, we forecast the number of adults using REMI PI+. Dividing forecasted residential energy consumption by forecasted adults in each year provides the baseline projection of energy expenditures per adult in Oregon. We then multiply this result by 2.68 to achieve a baseline average household energy expenditure, which we assume to be similar to a family-of-four. Finally, we divide the additional expenditures projected under the cap shown in Figure 19 (statewide) by the baseline projection for a family-of-four to determine the percent change in energy expenditures.

This analysis covers only "direct" cost to customers' energy bills – utility bills for electricity and gas and higher prices for petroleum products, mostly at the pump. Real income loss from commercial firms passing their higher cost of operation to local customers is not included, such as grocery stores (now burdened with higher electric rates but still needing copious power for refrigeration) increasing retail prices. It also does not include the effect of job losses or lower wages from changes in the labor market.

If these were to be included, then Figure 19 could be 1.5 to 2 times higher than direct costs alone.

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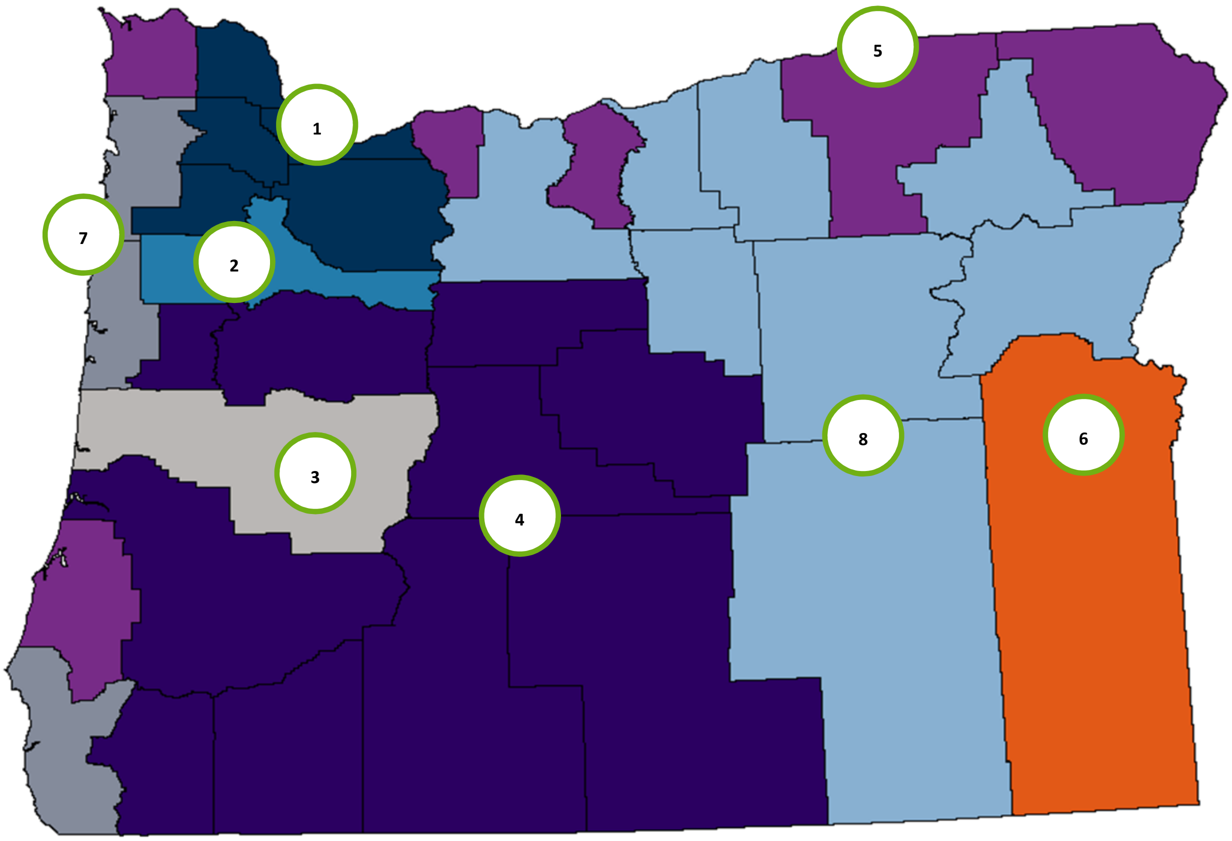
[22] Oregon has a population of 4.10 million and 1.53 million households, https://www.census.gov/quickfacts/table/PST045216/41, which is an average size of 2.68 people. While a family-of-four, defined as two adults and two children, obviously has four members, its share of energy consumption would not scale proportionally with each member. The second adult and each child would increase housing size and needs for fuels, car trips, and the quantity of appliances and electronics, but the family unit also offers economies of scale. For this reason, we assume a family-of-four in Oregon consumes the same as the average household of 2.68 members.

[23] Combining residential and transportation expenditures assuming 75 percent of motor gasoline and 25 of motor diesel expenditures were from households, http://www.eia.gov/state/seds/seds-data-complete.php?sid=US#PricesExpenditures

Appendix A: Regional Map of Oregon



The above map illustrates the division of Oregon's counties into 8-regions in the REMI model. The colors of the map by region are consistent with the colors of the regions' bars and lines in the various figures. This particular configuration reflects the dual mandate to divide Oregon into regions by sensible economic zones, mostly metropolitan statistical areas ("MSAs"), and by utility service territory to tailor the price outputs from PLEXOS into REMI inputs by region.

Figure 20: Oregon regional layout

#	Region	Counties
1	Portland MSA	Clackamas, Columbia, Multnomah, Washington, and Yamhill Counties
2	Salem MSA	Marion and Polk Counties
3	Eugene-Springfield MSA	Lane County
4	Corvallis, Medford, and Bend	Benton, Crook, Deschutes, Douglas, Jackson, Jefferson Josephine, Klamath, Lake, and Linn Counties
5	PacifiCorp Areas	Clatsop, Coos, Hood River, Sherman, Umatilla, and Wallowa Counties
6	Malheur County	Malheur County
7	Co-op Eastern Oregon	Curry, Lincoln, and Tillamook Counties
8	Co-op Coastal Oregon	Baker, Gillian, Grant, Harney, Morrow, Union, Wasco, and Wheeler Counties

Appendix B: DEQ and FTI differences in assumptions

DEQ Slide Page	Assumption	DEQ	FTI	Discussion
Baseline Forecast				
4	Clean Fuels Program	10% reduction in emissions from transportation fuels by 2025	10% reduction in the carbon-intensity of transportation fuels by 2025	SB 324 mandates a 10% reduction in carbon-intensity by 2025. DEQ's baseline shows petroleum emissions increasing, which would imply that the 10% reduction is more than offset by increased petroleum consumption.
21	Zero Emission Vehicles	90k EVs, 120k PHEVs by 2025 (consistent with Clean Fuels Program)	10% reduction in carbon-intensity parameter for transportation fuels met by interpolation by 2025	DEQ derived their numbers from an ICF study on the composition of the vehicular fleet under CFP,[24] which produces the explicit fleet mixture needed to achieve the goals, while FTI simply reduced the carbon-intensity parameters of transportation fuels in CTAM to generate a similar effect without laying out the specified changes in the fleet like ICF.
4	Renewable Portfolio Standard (RPS)	50% RPS by 2040, suspension of power generation from coal by 2031, likely not fully modeled as LEAP is not an electricity market forecasting model	• 20% RSP by 2020 • 27% RSP by 2025 • 35% RSP by 2030 • 45% RSP by 2035 • 50% RSP by 2040	DEQ results show little if any impact on electricity consumption emissions from the RPS as emissions grows over time regardless of the RPS mandate.
15	Electricity imports	DEQ says imports should be under the cap, but DEQ does not actually model imports. They simply assume compliance using CA's projected price path.	Coal imports face a carbon price through 2030 and then all imports stop in 2031. Gas imports face a carbon price throughout the modeling.	FTI electricity market modeling shows coal imports completely end after 2030, creating a large drop in Oregon emissions.
21	Boardman coal-fired power plant	Retires at the end of 2020	Retires at the end of 2020	
21	Coal-fired electricity imports	Suspended coal imports after 2030, but results imply that must not be the case as emissions from electricity consumption continue to grow	Suspended coal imports after 2030 by setting up specific transmission constraints and sub-regions in PLEXOS. Assumed PacifiCorp's coal generators reallocated to non-Oregon demand regions.	
21	Load growth and energy efficiency	Used "utility-projected load growth" but does not reference source.	Used Northwest Power & Conservation Council forecast, which has flat growth to 2050	
22	Fuel consumption growth rates	Used EIA AEO 2016 from 2015-2040	Used EIA AEO 2017 from 2015-2050 to calibrate baseline consumption in CTAM	
24	Overall baseline emissions trajectory	From 61 MMT CO_2e in 2015 to 58 MMT CO_2e in 2050	Emissions decreasing from 61 MMT CO_2e in 2015 to 51 MMT CO_2e in 2050	FTI forecast is conservative from the perspective of the cap-and-trade scenario modeling in that it decreases the carbon price needed to meet compliance targets. Using DEQ's assumptions would increase the carbon prices even further.

[24] https://www.oregon.gov/deq/RulesandRegulations/Documents/T3m3.pdf

Cap-and-Trade Forecast				
12	Allocations and auctions	Modeled both	Auction-only minus the allowances specifically alluded to in SB 1574 (2016)	
13	Offsets	Recommended offset rules should mirror Western Climate Initiative, "Offsets allowed, up to 8% of a facility's annual emissions," but not explicitly modeled.	No offsets included	Ran experimental cases on 8% offsets
16	Linking up with WCI	Discussed and recommended, but not modeled	Not modeled	
16	Allowance price floor	Recommended California's level; floor price modeled as a scenario	$13.57 in 2017$'s[25,26]	$10 nominal dollars in 2012, increasing at 5% plus inflation rate is the floor for AB32 in California
16	Allowance banking	Discussed and recommended, but not modeled	Not modeled	
21	"Reference Policy"	Same as baseline, but with coal imports suspended in 2031 and 50% RPS by 2040	Modeled 50% RPS by 2040, Boardman closure at the end of 2020, suspension of coal imports after 2030, CFP, and energy efficiency – that is, the complementary policies as the policy baseline	Our case is most similar to this one
21	"Aggressive Policy"	Same as reference, but includes 300,000 EVs, 600,000 PHEVs by 2030 plus a reduction in electricity load of 22,000 GWh by 2030	Not modeled	
25	Program coverage	All fuel consumption, "partial" coverage of industrial process emissions and landfills, no coverage of agricultural emissions	Fossil fuel combustion and electricity imports	
27-28	Scenario analysis	Considered a "Reference Policy" and "Aggressive Policy" versus cap-and-trade	Essentially considered "Reference Policy" only against the cap-and-trade goals	
33	Revenue recycling	Revenues distributed to consumers	SB 1574 routes revenues to state funds, not directly to households	

[25] • 2016: $12.73 in 2016$'s, https://www.arb.ca.gov/cc/capandtrade/auction/2016_annual_reserve_price_notice_joint_auction.pdf
[26] • 2017: $13.57 in 2017$'s; https://www.arb.ca.gov/cc/capandtrade/auction/2017_annual_reserve_price_notice_joint_auction.pdf

34	Free allocation	Assumes a set of cases where 100% of the permits are free allowances	Allocations modeled according to bill	
34	Allowances to energy-intensive, export-exposed (EITE) industries	No discussion	Included	
35	Carbon prices	Modeling input – assumed $32 and $89 based on research conducted for California for 2035	Modeled endogenously	
36	Loss factor	15% or 30% loss of revenues for “inefficiency” and out-of-state profits	Assumed 15% loss factor	
35	Overall cap-and-trade results	• $32/tCO2e to $89/tCO2e in 2035 (2015 $) • GDP range (-0.08% to 0.19%)	• $85/tCO2e (2016 $) in 2035 • GDP (-0.4%)	

Appendix C: DEQ and FTI differences in modeling

Modeling Approach	DEQ	FTI
Years modeled	*1 year (2035)*	*34 years (2017-2050)*
Regions modeled	*State level*	*State level and 8 regions within Oregon*
Electricity market modeling area	*Unknown*	*Major markets across the Western Interconnect*
Power generator modeling	*Unknown*	*Unit-level*
Electricity market price impacts	*No*	*Yes*
Fuel markets price impacts	*No*	*Yes*
Revenue forecast	*2035 only*	*2021-2050*
Macroeconomic model	*Static*	*Dynamic*
	Input-output (IO)	*Combined IO, computable general equilibrium (CGE), and behavioral model*
Price effects	*No*	*Yes*
		Affects both business competitiveness and households' real incomes
CO_2 price	*Fixed input*	*Solved by the models*
Allowance banking	*No*	*No*

Appendix D: DEQ and FTI analytical differences

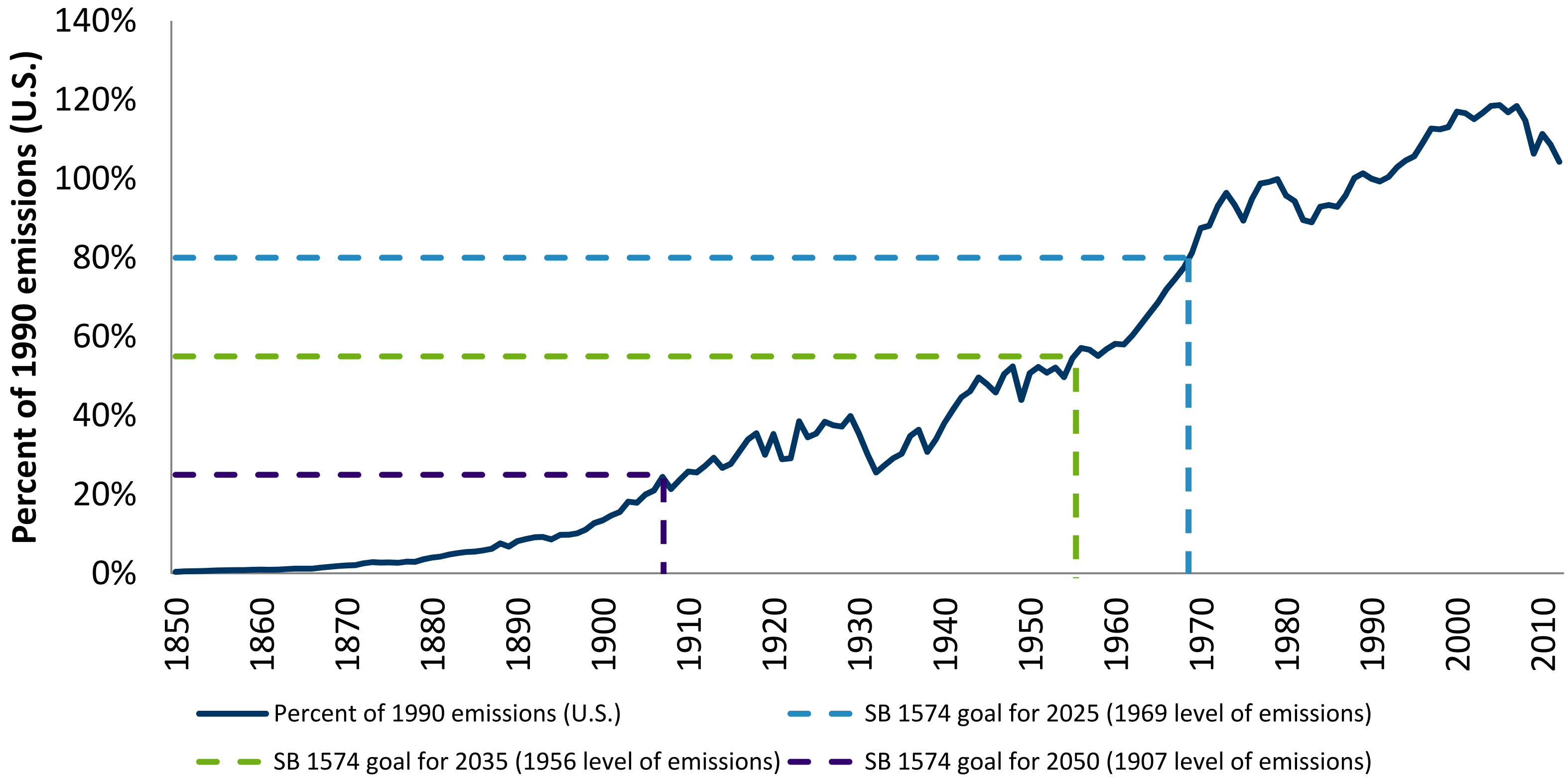
Matter	DEQ	FTI
Power sector modeling	LEAP lacks a representation of the power sector including realistic constraints for generation, transmission, and load demand	PLEXOS is an explicit model of the power sector, including dispatch, unit optimization, and optimal power flows in the long-term
Renewable portfolio standard	Electricity consumption emissions have little effect from RPS	Electricity consumption emissions decline as the RPS increases in the 2020s and 2030s to its maximum requirement of 50% by 2040
Electricity imports	Not explicitly represented in a power sector model	Explicitly represented in PLEXOS with coal imports ending after 2030
Load demand growth	Used “utility-projected load growth,” though without a source	Northwest Power and Conservation Council forecast, which has essentially flat load growth to 2050
Electricity prices	No impact reported	Explicitly reported
AEO Scenario	AEO 2016 Reference Case	AEO 2017 Reference Case
Carbon prices	Assumed \$32 and \$89 based on other research for California	Endogenously generated carbon prices in modeling
California and Oregon	Uses California (with a population of 39 million) as a proxy for Oregon (around 4 million people)	Explicitly modeled Oregon as Oregon, including its power sector and petroleum demand
CA and OR climate goals	40% below 1990 levels by 2030, 80% below 1990 levels by 2050, implied 50% in 2035	45% below 1990 levels by 2035, a difference of 5% from California
Timeline of prices	2035 only	Year-by-year results for 34 years (2017 through 2050)
Specific timing of 2035	Demand for allowances is likely to drop in the early 2030s after the end of coal imports in 2031 and 2035 is before the most stringent tightening of the cap in the 2040s, making 2035 likely to be a “soft” year	Individual years modeled throughout the period in order to see trends in prices, the cap’s interactions with complementary policies and changes in the power sector, and out to 2050

Auction revenues	2035 only	Year-by-year forecast
Regional detail	Oregon only	Eight regions within Oregon for macroeconomic results
Energy-intensive, export-exposed (EIEE) industries	Not addressed	Included a realistic estimate of what such adjustments might look like as a part of the economic modeling
Macroeconomic model	IMPLAN	REMI
Macro model type	Static input-output (IO)	Combined IO, computable general equilibrium (CGE), and behavioral
Macro model data updates	Most recent IMPLAN data is for 2015 with no forecast	Historical data through 2015, though with forecasts of the macro-economy and economic structure through 2030 and interpolated thereafter
Price effects for industry	None	Higher energy input costs erodes regional competitiveness
Price effects for households	None	Higher energy-related cost of living reduces consumers' real incomes, encourages out-migration from Oregon, and reduces in-migration
Demographics	None	Integrated with the economy through labor supply, consumption, and migration
National impact	Cites Nystrom and Luckow as an example of a positive impact from climate policy	Study done at the national level, and the U.S. has a much more closed economy overall than does any state economy, and neglects the assumption of a "border adjustment" or "carbon tariff" that may be possible at the national level but is impractical and illegal at the state level due to the Commerce Clause and Congress' prerogatives to regulate all interstate commerce

Rural/urban split	Cites both rural and urban states can benefit from policy	Study done at the U.S. Census region level, which combines 3-8 states per region, making state level pronunciations difficult, though the study identify the main drivers of “winners and losers” not as urban and rural but energy-exporting and -importing – the urbanized Dallas and Houston are not likely to gain, for example, given their dependence on fossil energy

Appendix E: Long-term historical context of emissions

SB 1574 Reduction Levels and Corresponding Historical Year



SB 1574 has aggressive goals that come online quickly, without a long period of caps above the baseline or extensive free allowances. From a historical context, the bill or any similar ones would require emissions reductions to levels last seen decades or over a century ago. Oregon's per capita emissions would "Europeanize," with the 2025 goals of 11.5 metric tonnes ("MT") per capita similar to industrialized nations in East Asia such as Japan and South Korea, 2035 goals of 7.5 MT per capita similar to Western Europe, and 2050 goals of 3.0 MT similar to less developed Caribbean countries. The ambition of these goals drives the high auction prices in the modeling – though $450 per MT is consistent with projections about Waxman-Markey for 2050. Oregon also lacks many large, singular emissions sources to target for reductions, such as the remaining coal fleets in the Midwest and Southwest of the U.S. in any national policies regarding GHG emissions.

Appendix F: Projected emissions-intensity of Oregon economy

Emissions-Intensity of the Oregon Economy