THE ECONOMIC, DEMOGRAPHIC, AND CLIMATE IMPACT OF ENVIRONMENTAL TAX REFORM IN WASHINGTON AND KING COUNTY

PREPARED BY

Regional Economic Models, Inc. (REMI)

SCOTT NYSTROM, M.A.

Senior Economic Associate

ALI ZAIDI, B.S.

Assistant Economist

1776 I St. NW
Suite 750
Washington, DC 20006
(202) 716-1397
<scott.nystrom@remi.com>

FRIDAY, DECEMBER 13, 2013

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Washington Environmental Tax Reform (ETR-WA) would like to thank everybody who supported this research project. Their individual and collective contributions to the report were invaluable. We would like to thank the researchers at the Northwest Economic Research Council (NERC) at Portland State University (PSU) for the inspiration in the original Oregon study, all those involved in the writing and funding of the Massachusetts study, and everyone in the economics and policy literature devoted to the analysis of the nexus between energy, economics, and the environment. We would like to thank the following for their editorial contributions. We are grateful for your generosity and time in making this study clearer, fairer, and a better representation of the economic and emissions impacts:

- **Dr. Yoram Bauman**, *Proprietor*, The Stand-Up Economist
- **Dr. Jenny Liu**, *Assistant Director*, Northwest Economic Research Center (NERC) at Portland State University (PSU)
- **Dr. James Peach**, *Regents Professor*, Arrowhead Center at New Mexico State University (NMSU)
- **Dr. Thomas Potiowsky**, *Director*, Northwest Economic Research Center (NERC) at Portland State University (PSU)
- **Jeff Renfro**, *Senior Economist*, Northwest Economic Research Center (NERC) at Portland State University (PSU)
- **Dr. Frederick Treyz**, *CEO*, Regional Economic Models, Inc. (REMI)
- **Dr. Dan Wei**, *Research Assistant Professor*, Price School of Public Policy at the University of Southern California (USC)

We would like to thank the analysts at the Washington Office of Financial Management (OFM) for pointing us in the correct direction for data on the budget for Washington and King County. In addition, ETR-WA thanks the following organizations for their support:

EXECUTIVE SUMMARY

This white paper explores the economic, demographic, distributional, fiscal, and climate implications of remaking portions of the Washington and King County budgets through carbon pricing and environmental tax reform. The main principles of the policy design include Pigouvian taxes on carbon emissions, revenue-neutrality of the collected funds, and their redistribution by lowering state business and ordinance (B&O) taxes, state and local sales taxes, and King County property levies while adding rebates to low-income individuals and households via the Working Family credit. Using REMI PI+, a dynamic, multiregional model of Washington and the Carbon Tax Analysis Model (or CTAM), we assessed if environmental tax reform could generate revenue, create jobs, help grow the economy, and reduce Washington's carbon footprint:

Key findings for Washington:

- *Washington could add a net of between 5,000 and 40,000 jobs from this tax reform by 2035, depending on scenario*
- *Annual GDP, when measured in 2013 dollars, is between $250 million and $2.75 billion higher than baseline by 2035*
- *Net impacts to costs of living are minimal, and the impact to the distribution of income in the state is relatively negligible*
- *Pricing carbon at $100/metric ton by 2033 will reduce state emissions to 75% of 1990 levels by 2035, complying with current state legislative goals*
- *Washington may even benefit if King County acts alone*

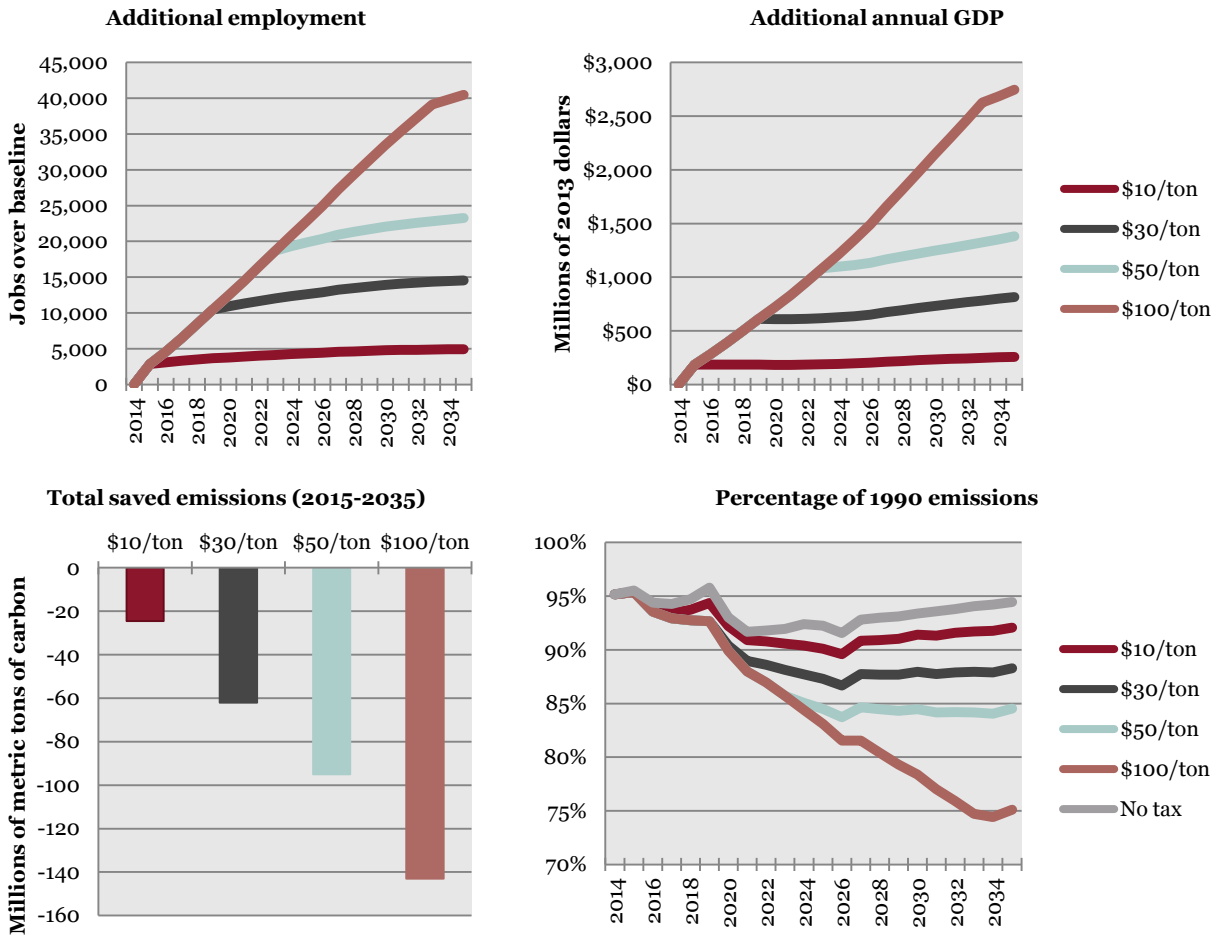
Key findings for King County:

- *King County could chose to "go it alone" with environmental tax reform and provide relief to local sales and property taxes*
- *Reform in King County could add between 1,000 and 8,000 jobs to the county by 2035*
- *Annual GDP in 2013 dollars could increase somewhere between $100 million and $600 million*
- *"Core" industries in Seattle and Redmond such as professional services, software, finance, construction, and wholesale might benefit the most*
- *Environmental tax reform saves emissions between 8 million metric tons and 34 million metric tons from 2015 out to 2035*

Environmental tax reform through a carbon tax offers an attractive balance between the state's multifaceted priorities of improving the economy, creating jobs, preventing the emission of (potentially) harmful carbon dioxide into the atmosphere, and offering tax relief. Furthermore, a carbon tax under these designs—the ones for revenue-neutrality and revenue recycling—does not have major influence on the distribution of income or costs of living in the state. Environmental tax reform has the potential to allow the state to increase its competiveness through lower taxes, improve its attractiveness to migrants with more jobs and lower sales taxes, and reduce the quantity of carbon emissions. The "give-and-take" here represents the net effects of the simulations for Washington and King County with summaries for both on the next two pages.

WASHINGTON SUMMARY

This report examines the economic, demographic, fiscal, and climate impacts of several environmental tax reform scenarios for the state. We looked at introducing a price on carbon emissions with a tax on carbon-emitting fossil fuels and electricity based on how much carbon dioxide they release into the atmosphere. Scenarios included a fee at $10 per metric ton, $30/ton, $50/ton, and $100/ton phased in at $5/year. This analysis was "revenue-neutral." For every dollar in revenue, we reduced the B&O tax, sales tax, and increased the Working Family rebate in total by the same amount as revenues. The subsequent division of "recycled" dollars did not redistribute funds, as the business and household sectors received tax cuts equal to their environmental tax payments. Major results include the impacts on jobs, GDP, and state emissions:

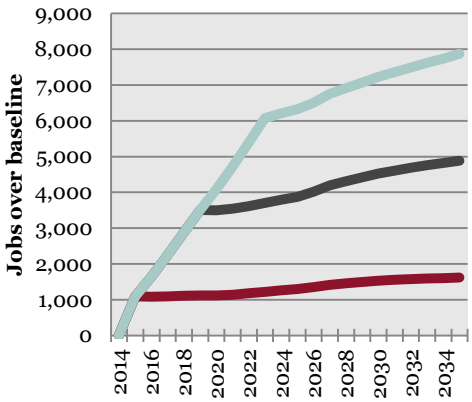


Each increase in the carbon tax's level has gradually less of an impact (about 60% of the $100/ton benefits coming in the initial $50/ton). The effect of the "tax swap" between taxing energy and the B&O and state sales taxes creates more jobs and GDP, helps to incentivize reductions in carbon emissions to 75% of 1990 levels by 2035, and brings Washington in line with its legislative goals to do the same.

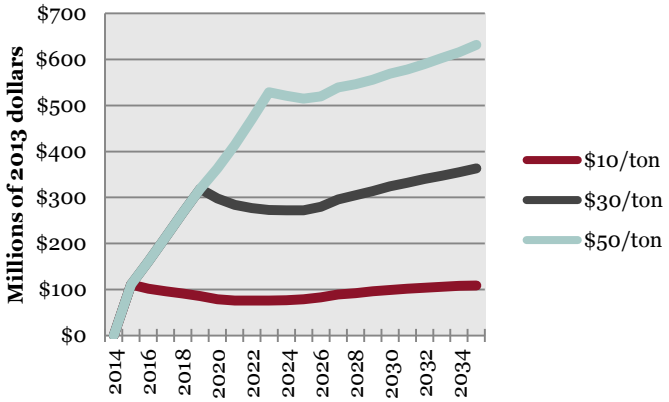
KING COUNTY SUMMARY

This report also examines the economic, demographic, and climate impact of several environmental tax reforms for King County **on its own**. We looked at introducing a price on carbon in King County with fees on carbon-emitting fuels and electricity based on how much carbon dioxide they release into the atmosphere. Scenarios include a fee at $10 per metric ton, $30/ton, and $50/ton phased in at $5/year. This analysis was "revenue-neutral." For every dollar in revenues, we used 50% of the money to reduce local sales taxes and the other 50% to reduce local property taxes. This "recycling" will help reduce the cost of living and strengthen businesses' competitiveness. Major results include the impacts to jobs, GDP, the county's estimated level of carbon emissions, and the performance of key sectors in King County:

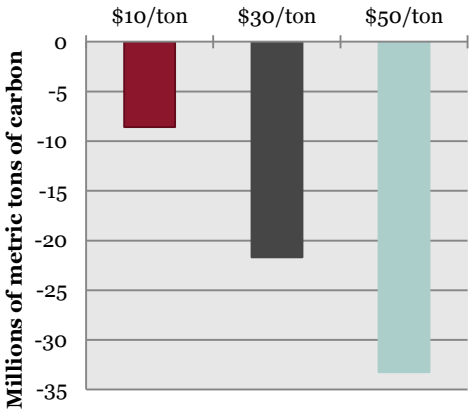
Additional employment



Additional annual GDP



Total saved emissions (2015-2035)

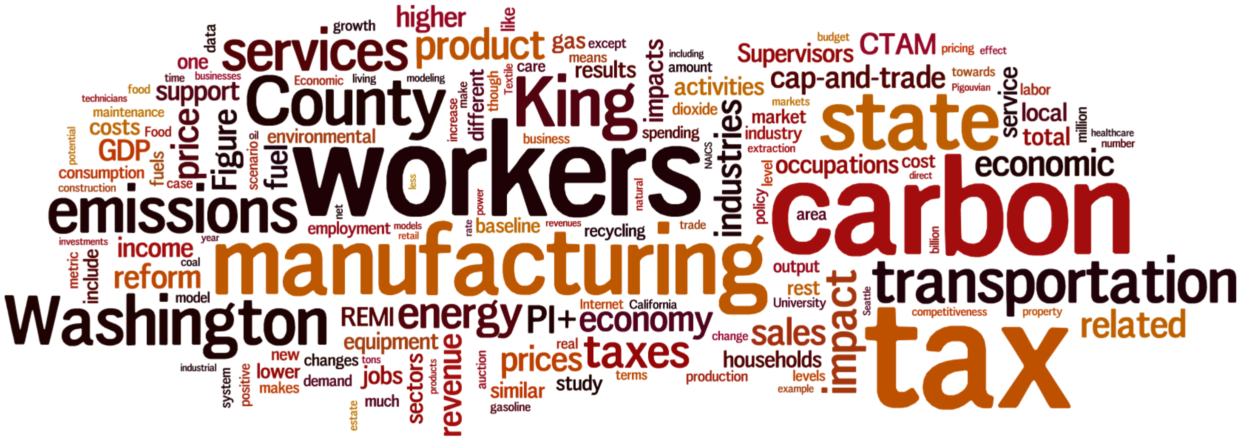


Top eight industries benefiting:

- *Construction*
- *Hospitals and ambulatory healthcare*
- *Monetary authorities – central bank; Credit intermediation and related*
- *Professional, scientific, and technical services*
- *Real estate*
- *Securities, commodity contracts, investments*
- *Real estate*
- *Wholesale and retail trade*

Environmental tax reform in King County alone has potential to improve the economy while saving carbon emissions. The net effect of the "tax swap" between carbon and local property and sales taxes creates more jobs, higher GDP, and incentivizes reductions in carbon releases. Key industries benefiting include the heart of the regional economy, such as construction, professional services, and real estate.

WORD CLOUD


tax
carbon
workers
manufacturing
state
Washington
transportation
County
King
emissions
services
product
economic
energy
PI+
economy
taxes
impact
industries
Figure
price
prices
sales
related
reform
income
GDP
costs
support
higher
CTAM
Supervisors
cap-and-trade
activities
occupations
local
total
service
revenue
sectors
jobs
equipment
environmental
employment
baseline
recycling
households
study
similar
REMI
fuel
fuels
impacts
results
market
industry
dioxide
spending
gas
area
output
rest
cost
consumption
maintenance
one
data
growth
like
labor
University
competitiveness
property
California
Internet
Seattle

BACKGROUND

Sometime in 1920, Arthur Cecil Pigou sat in his office at the University of Cambridge, where he worked as an economist and lecturer.[1] At some point, his thoughts turned to the local railway. Steel roads and the iron horse were not new technologies by the beginning of the Roaring Twenties—the first rail linkage amid Cambridge and London opened in 1845,[2] and massive industrial change was on the horizon with the rise of the personal automobile. To Pigou, they provided a useful example. A passenger bought a ticket and, for a given price, the railroad provided passage from Point A to Point B. On the surface, this is a simple case of "supply" (the company operating the trains and selling tickets to cover their costs in search of a profit) and "demand" (the eager passenger willing to pay the price to move to a new place in search of their own happiness). An earlier economist, Alfred Marshall, Pigou's advisor for his doctoral education, first created supply and demand curves to illustrate how want for the railroad, "demand," came together with the cost to provide it, "supply," to eventually settle at the market price. Both sides found the overall situation agreeable enough to do business, and the passengers bought the tickets and the railroad ran the trains. In theory, everybody was happier. Pigou took exception.

He agreed with the basics of Marshall's supply and demand concepts but felt they were limited in their scope. Yes, the railroad must be in a better position for having sold the ticket, else it would not sell them nor run their trains. Yes, the passengers must value their travel more than the money it took to acquire it. If not, they would simply never have parted with their pounds to purchase the tickets in the first place. Pigou asked, however, "What of those not directly involved in the transaction?" The wood- and coal-fired steam engines of the day tended to shed a significant amount of fuel and burnt waste when rolling over the English countryside. These operations, Pigou said, imposed significant hardships on, "people not directly concerned, through, say, uncompensated damage done to surrounding woods by sparks from railway engines."[3] Charred embers and potential forest fires lowered the value of the wood along the line, which was a lucrative sale item as lumber or firewood in the growing cities of London, Manchester, Birmingham, and Liverpool. If a significant quantity of fires harmed the commercial prospects of local landowners, their losses may outweigh the benefits of the direct operations of the railroad. On the other hand, local farmers often gleaned the coal and wood shed from the tracks to take home and burn in their own hearths, adding an additional economic and benefit-cost consideration unaccounted for by the passengers and railroads meeting at the marketplace of the ticket office.

The formal description, nomenclature, and recommendations on ways to resolve these sorts of situations made Pigou a seminal figure in welfare economics and one of the most important economists of the early twentieth century. In some cases, Pigou proposed what is now know as a "Pigouvian tax"—a fee or a tax, imposed by some level or entity of government to make buyers and sellers internalize the "externality" of their actions. Pigou defined an externality as a cost missing in market transactions where a policy lever might correct it. To return to the previous example, Parliament could impose an annual fee on every meter of track operated in woodland areas and then contribute the money to a system designed to insure losses against forest fires. This would compensate landowners in the case of a disaster. Moreover, the tax would change the behavior of the railroad and its riders. The company might attempt to reroute lines into open terrain or pass the cost along to passengers with more expensive tickets. Both of these correct, or "internalize," the externality because fewer trains run near forests due to avoidance of trouble or reduced demand. Pigouvian taxes engender fuller accounting of costs before taking action.

---

[1] Adapted from John Cassidy, "An Economist's Invisible Hand: Arthur Cecil Pigou, overlooked for decades, provides a guide to the financial crisis," *Wall Street Journal*, November 28, 2009, <http://online.wsj.com/news/articles/SB10001424052748704204304574545671352424680>

[2] Date from Gordon Biddle and O.S. Nock, *The Railway Heritage of Britain*, first printed in London by Michael Joseph, 1983, ISBN: 978-0-7181-2355-0

[3] Quoted in Cassidy, "An Economist's Invisible Hand," *Wall Street Journal*

Pigouvian ideas have seen application to a number of problems, but some of the most significant ones are those involving energy and the environment. Perhaps the most notable instance of this is the emission of carbon dioxide into the open atmosphere and its *potential* to induce climate disruptions on a planetary scale. Carbon dioxide is harmless to an individual. However, amplifying an isolated effect over a long timeline and global setting can have unintended consequences. Karl Benz, Ransom Olds, and Henry Ford revolutionized transportation with the production and marketing of the automobile in the early 1900s. It is unlikely they could have anticipated a billion or more cars and their exhaust potentially changing the composition of the atmosphere.[4] When the planetary scale of the climate renders localized, voluntary agreements impractical,[5] a Pigouvian tax is one way to correct for this situation. **This study does not argue for or against the dangers of higher concentrations of carbon in the atmosphere. Instead, we will examine the economic impact of addressing the assumed externality of carbon with environmental tax reform on Pigouvian principles.** This concept is a familiar one and has champions throughout the political spectrum. Gregory Mankiw, Harvard professor and former chair of the Council of Economic Advisors (CEA) under the George W. Bush administration, advocated for Pigouvian taxes as being, "the most direct and least invasive policy to address environmental concerns."[6] Against this backdrop, we begin our account of how such tax reform proposals would affect the economy and carbon emissions in the state of Washington.[7]

[4] John Sousanis, "World Vehicle Population Tops 1 Billion Units," *Ward's Auto*, August 15, 2011, <http://wardsauto.com/ar/world_vehicle_population_110815>

[5] This solution to externalities is the Coase theorem, named for Ronald H. Coase, who died earlier this year. Back to the railroad, landowners could pay the company to move, and each side could be better for it (the railway for receiving the payment, and landowners for saving more damage than costs in payments) without Parliament. Impracticality comes from nobody "owning" the whole of Earth's atmosphere and the transaction costs of coordination amid 7 billion humans. Please see, "Ronald H. Coase," *The Concise Encyclopedia of Economics*, <http://www.econlib.org/library/Enc/bios/Coase.html>

[6] Gregory Mankiw, "The Pigou Club Manifesto," *Greg Mankiw's Blog*, October 20, 2006, <http://gregmankiw.blogspot.com/2006/10/pigou-club-manifesto.html>

[7] All images credited to *Wikimedia* and used within permitted allowances

INTRODUCTION

This study examines the series of interactions between a state's economy, energy usage, carbon dioxide emissions, demographics, and fiscal policy. At current, Washington is considering a number of policy options for reducing carbon emissions. According to "Evaluation of Comprehensive GHG Emissions Reduction Programs Outside of Washington: Final Report," a study produced by the Science Applications International Corporation (SAIC) for the Washington State Climate Legislative Executive Workgroup (CLEW), there are several ways of pursuing this goal.[8] They list a cap-and-trade program,[9] carbon taxes,[10] reduction of vehicle miles travel (VMT), low carbon fuel standards, zero emissions vehicles, renewable portfolio standards (RPS), and many others. Only three of these—cap-and-trade, carbon tax, and low carbon fuel standard—have a "high" chance of reducing carbon emissions by a large degree; the low carbon fuel standard has "negative" impacts on the overall welfare of Washington's consumers and businesses.[11] The remaining two, carbon tax and a cap-and-trade, have "uncertain" welfare implications, according to the SAIC report. This uncertainty invites further study of an imperative issue for the state, which is where this study and ensuing white paper begins.

This "next step" in inquiring about environmental tax reform in Washington quantifies this uncertainty with a number of techniques. They include, chiefly, Pigouvian taxes, energy modeling, carbon dioxide emissions calculation, and dynamic regional modeling. The goal is to provide more information on the topic for policymakers and the public to strike the proper balance between legitimate concerns about job creation, economic growth, costs of energy, conditions for low-income households, competitiveness for businesses, and reducing carbon dioxide and associated pollutant emissions. Specifically, we will focus on a carbon tax as the simplest option for accomplishing these goals as well as how it differs from a cap-and-trade in its implementation. A carbon tax is a Pigouvian tax on fuels based on the internal carbon dioxide content associated with their combustion. The revenue from a carbon tax aids in balancing concerns about these reforms. Revenue can go towards lowering other taxes—called "revenue-neutrality," or a "tax swap," to reducing income, sales, or business taxes in exchange for the carbon tax covering the cash needs of the same partition of the budget. It can also go towards rebates or spending on other priorities like infrastructure, education, or research and development. This study considers these balances, and it will shed light on the uncertainties regarding environmental tax reform for Washington.

Washington Environmental Tax Reform (ETR-WA), a group of private citizens, contracted Regional Economic Models, Inc. (REMI) to carry out this study. It relies on two tools: the open-source Carbon Tax Analysis Model (CTAM) built by Keibun Mori for the Washington Department of Commerce,[12] and PI+, REMI's proprietary economic and demographic model of sub-national breakouts of the United States.[13] CTAM draws most of its underlying assumptions and data from the National Energy Modeling System (NEMS), a series of models on resource extraction, power generation and distribution, and energy

---

[8] Please see table of contents of the report, "Evaluation of Comprehensive GHG Emissions Reductions Programs Outside of Washington: Final Report," *Science Applications International Corporation (SAIC)*, September 20, 2013, <http://tinyurl.com/SAICwa>

[9] For a basic introduction to how a cap-and-trade works, please see, "How cap-and-trade works," *Environmental Defense Fund*, <http://www.edf.org/climate/how-cap-and-trade-works>

[10] For a basic introduction to how a carbon tax works, please see, "Considering a Carbon Tax: Frequently Asked Questions," *Resources for the Future: Center for Climate and Energy Policy*, <http://www.rff.org/centers/climate_and_electricity_policy/pages/carbon_tax_faqs.aspx>

[11] *SAIC*, pp. 4-5

[12] Keibun Mori, "Washington State Carbon Tax: Fiscal and Environmental Impacts," *Evans School of Public Affairs* at the *University of Washington*, July 2011, <http://www.commerce.wa.gov/Documents/Washington-State-Carbon-Tax.pdf>

[13] "PI+," *REMI*, <http://www.remi.com/products/pi>

consumption developed by the Energy Information Administration (EIA).[14] Using these tools in concert provides a more comprehensive and robust illustration of energy, environmental, and economic impacts of introducing a carbon tax in Washington. The showpiece of this paper describes the scenarios examined; it then presents their results in terms of economic impacts, demographics, and carbon emissions. The end covers a literature review of similar policies and studies, background on methodologies for CTAM and PI+, and information on the techniques and assumptions used to integrate them.

SCENARIOS

There are several dimensions of analytical inquiry in this study. The first of these is the level of carbon taxes implemented or auction prices for emission realized via cap-and-trade. The "prices" of emitting one metric ton of carbon into the atmosphere in this study are $10/ton, $30/ton, or $50/ton.[15] These levels come from a sensitivity analysis in the SAIC study, which described these prices as, "not a forecasted expectation of price, but simply a range of possible scenarios."[16] For the statewide scenario, we also added a $100/ton tax case, which goes towards achieving Washington's existing legislative benchmark of a 25% emission reduction from 1990 levels by 2035 in the state.[17] These tax scenarios will serve as the fee associated with the carbon tax. A second consideration is regions—this study makes use of a 2-region REMI PI+ model, with the state of Washington divided into King County and the rest of the state. King County has about the area of Rhode Island and contains Seattle, Bellevue, Redmond, and their suburbs. In 2010, it had a population of over 1.9 million and an economy of approximately $170 billion; this is 29.7% of the people in the state and 47.3% of economic activity. Therefore, these results do two things:

[14] For background on NEMS, please see, "The National Energy Modeling System: An Overview," *Energy Information Administration*, <http://www.eia.gov/oiaf/aeo/overview/>
[15] 1 metric ton = 1,000 kg = 2,204.62 pounds = 1.102 short-tons
[16] SAIC, p. 32
[17] "Greenhouse gas emissions reductions – reporting requirements," *Washington State Legislature*, <http://apps.leg.wa.gov/rcw/default.aspx?cite=70.235.020>

they break the impact on King County out from the whole state for statewide reforms, and they examine the economic impact if King County *went it alone* in implementing a county-level carbon tax.[18] Lastly, this study compares the implementation of a carbon tax to that of a cap-and-trade, including the experiences of British Columbia (with a carbon tax) and cap-and-trade policies in other places (such as in Europe or in California with AB32 and its allowance trading system).

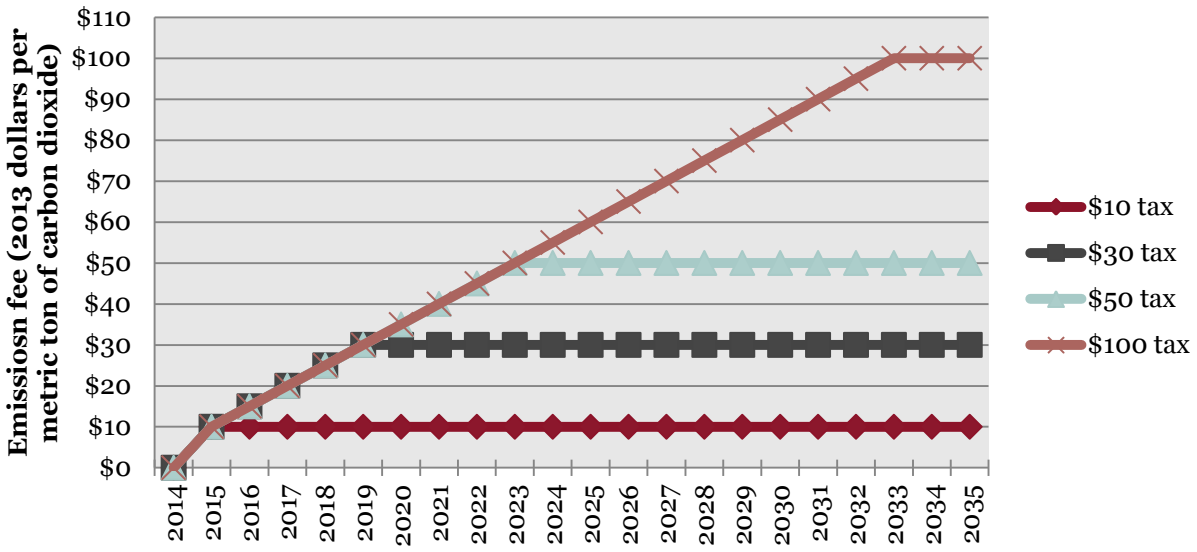


Figure 1.1 – This figure shows the fee applied to carbon emissions under the scenarios. This fee represents a carbon tax because the steady carbon pricing implies deliberate action on the behalf of policymakers to set the rate. Cap-and-trade can approximate this effect if auction prices were steady like the above; in reality, however, auctions would have a great deal of variability due to technology, volatility in world petroleum markets, and macroeconomic cycles. A carbon tax is the clearest, most predictable, and simplest incentive for households and business making decisions about future investments and decisions, which is the majority of the modeling approach here. The colors are consistent throughout the rest of the report—the $10/ton tax is always crimson and so forth.

One of the most vital facets of environmental tax reform is its provision of tax relief for those taxpayers supporting other parts of the federal, state, or local budget. Washington is in unison with almost every other state of the union for having a balanced budget amendment in its constitution, which means any money gained from a carbon tax will not upset Olympia's medium- and long-term needs to balance its revenues and expenditures. Theoretically, the carbon tax's revenue could go towards paying for state spending programs on education, infrastructure, efficiency, weatherization, or a myriad of other or newer ideas. This would mean, however, the state has permanently increased its spending over a baseline due to the new tax; **the conversation over the optimal level of revenues/expenditures relative to the size of the state economy, or expectations on government spending, is separate from the level of carbon pricing**. To avoid this issue and to concentrate strictly on tax reform, the carbon tax here is strictly "revenue-neutral"—the dollars in carbon tax revenue go towards a tax break of the same portions from somewhere else in the budget. The nature of this "tax swap" implies the taxation of energy usage and emissions replaces the taxing of consumption (the sales tax) and that of business operations (through the state business and occupation tax, "B&O," in Washington). The system here for revenue recycling used PI+ to test different schemes in order to settle at the optimal balance in terms of jobs, competitiveness and growth, prices, and fairness to low-income families.

[18] This requires the legislature passing laws to allow local jurisdictions to enact environmental tax reform

Tax reform always has the potential to modify the redistribution system, which is inherent in any budget, and disturb its balance between different levels of income, types of businesses, and between labor and capital. The revenue recycling in Washington can avoid upsetting this situation in a direct manner by returning the carbon tax's money to sections of the economy (such as individuals and households, and businesses) in a 1:1 manner to taxes initially paid. That is, if the household sector pays 60% of the carbon tax, then it should enjoy 60% of the subsequent tax cuts elsewhere. The chart below establishes the algorithm for revenue recycling in these results. Carbon taxes paid by businesses mean the reduction of B&O taxes, and carbon taxes paid by individuals mean a reduction in the state sales tax and refunds to low-income households (by means of the Working Family credit, rebates totaling 10% of *total* carbon tax revenues). Environmental taxes run the risk of being "regressive"—overpowering low-income households past their ability to afford higher energy costs.[19] Direct transfers, rebates to correct for higher prices on the market, and lower sales taxes on other commodities are several means correcting for this matter.[20] This helps the lower rungs of the ladder feel less pain and adjusts for one of the drawbacks of cap-and-trade and carbon taxes cited in the economic and policy literature.

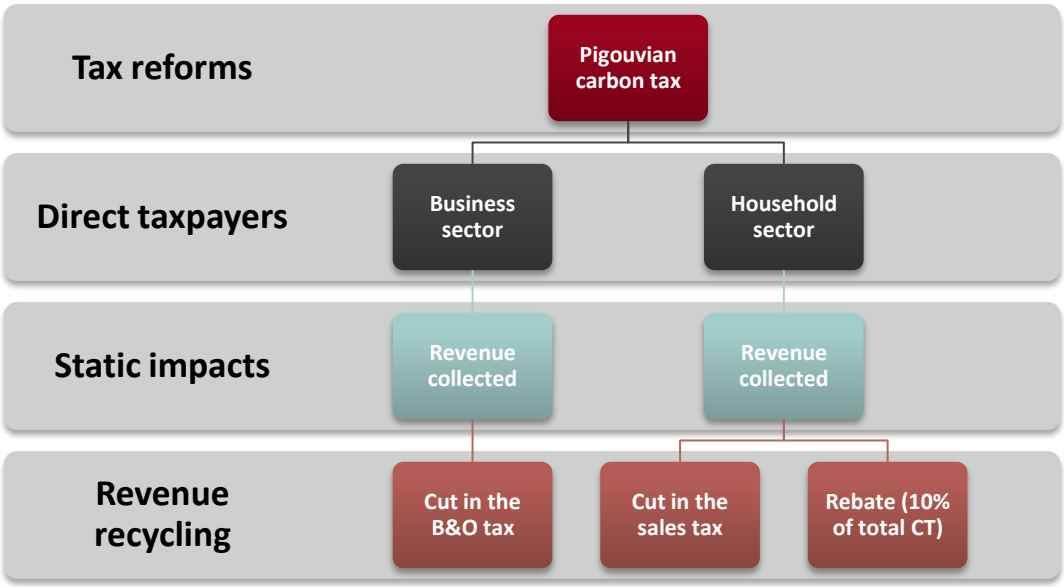


Figure 1.2 – This figure shows the revenue recycling for modeling. There are no direct additions to spending, and thus this study relies on pure revenue-neutrality. Broadly speaking, the different sectors of the economy receive what they paid in the first place, though this will not be true firm-to-firm or household-to-household given so many variations on their energy usage, preferences, incomes, and their preexisting tax payments. This provides a strong balance of priorities in the results.

Revenue-neutrality remains in the simulations for King County and King County alone, but the system for recycling has to change due to differences between the state budget and that of King County. King County, like many local governments, receives most of its money from sales and property taxes.[21] Under these

[19] See, for example, Corbett A. Grainger and Charles D. Kolstad, "Who Pays a Price on Carbon," *National Bureau of Economic Research (NBER)*, working paper #15239, August 2009, <http://www.nber.org/papers/w15239>

[20] See, for example, Terry Dinan, "Offsetting a Carbon Tax's Costs on Low-Income Households," *Congressional Budget Office*, working paper #2012-16, November 2012, <http://www.cbo.gov/sites/default/files/cbofiles/attachments/11-13LowIncomeOptions.pdf>

[21] "King County Budget," *King County*, <http://www.kingcounty.gov/exec/PSB/Budget/2014Budget.aspx>

circumstances, a balanced and simple approach of 50% of revenues reducing the sales tax and 50% reducing the property tax produced the strongest outcome. These cuts would mean lower retail prices for consumers and businesses as well as a lower ownership cost for housing, commercial space, and industrial equipment and facilities. REMI PI+ approximates the value of nonresidential and residential capital stock in a county, and this provided means for sharing the property tax cut between residential areas and commercial ownership. The sales tax falls by an amount equal to 50% of total carbon tax revenue—not an explicit rate cut in percentage terms, but rather a reduction in the total amount of sales tax collected in King County (or in Washington within other simulations) each year.

SIMULATION RESULTS

These results cover the economic, demographic, fiscal, and climate impact of seven scenarios: four (4) carbon taxes at $10/ton, $30/ton, $50/ton, and $100/ton for Washington, three more carbon taxes (3) for King County at $10/ton, $30/ton, and $50/ton (from SAIC). All results are against a "do-nothing" baseline, a "null hypothesis" that means no other changes happen in the state with the exception of the direct impacts to energy prices and taxes occurring because of environmental tax reform. There is an *et ceteris paribus* condition for everything else. Economic results include the impact to employment, the GDP for state or county, production by industry, consumer prices, jobs by industry, change in the mixture of occupations, and distribution of income. Demographic impacts include the change in state population. Fiscal impacts include the total amount of carbon tax revenue anticipated, either in a given year or over the cumulative horizon of 2015 to 2035. Results on carbon emissions include the baseline, how tax reform changes it, and a comparison to various benchmarks and goals.

Increasing the carbon tax to higher levels than those modeled, or even infinitely, will not necessarily mean an improvement to the economic impact or higher revenue forecasts for the state or county. However, for the levels studied, it does generate a progressively higher level of carbon emissions reductions, tax revenue, and therefore revenue for recycling up to the price of $100/ton. This trend begins to reverse itself somewhere between $140/ton and $160/ton as the region runs out of ways to reduce carbon emissions via demand cutbacks. The modeling below shows the beginning of this process, where 60% of the gains from the $100/ton scenario comes in the first $50/ton of tax, with only another 40% of gains added in the second $50/ton of carbon price.

Statewide Tax Reform

Additional Total Employment

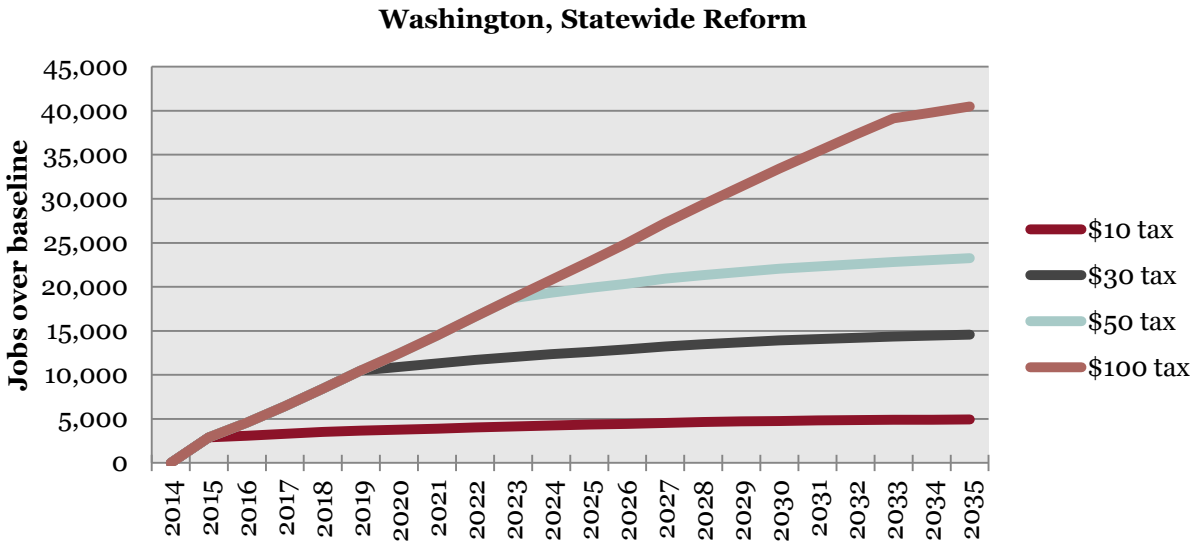


Figure 2.1 – Upon simulation, the tax reform measures discussed here create ***a net increase in employment over the baseline.*** *There are several reasons for this, including a decrease in energy imports making more dollars stay local, an increase in the growth of localized, labor-intensive industries, and additional competitiveness for the service sector from lower B&O taxes. The above represents jobs over a baseline—the total number of jobs available in the state economy in a year, which differs from a "rolling" concept of monthly or annual job creation reported by the national media.*

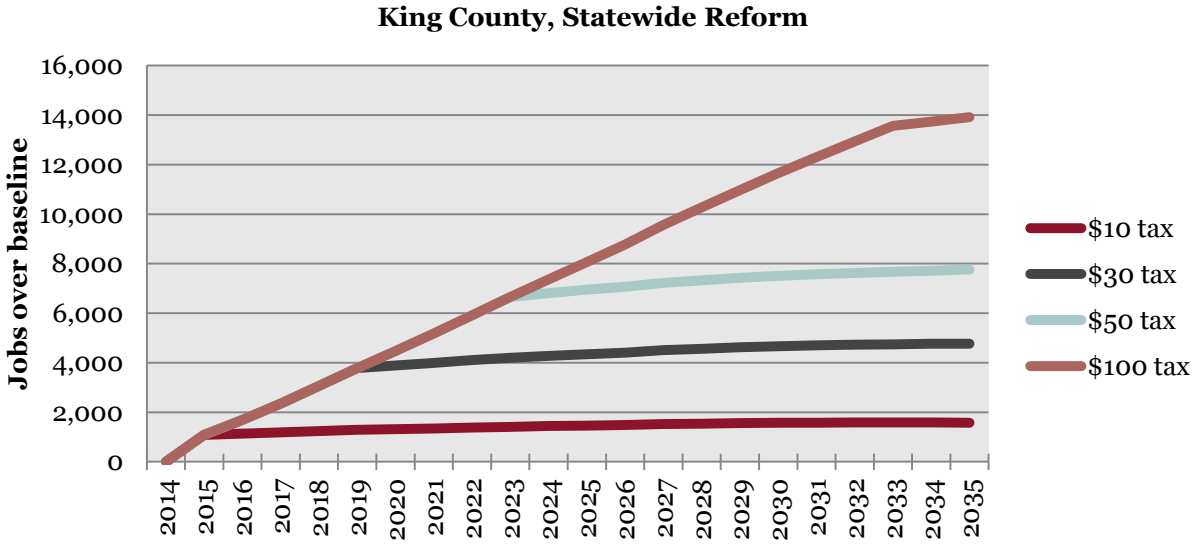


Figure 2.2 – King County sees a similar effect in increased employment due to a carbon tax. The high concentration of service and technology firms in the area help it enjoy a local benefit to job numbers, but the proportional impact to King County is approximately the same as that in the rest of the state in percentage terms. There is potential for broad benefits to such tax reform in Washington. This is because of new incentives creating a more "efficient" tax system—one that relies on taxing energy and carbon output instead of discouraging consumer spending and business activities.

ADDITIONAL GROSS DOMESTIC PRODUCT (ANNUAL)

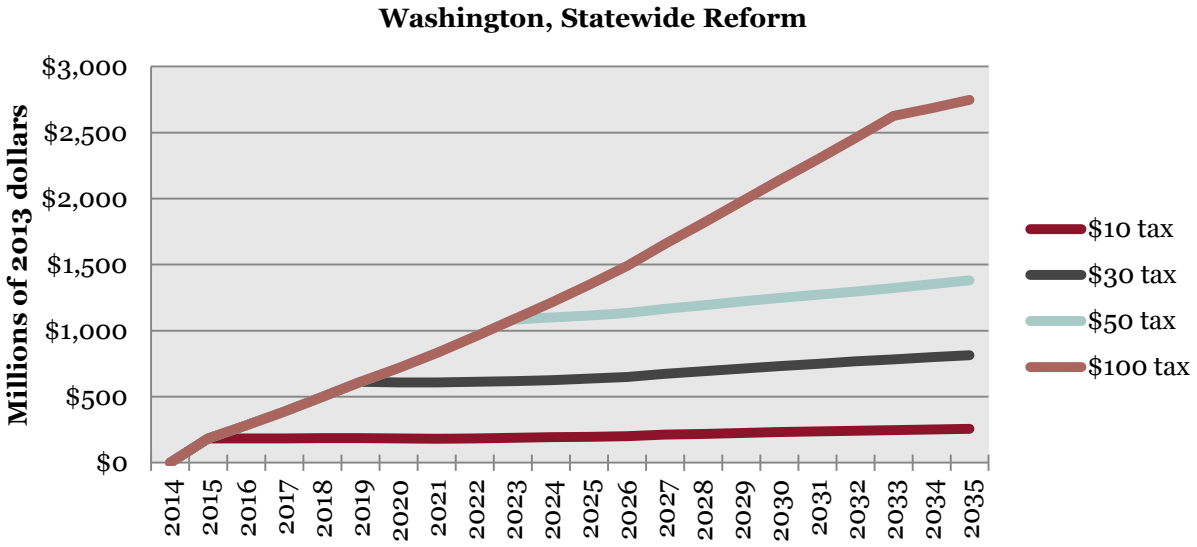


*Figure 2.3 – **The state's overall level of economic activity increases because of the carbon tax**. This point comes through measuring gross domestic product (GDP). GDP is the sum of new economic activity in an area during a timeframe. It includes consumption, investments, net exports, and government spending. The carbon tax means more local dollars stay local instead of spinning away to imports. Adding $2.7 billion to GDP in 2035 is about a 0.38% increase in total production, while adding $1.1 billion in 2025 is about 0.19% more in aggregate output for the state than in the baseline.*

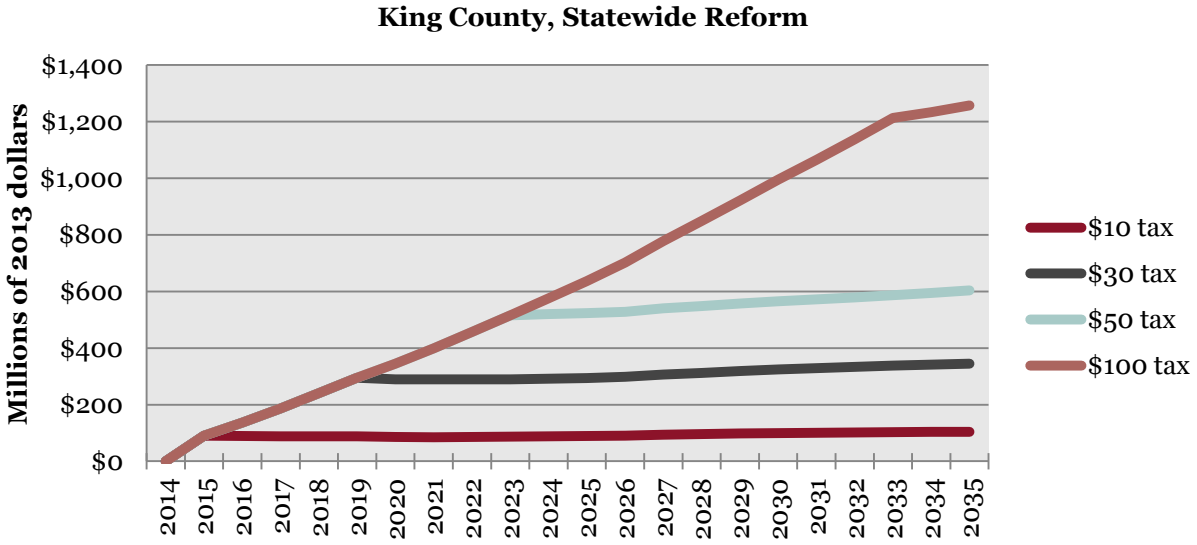


Figure 2.4 – King County sees growth here, too. King County is around 40% of the GDP of Washington. This is nearly the proportion of the impact here to the above change to total GDP in the state. King County's consumption of items like gasoline drift downwards compared to the baseline because of consumers' response to higher prices. Reduction in fuel demand means a reduction in demand for refineries (which Washington has a number of in the state), but also the ensuing supply-chain of pipelines, drilling, and extraction. These activities are typically outside of Washington and King County; in essence, this "exports" some of the impact of environmental tax reform to other states and nations. The $100/ton tax maximum adds about 0.33% to King County's GDP in 2035.

ADDITIONAL GROSS DOMESTIC PRODUCT (CUMULATIVE)

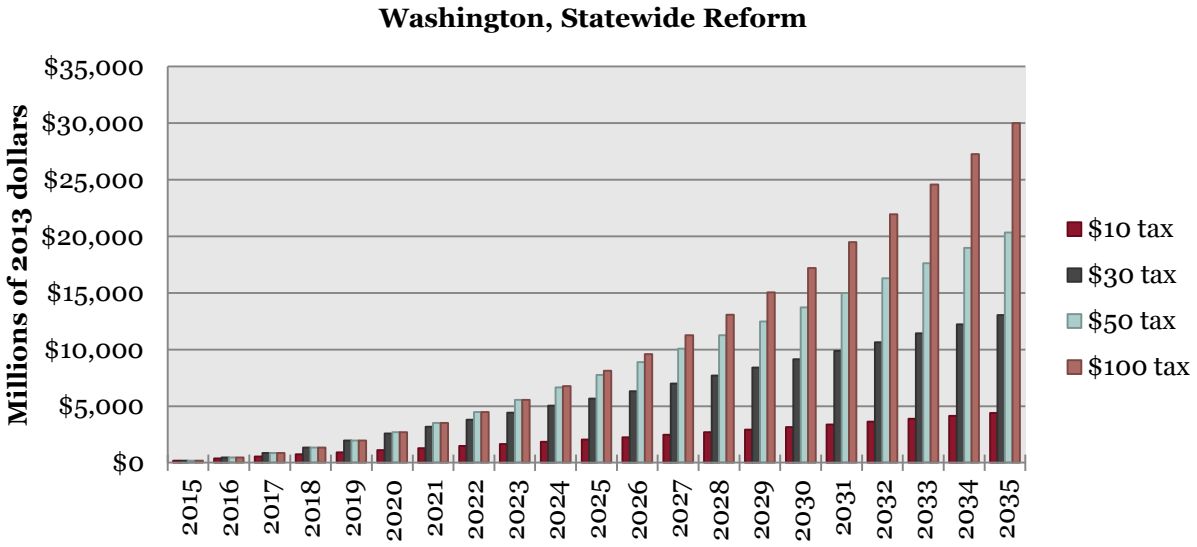


Figure 2.5 – GDP reproduces annually, which makes it appropriate to sum across years, "horizontally," like the above. For example, a 737 produced in 2013 counts towards GDP in that year but, since production on the same plane does not take place again in future years, it only counts for one year. To add to GDP in that year Boeing or another aircraft manufacturer would need to make another one. This makes the total amount of production over time cumulative, which the above graph stacks. These are the same figure from the past page presented in a different manner. Environmental tax reform in the state of Washington has the potential to expand the state's economy in the long-term, including adding $4 billion more in the $10/ton scenario and over $25 billion more in the $100/ton scenario.

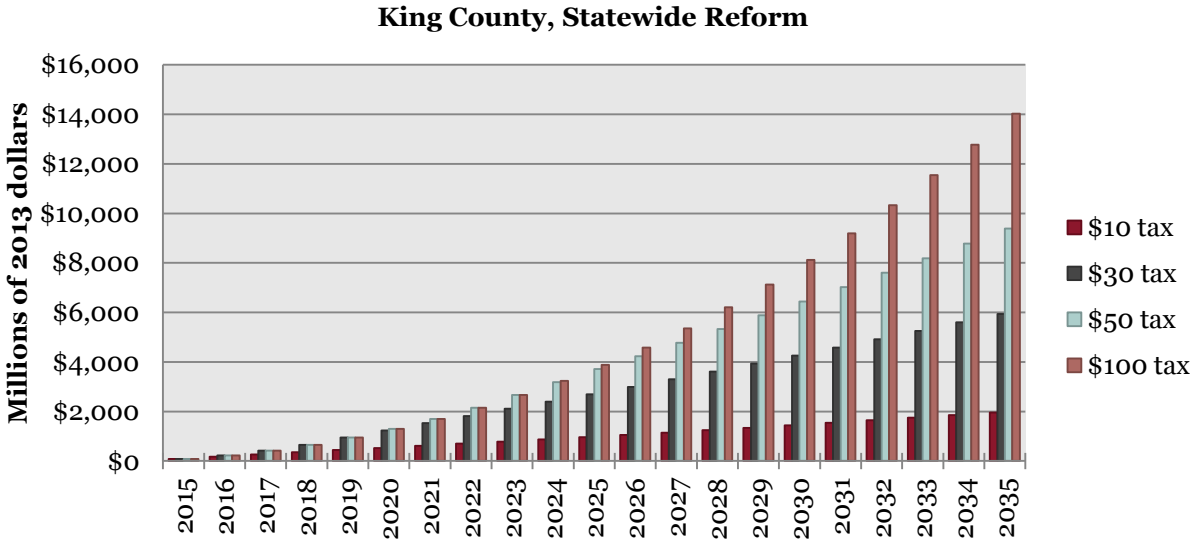
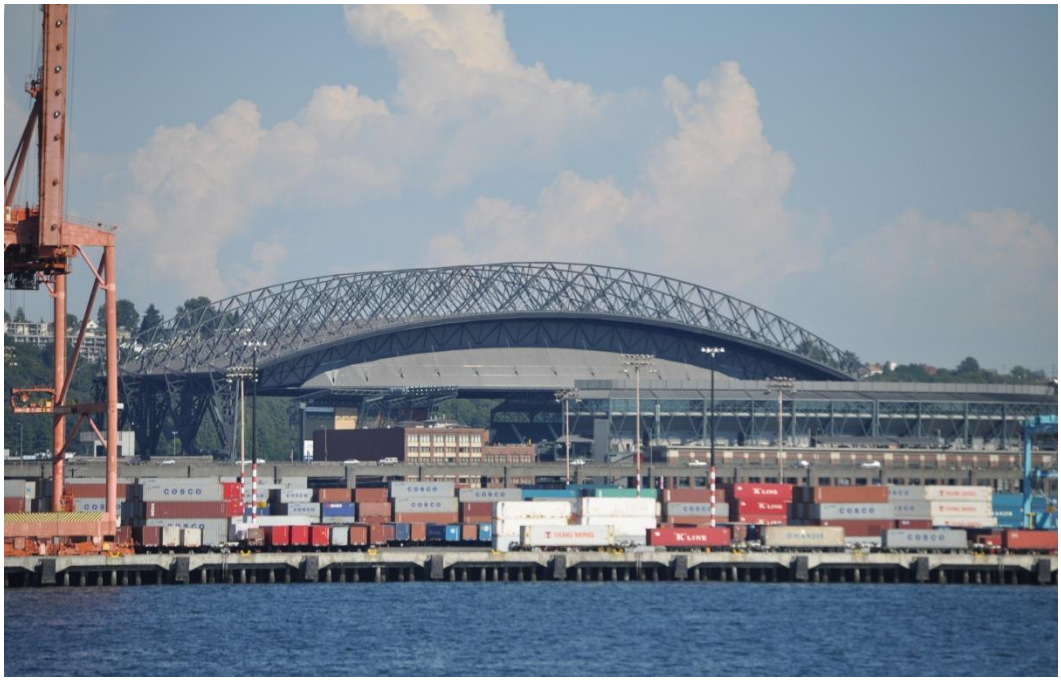


Figure 2.6 – King County is similar. It adds between $2 billion to $14 billion in economic activity from 2015 to 2035. The above proportions hold, too, where around 40% to 45% of all statewide benefits take place in King County and Seattle. This growth continues the pattern towards additional employment seen on previous graphs, increases the area's population, and expands the local tax base, which creates the potential for an increase in the number and quality of public services provided there.

This next section discusses the distributional implications of the macroeconomic impacts. There are several ways to examine this in REMI PI+ and its results: output by industrial sector, employment by industrial sector, occupational employment, prices, prices of specific commodities (such as fuels), and real income and income distribution. PI+ uses the North American Industrial Classification System (NAICS) to define its industries.[22] NAICS, developed by the U.S. Census, defines "industries" as groups of like firms competing with each other in the same market to sell similar products. Hyundai and General Motors both make cars. They may make different models and brands for different segments of the North American or Asian markets but, to NAICS, they are both "Motor Vehicle Manufacturing," which is 3361 when coded. All industries, from agriculture, to resources, to manufacturing, to transportation, retail, services, and finance behave differently in the REMI model owing to the different ways they use energy, pay taxes, trade in local or international markets, and interact together. The sum of their hiring and production make up total employment and GDP. Occupations take account of the type of job, not just its industry. For example, banks hire employees of all types, such as executives, analysts, accountants, account managers, receptionists, tellers, security guards, and grounds personnel. PI+ defines these according to the Standard Occupational Classification (SOC) system of the Bureau of Labor Statistics (BLS).[23] The SOC sorts jobs into hierarchical occupations in order to make comparisons of wage levels and skills. The other analytical considerations of distribution involve costs of living by Consumer Price Index (CPI), prices for specific fuel types, and the distribution of income by quintiles. This provides depth to the give-and-take that takes place in the economy when adjusting to changes in energy prices.

The results below consider King County and Washington under a state-level environmental tax reform. All output is in millions of 2013 dollars (USD). All jobs and occupations are by individual jobs available on the labor market in the given year. The results are for the highest $100/ton tax case to give a total sense of the scale and magnitude of the impacts across the industries and occupations. There are 70-sectors, which approximates 3-digit NAICS, and 95 occupations. This offers an idea of the sensitivity, comparatively, of different industries and occupations to environmental tax reform.



[22] "Introduction to NAICS," *United States Census Bureau*, <http://www.census.gov/eos/www/naics/>
[23] "Standard Occupational Classification," *Bureau of Labor Statistics*, <http://www.bls.gov/soc/>

FIGURE 2.7 – ANNUAL OUTPUT BY INDUSTRY (WASHINGTON, STATEWIDE, $100/TON)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$1.6	-$17.8	-$37.6	-$53.2	-$63.3
Agriculture and forestry support activities	$0.0	-$0.5	-$1.1	-$1.4	-$1.6
Oil and gas extraction	-$1.6	-$10.5	-$18.9	-$22.2	-$18.5
Mining (except oil and gas)	-$0.1	-$1.4	-$3.1	-$4.7	-$6.1
Support activities for mining	-$0.1	-$0.6	-$1.3	-$1.8	-$2.1
Utilities	-$15.0	-$45.3	-$66.4	-$78.9	-$78.5
Construction	$11.6	$88.9	$201.5	$344.7	$450.9
Wood product manufacturing	$0.8	$0.8	$0.2	$0.5	-$0.4
Nonmetallic mineral product manufacturing	$1.8	$6.0	$9.9	$14.4	$16.2
Primary metal manufacturing	-$0.8	-$10.6	-$22.9	-$33.5	-$41.7
Fabricated metal product manufacturing	$2.5	$9.8	$16.9	$25.2	$30.8
Machinery manufacturing	$0.7	$2.8	$4.4	$6.3	$7.3
Computer and electronic product manufacturing	$4.5	$17.2	$29.1	$45.5	$56.1
Electrical equipment and appliance manufacturing	$0.6	$1.5	$1.6	$1.4	$0.0
Motor vehicles, bodies and trailers, and parts manufacturing	$3.6	$14.1	$23.8	$33.3	$38.8
Other transportation equipment manufacturing	$1.8	-$0.8	-$10.3	-$21.8	-$37.6
Furniture and related product manufacturing	$1.6	$5.6	$8.8	$11.6	$12.4
Miscellaneous manufacturing	$2.0	$6.5	$8.3	$10.3	$12.0
Food manufacturing	$1.8	$3.9	$5.5	$8.6	$10.2
Beverage and tobacco product manufacturing	$1.9	$7.1	$12.3	$17.4	$20.0
Textile mills; Textile product mills	$0.1	$0.2	$0.1	$0.0	-$0.1
Apparel manufacturing; Leather and allied product manufacturing	$0.3	$1.3	$1.8	$2.8	$3.5
Paper manufacturing	$0.8	$1.2	$1.0	$1.1	$0.3
Printing and related support activities	$0.6	$2.0	$3.3	$4.8	$5.8
Petroleum and coal products manufacturing	-$73.8	-$522.6	-$1,038.8	-$1,508.8	-$1,888.1
Chemical manufacturing	$0.1	-$15.1	-$36.5	-$55.3	-$71.7
Plastics and rubber product manufacturing	$2.0	$5.7	$8.4	$10.9	$11.0
Wholesale trade	$25.0	$107.8	$208.3	$331.0	$433.9
Retail trade	$40.2	$191.4	$377.0	$600.7	$792.5
Air transportation	-$0.2	-$4.4	-$11.8	-$20.5	-$29.6
Rail transportation	$0.0	-$0.4	-$1.0	-$1.6	-$2.2
Water transportation	$0.0	-$0.7	-$1.8	-$3.1	-$4.3
Truck transportation	$1.6	$6.5	$11.9	$18.4	$23.6
Couriers and messengers	$0.4	$1.1	$1.7	$2.5	$2.9
Transit and ground passenger transportation	$0.2	$0.9	$1.6	$2.6	$3.5
Pipeline transportation	$0.0	-$0.1	-$0.1	-$0.2	-$0.2
Scenic and sightseeing transportation; Support activities for transportation	$0.0	-$0.6	-$2.1	-$4.7	-$8.8
Warehousing and storage	$1.9	$17.3	$35.0	$52.1	$63.1
Publishing industries, except Internet	$7.6	$18.0	$23.4	$35.9	$47.7
Motion picture and sound recording industries	$0.4	$1.6	$3.0	$4.7	$6.0
Internet publishing and broadcasting; ISPs, search portals, and data	$1.8	$7.9	$15.1	$24.1	$31.8
Broadcasting, except Internet	$0.6	$2.0	$3.2	$4.8	$6.1
Telecommunications	$13.5	$48.3	$86.8	$133.9	$173.8
Monetary authorities - central bank; Credit intermediation and related	$15.3	$52.2	$87.3	$123.9	$146.6
Securities, commodity contracts, investments	$8.2	$35.1	$61.4	$85.3	$97.8
Insurance carriers and related activities	$3.3	$12.6	$21.7	$30.8	$35.9
Real estate	$10.0	$23.4	$55.9	$123.9	$182.9
Rental and leasing services; Leasers of nonfinancial intangible assets	$3.8	$12.8	$22.2	$33.7	$42.4
Professional, scientific, and technical services	$19.6	$90.5	$168.5	$258.4	$327.2
Management of companies and enterprises	$2.4	$12.9	$23.1	$33.1	$37.9
Administrative and support services	$7.5	$24.6	$42.7	$66.1	$85.4
Waste management and remediation services	$0.7	$1.8	$3.5	$6.3	$8.5
Educational services	$2.1	$10.3	$21.5	$34.9	$46.2
Ambulatory health care services	$36.3	$132.3	$223.4	$318.0	$382.0
Hospitals	$9.5	$50.3	$102.3	$164.6	$220.9
Nursing and residential care facilities	$2.3	$11.2	$23.8	$40.0	$55.8
Social assistance	$1.1	$5.4	$11.5	$19.3	$26.8
Performing arts and spectator sports	$1.8	$7.6	$14.4	$22.7	$29.8
Museums, historical sites, zoos, and parks	$0.3	$1.3	$2.7	$4.5	$6.1
Amusement, gambling, and recreation	$1.9	$7.1	$13.0	$19.9	$25.5
Accommodation	$3.5	$8.6	$14.3	$23.8	$32.9
Food services and drinking places	$21.6	$88.0	$167.2	$260.5	$337.8
Repair and maintenance	$6.3	$24.3	$44.7	$68.5	$87.0
Personal and laundry services	$12.6	$44.0	$73.0	$101.3	$118.7
Membership associations and organizations	$2.6	$11.9	$24.7	$40.8	$54.8
Private households	$1.5	$5.4	$9.3	$13.2	$15.7
TOTAL OF ALL INDUSTRIES =	**$213.2**	**$619.3**	**$1,082.3**	**$1,831.8**	**$2,410.0**

FIGURE 2.8 – ANNUAL OUTPUT BY INDUSTRY (KING COUNTY, STATEWIDE, $100/TON)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$0.5	-$6.2	-$13.4	-$18.6	-$21.7
Agriculture and forestry support activities	$0.0	-$0.1	-$0.1	-$0.2	-$0.2
Oil and gas extraction	$0.0	$0.0	$0.0	$0.0	$0.0
Mining (except oil and gas)	$0.0	-$0.4	-$0.9	-$1.4	-$1.9
Support activities for mining	$0.0	-$0.1	-$0.2	-$0.3	-$0.3
Utilities	-$4.2	-$12.5	-$18.2	-$21.3	-$21.1
Construction	$3.2	$23.5	$55.1	$94.4	$116.8
Wood product manufacturing	$0.1	$0.3	$0.5	$0.7	$0.7
Nonmetallic mineral product manufacturing	$0.7	$2.4	$3.9	$5.4	$5.8
Primary metal manufacturing	-$0.1	-$1.8	-$4.0	-$6.1	-$8.0
Fabricated metal product manufacturing	$1.0	$3.6	$6.0	$8.7	$10.3
Machinery manufacturing	$0.4	$1.6	$2.5	$3.6	$4.1
Computer and electronic product manufacturing	$2.4	$8.9	$14.9	$23.0	$28.1
Electrical equipment and appliance manufacturing	$0.2	$0.6	$0.6	$0.6	$0.0
Motor vehicles, bodies and trailers, and parts manufacturing	$2.5	$10.0	$16.7	$23.2	$27.0
Other transportation equipment manufacturing	$0.9	-$0.9	-$6.7	-$13.7	-$23.2
Furniture and related product manufacturing	$0.5	$1.9	$2.9	$3.9	$4.2
Miscellaneous manufacturing	$1.5	$4.6	$5.8	$7.2	$8.4
Food manufacturing	$1.1	$2.9	$4.4	$6.7	$8.0
Beverage and tobacco product manufacturing	$1.2	$4.5	$7.7	$10.8	$12.3
Textile mills; Textile product mills	$0.1	$0.1	$0.1	$0.0	-$0.1
Apparel manufacturing; Leather and allied product manufacturing	$0.2	$0.9	$1.3	$2.0	$2.4
Paper manufacturing	$0.2	$0.4	$0.4	$0.5	$0.4
Printing and related support activities	$0.3	$0.9	$1.4	$2.0	$2.4
Petroleum and coal products manufacturing	-$2.2	-$11.8	-$22.1	-$31.7	-$39.6
Chemical manufacturing	$0.3	-$3.8	-$10.1	-$16.1	-$22.0
Plastics and rubber product manufacturing	$0.7	$1.9	$2.8	$3.5	$3.4
Wholesale trade	$12.3	$52.4	$100.9	$160.9	$211.4
Retail trade	$10.7	$51.6	$103.9	$168.8	$224.2
Air transportation	-$0.2	-$4.2	-$11.3	-$19.6	-$28.3
Rail transportation	$0.0	-$0.1	-$0.3	-$0.5	-$0.7
Water transportation	$0.0	-$0.6	-$1.6	-$2.8	-$4.0
Truck transportation	$0.7	$2.6	$4.8	$7.5	$9.5
Couriers and messengers	$0.2	$0.7	$1.1	$1.6	$1.9
Transit and ground passenger transportation	$0.1	$0.5	$0.9	$1.4	$1.8
Pipeline transportation	$0.0	$0.0	-$0.1	-$0.1	-$0.1
Scenic and sightseeing transportation; Support activities for transportation	$0.0	-$0.4	-$1.5	-$3.1	-$5.6
Warehousing and storage	$0.7	$6.6	$13.2	$19.7	$23.9
Publishing industries, except Internet	$7.2	$16.5	$20.9	$32.1	$42.8
Motion picture and sound recording industries	$0.3	$1.1	$2.1	$3.3	$4.2
Internet publishing and broadcasting; ISPs, search portals, and data	$1.5	$6.3	$12.0	$18.9	$24.9
Broadcasting, except Internet	$0.5	$1.4	$2.3	$3.4	$4.3
Telecommunications	$8.2	$29.0	$51.7	$79.8	$103.7
Monetary authorities - central bank; Credit intermediation and related	$7.0	$23.5	$39.1	$55.7	$66.3
Securities, commodity contracts, investments	$6.4	$26.2	$45.1	$62.4	$71.4
Insurance carriers and related activities	$2.2	$8.1	$13.8	$19.5	$22.6
Real estate	$5.8	$18.7	$46.9	$97.6	$142.8
Rental and leasing services; Leasers of nonfinancial intangible assets	$1.8	$5.7	$9.4	$13.8	$16.7
Professional, scientific, and technical services	$12.2	$50.8	$92.8	$142.7	$181.2
Management of companies and enterprises	$1.8	$8.8	$15.3	$21.9	$24.9
Administrative and support services	$3.1	$8.1	$12.6	$19.8	$26.2
Waste management and remediation services	$0.2	$0.9	$1.7	$2.8	$3.9
Educational services	$1.1	$5.2	$10.5	$16.8	$21.8
Ambulatory health care services	$13.3	$47.2	$78.1	$109.1	$127.8
Hospitals	$3.9	$18.6	$36.2	$56.8	$74.2
Nursing and residential care facilities	$0.8	$3.4	$6.8	$11.1	$14.9
Social assistance	$0.6	$2.7	$5.7	$9.4	$12.9
Performing arts and spectator sports	$1.4	$5.9	$11.0	$17.3	$22.6
Museums, historical sites, zoos, and parks	$0.2	$0.8	$1.6	$2.7	$3.7
Amusement, gambling, and recreation	$0.7	$2.6	$4.6	$7.0	$8.9
Accommodation	$2.0	$5.2	$8.7	$14.1	$19.1
Food services and drinking places	$8.6	$33.4	$61.5	$94.0	$119.8
Repair and maintenance	$2.2	$7.8	$14.0	$21.0	$26.1
Personal and laundry services	$6.1	$21.0	$34.4	$47.3	$55.3
Membership associations and organizations	$1.1	$4.8	$9.5	$15.3	$20.0
Private households	$0.5	$1.8	$3.1	$4.3	$5.1
TOTAL OF ALL INDUSTRIES =	**$135.9**	**$505.7**	**$912.7**	**$1,420.5**	**$1,798.6**

Washington stands to gain from environmental tax reform and these Pigouvian adjustments. Some of the greatest benefits come from vital drivers of the state's economy in the classically Seattle- or Redmond-based sectors like technology, research, professional services, distribution, and healthcare, which see little increase in their costs yet could see a net reduction in their net tax burdens.

Each industry has a different profile of energy consumption, B&O taxes paid, and other inputs. Some of the "losers" in this scenario include heavy manufacturers such as **primary metals**, **transportation equipment,**[24] **chemical manufacture**, [25] and from **petroleum and coal products**.[26] Of these, only petroleum and coal products face sizable impacts—to the tune of about $1.9 billion less in output, each year, by 2035. This industry is the producer for petroleum products (such as gasoline and diesel) and coal for electricity generation. Assuming carbon emissions create externalities and a Pigouvian tax is the best way to adjust for them, the ensuing higher prices for energy reduces the demand for these goods. Lower demand will bring a reduction in output, which lowers the anticipated production for NAICS 324 in the future after the start of this scenario. On the other hand, petroleum and its supply-chain play an important role in the United States' economy. Washington still has a significant amount of output tied to it (even if refinery output in Washington is approximately 8% of that on the Gulf Coast). In 2012, for one instance, petroleum and coal products had an output in Washington of over $21 billion. By 2035, a reduction of $1.5 billion/year is a 4.5% decline (against baseline) in PI+. This industry does have losses compared to the baseline, but the losses are proportionally small. Many other sectors in manufacturing, like **computers and electronics** and even **leather**, in fact see a slight *increase*, which means some of the industries in the region could benefit back from these policies.

Most of the industries have a mixed or positive effect. Some of the mixed ones are in the supply-chain for petroleum refining, including the aforementioned chemicals (feedstock) and primary metals (steel and equipment, particularly pipes). Resource extraction sees some slight losses, including those in **forestry and fishing**, **utilities**,[27] and **mining**. These industries concentrate on the state's perimeter, while the technology and service clusters in Seattle and King County stand to gain the most to drive the economy forward. Gains come from **wholesale and retail**, **food services, and drinking establishments**, **telecommunications**, **banking or other finance**, **healthcare**, and the assortment of **professional services**.[28] The main factor here is these industries do not require a lot of power or fuel. Comparatively, they use little energy to stack pallets, cook food, or run ordinary office equipment. This means they pay very little in the direct carbon tax, but the reduced B&O tax rates create a strong response in terms of added output and job creation. The lower sales tax and rebates to low-income households engender more real purchasing power for consumers, and their direct spending goings to stores, restaurants, and other entertainment sectors. **Construction** is a broad industry with ties to every part of the economy. The growth in the economy requires commercial space, industrial footage, and housing for additional workers as well as their families. The construction industry will supply all of this over time.

---

[24] NAICS 3364 through 3369, which includes the production of aircraft by Washington stalwarts like Boeing, as well as the production of railroad equipment, ships, and watercraft, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=3364&search=2012%20NAICS%20Search>

[25] NAICS 325, which includes the production of all organic or inorganic materials for the formulation of non-fuel products, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=325&search=2012%20NAICS%20Search>

[26] NAICS 324, which is primarily the refining of raw petroleum into sellable products, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=324&search=2012%20NAICS%20Search>

[27] NAICS 22, including NAICS 2211 for power generation, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=2211&search=2012%20NAICS%20Search>

[28] NAICS 54, a collection of white-collar professional trades, including legal services, accounting, consulting, architectural and engineering, design, advertising, and software development, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=54&search=2012%20NAICS%20Search>

FIGURE 2.9 – EMPLOYMENT BY INDUSTRY (WASHINGTON, STATEWIDE, $100/TON)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-4	-34	-60	-72	-76
Agriculture and forestry support activities	0	-11	-20	-21	-18
Oil and gas extraction	-4	-24	-38	-43	-38
Mining (except oil and gas)	0	6	16	29	41
Support activities for mining	0	-1	-2	-1	-1
Utilities	-21	-56	-74	-79	-70
Construction	119	1,123	2,567	4,122	5,279
Wood product manufacturing	4	20	44	71	92
Nonmetallic mineral product manufacturing	7	35	68	101	122
Primary metal manufacturing	0	-3	-3	-2	1
Fabricated metal product manufacturing	10	46	82	119	144
Machinery manufacturing	3	13	22	30	34
Computer and electronic product manufacturing	11	36	53	67	70
Electrical equipment and appliance manufacturing	2	5	7	7	5
Motor vehicles, bodies and trailers, and parts manufacturing	6	20	29	36	36
Other transportation equipment manufacturing	5	19	30	41	46
Furniture and related product manufacturing	9	30	47	59	62
Miscellaneous manufacturing	9	26	32	36	38
Food manufacturing	5	22	43	64	80
Beverage and tobacco product manufacturing	3	12	21	29	34
Textile mills; Textile product mills	1	3	5	6	7
Apparel manufacturing; Leather and allied product manufacturing	5	17	22	29	30
Paper manufacturing	2	13	25	34	38
Printing and related support activities	4	14	23	28	30
Petroleum and coal products manufacturing	-6	-30	-43	-47	-44
Chemical manufacturing	1	-2	-2	0	2
Plastics and rubber product manufacturing	7	28	51	72	84
Wholesale trade	116	488	883	1,277	1,527
Retail trade	500	2,176	3,857	5,437	6,358
Air transportation	0	-6	-14	-21	-27
Rail transportation	0	1	1	3	4
Water transportation	0	1	4	8	13
Truck transportation	12	53	102	160	207
Couriers and messengers	3	14	26	40	53
Transit and ground passenger transportation	4	17	34	54	71
Pipeline transportation	0	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	0	1	-2	-6	-15
Warehousing and storage	22	192	374	531	615
Publishing industries, except Internet	11	31	44	56	60
Motion picture and sound recording industries	3	11	17	22	25
Internet publishing and broadcasting; ISPs, search portals, and data	4	17	26	32	34
Broadcasting, except Internet	2	7	12	17	20
Telecommunications	21	72	120	163	186
Monetary authorities - central bank; Credit intermediation and related	42	138	218	284	310
Securities, commodity contracts, investments	74	287	457	573	598
Insurance carriers and related activities	12	48	83	112	127
Real estate	39	168	377	652	862
Rental and leasing services; Leasers of nonfinancial intangible assets	10	34	56	78	90
Professional, scientific, and technical services	142	672	1,232	1,806	2,195
Management of companies and enterprises	11	53	82	100	98
Administrative and support services	128	520	943	1,384	1,691
Waste management and remediation services	3	16	34	57	77
Educational services	41	228	476	745	957
Ambulatory health care services	317	1,167	2,000	2,844	3,419
Hospitals	63	342	685	1,064	1,375
Nursing and residential care facilities	35	188	402	664	910
Social assistance	22	124	266	433	578
Performing arts and spectator sports	36	150	271	394	480
Museums, historical sites, zoos, and parks	2	11	22	34	42
Amusement, gambling, and recreation	39	166	317	476	596
Accommodation	32	97	170	258	325
Food services and drinking places	335	1,370	2,485	3,589	4,306
Repair and maintenance	55	212	383	561	682
Personal and laundry services	175	585	929	1,216	1,343
Membership associations and organizations	33	157	318	498	637
Private households	191	611	977	1,275	1,390
TOTAL OF ALL INDUSTRIES =	**2,709**	**11,745**	**21,611**	**31,584**	**38,248**

FIGURE 2.10 – EMPLOYMENT BY INDUSTRY (KING COUNTY, STATEWIDE, $100/TON)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	-4	-7	-8	-8
Agriculture and forestry support activities	0	-2	-5	-5	-5
Oil and gas extraction	0	0	0	0	0
Mining (except oil and gas)	0	4	10	18	26
Support activities for mining	0	0	0	0	0
Utilities	-5	-14	-17	-16	-13
Construction	32	312	732	1,170	1,477
Wood product manufacturing	0	2	4	6	7
Nonmetallic mineral product manufacturing	3	11	19	26	29
Primary metal manufacturing	0	-1	-1	-1	-1
Fabricated metal product manufacturing	4	16	27	38	44
Machinery manufacturing	2	6	10	13	14
Computer and electronic product manufacturing	6	17	25	30	31
Electrical equipment and appliance manufacturing	1	2	2	2	2
Motor vehicles, bodies and trailers, and parts manufacturing	4	13	20	23	23
Other transportation equipment manufacturing	3	9	13	18	19
Furniture and related product manufacturing	3	9	14	18	20
Miscellaneous manufacturing	6	18	21	24	25
Food manufacturing	2	9	17	25	31
Beverage and tobacco product manufacturing	1	6	10	14	16
Textile mills; Textile product mills	0	1	2	2	2
Apparel manufacturing; Leather and allied product manufacturing	3	12	15	19	20
Paper manufacturing	0	1	3	4	4
Printing and related support activities	2	6	10	12	13
Petroleum and coal products manufacturing	0	0	-1	-1	-1
Chemical manufacturing	0	0	-1	-1	-1
Plastics and rubber product manufacturing	2	7	11	15	17
Wholesale trade	51	212	381	550	657
Retail trade	116	516	933	1,334	1,565
Air transportation	0	-5	-13	-20	-26
Rail transportation	0	0	0	1	1
Water transportation	0	1	4	7	11
Truck transportation	4	19	36	55	70
Couriers and messengers	2	8	14	22	28
Transit and ground passenger transportation	2	9	17	27	35
Pipeline transportation	0	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	0	0	-2	-5	-10
Warehousing and storage	8	71	137	195	227
Publishing industries, except Internet	10	27	40	51	54
Motion picture and sound recording industries	2	6	9	12	14
Internet publishing and broadcasting; ISPs, search portals, and data	3	11	18	22	22
Broadcasting, except Internet	1	4	7	10	12
Telecommunications	10	32	51	68	77
Monetary authorities - central bank; Credit intermediation and related	14	43	65	83	88
Securities, commodity contracts, investments	51	190	298	373	389
Insurance carriers and related activities	7	26	43	58	65
Real estate	16	90	205	344	452
Rental and leasing services; Leasers of nonfinancial intangible assets	2	7	12	15	17
Professional, scientific, and technical services	80	340	612	897	1,090
Management of companies and enterprises	8	34	51	62	60
Administrative and support services	47	179	326	490	616
Waste management and remediation services	1	4	8	14	18
Educational services	21	114	234	360	454
Ambulatory health care services	112	400	672	937	1,098
Hospitals	25	122	236	358	450
Nursing and residential care facilities	12	56	115	184	243
Social assistance	11	59	124	199	262
Performing arts and spectator sports	24	99	179	260	318
Museums, historical sites, zoos, and parks	1	6	11	17	22
Amusement, gambling, and recreation	10	39	72	106	131
Accommodation	17	53	91	136	169
Food services and drinking places	122	481	851	1,209	1,426
Repair and maintenance	17	63	111	159	189
Personal and laundry services	76	251	394	513	564
Membership associations and organizations	13	57	111	169	211
Private households	64	202	320	416	452
TOTAL OF ALL INDUSTRIES =	**1,025**	**4,264**	**7,709**	**11,135**	**13,316**

Labor productivity is the concept for understanding the above table and its relationship to the earlier ones on output by industry. Labor productivity relates the amount of production by a firm to the number of workers it employs. For example, if a production team of 120 at a factory (including machinists, software technicians, and managers) can produce $36 million of batteries in a year, then output per unit of labor (one of the 120 workers) is $300,000/year—mathematically $36 million over 120. This concept is present throughout the whole economy, and different workers in different industries tend to have higher or lower levels of productivity because of the nature of their business or trades, technology, and the amount of capital used in their production process. The example of batteries above is an instance of a high-level of labor productivity, given the degree of automation and the utilization of machines in most assembly lines. Conversely, a "labor-intensive" industry such as retail, construction, or healthcare, uses relatively more labor to attain its needed quantities of output. Those industries need more labor to perform tasks, which makes their labor productivity somewhat less than the highly productive $300,000/worker for batteries. The general equation to relate these concepts together is the following:

$$Output = Labor * Labor\ Productivity$$

In terms of jobs, not output, one of the benefits seen in the carbon tax simulations is growth in total level of employment in labor-intensive service sectors. In the same instance, the output losses in some forms of heavy manufacturing and resource extraction are not particularly damaging to the total amount of employment, given their productivity. To give one example, in 2012, **petroleum refining and coal products** employed one worker for each $8.7 million of output, while **food service** employed one for each $63,000 in output in Washington. Hence, the large output losses in manufacturing industries do not have a strong effect on employment, while the gains in the services and retail sectors (due to lower B&O taxes and a bump in consumer spending from lower sales taxes) mean a proportionally higher number of net adds to employment. Some manufacturing sectors add jobs, as well, including **computers and electronic equipment**. Gains are modest, but a lower cost curve and substitution away from the more expensive fuels and towards labor might lead to increased employment.

Out of the service sector, there are two patterns: employment growth in sectors tied directly to consumer spending and growth in those competing nationally or internationally for market share. The largest ones in the former are retail, wholesale, and food service, which primarily serve households. These industries experience a surge in demand due to higher disposable incomes. Other focus sectors are some of the centerpieces of the Washington economy. These are **banking and finance**, **professional services**, **management and administration**, and **healthcare services**. These sectors are "services" and on the labor-intensive side. Nevertheless, they compete on a global and international scale with similar firms for business. An **engineering consultancy** in Seattle will fight for contracts with similar companies in Oakland, Los Angeles, Raleigh, and all the way to Sydney, Tokyo, and Hong Kong. Their low carbon-usage and the low B&O tax shifts their cost profiles and allows them to compete efficiently on these markets, grab business, expand the state's GDP, and hire additional workers. This is true of the "export-oriented" industries above with ties to international markets and business-to-business services and transactions, as opposed to the level of direct consumer spending. Washington houses eight Fortune 500 companies' headquarters: Costco, Microsoft, Amazon, Paccar, Starbucks, Nordstrom, Weyerhaeuser, and Expeditors International of Washington.[29] The strength of King County and the region in retail, logistics, software, and resources is self-evident from this list, and the economic impacts on employment by industry from environmental tax reform are in keeping with the same. Impacts on occupations in King County and the rest of the state are similar. There is a concentration in services and technology driving most of the implications for firms' labor demand in the state.

[29] "Fortune 500, States, Washington," *CNN*, 2012, <http://money.cnn.com/magazines/fortune/fortune500/2012/states/WA.html>

FIGURE 2.11 – EMPLOYMENT BY OCCUPATION (WASHINGTON, STATEWIDE, $100/TON)

SOC Occupations	2015	2020	2025	2030	2035
Top executives	39	169	307	442	523
Advertising, marketing, promotions, public relations, and sales managers	11	48	86	123	147
Operations specialties managers	23	98	174	249	296
Other management occupations	33	156	306	470	587
Business operations specialists	55	261	495	741	916
Financial specialists	51	213	373	521	603
Computer occupations	54	239	432	629	760
Mathematical science occupations	1	6	10	15	18
Architects, surveyors, and cartographers	3	14	26	38	47
Engineers	15	71	132	197	242
Drafters, engineering technicians, and mapping technicians	8	36	66	96	114
Life scientists	3	12	23	35	44
Physical scientists	2	11	20	31	38
Social scientists and related workers	3	14	25	37	45
Life, physical, and social science technicians	3	12	23	35	43
Counselors and Social workers	18	79	150	228	289
Miscellaneous community and social service specialists	9	40	77	119	153
Religious workers	1	2	5	7	9
Lawyers, judges, and related workers	9	39	69	96	111
Legal support workers	5	23	42	60	72
Postsecondary teachers	21	99	196	303	382
Preschool, primary, secondary, and special education school teachers	41	169	317	479	588
Other teachers and instructors	11	47	92	139	174
Librarians, curators, and archivists	3	13	25	37	44
Other education, training, and library occupations	15	66	126	191	236
Art and design workers	10	41	73	103	122
Entertainers and performers, sports and related workers	13	57	106	158	196
Media and communication workers	10	43	80	118	146
Media and communication equipment workers	3	13	22	31	37
Health diagnosing and treating practitioners	114	479	877	1,299	1,613
Health technologists and technicians	76	312	565	828	1,016
Other healthcare practitioners and technical occupations	2	9	18	26	33
Nursing, psychiatric, and home health aides	53	247	482	753	987
Occupational therapy and physical therapist assistants and aides	5	23	41	61	76
Other healthcare support occupations	55	201	343	482	571
Supervisors of protective service workers	3	10	19	28	33
Fire fighting and prevention workers	3	12	21	32	38
Law enforcement workers	12	44	80	118	142
Other protective service workers	26	110	203	301	370
Supervisors of food preparation and serving workers	27	111	201	291	349
Cooks and food preparation workers	85	347	631	915	1,101
Food and beverage serving workers	202	834	1,524	2,218	2,682
Other food preparation and serving related workers	40	160	288	413	493
Supervisors of building and grounds cleaning and maintenance workers	4	17	32	48	59
Building cleaning and pest control workers	133	453	762	1,048	1,204
Grounds maintenance workers	24	99	183	273	336
Supervisors of personal care and service workers	6	20	34	49	58
Animal care and service workers	11	43	75	106	126
Entertainment attendants and related workers	14	59	108	161	199
Funeral service workers	9	31	50	66	73
Personal appearance workers	62	223	366	494	562
Baggage porters, bellhops, and concierges; Tour and travel guides	2	7	13	20	25
Other personal care and service workers	122	454	796	1,137	1,362
Supervisors of sales workers	45	193	344	489	576
Retail sales workers	279	1,196	2,124	3,007	3,532
Sales representatives, services	34	136	231	315	359
Sales representatives, wholesale and manufacturing	35	155	285	417	504
Other sales and related workers	18	80	157	243	305
Supervisors of office and administrative support workers	30	125	224	322	385
Communications equipment operators	3	9	15	18	18
Financial clerks	71	293	529	764	914
Information and record clerks	115	454	798	1,137	1,349
Material recording, scheduling, dispatching, and distributing workers	73	316	557	776	894
Secretaries and administrative assistants	83	348	635	924	1,112
Other office and administrative support workers	75	320	587	858	1,035
Supervisors of farming, fishing, and forestry workers	0	-1	-2	-2	-2
Agricultural workers	2	4	8	14	20
Fishing and hunting workers	-1	-5	-8	-9	-10
Forest, conservation, and logging workers	-1	-11	-20	-24	-25

Supervisors of construction and extraction workers	8	74	169	271	347
Construction trades workers	72	623	1,408	2,253	2,878
Helpers, construction trades	5	51	118	192	249
Other construction and related workers	5	27	55	86	107
Extraction workers	0	0	4	11	18
Supervisors of installation, maintenance, and repair workers	8	37	73	111	137
Electrical and electronic equipment mechanics, installers, and repairers	11	49	92	136	164
Vehicle and mobile equipment mechanics, installers, and repairers	41	175	320	467	566
Other installation, maintenance, and repair occupations	42	220	455	717	912
Supervisors of production workers	7	26	45	64	76
Assemblers and fabricators	19	77	133	187	219
Food processing workers	10	45	80	114	134
Metal workers and plastic workers	15	66	120	176	213
Printing workers	3	11	18	24	26
Textile, apparel, and furnishings workers	27	89	136	176	191
Woodworkers	4	17	31	45	54
Plant and system operators	-3	-9	-11	-7	-1
Other production occupations	29	120	213	304	360
Supervisors of transportation and material moving workers	7	36	67	98	119
Air transportation workers	0	-1	-3	-5	-7
Motor vehicle operators	58	259	484	718	879
Rail transportation workers	0	1	1	2	3
Water transportation workers	1	3	6	9	12
Other transportation workers	15	52	86	117	133
Material moving workers	81	387	717	1,039	1,241
TOTAL OF ALL OCCUPATIONS =	**2,892**	**12,443**	**22,871**	**33,447**	**40,486**

FIGURE 2.12 – EMPLOYMENT BY OCCUPATION (KING COUNTY, STATEWIDE, $100/TON)

SOC Occupations	2015	2020	2025	2030	2035
Top executives	16	65	116	164	191
Advertising, marketing, promotions, public relations, and sales managers	5	21	36	51	60
Operations specialties managers	11	45	78	109	127
Other management occupations	13	60	117	176	216
Business operations specialists	26	112	206	303	369
Financial specialists	28	110	188	257	292
Computer occupations	29	117	207	298	357
Mathematical science occupations	1	3	5	7	8
Architects, surveyors, and cartographers	1	7	12	18	22
Engineers	8	35	63	92	110
Drafters, engineering technicians, and mapping technicians	4	17	30	42	50
Life scientists	1	6	10	15	19
Physical scientists	1	6	10	15	18
Social scientists and related workers	1	5	9	14	17
Life, physical, and social science technicians	1	6	11	16	19
Counselors and Social workers	7	28	53	79	98
Miscellaneous community and social service specialists	3	14	27	42	52
Religious workers	0	1	2	3	3
Lawyers, judges, and related workers	5	19	32	45	51
Legal support workers	3	11	20	29	34
Postsecondary teachers	9	42	82	125	155
Preschool, primary, secondary, and special education school teachers	14	57	105	155	186
Other teachers and instructors	4	19	36	54	66
Librarians, curators, and archivists	1	5	9	14	16
Other education, training, and library occupations	6	24	45	67	82
Art and design workers	5	18	32	46	54
Entertainers and performers, sports and related workers	7	31	57	84	103
Media and communication workers	6	22	39	56	67
Media and communication equipment workers	2	7	11	16	19
Health diagnosing and treating practitioners	41	163	292	424	515
Health technologists and technicians	26	103	182	263	317
Other healthcare practitioners and technical occupations	1	4	6	9	11
Nursing, psychiatric, and home health aides	19	83	157	240	305
Occupational therapy and physical therapist assistants and aides	2	8	14	20	24
Other healthcare support occupations	20	71	118	163	189
Supervisors of protective service workers	1	3	6	9	10
Fire fighting and prevention workers	1	4	6	9	10
Law enforcement workers	4	13	23	33	39
Other protective service workers	10	40	74	111	138
Supervisors of food preparation and serving workers	10	38	68	97	115
Cooks and food preparation workers	30	119	212	303	359
Food and beverage serving workers	73	291	519	744	886

Other food preparation and serving related workers	15	57	100	141	165
Supervisors of building and grounds cleaning and maintenance workers	2	6	12	18	22
Building cleaning and pest control workers	47	160	269	370	425
Grounds maintenance workers	9	35	64	96	119
Supervisors of personal care and service workers	2	8	13	18	21
Animal care and service workers	5	19	32	46	54
Entertainment attendants and related workers	6	24	43	64	78
Funeral service workers	4	13	21	28	31
Personal appearance workers	27	95	154	207	235
Baggage porters, bellhops, and concierges; Tour and travel guides	1	3	6	9	11
Other personal care and service workers	42	156	271	385	457
Supervisors of sales workers	12	52	93	133	157
Retail sales workers	72	308	555	794	934
Sales representatives, services	19	71	118	157	175
Sales representatives, wholesale and manufacturing	15	65	117	170	205
Other sales and related workers	7	34	67	104	131
Supervisors of office and administrative support workers	12	46	81	116	137
Communications equipment operators	1	3	5	6	6
Financial clerks	27	109	193	275	326
Information and record clerks	47	179	307	432	505
Material recording, scheduling, dispatching, and distributing workers	22	95	167	234	270
Secretaries and administrative assistants	35	140	250	358	423
Other office and administrative support workers	31	125	225	324	385
Supervisors of farming, fishing, and forestry workers	0	0	0	0	0
Agricultural workers	1	2	4	7	9
Fishing and hunting workers	0	0	-1	-1	-1
Forest, conservation, and logging workers	0	-1	-2	-2	-2
Supervisors of construction and extraction workers	2	21	49	78	99
Construction trades workers	20	177	408	649	817
Helpers, construction trades	1	14	34	55	70
Other construction and related workers	2	8	17	26	32
Extraction workers	0	2	4	7	10
Supervisors of installation, maintenance, and repair workers	3	12	24	36	44
Electrical and electronic equipment mechanics, installers, and repairers	4	17	32	46	55
Vehicle and mobile equipment mechanics, installers, and repairers	12	50	91	132	158
Other installation, maintenance, and repair occupations	16	81	165	256	321
Supervisors of production workers	3	11	18	24	27
Assemblers and fabricators	8	31	51	70	80
Food processing workers	3	13	23	33	39
Metal workers and plastic workers	6	25	43	60	70
Printing workers	1	5	8	10	11
Textile, apparel, and furnishings workers	12	39	58	73	78
Woodworkers	1	4	7	10	11
Plant and system operators	0	0	1	3	4
Other production occupations	12	44	75	104	121
Supervisors of transportation and material moving workers	3	13	24	35	42
Air transportation workers	0	-1	-4	-7	-8
Motor vehicle operators	22	93	172	252	305
Rail transportation workers	0	0	0	1	1
Water transportation workers	0	1	3	6	8
Other transportation workers	6	20	32	43	48
Material moving workers	28	132	242	350	416
TOTAL OF ALL OCCUPATIONS =	**1,082**	**4,469**	**8,066**	**11,649**	**13,915**

Occupational impacts are consistent with those to industries, which follow from industries hiring based on their level of demand, competitiveness, and output in PI+. Notably, few occupational categories see a negative impact. While **petroleum and coal** or **utilities** may not need quite as many engineers as they did before, those same educational backgrounds and skill sets would have applications elsewhere, such as within **fabricated metals**, **electronics**, and **automobiles**. These are relatively small changes, so a mechanism for the "transfer" of labor from one industry to another is a change in the rate of new hires. For instance, environmental tax reform might make engineering majors at the state schools more likely to find a job in a different industry than before but not necessarily a new, different occupation. This means employment by industry may have negative impacts while employment by occupations remains neutral or goes positive relative to the baseline. The numbers above show this effect occurring in high-skilled professional and skilled trades. Those jobs will go on to support a large quantity of core spending and other jobs tied to retail and personal services.

Personal Consumption Expenditure (PCE)-Price Index

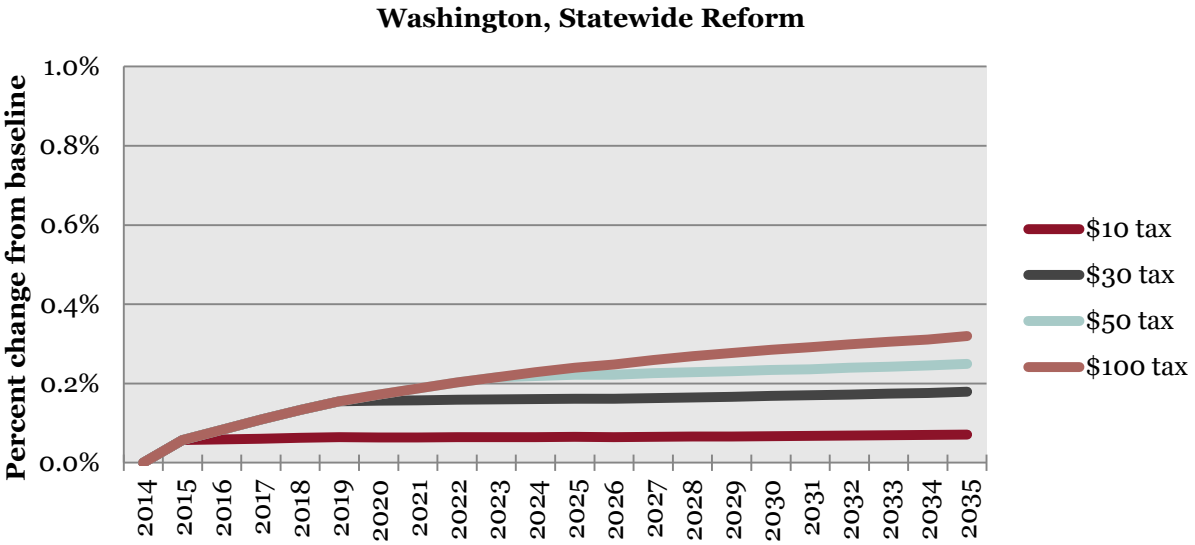


Figure 2.13 – This shows the change in the PCE-Price Index in PI+ under the tax scenarios. ***The results for King County and Washington are similar, so this only includes statewide figures.*** *The PCE is REMI's version of the consumer price index (CPI),[30] which is a weighted basket of goods used to study inflation, purchasing power, and the real value of nominal wages over time. For example, $1 in 1987 would need to be $2 in 2013 to have the same real value when accounting for the CPI. This tax reform increases the cost of living in Washington to only a small degree. The above is a percent adjustment against a baseline—that is, inflation would be slightly higher from 2015 to 2025 and then steady against underlying inflation rate. This is not a compounding factor but rather a change against the baseline. This makes it something of a "one-time" adjustment of less than 1% over the course of a decade. The calculation of the PCE accounts for seventy-five consumption categories, local tax rates, and costs passed onto consumers by businesses. Hence, the results above are the net of higher energy prices from Pigouvian taxes, lower sales taxes rates, and whatever firms try to pass on to customers.*

PCE-Price Index by Income Quintile

Quintile	2015	2020	2025	2030	2035
Lowest 20%	+0.06%	+0.18%	+0.25%	+0.30%	+0.33%
Low-Middle 20%	+0.06%	+0.18%	+0.25%	+0.29%	+0.33%
Middle 20%	+0.06%	+0.17%	+0.24%	+0.29%	+0.32%
High-Middle 20%	+0.06%	+0.17%	+0.23%	+0.28%	+0.31%
Highest 20%	+0.06%	+0.17%	+0.23%	+0.27%	+0.31%

Figure 2.14 – These results are for the $100/ton scenario. One concern with carbon taxes or a cap-and-trade is its potential to be disproportionately harmful to the welfare of low-income families. Fuel for transportation and heating can make up a large share of low-income purchases than it does for higher-income groups. The "first dollar" in any home goes towards necessities, such as housing, food, gasoline, clothing, or heating. When incomes rise, more "last dollars" come about, and consumers allocate them to luxury goods like extra vehicles, entertainment, or electronics. If a family has only "first dollars" then a carbon tax on fuel and energy might hurt those most. Conversely, this chart shows this is not the case. The lower sales tax helps make up the difference through other means. Higher-income earners also use more energy with larger homes and extra vehicles, which keeps the proportions here even.

[30] "Consumer Price Index," *Bureau of Labor Statistics*, <http://www.bls.gov/cpi/>

Changes in Energy Prices from Baseline

The effect of the carbon tax is the strongest within four PI+ consumption categories: natural gas, motor vehicle fuels (including gasoline and diesel), petroleum-based distillates and fuel oils, and electricity. The cost impact will depend on three factors, including carbon-intensity, underlying consumption rates, and the level of carbon tax or cap-and-trade auction. For the same number of BTUs,[31] natural gas tends to emit a smaller amount of carbon than petroleum. This makes gas *relatively* more immune from large changes in retail prices. However, the Pacific Northwest already utilizes a significant quantity of natural gas for heating and cooking. This give-and-take and the level of tax produce a cost impact. Just as with the PCE, these are "one-time" adjustments against a moving baseline. They do not imply higher fuel prices in the future—fossil energy prices in the United States have fallen in the aftermath of unconventional shale, and they may continue to do so in the future. These "increased prices" below may come in a world of falling or, at least historically low, energy prices.

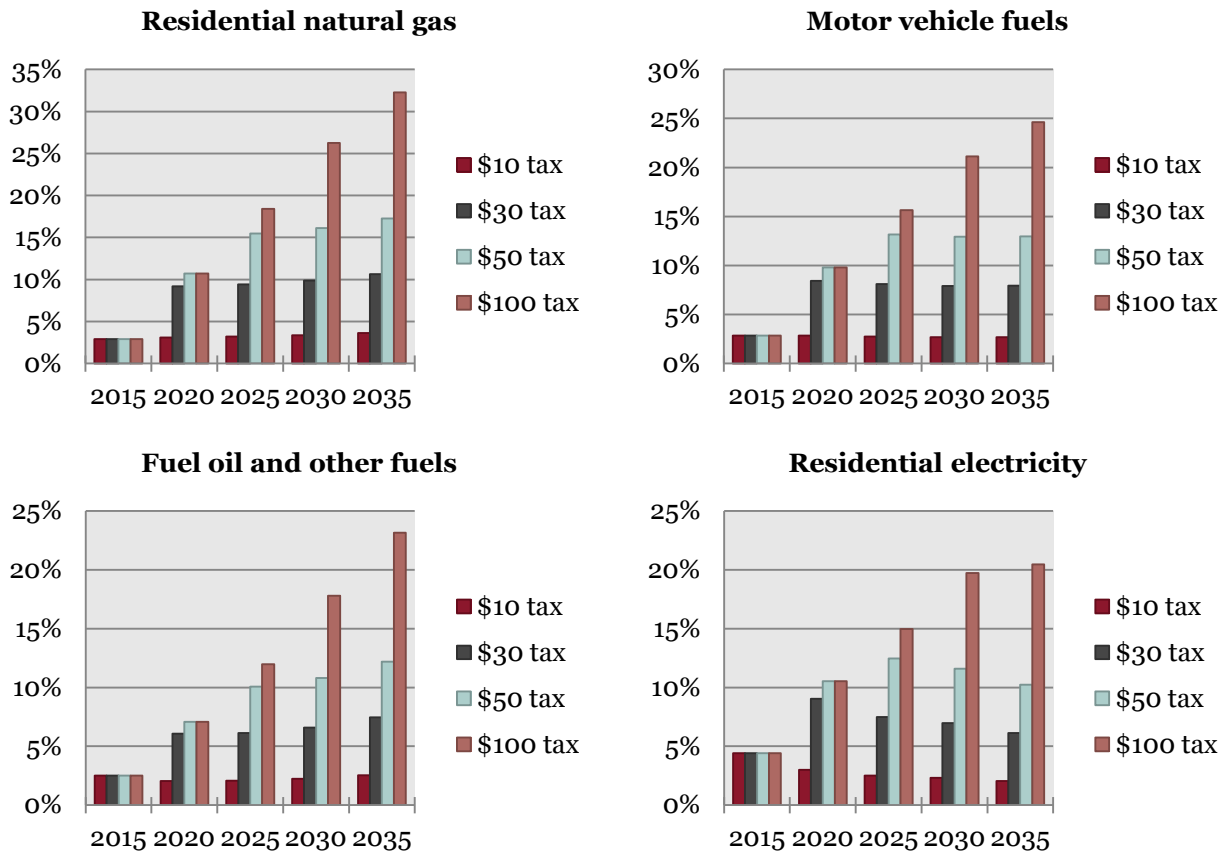
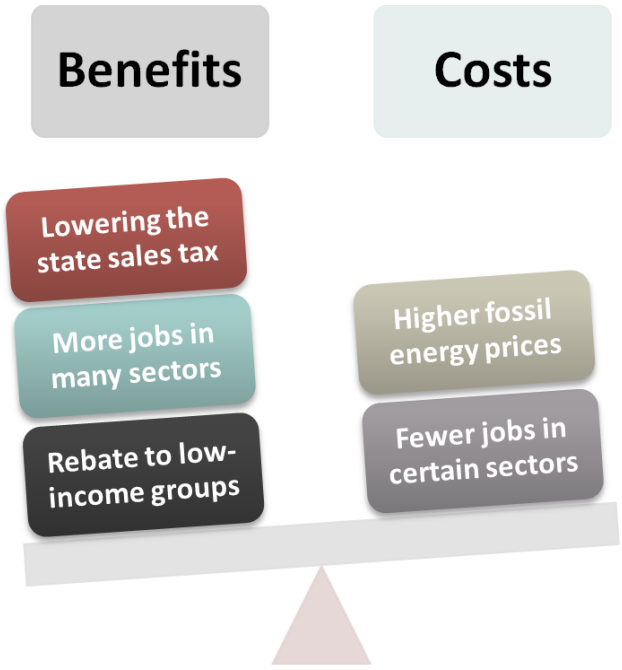


Figure 2.15 – This shows the cost difference to energy categories from implementing a carbon tax in Washington. While a higher cost, this is a "feature" and not a "bug" of policy. The higher costs generate revenue for other tax cuts and discourage the use of these fuels, which reduces the overall emissions level for the state. To emphasize, these changes are against a preexisting baseline, and one that might already include already falling or lower prices (depending on another series of assumptions).

[31] A unit of heat defined as the amount of thermal energy needed to raise the temperature of one pound of water by one degree Fahrenheit, or approximately 1,055 joules or 252 calories, <http://www.britannica.com/EBchecked/topic/80372/British-thermal-unit-BTU>

The next section discusses the impact of this tax reform on personal income when accounting for the cost of living. "Real disposable income" depends on a number of factors, and the balance to the right lays them out. The higher number of jobs in the state increases aggregate wages, and, after dividing by the changes in the price index due to higher energy costs but low taxes, the result is "real income." REMI PI+ includes a methodology for calculating these by quintiles. It relies on the changes in the mixture of jobs from one of the industries to the next and, given the fact some industries pay better than the median and some pay worse, how the whole distribution of wages would change between the groups during an economic simulation.[32]



[32] "Decomposing Policy Effects on Employment, Wages, and Prices by Income Groups," *REMI*, <http://www.remi.com/download/documentation/pi+/pi+_version_1.3/Income_Distribution.pdf>

ADDITIONAL REAL DISPOSABLE PERSONAL INCOME

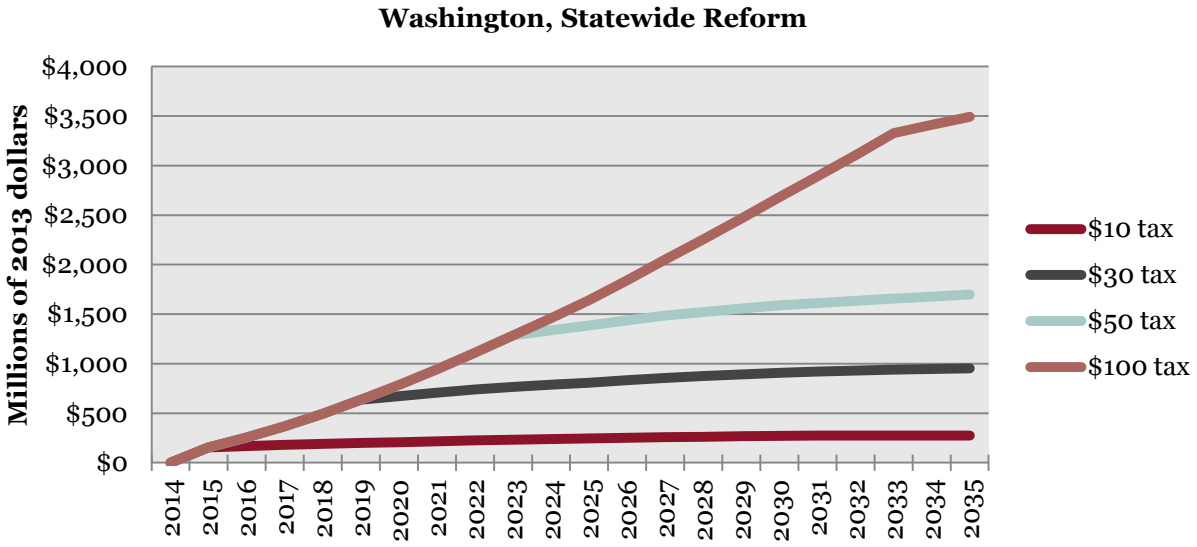


Figure 2.16 – The impact to real income is positive in all the scenarios. Higher energy prices and the elevated PCE would drag real incomes down on their own. On the other hand, boosted economic performance overall, additional employment, and higher nominal wages to go with it means real incomes in the state increase on net. The surge in income generates other responses in the model, such as net migration into the state, which would make these results muted in per capita terms compared to the aggregate concepts reported here for total quantities of income earned in the area.

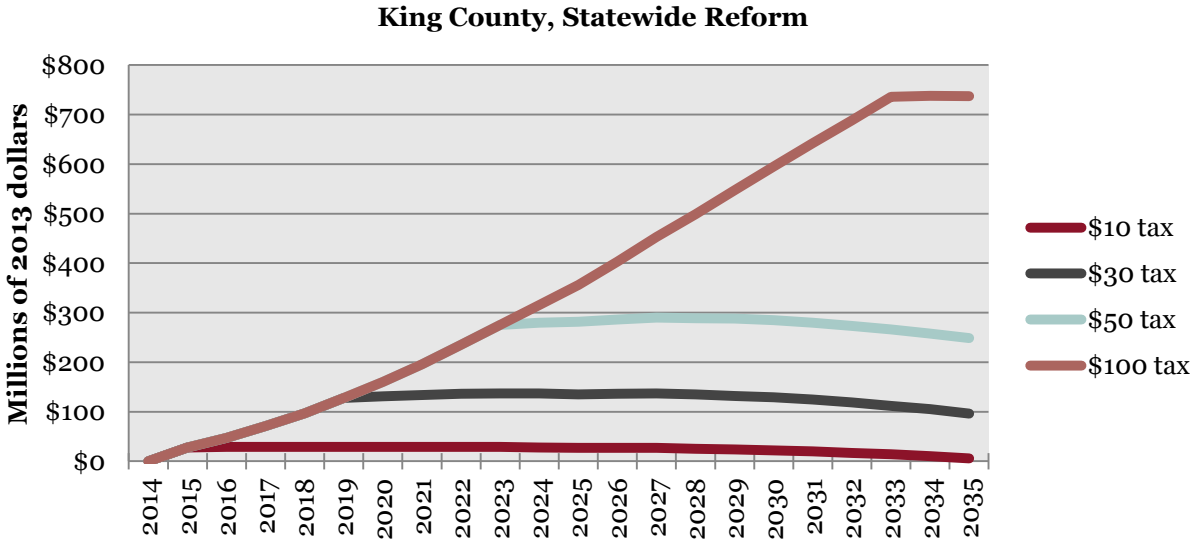


Figure 2.17 – King County has a smaller impact to incomes than the rest the state, and one much smaller than a strict proportion of GDP or population. King County is about half of Washington's GDP, but the above is between 10% and 20% of the impact to income. This is due to income mobility through commuting in PI+ and its modeling of the same. Like many urban areas, King County experiences a net outflow of people in the evening, working at King County jobs but living elsewhere for lifestyle reasons or for a lower cost of living. This takes their paychecks with them. In 2012, PI+ estimated this outflow as $20 billion/year compared to $5 billion/year inflow for a net loss of -$15 billion/year. The pattern continues in the results above where income flow leaks out of King County.

INCOME BY QUINTILE

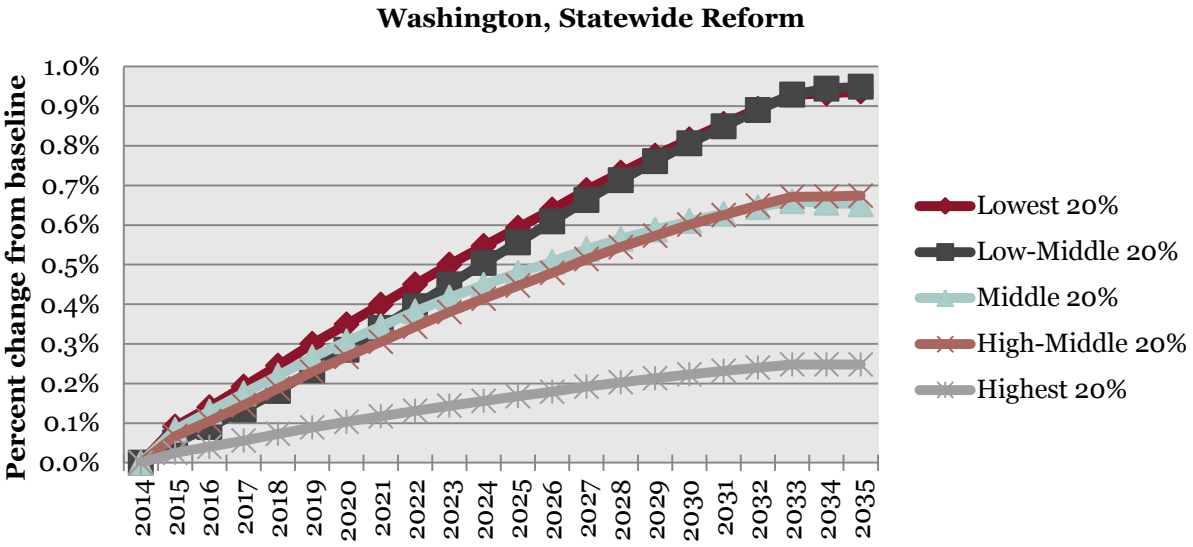


Figure 2.18 – The above figure is for the $100/ton case. This tax reform would not have a tremendous impact on income distribution from this data. Households in the lowest 20% of income actually see close to the most benefit when adjusting for the Working Family rebate—the amount equal to 10% of total carbon tax revenue. Without this, the impact on their nominal income would be close to 0%, and the higher PCE-Price Index would mean their real incomes are lower. This adjustment brings the impact to their incomes in line with the middle 60% and keeps the overall distributional impact neutral.

ADDITIONAL POPULATION

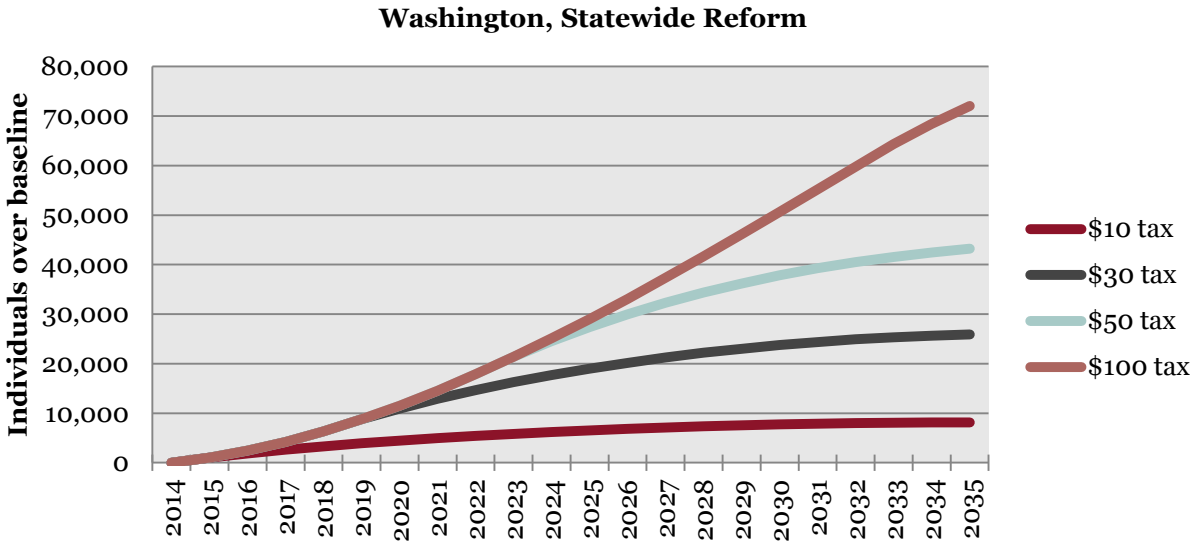


Figure 2.19 – PI+ includes a demographic response to tax reform, as well. This is certainly the case in Washington, where better job opportunities, higher wages and minimal impacts to the cost of living, and quality of life mean a population increase of up to 70,000 over the null in the $100/ton scenario. ***Note, this only accounts for improvements in labor market conditions—it makes no assumptions about directly increased quality of life from introduction carbon pricing, such as lowered qualifying air pollutants in King County and Washington.***

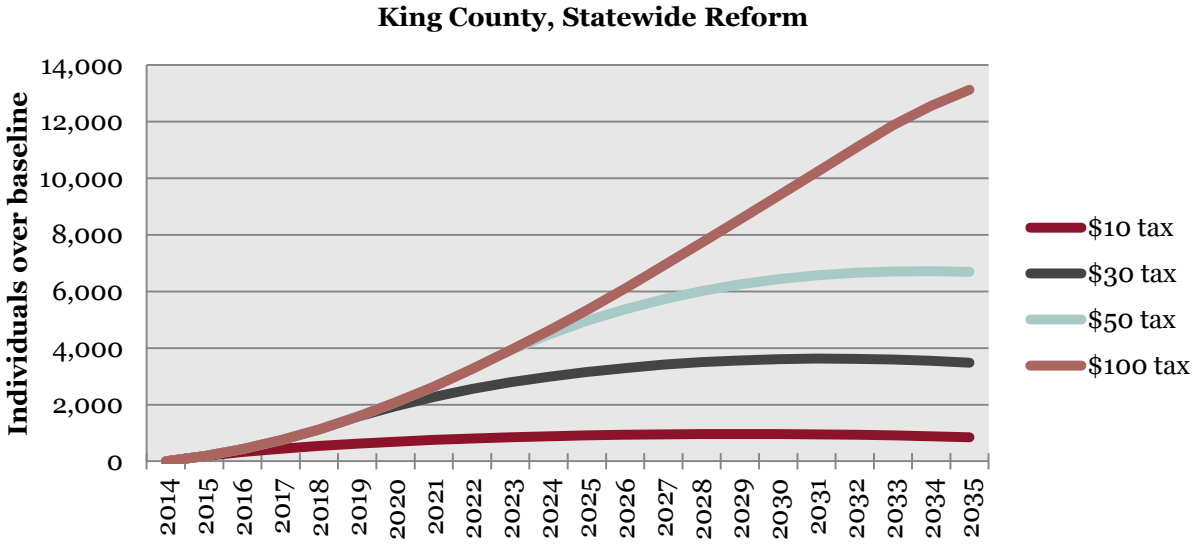


Figure 2.20 – King County has a similar population response, though the bounce here is not as large as in the rest of the state. King County has high land and costs compared to many of the areas in the remainder of Washington—this makes people moving into the state likely to behave as those in the rest of it in living elsewhere and enjoying the strong job market in Seattle via commuting. There is still a positive demographic shift in Seattle and its suburbs from the carbon tax policy, where the higher job opportunity draws people in from other parts of the state and the United States to make a living. This effect continues despite the higher PCE given the raw number of jobs available.

Carbon Tax Revenues (Annual)

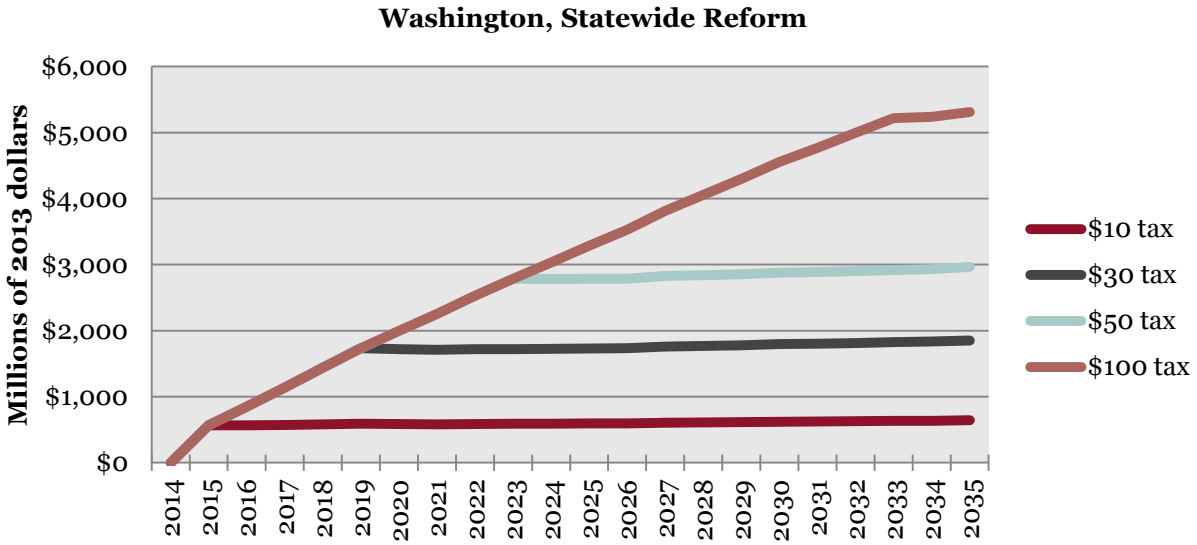


Figure 2.21 – These results are from CTAM, not PI+. They cover the eventual revenues gained from the carbon tax at varying levels. This is how much money recycles into the state economy with lower B&O taxes, sales taxes, and the rebate to low-income households. Introducing the tax generates progressively more revenue until it hits its peak; this causes a fall in carbon emissions. However, the NEMS baseline forecasts an increase in energy demand in Washington and the Pacific region in the future, which means the total amount of revenue "balances" against this demand growth. In essence, revenues are steady between the "push" of growing fuel demand and the "pull" of the price response away from emitting due to the carbon tax. This holds emissions down but keeps revenues up for the state.

Carbon Tax Revenues (Cumulative)

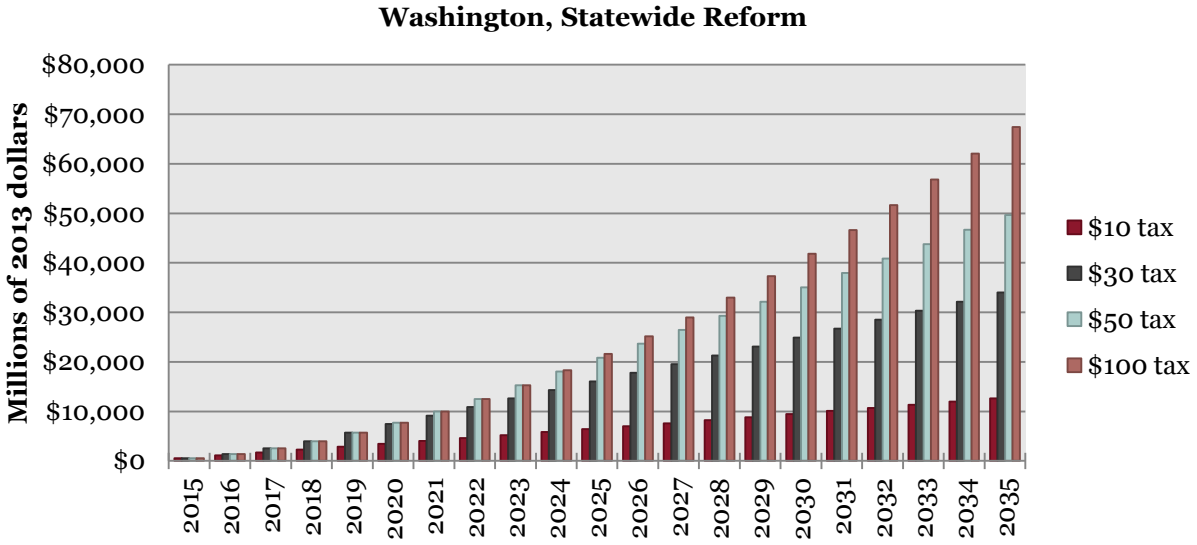


Figure 2.22 – This graph displays the total amount of cumulative revenue from the carbon tax over time. It is the same annual information above presented in a different manner. For context, Washington's GDP in 2012 was about $375 billion. The revenue here could easily be over 0.5% of GDP in a given year and replace much of the taxes covering other portions of Washington's state budget.

CARBON DIOXIDE EMISSIONS (ANNUAL FORECAST)

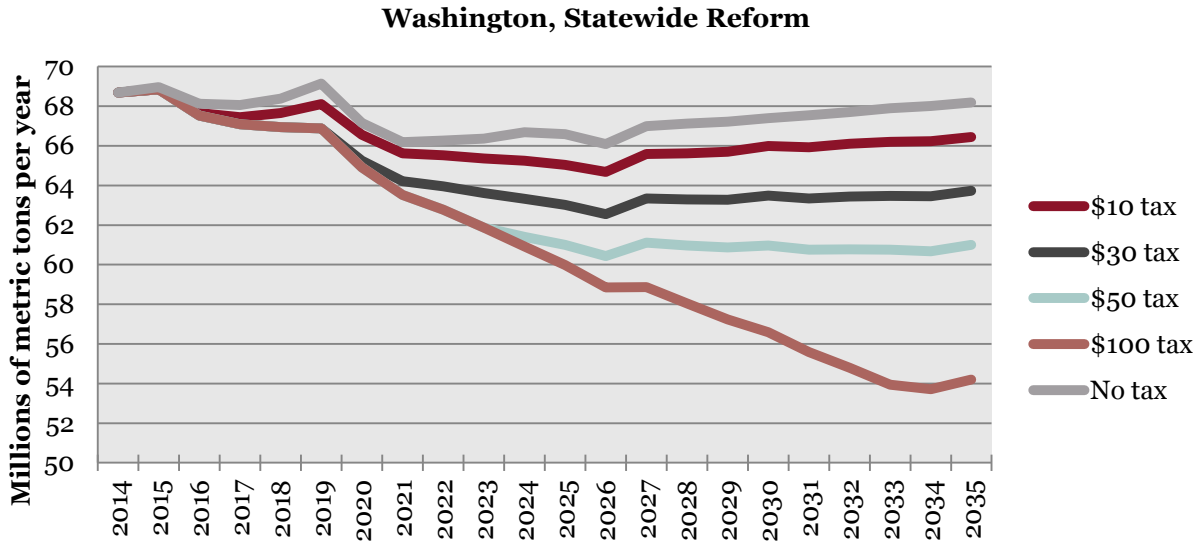


Figure 2.23 – This shows the baseline forecast for emissions from the EIA Extended Outlook forecast and the impact of environmental tax reform on statewide emissions. Each higher level of tax drives emissions lower with higher prices; for instance, a $50/ton carbon tax would mean about 61 million metric tons emitted in 2035 instead of the baseline of approximately 68 million metric tons.

CARBON DIOXIDE EMISSIONS REDUCTIONS (ANNUAL DIFFERENCE)

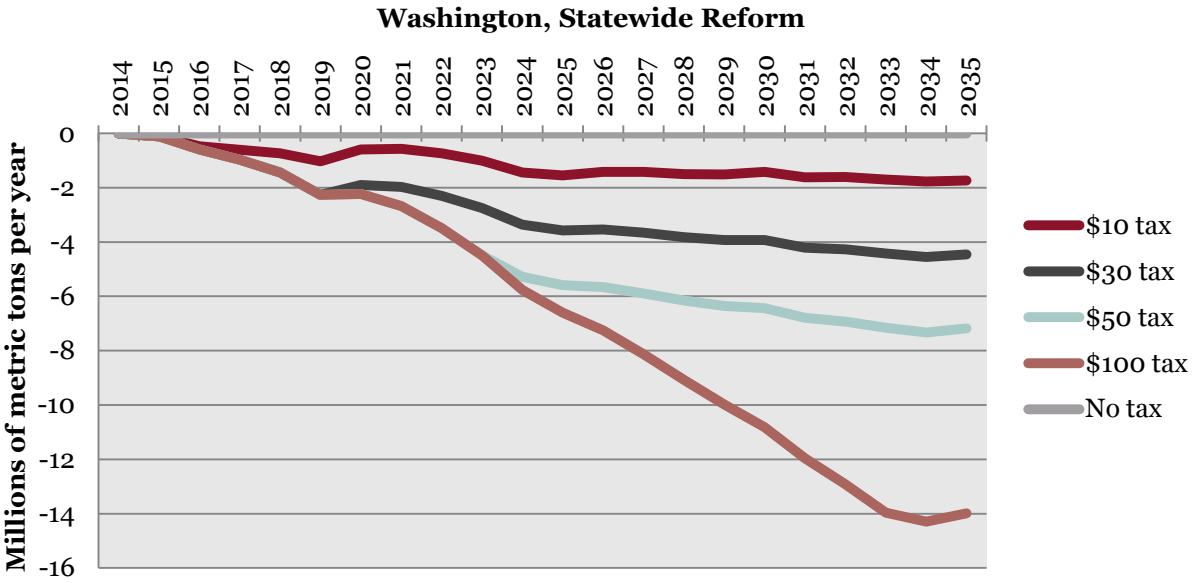


Figure 2.24 – This figure makes the previous baseline of no tax into the x-axis and compares the difference in emissions saved between the four cases. Washington responds to the carbon tax; the tax induces enough of a behavioral change in the $100/ton scenario to reduce emissions by approximately 14 million metric tons per year by 2035. According to the Environmental Protection Agency (EPA), in 2011, the state of Delaware emitted 13.11 million metric tons of carbon dioxide and equivalent from fuel and power generation.[33] The $100/ton case represents a decline of the same amount in 2035.

CARBON DIOXIDE EMISSIONS (CUMULATIVE DIFFERENCE)

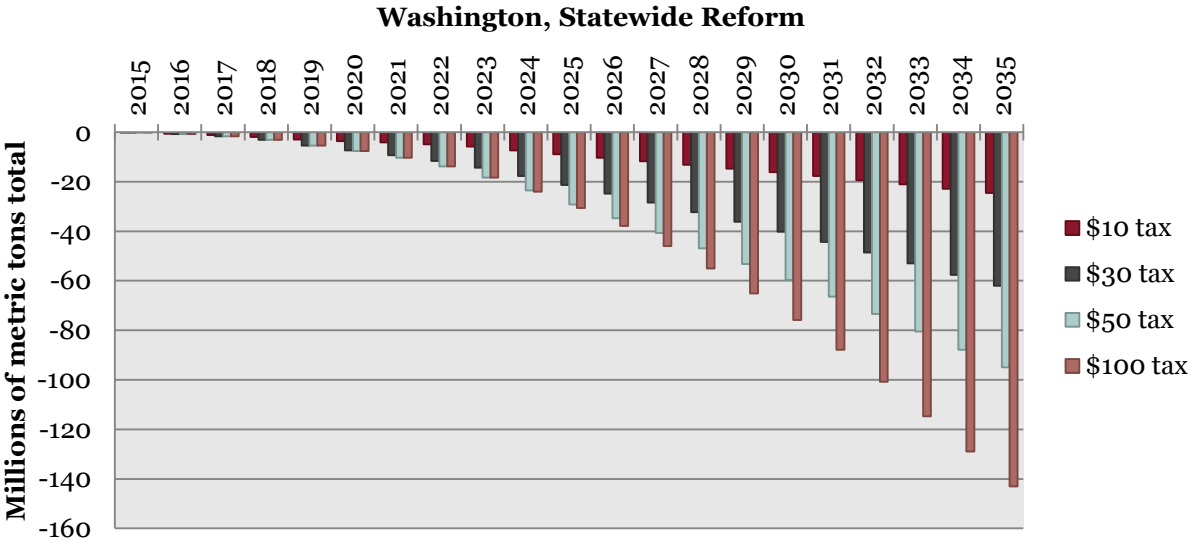


Figure 2.25 – This is the long-term emissions savings, cumulative from the baseline, from the figure above. For context, 140 million metric tons of carbon dioxide was about the annual carbon emissions of states such as Alabama, Georgia, Kentucky, and Missouri in 2011, according to the EPA.

[33] "State Energy CO_2 Emissions," *Environmental Protection Agency*, <http://epa.gov/statelocalclimate/resources/state_energyco2inv.html>

CARBON DIOXIDE EMISSIONS (1990 BENCHMARK)

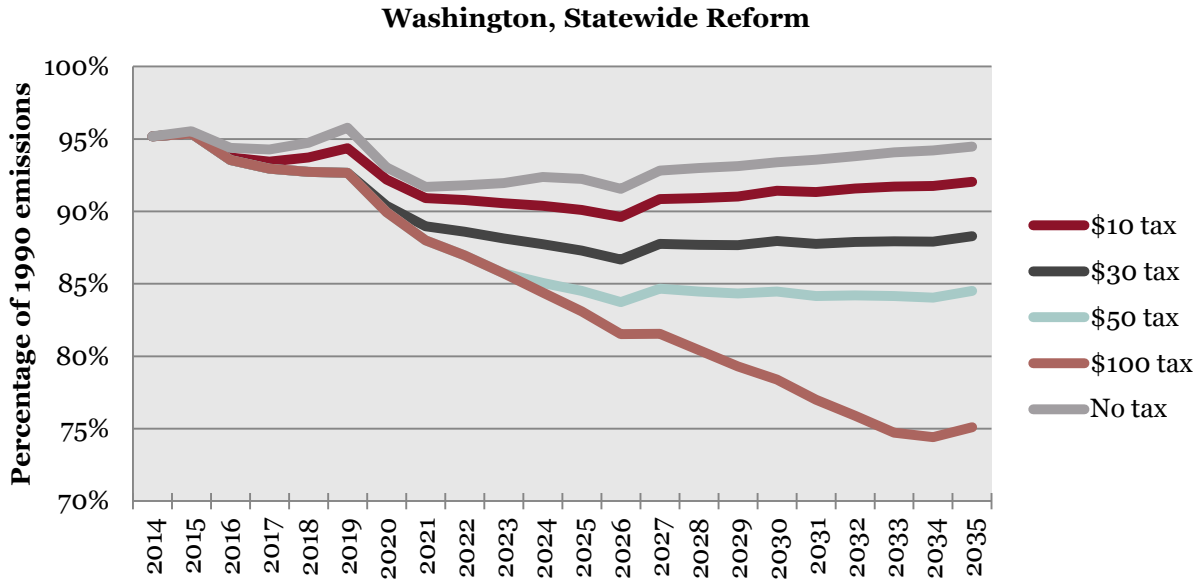


Figure 2.26 – This benchmarks Washington emissions to 1990. In 1990, Washington emitted 72.18 million metric tons of carbon into the air.[34] The use of 1990 as a benchmark is arbitrary, but it derives from the Kyoto Protocol, a series of international treaties between industrialized nations and developing ones for emissions using 1990 levels as a significant signpost for further negotiations.[35] Washington is already below its 1990 levels, though only slightly, and a carbon pricing system would help drive emissions below 90% and towards 85% or 75% depending on the scenario. The state's emissions are slow to fall, however, given the previous embrace of natural gas for fuel and hydroelectric power; some obvious efficiency is already present in the NEMS baseline for Washington. Nonetheless, the state experiences a reduction in emission from carbon pricing, and a $30/ton tax or auction price (or anything above that) prevents noteworthy growth in the level of emissions in the future.

The environmental tax reform measures above aid the state towards meeting Governor Jay Inslee's goals for emission reductions. In keeping with existing state reductions criteria, Washington endeavors to equal 1990 emissions levels by 2020 and 75% of 1990 levels by 2035.[36] The state has the further initiative of reaching 50% of 1990 emissions by 2050, though the NEMS Extended Outlook baseline only allow for analysis out to 2035. According to the most recent historical data from the EPA, Washington is already below its Kyoto allowance for 1990 levels (emitting 72.18 million metric tons of carbon dioxide in 1990 and 70.81 million metric tons in 2011, a reduction of 1.9%).[37] The growths in CTAM and NEMS baselines of energy demand in Washington from 2020 to 2035 keep the state from seeing much more of a "natural drift" for reduction in emissions. Some form of a carbon price in the state would help to rectify these situations. The $50/ton tax scenario comes close; it meets an 85% goal of 1990 levels by 2035, but the doubling in the event of the maximum—the $100/ton carbon tax—does meet 75% by 2033, 2034, and 2035. This is beyond the hypothetical range of carbon pricing in the SAIC report,[38] but we included the $100/ton case here to show the economic impact of meeting the goal.

[34] EPA
[35] For more information, please see, "Kyoto Protocol," *United Nations Framework Convention on Climate Change*, <http://unfccc.int/kyoto_protocol/items/2830.php>
[36] <http://apps.leg.wa.gov/rcw/default.aspx?cite=70.235.020>
[37] EPA
[38] SAIC, pp. 4-5

County Tax Reform

The next study area examines a hypothetical environmental tax reform built on carbon taxation for King County by itself. King County has an open economy, much like Washington and many of the other states of the union. It has a large service sector and little in terms of natural resources and the supply-chain for oil or natural gas. Reducing the importation of these fuels may have positive impacts for keeping "local dollars" local. This is especially true when combined with relief to property and sales taxes in the county. The simulations are quite similar to the ones for Washington statewide, though differences exist within the revenue recycling owing to the discontinuities between a county-level budget and the one for Olympia. Without a B&O tax, a reduction in property taxes—which impacts both residential real estate and commercial/industry square footage—serves the same role. The "help" to households comes in the form of a lower local sales tax. For these scenarios, 50% of tax revenues go to reducing sales taxes and the other 50% towards local property taxes:

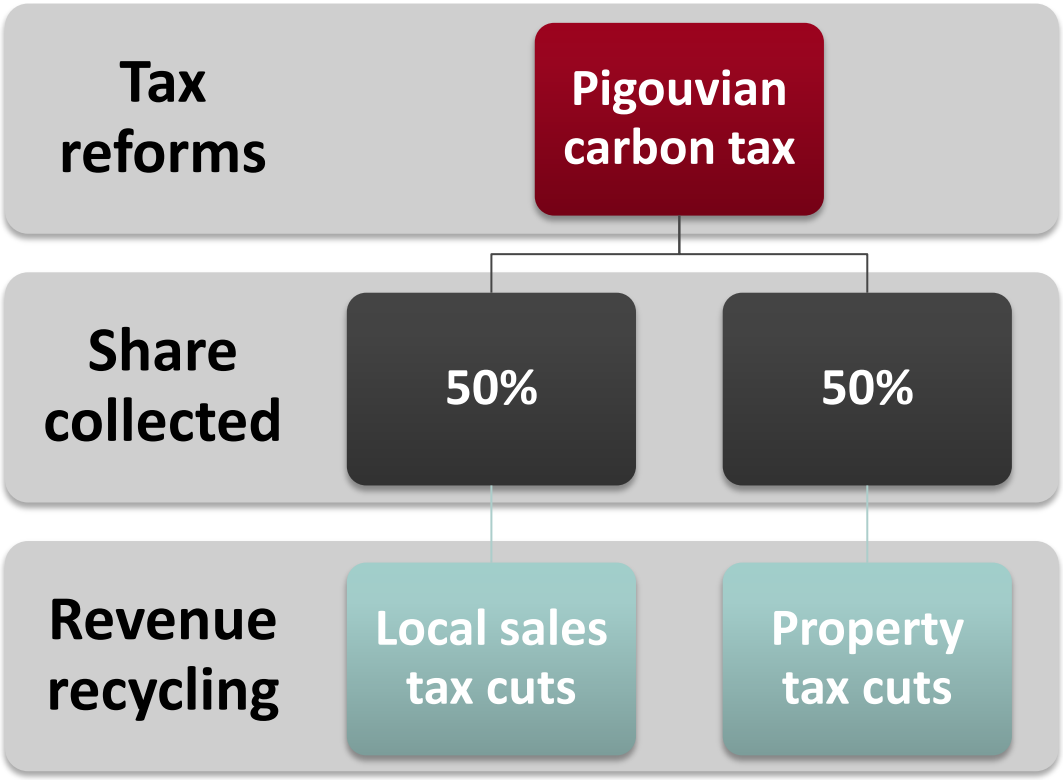


Figure 3.1 – This is the recycling scheme for King County's tax reform modeled here. After a few iterations to test sensitivities in PI+, this provided a strong balance between maintaining local competitiveness, a neutral impact on the cost of living, and protecting lower-income households from any potentially regressive impacts or changes from these policies. PI+ includes variables for the imputed or actual rent costs of housing, apartments, and commercial/industrial space, which, when modified, adjust accordingly in response to implementing these changes on the local tax regime.

The results for King County are the same as those for the statewide tax reform, though with some minor simplifications for displaying information for 1-region (King County) instead of 2-regions. This includes the major economic indicators, demographics, distributional impacts, tax revenue, and implications for emissions. Altogether, King County sees a modest impact from implementing a carbon tax. It is a positive impact in all the same aspects as the statewide ones. The scenarios are the same with $10/ton, $30/ton, and $50/ton (from SAIC) carbon rates to give an overview of local sensitivities.

ADDITIONAL TOTAL EMPLOYMENT

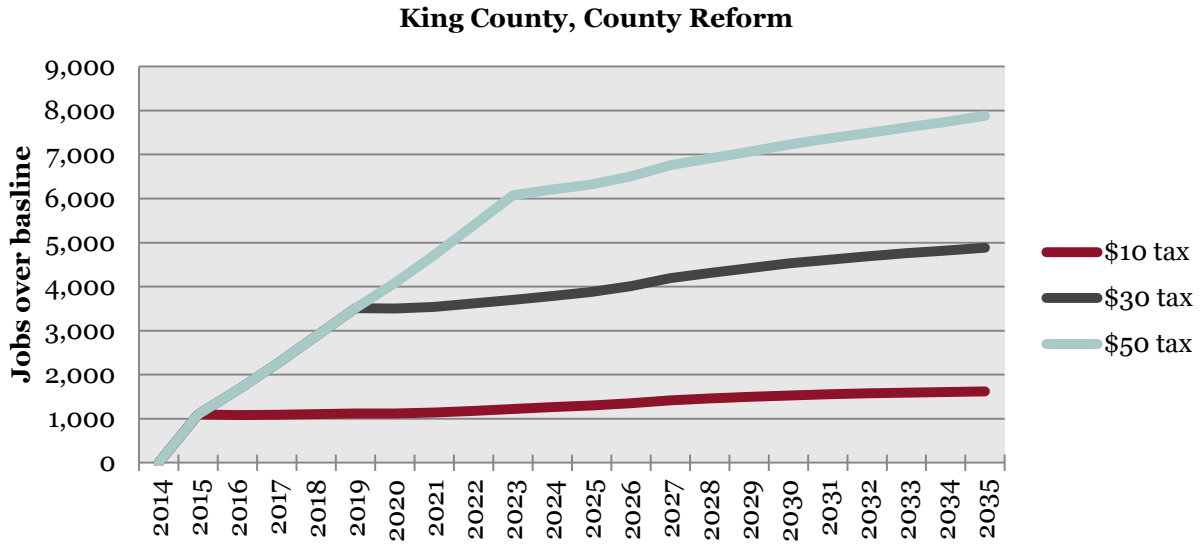


Figure 3.2 – ***King County experiences a net positive impact to total employment under a county-level environmental tax reform.*** *Narratives are much the same. Competitiveness for local, labor-intensive businesses increases, and imports of out-of-county and out-of-state fuel sources diminishes, leaving Seattle and the surrounding area to grow. This is a general case in state and local taxation, where taxing things made out of the area is typically a better way to find revenue in a less damaging setting than drawing from local income, consumption, or business activities.*

ADDITIONAL GROSS DOMESTIC PRODUCT (ANNUAL)

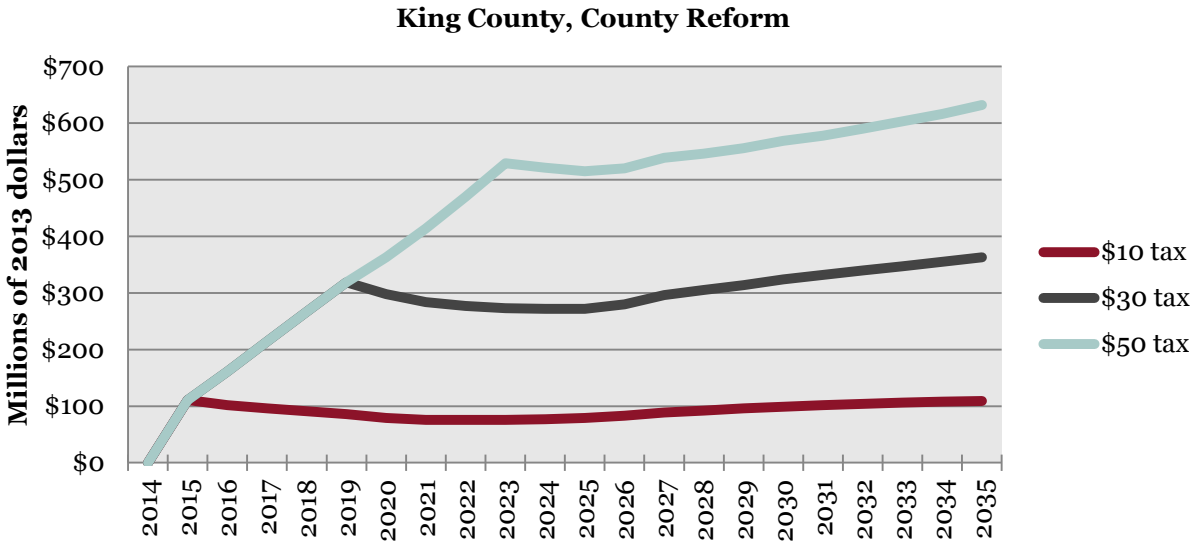


Figure 3.3 – As before, ***carbon taxes and revenue recycling add to the total level of economic activity in King County compared to the baseline.*** *The impact of King County "going alone" is less than a statewide scenario because of the linkages between the Seattle metro and the rest—the economic expansion in the whole state creates a positive impact back into its largest metropolitan area and vice versa. The highest impact of $600 million/year is about 0.17% of King County's GDP.*

ADDITIONAL GROSS DOMESTIC PRODUCT (CUMULATIVE)

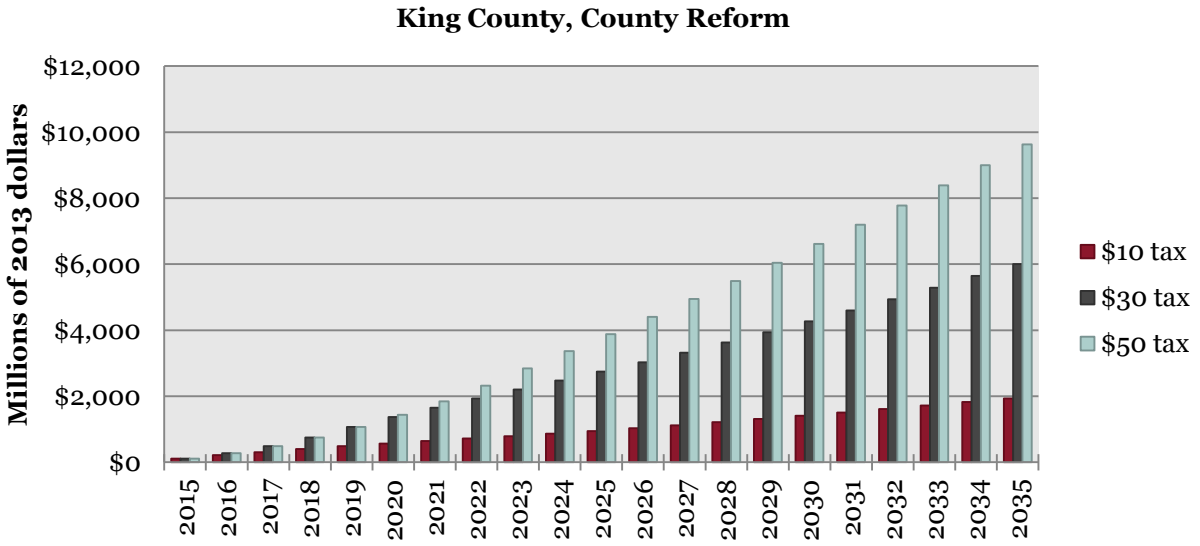


Figure 3.4 – This is the same exercise as the total amount of additional GDP over time. King County had a GDP of about $175 billion in 2012. These numbers could hit over 2% of county GDP, which would greatly reduce other tax burdens and cover other revenue categories. King County's most recent budget totaled $7.6 billion. The above dollars could significantly rework how this influences the economy—covering up to 30% of current expenditures and much of current local receipts.[39]

[39] "2013 Budget," *King County*, <http://www.kingcounty.gov/council/budget/2013_budget.aspx>

FIGURE 3.5 – ANNUAL OUTPUT BY INDUSTRY (KING COUNTY, COUNTY REFORM, $50/TON)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$0.6	-$7.7	-$15.5	-$17.0	-$15.7
Agriculture and forestry support activities	$0.0	-$0.1	-$0.2	-$0.2	-$0.2
Oil and gas extraction	$0.0	$0.0	$0.0	$0.0	$0.0
Mining (except oil and gas)	$0.0	-$0.5	-$1.1	-$1.4	-$1.5
Support activities for mining	$0.0	-$0.1	-$0.2	-$0.3	-$0.3
Utilities	-$4.0	-$12.3	-$16.0	-$15.9	-$15.6
Construction	$7.7	$45.1	$75.8	$77.4	$77.3
Wood product manufacturing	$0.2	$0.4	$0.3	$0.1	$0.1
Nonmetallic mineral product manufacturing	$0.8	$2.3	$2.6	$2.2	$2.0
Primary metal manufacturing	-$0.1	-$2.0	-$4.1	-$4.8	-$4.9
Fabricated metal product manufacturing	$0.9	$2.8	$3.3	$3.1	$3.3
Machinery manufacturing	$0.3	$0.8	$0.6	$0.3	$0.3
Computer and electronic product manufacturing	$1.7	$3.2	$0.8	-$0.7	$0.0
Electrical equipment and appliance manufacturing	$0.2	$0.1	-$0.4	-$0.8	-$1.1
Motor vehicles, bodies and trailers, and parts manufacturing	$2.5	$8.7	$11.5	$11.4	$11.5
Other transportation equipment manufacturing	-$0.3	-$9.3	-$21.1	-$26.1	-$27.6
Furniture and related product manufacturing	$0.5	$1.3	$1.4	$1.2	$1.1
Miscellaneous manufacturing	$0.9	$2.2	$1.4	$0.8	$1.0
Food manufacturing	$0.3	-$1.2	-$3.2	-$3.3	-$2.6
Beverage and tobacco product manufacturing	$0.9	$2.9	$4.2	$4.6	$4.7
Textile mills; Textile product mills	$0.0	$0.0	-$0.2	-$0.2	-$0.2
Apparel manufacturing; Leather and allied product manufacturing	$0.2	$0.7	$0.6	$0.7	$0.8
Paper manufacturing	$0.1	$0.1	-$0.1	-$0.1	-$0.2
Printing and related support activities	$0.2	$0.5	$0.6	$0.6	$0.7
Petroleum and coal products manufacturing	-$2.1	-$12.3	-$21.3	-$23.9	-$24.9
Chemical manufacturing	$0.0	-$5.1	-$11.9	-$14.5	-$15.1
Plastics and rubber product manufacturing	$0.6	$1.4	$1.1	$0.6	$0.4
Wholesale trade	$10.9	$38.1	$56.6	$65.8	$75.7
Retail trade	$14.3	$57.9	$91.0	$107.9	$123.8
Air transportation	-$0.4	-$5.3	-$11.9	-$15.2	-$16.9
Rail transportation	$0.0	-$0.2	-$0.5	-$0.6	-$0.6
Water transportation	$0.0	-$0.5	-$1.2	-$1.5	-$1.7
Truck transportation	$0.6	$1.8	$2.4	$2.6	$3.1
Couriers and messengers	$0.1	$0.2	-$0.1	-$0.2	-$0.2
Transit and ground passenger transportation	$0.0	$0.0	-$0.1	$0.0	$0.2
Pipeline transportation	$0.0	$0.0	-$0.1	-$0.1	-$0.1
Scenic and sightseeing transportation; Support activities for transportation	-$0.1	-$1.7	-$4.3	-$6.1	-$7.4
Warehousing and storage	$0.0	$0.1	$0.0	-$0.1	-$0.1
Publishing industries, except Internet	$3.3	$2.2	-$5.2	-$7.6	-$4.7
Motion picture and sound recording industries	$0.2	$0.6	$0.9	$0.9	$1.1
Internet publishing and broadcasting; ISPs, search portals, and data	$0.6	$1.6	$2.6	$3.7	$5.0
Broadcasting, except Internet	$0.3	$0.4	$0.0	-$0.3	-$0.2
Telecommunications	$6.0	$15.8	$19.5	$20.6	$23.7
Monetary authorities - central bank; Credit intermediation and related	$6.9	$19.8	$25.0	$25.3	$27.5
Securities, commodity contracts, investments	$4.7	$15.2	$20.3	$20.4	$20.8
Insurance carriers and related activities	$1.4	$4.6	$6.6	$7.5	$8.3
Real estate	$56.0	$197.2	$288.9	$317.7	$344.2
Rental and leasing services; Leasers of nonfinancial intangible assets	$1.8	$4.4	$4.9	$4.2	$4.0
Professional, scientific, and technical services	$7.1	$14.4	$12.3	$11.1	$15.2
Management of companies and enterprises	$0.5	-$2.2	-$6.7	-$9.0	-$9.4
Administrative and support services	$2.4	-$0.8	-$8.2	-$12.5	-$13.4
Waste management and remediation services	$0.4	$1.1	$1.6	$1.8	$2.2
Educational services	$0.7	$4.3	$8.7	$11.5	$13.2
Ambulatory health care services	$4.2	$11.3	$15.7	$19.8	$26.7
Hospitals	$1.6	$11.3	$25.1	$35.9	$44.0
Nursing and residential care facilities	$0.2	$1.9	$4.7	$7.4	$9.6
Social assistance	$0.2	$1.8	$4.0	$5.8	$7.1
Performing arts and spectator sports	$1.0	$3.8	$6.2	$7.6	$8.9
Museums, historical sites, zoos, and parks	$0.1	$0.8	$1.5	$2.0	$2.3
Amusement, gambling, and recreation	$0.4	$1.4	$2.1	$2.6	$3.1
Accommodation	$1.8	$3.1	$2.3	$1.9	$2.6
Food services and drinking places	$10.9	$42.2	$66.3	$76.4	$82.8
Repair and maintenance	$2.3	$7.3	$10.6	$11.9	$13.1
Personal and laundry services	$6.3	$19.7	$25.4	$25.0	$25.3
Membership associations and organizations	$0.9	$5.2	$10.2	$13.5	$15.5
Private households	$0.6	$1.9	$2.5	$2.6	$2.6
TOTAL OF ALL INDUSTRIES =	**$159.4**	**$501.9**	**$688.6**	**$754.3**	**$850.1**

FIGURE 3.6 – EMPLOYMENT BY INDUSTRY (KING COUNTY, COUNTY REFORM, $50/TON)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	-5	-8	-7	-5
Agriculture and forestry support activities	0	-5	-9	-8	-5
Oil and gas extraction	0	0	0	0	0
Mining (except oil and gas)	0	3	9	14	18
Support activities for mining	0	0	0	0	0
Utilities	-5	-13	-14	-12	-10
Construction	61	448	845	972	1,035
Wood product manufacturing	1	2	3	4	4
Nonmetallic mineral product manufacturing	3	10	15	16	16
Primary metal manufacturing	0	-1	-1	-1	0
Fabricated metal product manufacturing	4	13	18	20	22
Machinery manufacturing	1	4	6	6	7
Computer and electronic product manufacturing	4	9	8	8	9
Electrical equipment and appliance manufacturing	0	1	0	0	0
Motor vehicles, bodies and trailers, and parts manufacturing	4	12	14	12	11
Other transportation equipment manufacturing	0	-5	-7	-1	6
Furniture and related product manufacturing	2	7	8	7	7
Miscellaneous manufacturing	4	10	9	8	9
Food manufacturing	1	3	7	11	14
Beverage and tobacco product manufacturing	1	4	7	8	8
Textile mills; Textile product mills	0	0	1	1	1
Apparel manufacturing; Leather and allied product manufacturing	3	9	8	9	9
Paper manufacturing	0	1	2	2	2
Printing and related support activities	1	5	7	7	7
Petroleum and coal products manufacturing	0	0	-1	0	0
Chemical manufacturing	0	-1	-3	-2	-1
Plastics and rubber product manufacturing	2	5	7	8	8
Wholesale trade	45	166	249	285	313
Retail trade	154	585	854	922	952
Air transportation	-1	-7	-14	-13	-11
Rail transportation	0	0	0	1	1
Water transportation	0	2	4	7	10
Truck transportation	4	15	23	29	34
Couriers and messengers	1	4	8	11	14
Transit and ground passenger transportation	1	1	3	8	13
Pipeline transportation	0	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	0	-7	-15	-16	-14
Warehousing and storage	1	2	3	3	5
Publishing industries, except Internet	5	15	23	29	33
Motion picture and sound recording industries	1	4	5	6	6
Internet publishing and broadcasting; ISPs, search portals, and data	1	4	7	8	8
Broadcasting, except Internet	1	2	3	4	5
Telecommunications	7	21	29	32	34
Monetary authorities - central bank; Credit intermediation and related	14	39	49	50	51
Securities, commodity contracts, investments	38	115	146	141	136
Insurance carriers and related activities	5	17	28	33	35
Real estate	118	438	660	725	762
Rental and leasing services; Leasers of nonfinancial intangible assets	2	6	7	7	8
Professional, scientific, and technical services	48	135	189	235	298
Management of companies and enterprises	2	-3	-10	-8	-3
Administrative and support services	38	78	102	145	208
Waste management and remediation services	1	5	9	11	14
Educational services	15	101	206	270	306
Ambulatory health care services	36	110	172	226	300
Hospitals	11	81	177	244	288
Nursing and residential care facilities	4	37	90	136	173
Social assistance	5	44	99	139	166
Performing arts and spectator sports	17	71	118	144	161
Museums, historical sites, zoos, and parks	1	5	11	14	15
Amusement, gambling, and recreation	6	25	44	56	66
Accommodation	15	39	52	62	74
Food services and drinking places	153	597	919	1,017	1,048
Repair and maintenance	18	61	91	103	111
Personal and laundry services	79	238	301	287	279
Membership associations and organizations	11	62	120	153	169
Private households	74	214	269	250	237
TOTAL OF ALL INDUSTRIES =	**1,020**	**3,837**	**5,962**	**6,834**	**7,473**

FIGURE 3.7 – EMPLOYMENT BY OCCUPATION (KING COUNTY, COUNTY REFORM, $50/TON)

SOC Occupations	2015	2020	2025	2030	2035
Top executives	16	58	88	99	105
Advertising, marketing, promotions, public relations, and sales managers	4	15	23	26	29
Operations specialties managers	9	30	44	51	57
Other management occupations	20	81	131	151	163
Business operations specialists	22	81	129	155	178
Financial specialists	25	83	118	129	138
Computer occupations	20	63	92	111	132
Mathematical science occupations	1	2	2	3	3
Architects, surveyors, and cartographers	1	3	5	6	7
Engineers	6	18	26	32	39
Drafters, engineering technicians, and mapping technicians	3	9	13	15	18
Life scientists	1	3	4	6	7
Physical scientists	1	3	4	5	6
Social scientists and related workers	1	3	5	6	7
Life, physical, and social science technicians	1	3	5	6	7
Counselors and Social workers	4	19	36	47	55
Miscellaneous community and social service specialists	2	11	22	28	33
Religious workers	0	1	1	1	2
Lawyers, judges, and related workers	3	10	13	15	18
Legal support workers	2	6	9	11	12
Postsecondary teachers	8	40	74	93	104
Preschool, primary, secondary, and special education school teachers	16	61	100	116	124
Other teachers and instructors	4	18	32	39	44
Librarians, curators, and archivists	1	5	8	10	11
Other education, training, and library occupations	6	24	41	50	54
Art and design workers	4	12	18	21	24
Entertainers and performers, sports and related workers	5	23	40	50	56
Media and communication workers	4	15	25	31	36
Media and communication equipment workers	1	4	6	8	9
Health diagnosing and treating practitioners	19	81	148	196	237
Health technologists and technicians	13	53	91	116	140
Other healthcare practitioners and technical occupations	0	2	4	5	6
Nursing, psychiatric, and home health aides	8	43	86	123	155
Occupational therapy and physical therapist assistants and aides	1	3	5	7	9
Other healthcare support occupations	9	30	46	55	66
Supervisors of protective service workers	1	3	5	6	6
Fire fighting and prevention workers	1	4	6	6	7
Law enforcement workers	5	15	22	24	25
Other protective service workers	10	33	51	62	73
Supervisors of food preparation and serving workers	12	46	71	79	82
Cooks and food preparation workers	37	142	220	246	256
Food and beverage serving workers	89	350	544	609	636
Other food preparation and serving related workers	18	68	103	114	117
Supervisors of building and grounds cleaning and maintenance workers	2	7	10	12	13
Building cleaning and pest control workers	58	180	248	257	264
Grounds maintenance workers	11	33	49	57	66
Supervisors of personal care and service workers	2	7	10	11	12
Animal care and service workers	5	16	23	25	27
Entertainment attendants and related workers	5	19	31	37	42
Funeral service workers	4	13	16	16	15
Personal appearance workers	28	90	118	116	116
Baggage porters, bellhops, and concierges; Tour and travel guides	1	4	6	7	8
Other personal care and service workers	41	139	204	226	243
Supervisors of sales workers	15	55	80	88	92
Retail sales workers	96	357	522	566	587
Sales representatives, services	15	46	63	68	73
Sales representatives, wholesale and manufacturing	13	50	76	87	97
Other sales and related workers	20	73	112	127	138
Supervisors of office and administrative support workers	10	36	55	63	71
Communications equipment operators	1	3	4	4	3
Financial clerks	26	91	137	157	174
Information and record clerks	41	134	195	222	248
Material recording, scheduling, dispatching, and distributing workers	23	78	112	122	129
Secretaries and administrative assistants	32	117	182	210	231
Other office and administrative support workers	32	115	177	203	223
Supervisors of farming, fishing, and forestry workers	0	0	0	0	0
Agricultural workers	1	1	1	2	3
Fishing and hunting workers	0	-1	-1	-1	-1
Forest, conservation, and logging workers	0	-2	-3	-2	-2

Supervisors of construction and extraction workers	4	30	57	65	70
Construction trades workers	36	248	462	531	567
Helpers, construction trades	3	20	38	45	49
Other construction and related workers	2	10	16	19	20
Extraction workers	0	2	4	6	7
Supervisors of installation, maintenance, and repair workers	4	16	26	30	32
Electrical and electronic equipment mechanics, installers, and repairers	4	15	23	26	29
Vehicle and mobile equipment mechanics, installers, and repairers	13	49	73	83	91
Other installation, maintenance, and repair occupations	35	140	225	256	276
Supervisors of production workers	3	8	11	12	13
Assemblers and fabricators	7	19	25	28	32
Food processing workers	3	12	18	21	22
Metal workers and plastic workers	6	18	26	30	34
Printing workers	1	3	5	5	5
Textile, apparel, and furnishings workers	12	34	41	40	39
Woodworkers	1	4	5	5	5
Plant and system operators	0	0	1	2	3
Other production occupations	10	29	40	46	52
Supervisors of transportation and material moving workers	2	8	12	14	16
Air transportation workers	0	-3	-5	-5	-3
Motor vehicle operators	21	76	118	138	154
Rail transportation workers	0	0	0	0	1
Water transportation workers	0	1	3	5	7
Other transportation workers	6	19	25	25	25
Material moving workers	25	87	129	149	167
TOTAL OF ALL OCCUPATIONS =	**1,094**	**4,083**	**6,323**	**7,226**	**7,876**

Much of the discussion for King County alone remains the same as for Washington considering the major impacts by industry and the occupations. *All results above are for the higher case of a $50/ton tax, as all previous reports formatted the same*. King County, on the other hand, does not have much output in the **petroleum and coal** industry from the remainder of the state. Additionally, in King County, this tax reform has a significant impact on **construction** and **real estate**.[40] These industries respond to the change in the local property tax much as the service and manufacturing industries replied to the change in the state B&O tax in other simulations. A lower price for real estate and commercial space induces population movement into King County, a higher rate of rental transactions, and investments in the area's capital stock as demand increases. **Construction** and **real estate** stand to gain from this, being within a position "in the middle" of these industries. Both are "local" industries by nature and labor-intensive, which yields an increases in employment in these industries.

The sales tax explains many of the other changes observed in King County. Another large set of impacts takes place in the **retail** and **food service** sectors, which enjoy a boost in real purchasing power out of households no longer paying quite as high of a rate for consumer goods. Secondary industries in this same basket include **accommodation**, **amusements and gaming**,[41] and even **healthcare**. The additional real income of households goes somewhere, and these industries are the most likely to receive much of the extra "last dollars" in the economy. The effect of increased competitiveness and market shares are present as well in industries such as **insurance**, **professional services**, **administration and support**, **education**, **investment securities**, and **publishing**. There are broad implications for occupations in King County from the carbon tax—and almost all of them positive. Only **forest, conservation, and logging workers** and **air transportation workers** have negative numbers associated with them, and those are near zero for all years. This means workers in King County will have a chance to shift their skills between industries in the face of these economic changes, finding different industries with need of approximately the same skills as the economy continues to evolve.

[40] NAICS 531, an industry usually concerned with the buying, renting, and leasing of real estate, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=531&search=2012%20NAICS%20Search>
[41] NAICS 713, another broad industry including destinations for disposable income such as amusement parks, arcades, gambling, boating marinas, and various other activities, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=713&search=2012%20NAICS%20Search>

PERSONAL CONSUMPTION EXPENDITURE (PCE)-PRICE INDEX

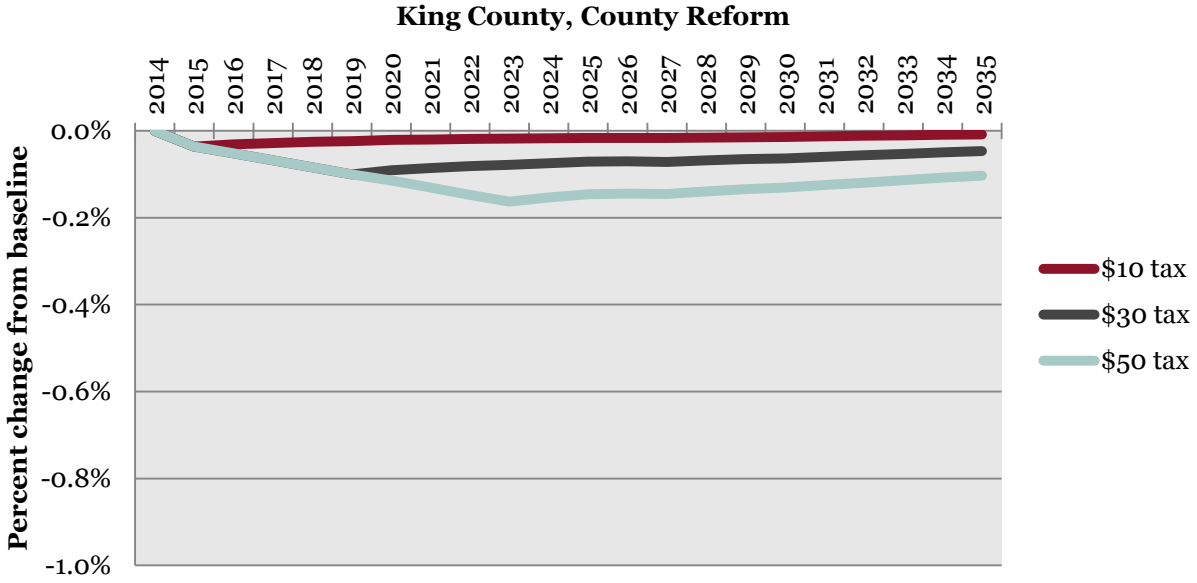


Figure 3.8 – King Country actually has a downward impact to its PCE in the simulations. That is, when accounting for the net difference between lower sales taxes, lower property taxes, and higher energy costs, the cost of living in the area actually drops slightly. All cases are less than 0.5%, but there is a slight, "one-time" adjustment in costs before the drift back towards the baseline in the later years. This will contribute to growth in real income and make King County a more attractive place to live, drive real estate investment, and tie back into the strong impact on construction and real estate seen in the previous distributional data. This cost concept is a large positive from this tax development.

PCE-Price Index by Income Quintile

Quintile	2015	2020	2025	2030	2035
Lowest 20%	-0.04%	-0.12%	-0.15%	-0.13%	-0.11%
Low-Middle 20%	-0.04%	-0.12%	-0.15%	-0.13%	-0.11%
Middle 20%	-0.04%	-0.12%	-0.15%	-0.13%	-0.10%
High-Middle 20%	-0.04%	-0.11%	-0.14%	-0.13%	-0.10%
Highest 20%	-0.04%	-0.11%	-0.14%	-0.13%	-0.10%

Figure 3.9 – As before, the price impact across different income quintiles (in the $50/ton scenario) are approximately the same. This gives the impact of this case a neutral profile in terms of income. At the very least, nobody feels harm, especially given even the lowest 20% still see a fall in the prices that they experience. The gist of the results remains positive, which continues here. This contributes to strong growth in real income in King County under its "individual" tax reform considering how the sales tax cut and property tax cut—which covers most of household spending—more than makes up for the difference in energy prices. The same ideas about low-income households spending more of their income on necessities like fuels applies here, though the share of energy consumption by income continues to stay rather constant across quintiles due to differences in house size, use of electronics by income level, and increases in travel budgets. Distributional impacts are still modest for King County, and the pattern on income paid to quintiles is similar with the growth in below-median wage industries above.

CHANGES IN ENERGY PRICES FROM BASELINE

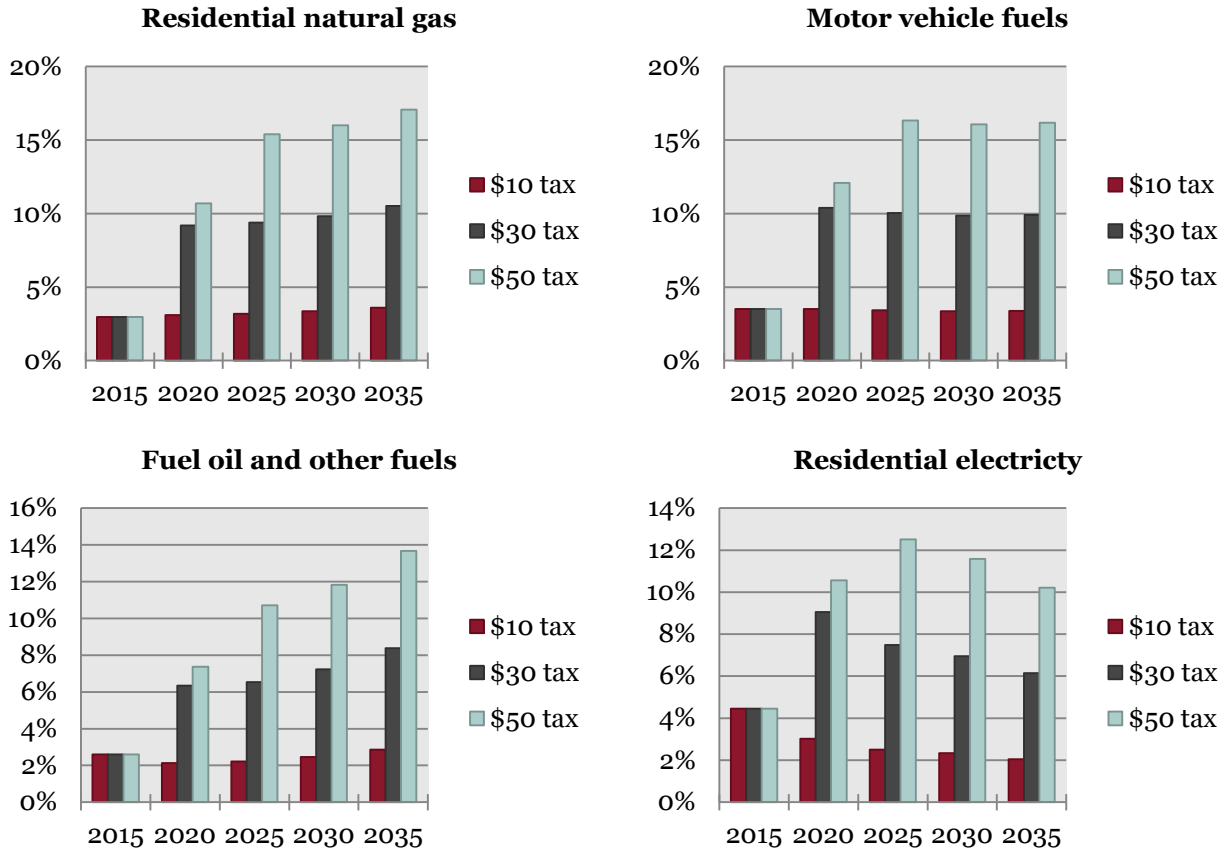


Figure 3.10 – Much of the impact in King County alone is similar to that of the whole state. There is one exception in a greater impact to motor vehicle fuel costs because of King County's high usage of motor gasoline for commuting, its wealthier population, and its relatively inefficient road network from geographical constraints and monster traffic.[42] King County would experience an increase in fuel prices. Yet, this generates much of the benefits of the policy by reducing energy consumption, carbon emission, and generating revenue for recycling into other budget categories. Gasoline prices have routinely swung between $3/gallon and $4/gallon in the United States in the past five years, and the highest numbers would represent an increase of about $0.45/gallon for the $50/tax scenario.

[42] Seattle ranks seventh-worst according to one survey, just ahead of infamous I-495 traffic snarls surrounding Washington, DC and behind the congestion in the Bay Area of California, please see, Alexander E.M. Hess and Samuel Wigley, "Ten cities with worst traffic," *USA Today*, May 4, 2013, <http://www.usatoday.com/story/money/cars/2013/05/04/worst-traffic-cities/2127661/>

ADDITIONAL REAL DISPOSABLE PERSONAL INCOME

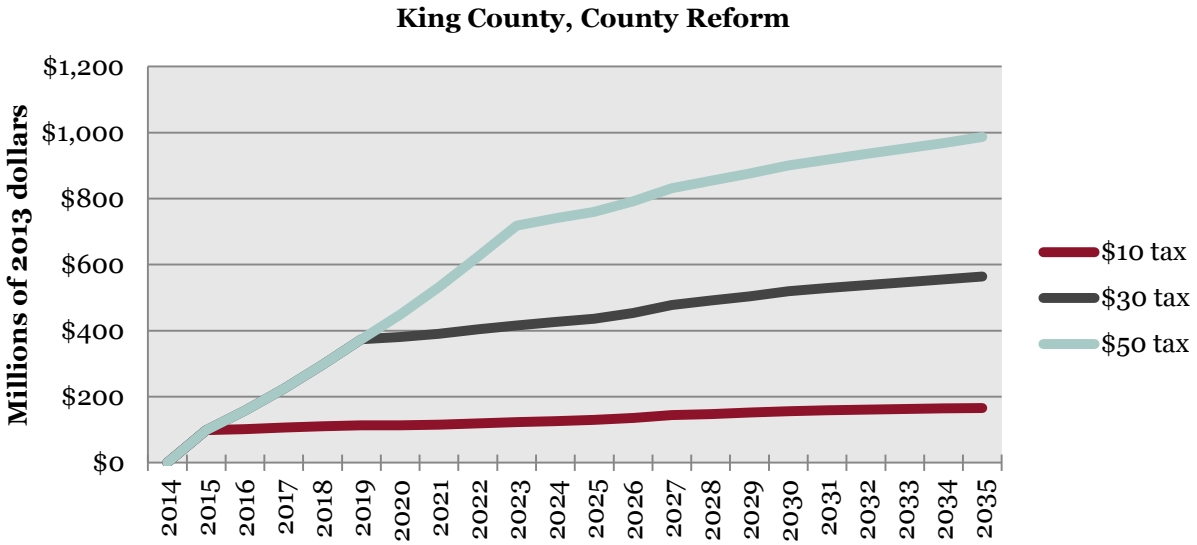


Figure 3.11 – This result differs from the statewide reform. This time, King County does much better than it does when the rest of the state undertakes a like carbon pricing system. The rest of the state economy does improve when King County acts alone (but not as much). The lower cost of living in the area and higher job opportunity draws a greater number of people and economic activity to the region. In the statewide scenario, the shares of GDP and income stay relatively the same between King County and the rest of the state—in these simulations, King County gains relative to the rest of Washington. The lower cost of living in the area also pushes these numbers higher from the lower PCE.

INCOME BY QUINTILE

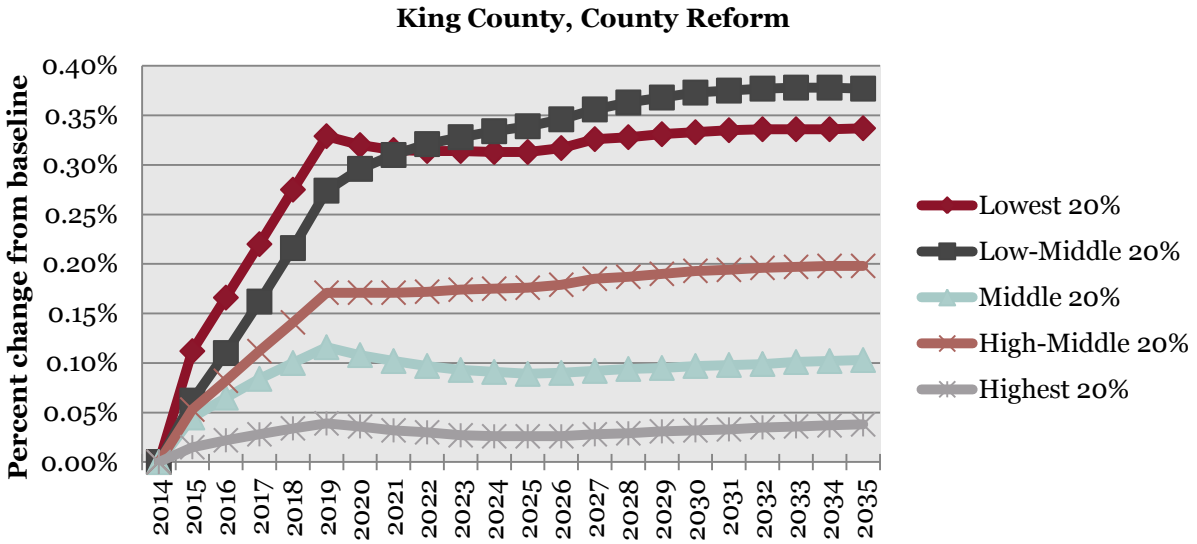


Figure 3.12 – There is not a strong distributional pattern for King County in implementing a carbon tax when combined with the other tax relief measures. The lowest two quintiles see the most gain, mostly owing to the creation of below-median wage jobs in the service and hospitality sectors, and for their reliance on large parts of their income going towards taxable commodity groups (such as food and clothing) and housing or rent. This should alleviate some concerns about the distributional worries about a carbon tax when applied on something like the King County-level.

ADDITIONAL POPULATION

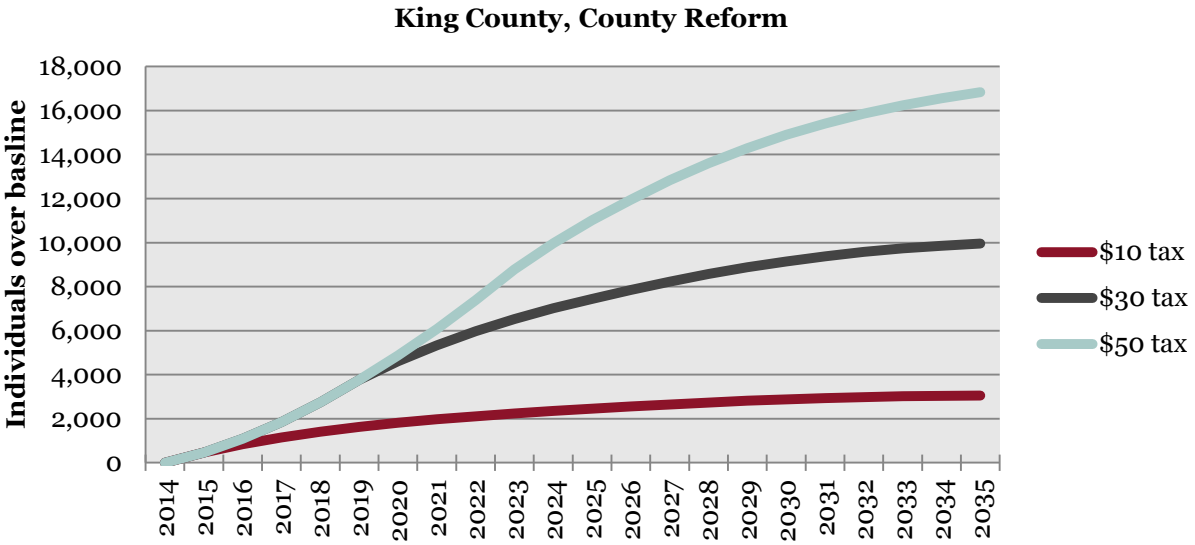


Figure 3.13 – King County adds population in the event of a carbon tax due to the increased job opportunity in the area and a reduced cost of living. Many of these are people moving in from the rest of the state, though some are "new" from the rest of the United States. This growth adds to the economy through investment in housing and square footage and new services, as seen in the simulations.

Carbon Tax Revenues (Annual)

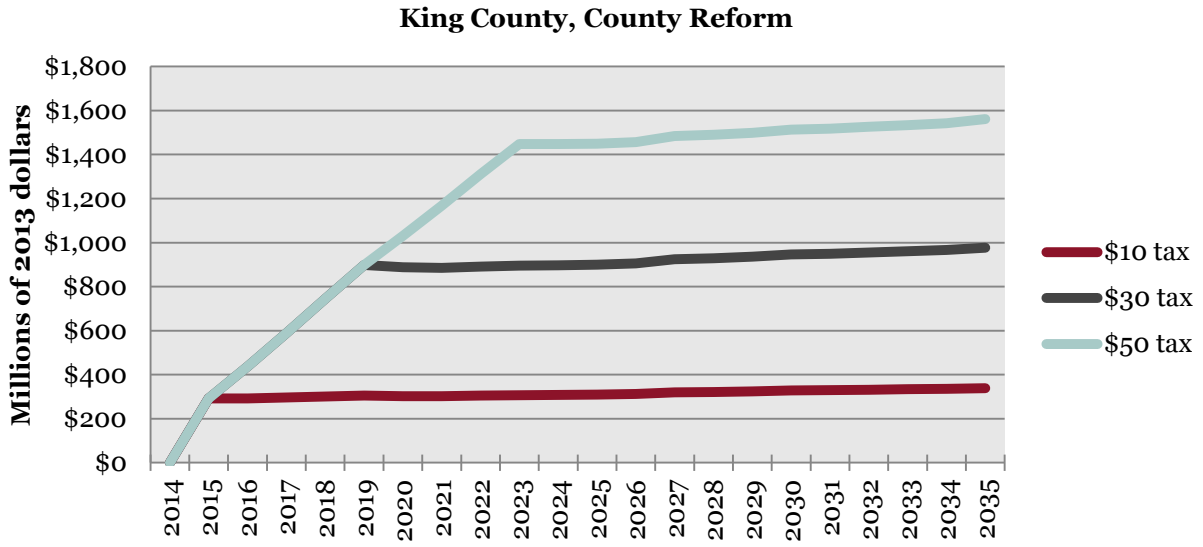


Figure 3.14 – This shows the revenue from a King County carbon tax from CTAM. Economic activity and fuel consumption in this area is about half of the state's total; hence, the expected revenues in the way CTAM models and shares dollars is similar. This is, again, well over 1% of the area's economy in the $50/ton case, which would have much to do with how the local government allocates resources and influence economic growth with its budget. Other trends are similar to those from before: the early phasing-in of the carbon tax brings in more revenues, people respond, but the NEMS long-term forecast of increased energy consumption in Washington keeps total revenues flat out towards 2035.

Carbon Tax Revenue (Cumulative)

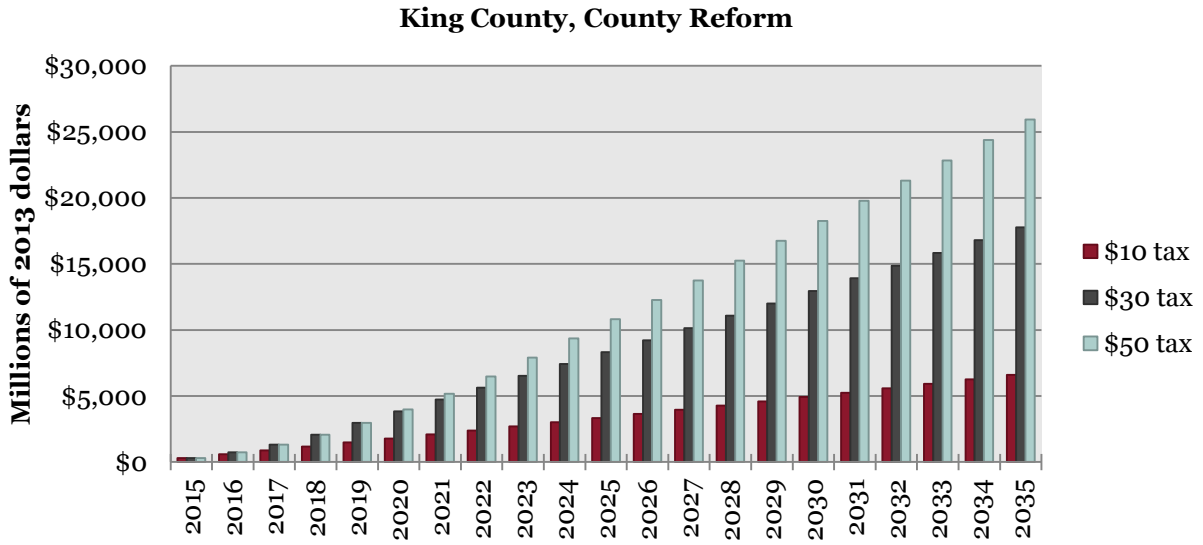


Figure 3.15 – This totals the above over time. Cumulative revenues to 2035 from this carbon pricing could total upwards of $25 billion for King County. This is, again, approximately half of the $50 billion modeled from the statewide tax, but this is a very significant amount of money, particularly if it remains in the King County region and goes towards improving its economy specifically. This positive displacement of imports and revenues can have a powerful result, as seen in the simulations.

CARBON DIOXIDE EMISSIONS (ANNUAL FORECAST)

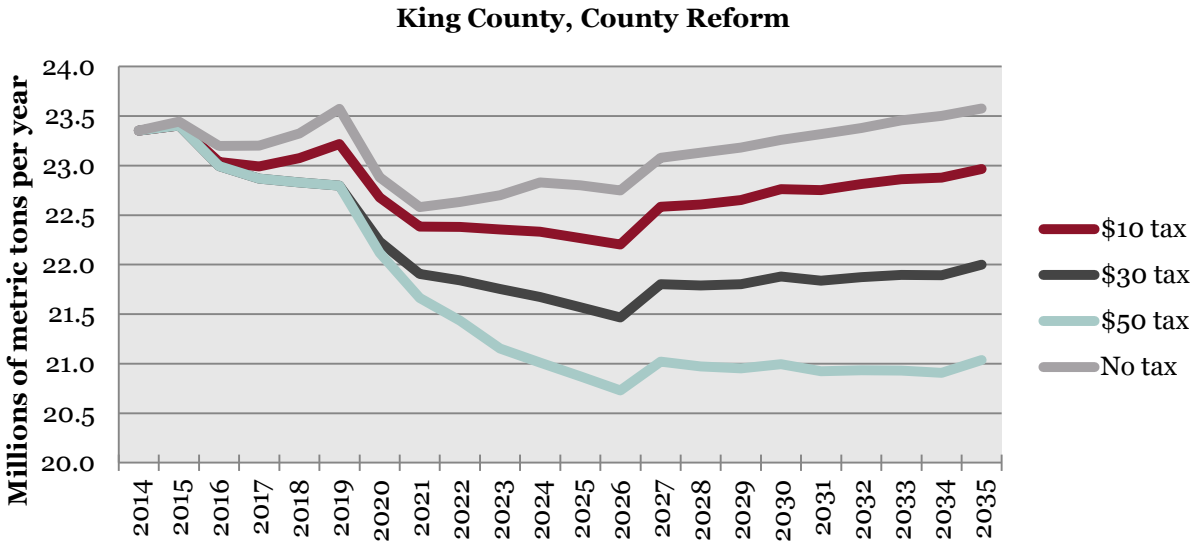


*Figure 3.16 – This is the adjusted forecast from CTAM for carbon emission from King County with various levels of carbon pricing. CTAM is technically a state-level model, so the above represents a share of emissions for King County based on the equivalents in PI+ (to provide an example, PI+ has separate forecasts for motor gasoline purchases in King County and the rest of state, which then share gasoline-sourced carbon emissions in these results). These are estimates, and the lack of an EPA data table for counties makes them more difficult to verify.[43] They are likely to be high—**CTAM and PI+ require carbon taxes paid by location, which is different from location of generation (mostly from power plants).** CTAM better captures the impacts of demand shifts from price.*

CARBON DIOXIDE EMISSIONS REDUCTIONS (ANNUAL DIFFERENCE)

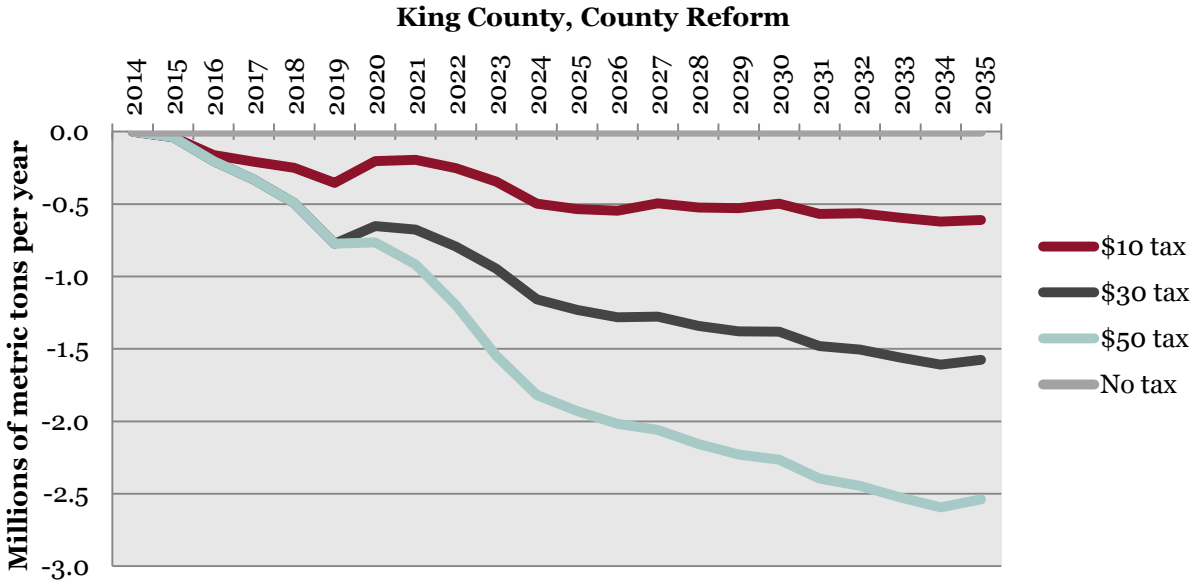


Figure 3.17 – These amounts are, again, equivalent to the annual emissions of the District of Columbia.

[43] The closest analog was the Vulcan Project at Purdue University, last updated in 2008 however, and now seemingly defunct, <http://www.purdue.edu/eas/carbon/vulcan/index.php>

CARBON DIOXIDE EMISSIONS (CUMULATIVE DIFFERENCE)

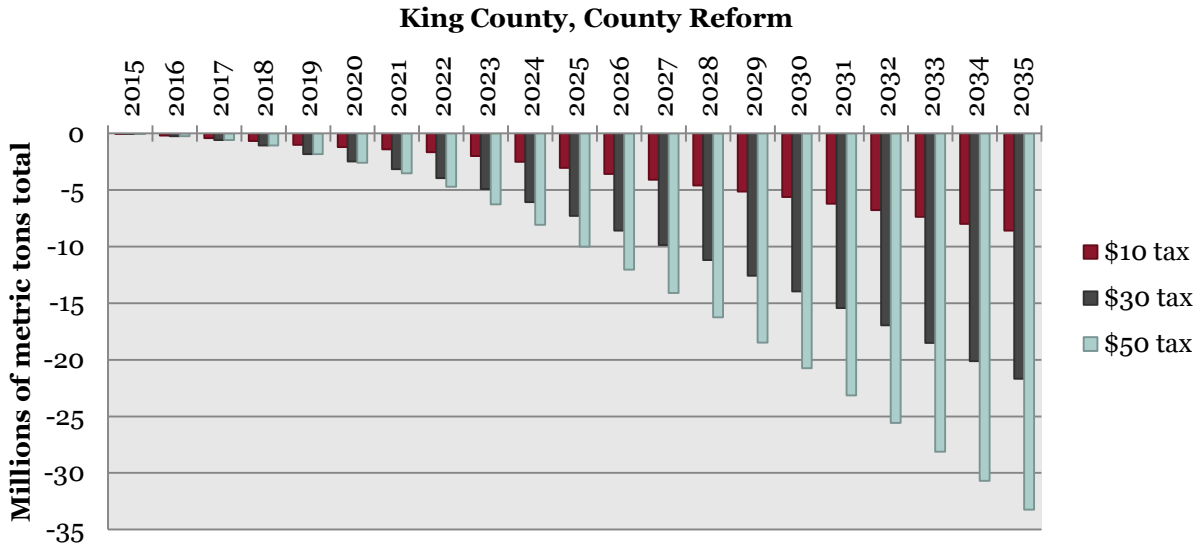


Figure 3.18 – This is the sum of reduced emissions by King County over time. A total of 33 million metric tons is approximately the current annual output of Alaska, Connecticut, Montana, or Nevada.[44] These are small reductions in percentage terms, though they do pile-up over time. Without reliable data for King County on either present emissions, 2011 emissions (the most recent history year), or historical data to 1990, making a comparison to the 1990 benchmark is an uncertain proposition.

[44] EPA

LITERATURE

The conclusions of this study are broadly consistent with the findings of other studies on the potential impact of state-level carbon pricing systems in American states or Canadian provinces. The most relevant examples include a study in Oregon by the Northwest Economic Research Center (NERC) at Portland State University,[45] a study on the performance of the British Columbia carbon tax by the University of Ottawa,[46] and a previous REMI study on a similar carbon tax effort in the state of Massachusetts.[47] State and provincial policies are leading many efforts at environmental tax reform after the stalling of Waxman-Markey and the federal cap-and-trade bill in Washington, DC in 2009.[48] The tax in British Columbia is unique for North America in being currently active, and its impacts may mirror the results of the economic and carbon modeling above.

Several major findings emerged in the study out of the University of Ottawa.[49] British Columbian carbon emissions on a per capita basis fell at a much faster rate from 2008 to 2011 than the rest of Canada. Total rest of Canada emissions were down 1.1% over that period, but British Columbia saw a total fall of 10.0%. The British Columbian tax focused strongly on revenue-neutrality and its recycling. The tax began a $10/ton (CAD) in 2008, and gradually escalated at $5/year to a maximum $30/ton in 2012. Policymakers in Victoria used this revenue to provide tax relief through credits, personal income tax cuts, reductions in the tax burdens on small businesses, and some remittance to low-income households to protect them from the direct effect of higher energy prices. British Columbia's economy, while struggling in the wake of the major recession, did not "crash" relative to the rest of Canada: per capita GDP numbers slipped by -0.15% from 2008 to 2013 while the rest of Canada fell back -0.23%. This experience is an example of cutting carbon dioxide emissions while having minimal economic impacts.

NERC and REMI found similar results to those in Washington. The NERC study used a different model, and both studies examined a similar state to Washington. NERC used CTAM, calibrated for Oregon, and ran the inputs through IMPLAN—an input/output model that produces multipliers from the different types of economic activity in a region. Depending on the reinvestment of the funds, an Oregon carbon tax adds a net of 1,200 to 8,000 jobs to the economy. IMPLAN differs from PI+ in relying only on demand variables, which forces the assumption that a $1 increase in energy costs will mean a $1 decrease in output, which is a more complicated situation requiring cost variables and notions of competitiveness. Using PI+ and relying on energy costs, the Massachusetts study found a generally positive impact from a carbon tax on the Bay State economy. Results included an average of between 2,000 and 9,000 additional annual jobs depending on the maximum tax. Washington and Massachusetts behaved in a comparable manner in these two studies because the displacement of energy imports and tax relief on the local level improved economies. This makes sense, too, given their similarities: they both have large metropolitan areas (Seattle and Boston) producing half of GDP and both rely on technology as their Hercules, have small amounts of resource extraction, and very little in terms of oil and gas.

---

[45] Jenny H. Liu and Jeff Renfro, "Carbon Tax and Shift: How to Make it Work for Oregon's Economy," *NERC*, March 1, 2013, <http://www.pdx.edu/nerc/sites/www.pdx.edu.nerc/files/carbontax2013.pdf>

[46] Stewart Elgie and Jennifer Wesanki, "BC's Carbon Tax Shift After Five Years: An Environmental (and Economic) Success Story," *University of Ottawa*, July 24, 2013, <http://www.sustainableprosperity.ca/article3685>

[47] Scott Nystrom and Ali Zaidi, "Modeling the Economic, Demographic, and Climate Impacts of a Carbon Tax in Massachusetts," *REMI*, July 11, 2013, <http://www.committeeforagreeneconomy.com/>

[48] "H.R. 2454 – American Clean Energy and Security Act of 2009," *Open Congress*, June 26, 2009, <http://www.opencongress.org/bill/111-h2454/show>

[49] Thanks to David Roberts for compiling them, please see, David Roberts, "The positive economic impact of a carbon tax," *Grist*, <http://grist.org/climate-energy/the-positive-economic-impact-of-a-carbon-tax-in-uh-hang-on-10-charts/>

REGIONAL ECONOMIC MODELS, INC. (REMI)

REMI is a modeling firm specializing in services related to economic impacts and policy analysis. Its headquarters is in Amherst, Massachusetts, though this report originated in its office in Washington, DC. REMI was first an applied project at the University of Massachusetts-Amherst by a research professor, Dr. George Treyz, on the economic impact of expanding Interstate 90 from Boston, to Worcester, Springfield, and eventually Albany and Buffalo, New York. Dr. Treyz generalized the methodology and incorporated the present entity in 1980. REMI operates to provide software, support services, and issue-based expertise and consulting in almost every state, the District of Columbia, and other countries in North America, Europe, Latin America, the Middle East, and Asia. The typical REMI users or consulting client works for a federal agency, planning organization, regional/metropolitan authority, state government (such as a DOR or DOT), consulting firm, university, or a non-profit research group. Current REMI clients in Washington include the state Office of Financial Management (OFM)[50] and non-profit Washington Research Council (WRC).[51] There are peer users throughout the rest of the country, but one of note in the Pacific Northwest is the Legislative Revenue Office (LFO) in the state of Oregon.[52]

PI+

REMI used a 2-region, 70-sector version of its PI+ modeling software configured to gently shatter and divide King County from Washington in the build software. PI+ is a computerized, multiregional, dynamic model of the states or other sub-national units of the United States economy underneath a Windows-

[50] <http://www.ofm.wa.gov/>
[51] <http://researchcouncil.org/>
[52] For a complete list, please see, "Clients," *REMI*, <http://www.remi.com/clients>

based graphic user interface (GUI). PI+ relies on four quantitative methodologies to guide its approach to economic modeling. This allows their strengths to come through and their interactions to supplement any weaknesses they may have without the other portions:

1. **Input/output tabulation (IO)** – IO models, sometimes called "social accounting matrices" (SAM), quantifies the interrelation of industries and households in a computational sense. It models the flow of goods between firms in supply-chains, wages paid to households, and final consumption by households, government, and the international market. These channels create the "multiplier" effect of $1 going further than when accounting for its echoing. The make-and-use table needed to make an input-output matrix comes from the Bureau of Labor Statistics (BLS),[53] and the work behind it won New York University and Harvard University professor Wassily Leontief the Nobel Prize in economic science in 1973.[54]
2. **Computable general equilibrium (CGE)** – This is a broad classification of models, and PI+ employs this modeling system. CGE modeling adds market concepts to the IO structure. This includes how those structures evolve over time and how they respond to alternative policies. CGE involves concepts on markets for labor, housing, consumer goods, imports, and the importance of competitiveness to fostering economic growth over time. Changing one of these will influence the others—for instance a new knife factory in Washington would improve the labor market, and then bring it to a head by increasing migration into the area, drive housing and rent prices higher, and induce the market to create a new subdivision to return to "market clearing" conditions. This accounting for long-term effects makes PI+ unique amongst regional models.
3. **Econometrics** – REMI uses statistical parameters and historical data to populate the numbers inside the IO and CGE portions. The estimation of the different parameters, elasticity terms, and figures gives the strength of various responses. It also gives the "time-lags" from the beginning of a policy to the point where markets have had a chance to clear. This contrasts with many of the "pure" CGE models, which only have a "before" and "after" component.
4. **New Economic Geography** – Economic geography provides REMI a sense of economies of scale and agglomeration. In literal terms, this is the quantification of the strength of clusters in an area and their influence on productivity. One example would include the technology and research industries in Seattle. The labor in the area specializes to serve firms like Amazon and Microsoft, and, thus, their long-term productivity grows more quickly than that of smaller regions with no proclivity towards software development (such as Helena, Montana). The same is true on the manufacturing side with physical inputs, such as with the supply-chain for Boeing and Paccar in Washington in the production of transportation equipment. Final assembly will have a close relationship and a high degree of proximity to its suppliers of parts, repairs, transportation, and other professional services, which show up in clusters in the state.

The methodologies and equations behind PI+ are publically available and peer-reviewed. The initial set of publications by Dr. Treyz and his research staff appeared in *Journal of Regional Science*, the *American Economic Review*, and *Review of Economics and Statistics*.[55] REMI relies on data from public sources. These include the Bureau of Economic Analysis (BEA), BLS, EIA, and the Census Bureau.[56] Forecasts for

[53] "Inter-industry relationships (Input/output matrix)," *Bureau of Labor Statistics*, <http://www.bls.gov/emp/ep_data_input_output_matrix.htm>
[54] "Wassily Leontief," *Library of Economics and Liberty*, <http://www.econlib.org/library/Enc/bios/Leontief.html>
[55] For a full listing of journal citations, please see p. 47, "Model Equations," *REMI*, <www.remi.com/download/documentation/pi+/pi+_version_1.5/PI+_v1.5_Model_Equations.pdf>
[56] "Data Sources and Estimations Procedures," *REMI*, <http://www.remi.com/download/documentation/pi+/pi+_version_1.5/Data_Sources_and_Estimation_Procedures.pdf>

future macroeconomic conditions in REMI come from a combination of resources, including the Research Seminar in Quantitative Economics (RSQE),[57] the University of Michigan, and the BLS. This serves as the main framework for the software model needed to perform simulations.

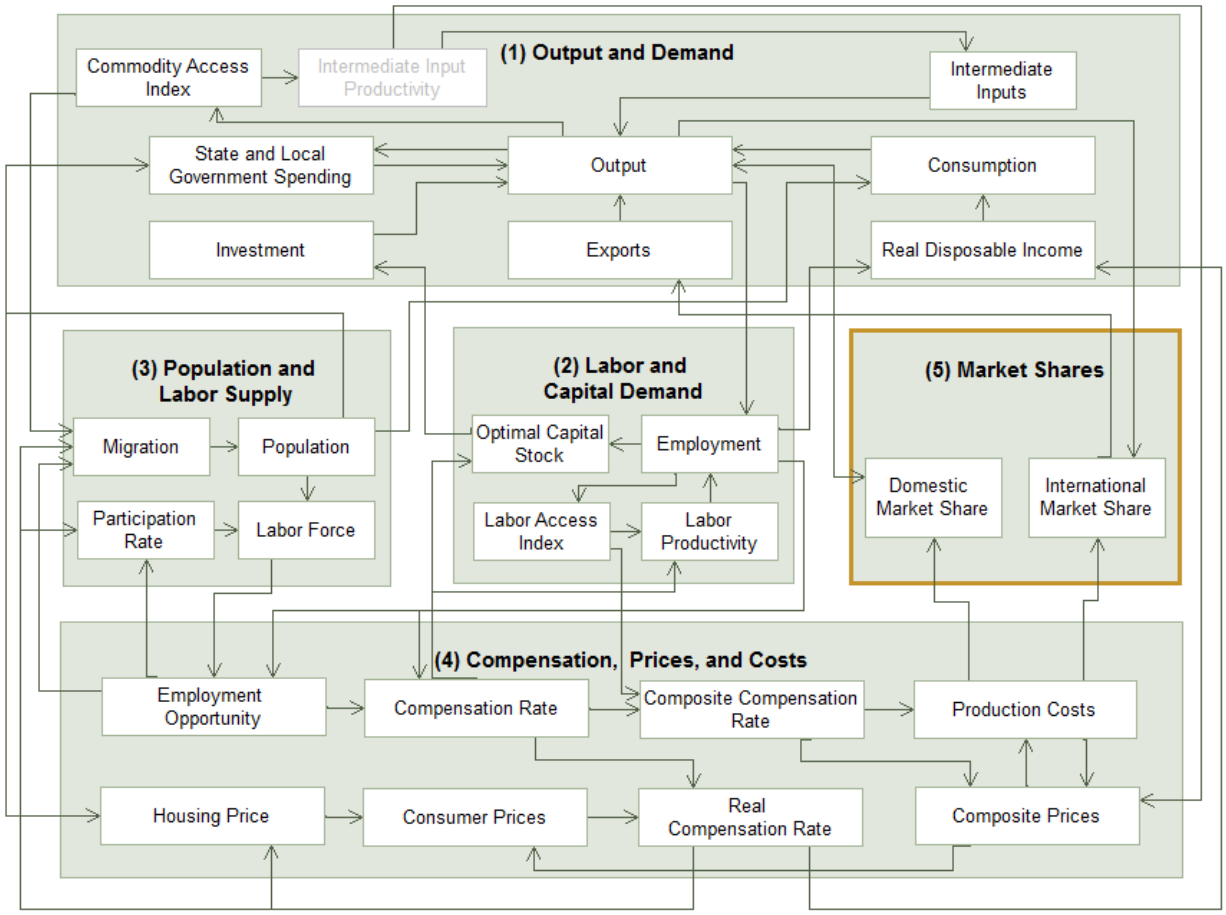


Figure 4.1 – This diagram represents the structure and linkages of the regional economy in PI+. Each rectangle is a discreet, quantifiable concept or rate, and each arrow represents an equation linking the two of them. Some are complex econometric relationships, such as the one for migrant, while some are rather simple, such as the one for labor force, which is just the population times the participation rate. The change of one relationship causes a change throughout the rest of the structure because different parts move and react to incentives at different points. At the top, Block 1 represents the macroeconomic whole of a region with final demand and final production concepts behind GDP, such as consumption, investments, net exports, and government spending. Block 2 forms the "business perspective:" an amount of sales orders arrive from Block 1, and firms maximize profits by minimizing costs when making optimal decisions about hiring (labor) and investment (capital). Block 3 is a full demographic model. It has births and deaths, migration within the United States to labor market conditions, and international immigration. It interacts with Block 1 through consumer and government spending levels and Block 4 through labor supply. Block 4 is the CGE portion of the model, where markets for housing, consumer goods, labor, and business inputs interact. Block 5 is a quantification of competitiveness. It is literally regional purchase coefficients (RPCs) in modeling and proportional terms, which show the ability of a region to keep imports away while exporting its goods to other places and nations.

[57] <http://rsqe.econ.lsa.umich.edu/>

For the environmental tax reform work here, four of the above rectangles (and corresponding variables underneath them) formed the basis for the policy simulation. They included:

- **Consumer prices** – For higher consumer costs and prices for fuel oil, gasoline, diesel, natural gas, electricity, but offsets for lower prices in commodities eligible for the sales tax
- **Housing prices** – This was the variable for offsetting the reduction of property tax rates in King County in response to revenue recycling from the carbon tax
- **Production costs** – This variable adjusted the competitiveness of industry based on variables for the cost of natural gas, petroleum-products, electricity, the cost of capital (in the case of the property taxes), and the overhead costs associated with the B&O tax
- **Real disposable income** – The 10% rebate to low-income households fell into this category to directly increase their income and spending

The REMI model has two main purposes: forecasting and the analysis of alternatives. All models have a "baseline" forecast of the future of a regional economy at the county-level. Using the model involves the supplying of "exogenous" shocks, which implicates a response in local economic performance and the area's demographics. These shocks, "policy variables" in REMI terminology, represent the direct effect of a carbon tax in King County and Washington. The structure handles the translation of the static effects from CTAM into the full economic, demographic, wage, price, and distributional impacts seen in this report. This makes PI+ a powerful tool for conveying the economic "story" behind policy. PI+ translates these considerations into understandable concepts for everyone like GDP and jobs.

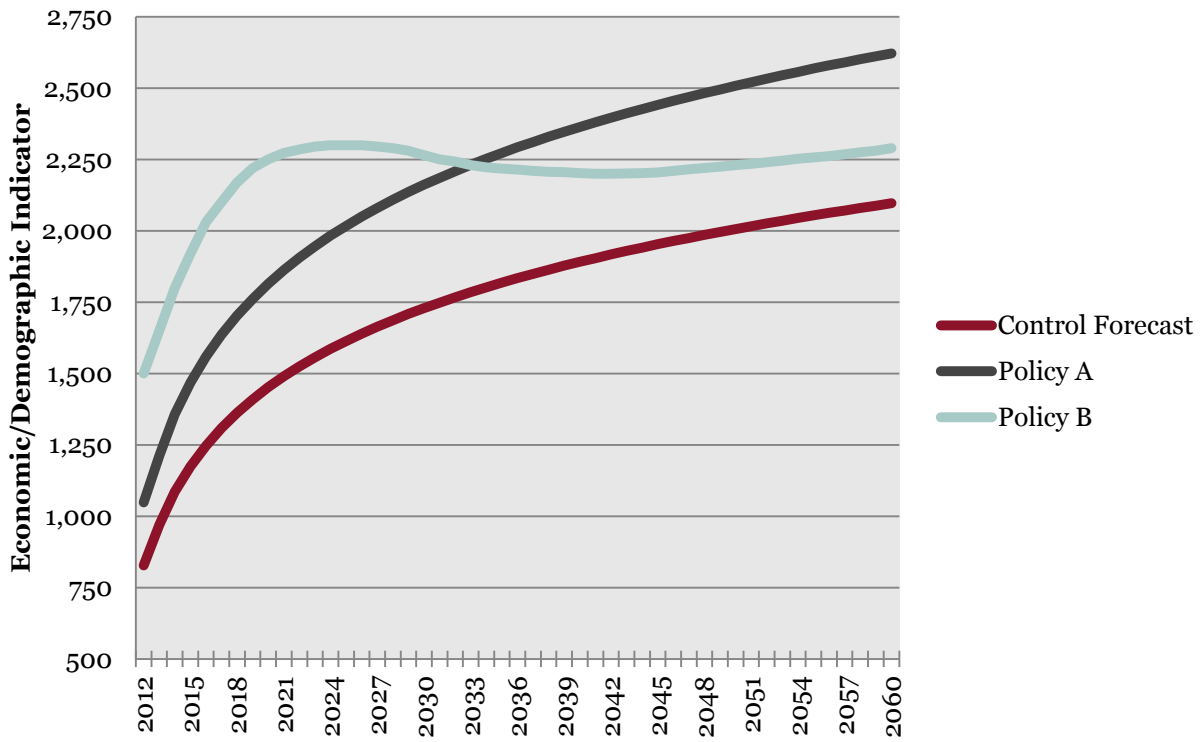


Figure 4.2 – This shows the basic process of simulation in PI+. The control forecast, the red line above, is a "do-nothing" scenario, a null hypothesis of making no changes. The other lines represent a new forecast after introducing some exogenous considerations with the policy variables in the structure. The main point of the model is to compare the difference—the delta—between the lines to see the "impact." Policy A has stronger long-term performance, though Policy B is better in the immediate, though both of them are certainly a superior option to doing nothing by the generic metric to the left.

CARBON TAX ANALYSIS MODEL (CTAM)

This study used CTAM, which first appeared for the state of Washington a few years previously. The results here include an updated CTAM for the most recent *Annual Energy Outlook* from the EIA.[58] There are fuller descriptions of CTAM available elsewhere, including a detailed one on pp. 22-23 of the NERC study for Oregon. CTAM is open-source, Microsoft Excel-based and available online.[59] CTAM takes the projections of anticipated consumption in different energy sorts (such as gasoline, distillates, natural gas, or electricity) from the EIA. The EIA and NEMS Extended Outlook forecast is at the U.S. Census regions level,[60] and a combination of historical data and fixed shares leads to a state-level totals for consumption and emissions. The assumptions behind NEMS are the baseline for CTAM. From there, the user enters levels of carbon taxes—the starting level, the annual increase, and the maximum rate implemented. CTAM includes parameters for the price response by major fuel types. That is, it includes an elasticity of how strongly consumers cut back on energy usage in the face of higher prices. Neither NERC nor REMI updated the default elasticity for fuel types in CTAM, which came from an analysis of their estimations by Keibun Mori. Using the default parameters from Mori was at the request of ETR-WA.

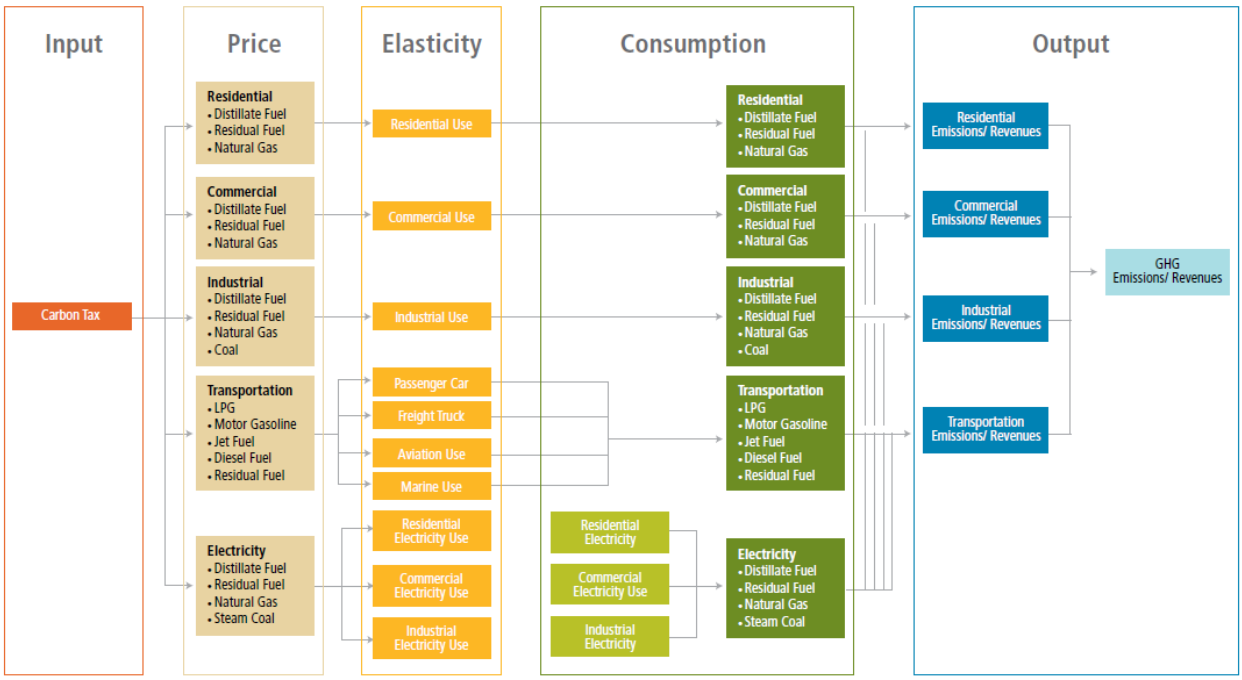


Figure 5.1[61] – This shows the processes inside of CTAM to develop an impact to carbon tax revenues and carbon dioxide emissions. It starts on the left with the level of tax, and then assigns a price change to a host of fuel categories from their internal carbon content in chemical terms. The elasticity in the middle determines the strength of the demand response, which will reduce total consumption of energy—and therefore carbon dioxide emissions—before leading to the final results of money raised and the emissions reduced. This produced the information needed to simulate these cases in PI+. CTAM and PI+ work well together for both being multiyear and having multiple layers of fuel price changes.

[58] "Annual Energy Outlook 2013," *Energy Information Administration*, <http://www.eia.gov/forecasts/aeo/>
[59] Eric de Place, "Washington Carbon Tax: New Model and Analysis," *Sightline Daily*, August 10, 2011, <http://daily.sightline.org/2011/08/10/washington-carbon-tax-new-model-and-analysis/>
[60] Washington is in the "Pacific" region with Alaska, California, Hawaii, and Oregon
[61] From p. 26 of the Oregon study

INTEGRATING PI+ AND CTAM

The bridge between the two models follows from their dimensions. These dimensions are multiple years, the multiple fuel types by sectors, and how they relate to each other in CTAM and PI+ terminology, data, and variables. CTAM has four major sectors for fuel demand and emissions—residential, commercial, industrial, and transportation. These correspond to sectors and variables in PI+ between households and NAICS industries. CTAM provides more granularity than PI+ in terms of fuel types, so we agglomerated up from CTAM categories to the REMI layers of electricity, natural gas, and petroleum-products. The following shows the exact factor out of CTAM and its process to become an input in REMI. In addition, because CTAM is state-level, there were several factors in REMI to divide between King County and the rest of the state by fuel source, which was different than the Massachusetts study, and this adds an extra column here. These factors came from the REMI baseline projections.

Sector	CTAM	PI+	Regional Shares
Residential	Kerosene, Distillate Fuel Oil	Consumer price (fuel oil and other fuels)	*Consumer spending (fuel oil and other fuels)*
	Natural Gas	Consumer price (natural gas)	*Consumer spending (natural gas)*
	Electricity	Consumer price (electricity)	*Consumer spending (electricity)*
Commercial	Liquefied Petroleum Gases, Motor Gasoline, Kerosene, Distillate Fuel Oil	Residual (commercial sectors) fuel costs	*Output of all commercial sectors*
	Natural Gas	Natural gas (commercial sectors) fuel costs	*Output of all commercial sectors*
	Electricity	Electricity (commercial sectors) fuel costs	*Output of all commercial sectors*
Industrial	Motor Gasoline, Distillate Fuel Oil	Residual (industrial sectors) fuel costs	*Output of all industrial sectors*
	Natural Gas	Natural gas (industrial sectors) fuel costs	*Output of all industrial sectors*
	Electricity	Electricity (industrial sectors) fuel costs	*Output of all industrial sectors*
Transportation	Motor Gasoline	Consumer price (motor vehicle fuels, lubricants, and fuels)	*Consumer spending (motor vehicle fuels, lubricants, and fuels)*
	Distillate Fuel Oil	Consumer prices (fuel oil and other fuels)	*Consumer spending (fuel oil and other fuels)*

Figure 5.2 – This shows the mapping of CTAM data into PI+ variables. The column on the right is the factor in the regional baselines of PI+ used to spread the impact of the carbon tax from emissions between King County and the rest of Washington based on the logical factor to use for correlation.

The spreading of tax and auction revenues between King County and the rest of the state was different. Using data graciously provided by OFM, we determined the share of B&O taxes paid by NAICS industry in each region. These shares became the share each industry received of the B&O tax cuts from revenue recycling. We used OFM data on the amount of sales tax collected by consumption category by region, which we used to adjust consumer price when recycling the revenue in that way. This meant taxable commodities (such as new furniture) saw reductions in prices, while items or services left untaxed by the state (such as a trip to the dentist's office) saw no large changes.


WASHINGTON

Regional Economic Models, Inc. (REMI)

1776 I St. NW Suite 750
Washington, DC 20006
(202) 469-7861

433 West Street
Amherst, MA 01003
(413) 549-1169

Scott Nystrom received his B.A. in history, B.S. in economics (*summa cum laude* with each), and his M.A. in economic history (with distinction) from Iowa State University in Ames, IA. He has worked at REMI since 2011. He is the chief point of contact in its Washington, DC office for software training, technical support, and related economic consulting projects. Mr. Nystrom works and on a daily basis with state governments on taxation and transportation research, local and regional authorities, federal agencies, consultants, universities, non-profits, and research institutions. Other responsibilities include research on integrating energy models into a regional framework, theoretical research on modeling intermodal transportation, and business development. His major projects have included impact analyses on energy, healthcare, labor, transportation, state taxes and budgets, and federal fiscal policy. Highlights include the "fiscal cliff," the TransCanada Keystone XL pipeline, and the Southern California Association of Governments (SCAG) regional transportation plan (RTP) to 2035.

Ali Zaidi is an assistant economist and research assistant with REMI in Washington, DC. He holds a B.A. in economics from the University of Massachusetts-Amherst. He performed the calibration of the CTAM model for Washington, "WACTAM," and assisted Mr. Nystrom in validating the results and developing this report. Mr. Zaidi has also assisted on analyses of a carbon tax in Massachusetts, federal immigration reform, and integrating regional models with agent-based systems to perform studies of national security scenarios, international trade stoppages, and capital flows.

This report does not reflect the institutional views of REMI. It is the result of the professional opinions of the authors and the findings of the models reported within this document.