Environmental Tax Reform in California: Economic and Climate Impact of a Carbon Tax Swap

Prepared By
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Prepared For
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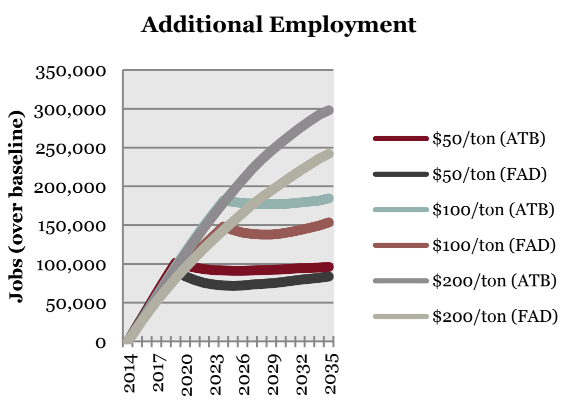
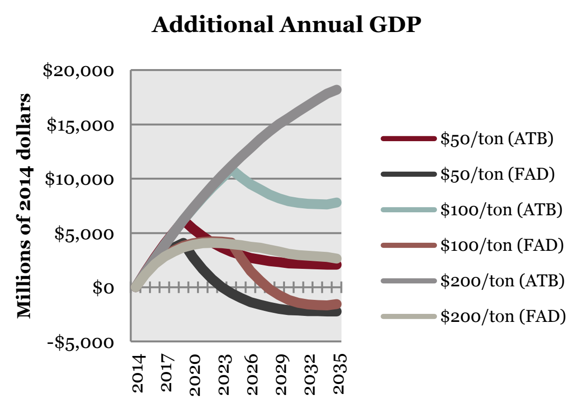
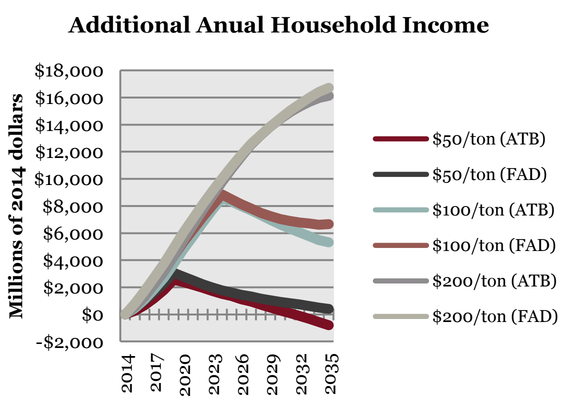
[1] <http://citizensclimatelobby.org/>
[2] <http://etr-us.org/>
[3] <http://www.committeeforagreeneconomy.com/>
[4] <http://www.zza-inc.com/#!/CompanyProfile>
[5] <http://climateactioncoalition.org/>
[6] <http://www.remi.com/>

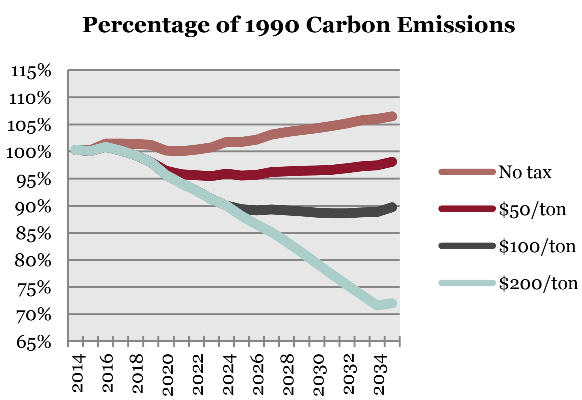
EXECUTIVE SUMMARY

This report examines the economic, demographic, and climate impact of environmental tax reform in California. The primary policy levers behind this investigation are a carbon tax and revenue-neutrality. The carbon tax supposes the state begins to assess retail or wholesale sales taxes on energy (electricity, natural gas, and petroleum products) based on the underlying carbon content of the fuel to discourage their use and help to cut state emissions (in addition to AB32). The levels of pricing included here are $50/metric ton, $100/ton, and $200/ton. The first $4 billion/year in revenue is always for a fund meant to grow renewable investments. From there, there are two ideas here for returning the revenue without increasing spending: an "across-the-board" tax cut to income, sales, and corporation taxes (ATB) or a "fee-and-dividend" paid out to households modeled on the Alaska Permanent Fund (FAD). The results are from REMI PI+, an economic model of the state economy and CTAM, a model that forecasts emissions and revenues based on demand responses without the switching of power generation types. California may be able to prosper while reducing emissions. Higher energy costs have negative effects, but tax relief helps to restore state competitiveness. More household income encourages spending on local businesses. In contrast, reduced energy demands have little impact on jobs and gross domestic product (GDP). This "tax swap" could mean 300,000 more jobs in the state and an extra $18 billion in annual GDP by 2035, $16 billion more in annual income, and a reduction of emissions by 31% from the "no-tax" baseline.









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INTRODUCTION

This white paper examines the series of interactions within the state of California amid its economy, demographics, the demand for energy, carbon dioxide emission, and the state budget in Sacramento. Specifically, it considers the impacts of implementation for several levels of carbon taxes upon the same. A carbon tax (alternatively known as an "emissions fee" or "pollution tax") is a tax charged by some level of government on the households and businesses within their jurisdiction for emitting a certain quantity of carbon into the atmosphere.[7] By chemical default and due to the economics of buying and selling, all carbon dioxide emissions subject to the tax come from the combustion of tradable hydrocarbons—things such as coal (as electricity), natural gas (as electricity or in other forms), and petroleum (through various refined products). In essence, this makes a carbon tax another form of a sales tax when applied at some point upstream or downstream in the energy supply-chain. Consequently, a carbon tax is an appropriate subject for assessment via the standard, traditional tools of **fiscal analysis** such as economic impact modeling. A carbon tax is a fiscal issue as much as an environmental one because the new revenues collected may go towards allocations on other priorities (education, transportation, energy efficiency) or replacing other revenue streams and providing tax relief in a revenue-neutral swap. The potential for a significant quantity of revenues from carbon taxes exists. For instance, in 2011, the United States emitted approximately 5.75 billion metric tons of carbon.[8] At a $50/metric ton tax, this is about $280 billion or 8% of the federal budget.[9] This invites the consideration of a carbon tax as an economic, fiscal, and environmental issue.

Citizens Climate Lobby (CCL), a group of private citizens based in Coronado, California, contracted Regional Economic Models, Inc. (REMI) to examine these issues and their interrelationships through the lens of economic modeling. This study uses two tools: REMI PI+, a proprietary economic and demographic model of sub-national units of the United States' economy (to county geographies) and the Carbon Tax Analysis Model (or CTAM),[10] an open-source, Microsoft Excel-based model of state-level carbon emission and tax revenues derived from the National Energy Modeling System (NEMS) of the U.S. Energy Information Administration (EIA).[11] Integration among PI+ and CTAM and

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[7] For a discussion of other alternative names, please see, Kate Galbraith, "A Carbon Tax by Any Other Name," *New York Times*, July 24, 2013, <http://www.nytimes.com/2013/07/25/business/global/a-carbon-tax-by-any-other-name.html>

[8] "Overview of Greenhouse Gases: Carbon Dioxide Emissions," *U.S. Environmental Protection Agency*, <http://www.epa.gov/climatechange/ghgemissions/gases/co2.html>

[9] "The U.S. Federal Budget," *Congressional Budget Office*, <http://www.cbo.gov/publication/42636>

[10] Keibun Mori, Roel Hammerschlag, and Greg Nothstein, "Carbon Tax Modeling for Washington State," *Western Energy Policy Research Conference*, September 5, 2013, <http://epi.boisestate.edu/media/21329/keibun%20mori,%20nothstein%20and%20hammerschlag%20-%20carbon%20tax%20modeling%20for%20washington%20state.pdf>

[11] "The National Energy Modeling System: An Overview," *U.S. Energy Information Administration*, <http://www.eia.gov/oiaf/aeo/overview/>

calibration of their baselines to the NEMS outlook then creates a regular framework for assessing impacts to the economy and carbon emissions inside of states. The results include the impact to jobs, gross domestic product (GDP), and incomes as well as to the quantity of anticipated emissions in the future (the total amount or by some benchmark, such as 1990 levels). REMI does not advocate specific courses of action or policies; the intention of this study is to inform California on climate policy through modeling the direct and implied upshot of a carbon tax. **We do not comment for or against the dangers posed from concentration of carbon dioxide in the atmosphere in terms of climate variability.** Additionally, there are further dimensions this study "leaves on the table," such as the contrasting impacts in regions within California (the Bay Area, Central Valley, High Sierras, Inland Empire, Los Angeles Basin, San Diego, etc.). Another factor would include the respiratory health, quality of life, and the overall wellness benefits of reduced emissions of pollutants like mono-nitrogen oxides (NOX), sulfur dioxide (SOX), and particulate matters (PM); these emissions can correlate with carbon dioxide.[12] These are all interesting points from a policy vista, though they are "in addition" to economic and fiscal impacts seen from economic modeling in PI$^+$ and CTAM for the state of California and potential policies.[13]

[12] Mark Z. Jacobson, "On the causal link between carbon dioxide and air pollution mortality," *Geophysical Research Letters*, Vol. 35, 2008, L03809, <https://www.stanford.edu/group/efmh/jacobson/Articles/V/2007GL031101.pdf>

[13] All images are open-source from *Wikimedia*

The rest of this study covers many areas, including the precise scenarios modeled in PI+ and CTAM, the results (in economic and climate terms) of the simulations, a discussion the potential relationship of a tax and AB32,[14] and background on the methodology of the models. A carbon tax and AB32, which created California's nascent cap-and-trade system,[15] would interact. On the other hand, it is perfectly possible for the two to coexist and reinforce the same objectives of reducing carbon emissions (both policies).[16] Both influence the economy (the carbon tax in particular, though revenues from a cap-and-trade can have budget impacts in the same manner as tax revenues). The descriptions in the appendix go into greater depth on the structure, data, and methodologies for PI+ and CTAM as well as the figures and variables used to bridge the gap between the carbon emissions and revenues in the latter with the economics and demographics in the former. For those with additional interest in the topic of regional carbon taxes, studies like this exist for three other states and one province in Canada, including Oregon,[17] Massachusetts,[18] the state of Washington and King County, Washington,[19] and British Columbia (who first implemented carbon taxes in 2008).[20]

[14] "Assembly Bill 32: Global Warming Solutions Act," *California Air Resources Board*, <http://www.arb.ca.gov/cc/ab32/ab32.htm>

[15] "Cap-and-Trade," *U.S. Environmental Protection Agency*, <http://www.epa.gov/captrade/>

[16] "Mapping Carbon Pricing Initiatives: Developments and Prospects," *World Bank*, May 2013, p. 55, <http://tinyurl.com/worldbankct>

[17] Jenny Liu and Jeff Renfro, "Carbon Tax Shift: How to make it work for Oregon's economy," March 1, 2013, <http://www.pdx.edu/nerc/sites/www.pdx.edu.nerc/files/carbontax2013.pdf>

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

[19] Scott Nystrom and Ali Zaidi, "The Economic, Demographic, and Climate Impact of Environmental Tax Reform in Washington and King County," *REMI*, December 13, 2013, <http://tinyurl.com/REMI-WA>; Erin Ailworth, "Environmentalists call for a MA carbon tax," *Boston Globe*, June 24, 2013, <http://www.bostonglobe.com/business/2013/06/23/group-seeks-carbon-tax-combat-climate-change/EGvlBc9ltLUCskJPgad0fL/story.html>

[20] Stewart Elgie and Jessica McClay, "BC's Carbon Tax after Five-Years: An Environmental (and Economic) Success," *University of Ottawa*, <http://www.sustainableprosperity.ca/dl1026&display>

How Does a Carbon Tax Work?

The fundamental goal of a carbon tax is to incentivize economic agents (individuals, the household, and the firm) to "internalize" external cost of carbon dioxide in their day-to-day purchasing decisions. Carbon, while harmless at dilute concentrations and to single organisms, may produce an "externality" or a "social cost" when spread across the globe. There is the potential that—in enough quantities—it disrupts existing economic activities by changing climate and raising sea levels. A carbon tax is "Pigouvian" for applying the externality to the cost of goods or services.[21] Carbon taxes have advantages in their simplicity and reliance on preexisting economic and social practices—namely, sales taxes and the current markets for energy. There are many places to apply a final price on carbon in the energy supply-chain, such as the point of extraction, refinement, or final sale. In this case, due to the architecture of CTAM, the hypothetical carbon tax in California is a retail sales tax on energy based on the carbon content inherent in electricity or fuel. Calculating the carbon content is a matter of stoichiometry. For example, one gallon of motor gasoline (depending on the particular blend) weighs 6.3 pounds.[22] Those 6.3 pounds produce 19.6 pounds of carbon dioxide when combusted with the oxygen in the air.[23] Converting this into metric tons implies a carbon tax of $0.009/gallon for each $1/ton of carbon tax.[24] The exercise is equivalent for all fuel types based on their typical unit for retail purchases, the average amount of carbon emissions in that unit, and the excise tax derived from the carbon content. This pricing of emissions means consumers (both individuals and businesses) have an incentive to purchase less of the fuel or electricity—satisfying the design of reducing emissions with the added benefit of the subsequent revenue is now available for many other purposes throughout the state, federal, or civic budget.

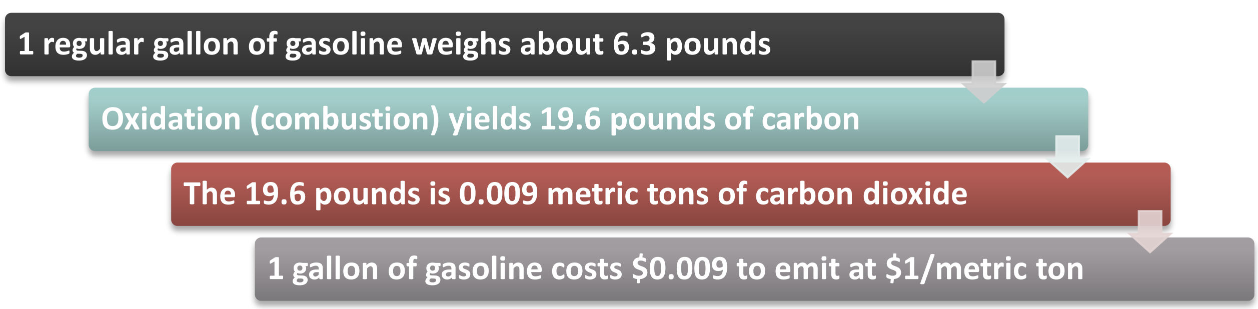


Figure 1.1 – This example shows the calculation of carbon content and the application of the carbon tax inherent in the CTAM model and this policy's design.

[21] Robert H. Frank, "Heads, You Win, Tails, You Win, Too," *New York Times*, January 5, 2013, <http://www.nytimes.com/2013/01/06/business/pigovian-taxes-may-offer-economic-hope.html>
[22] "Fact #519," *U.S. Department of Energy*, May 19, 2008, <http://www1.eere.energy.gov/vehiclesandfuels/facts/2008_fotw519.html>
[23] "How much carbon dioxide is produced by burning gasoline," *U.S. Energy Information Administration*, <http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11>
[24] 1 pound = 0.00045359237 metric tons; 1 metric ton = 2,204.62 pounds

Another long-term feature with a carbon tax is predictability and its relationship to the confidence of investors. "Investors" are a huge group, as well, which include traditional investment banks, venture capital, energy companies financing future projects off their own balance sheets, pension funds, and even individuals making personal choices about their pick of vehicles, appliances, heating, and retirements. Applying set prices on fuels and electricity based on the internal carbon content—as outlined with *Figure 1.1*—and increasing the rate over time (such a $10/year) sends signals to investors regarding the potential for higher fossil energy prices in the future. For example, gasoline prices in the United States have increased from $1.54/gallon to $3.58/gallon (in 2014 dollars) from 1998 to 2013.[25] That is a 132% increase in real terms in fifteen years. Recently, on the other hand, prices have hovered between $3.00/gallon and $4.00/gallon due to the weak national economy, additional supply in the western United States, and a host of other factors.[26] Knowing the future trajectories of these prices is extremely complicated; uncertainty about the future often leads investors to "stay the course" into the mists on the horizon. Having guaranteed price changes under a carbon tax might help to modify this mentality. If the rate rises at $10/year, the formula within *Figure 1.1* says prices for gasoline fifteen years hence will be at least $1.35/gallon more if the growth in global demand and fundamentals dictate no real change to prices. This changes the mindset of investors on the market to look for energy efficiency and less carbon-intensive business practice and capital projects. Households are more likely to buy efficient cars, windows, or homes if they think they can save money on them over a decade or more, and firms might feel more comfortable they will realize 8% to 10% return-on-investment (ROI) on renewable energy and the related. These processes help create "tipping points" within markets where low-carbon business setups and lifestyles become more popular, and PI+ and CTAM illustrates these gradually with their elasticity concepts.

[25] "U.S. All Grades All Formulations Retail Gasoline Prices," *U.S. Energy Information Administration*, <http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_NUS_DPG&f=A>

[26] For a discussion of some of the factors in California, please see Mark Glover, "Unlike past years, California gas prices remaining flat," *Sacramento Bee*, February 11, 2014, <http://www.sacbee.com/2014/02/11/6148057/aaa-unlike-past-years-california.html>

Policy Scenarios

The simulations here consider six discreet policy scenarios in two principle dimensions. The primary consideration of a carbon tax is the actual level of carbon pricing—this is part of the energy prices on the market, and therefore the level helps to determine the incentives to cut back on emissions, the revenues coming into the state budget, and the dynamic response of the economy to the net effect of these factors. For this study, there are three graduations for the carbon tax: $50/metric ton, $100/ton, and $200/ton. The three are "test cases" with a basis at $50/ton and a short sequence (on powers of two) up to $200/ton. These are not the only options for the state, but they do give a good sense of the sensitivity over an expansive range. All carbon taxes begin at $10/ton in 2015 and accelerate at $10/year until reaching their maximum level ($50/ton in 2019, $100/ton in 2024, $200/ton in 2034). The imbedded simplicity and predictability of this system allows households and businesses to make purchasing decisions in anticipation of the carbon taxes in the future. In contrast, cap-and-trade does not ensure any firm prices, which makes anticipation a more difficult affair. The preference is for a stability of the impact on the economy and budget while allowing the market to choose a new level of emissions—not a certain one, but certainly a lower one.

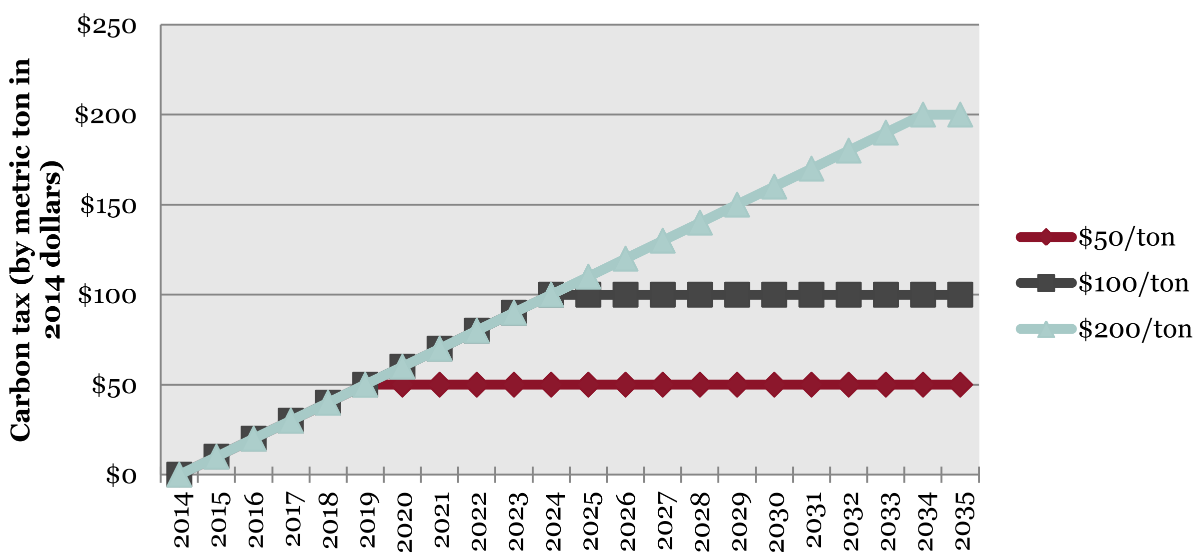


Figure 2.1 – These are the fees applied to carbon dioxide emissions in the six scenarios. All taxes begin at $10/metric ton in 2015 and phase-in at $10/year until reaching the maximum rates of $50/ton, $100/ton, and $200/ton. For the sake of consistency, the coloration of the lines in the remainder of the report will remain the same where possible (though with three more for alternative recycling of the revenues).

The other principal concern with a carbon tax is how to allocate the revenue. There are an infinite number of ways to use the funds once a carbon tax becomes a part of the state budget—financing the traditional government expenditures on infrastructure, setting up novel programs, or revenue-neutrality. The simulations herein take two approaches: an "across-the-board" (ATB) cut to California's state income tax, sales tax, and corporation taxes, and a "fee-and-dividend" (FAD) system of holding funds and redistributing them throughout the economy in an annual, per capita check to households. Before returning the revenue, each plan for the recycling of the revenue allocates $4 billion/year to a renewable development fund to encourage the expansion of wind and solar capacity and energy efficiency. ATB means to lower taxes while making no overarching changes to the preexisting California tax code—the idea being the state's politics has already settled on an acceptable system for itself (a "least-disruption" directive). On the other hand, FAD derives from the Alaska Permanent Fund, which pays dividends to state residents from royalties and earned interest,[27] and a CCL proposal for a similar system at the federal-level.[28] The approach is to apply ideas regarding federal policy to a state and examine its implications. The three tax graduations and options for the recycling of the revenues arrive at six scenarios modeled and described in this report.

Across-the-Board (ATB)

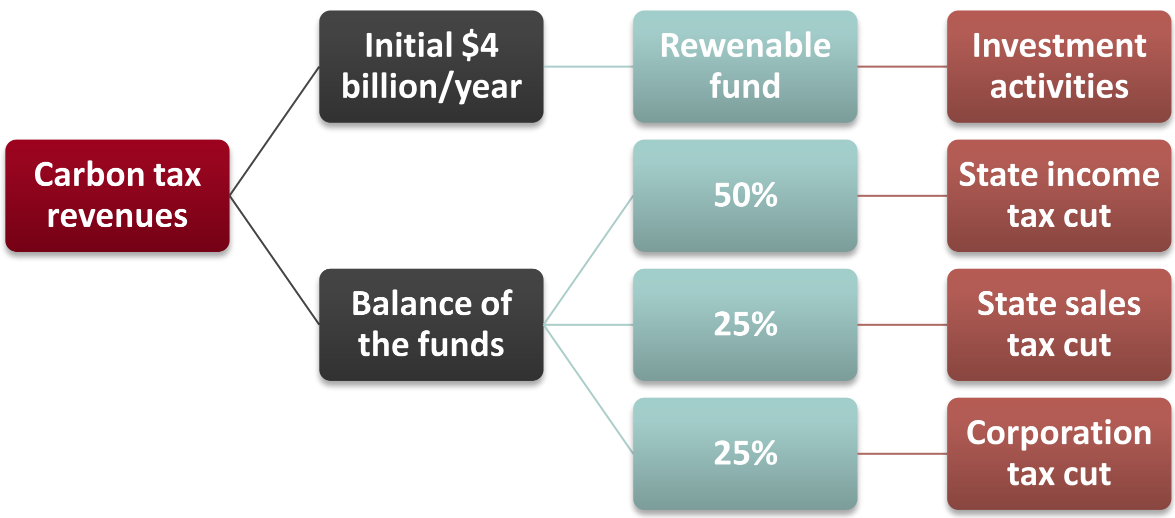


Figure 2.2 – This flowchart shows the destination of the revenues from the carbon tax. After the first $4 billion/year goes towards replenishing a fund for the advancement of wind and solar power, the rest goes back into the economy via changes to existing taxes. The 50:25:25 ratios above come from the current mixture of revenues paid to Sacramento from the state income, state sales, and state corporation tax.[29] The ratios are—roughly—the proportion already paid by revenue source, and therefore this represents a minimal disruption to the way California already does its taxes.

[27] "About the Fund," *Alaska Permanent Fund*, <http://www.apfc.org/home/Content/aboutFund/aboutPermFund.cfm>
[28] Todd J. Smith and Danny Richter, "Carbon Fee and Dividend FAQ," *Citizens Climate Lobby*, <http://citizensclimatelobby.org/about-us/faq/>
[29] "California Budget," *California Department of Finance*, <www.ebudget.ca.gov>

FEE-AND-DIVIDEND (FAD)

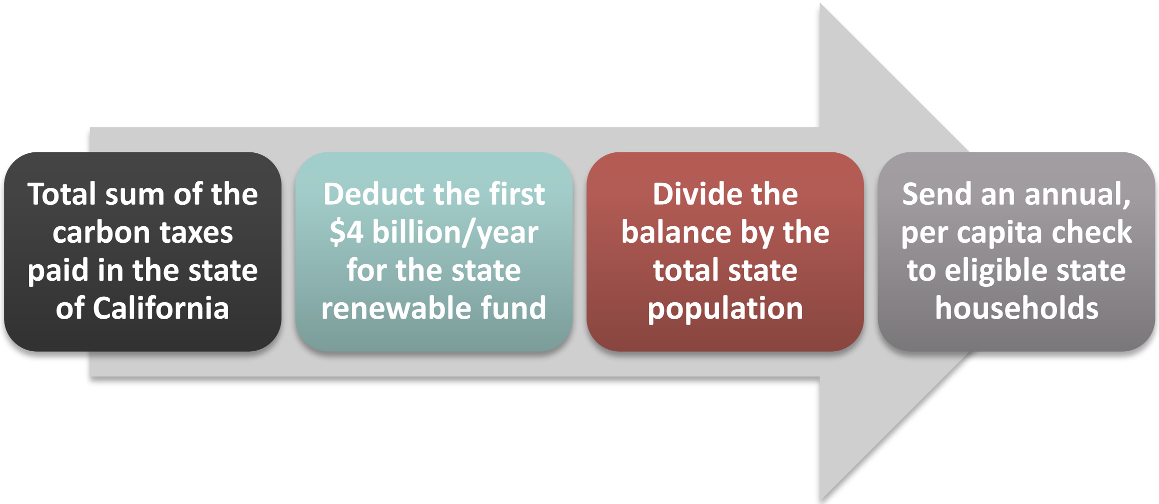
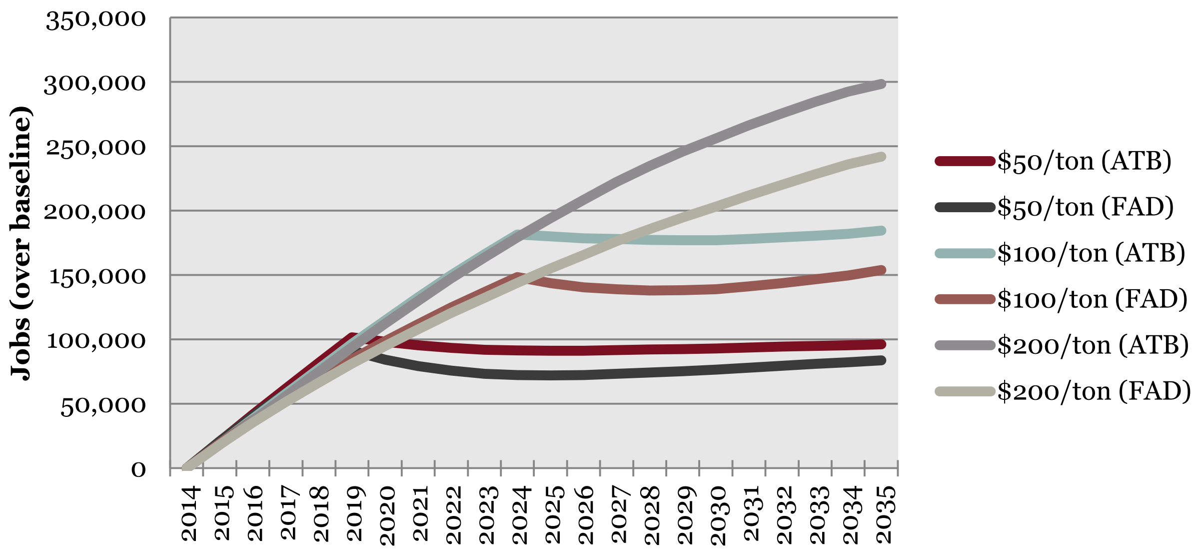


Figure 2.3 – This shows the process of recycling of the revenue for fee-and-dividend. It is similar to across-the-board because the first $4 billion/year always goes towards the state renewable fund but, from there, this system takes its cues from the Alaska Permanent Fund and its "oil check" methodology to return the money. The state cuts a check, its size determined by revenues and eligible population, and sends it to qualified Californian households based on the number of people in each individual family.

SIMULATION RESULTS

Results of the simulations cover the economic, demographic, fiscal, and climate impacts of implementing a theoretical carbon tax in California. They cover six scenarios: a 3x2 matrix of three tax levels ($50/metric ton, $100/ton, and $200/ton) and then two systems for revenue-neutrality. One relies on across-the-board (ATB) tax cuts within the context of current state fiscal policy. The other utilizes a model sourced from the Alaska Permanent Fund fee-and-dividend (FAD) scheme where the money collects in a fund and the state sends annual checks of it back to households. All of the results below are against a "do-nothing" baseline; this "null hypothesis" supposes and illustrates the drift of the California economy into the future and models how it would respond to the net tax changes of adding the carbon tax and undertaking ATB or FAD recycling. In essence, the results show the net implications of these policies, *et ceteris paribus* to any other developments in the regional, national, or global economies. Results include the impact on jobs, GDP, jobs by industry, jobs by occupational category, output by industry, the impact to the cost of living, prices for energy categories, household incomes, revenues paid in carbon taxes, and the size of the annual check under FAD. It also includes the impact on the household-level metrics by quintiles to give a sense of the stratification of impacts over the income distribution ladder.

ADDITIONAL TOTAL EMPLOYMENT (OVER BASELINE)



Figures 3.1 – All scenarios for implementing a carbon tax with revenue-neutrality generate a ***net increase in employment over the baseline.*** *In essence, whatever "job destruction" of higher energy cost is less than the "job creation" inherent in the lower taxes or an increase in direct consumer spending out of the dividend.*

ADDITIONAL GROSS DOMESTIC PRODUCT (ANNUAL)

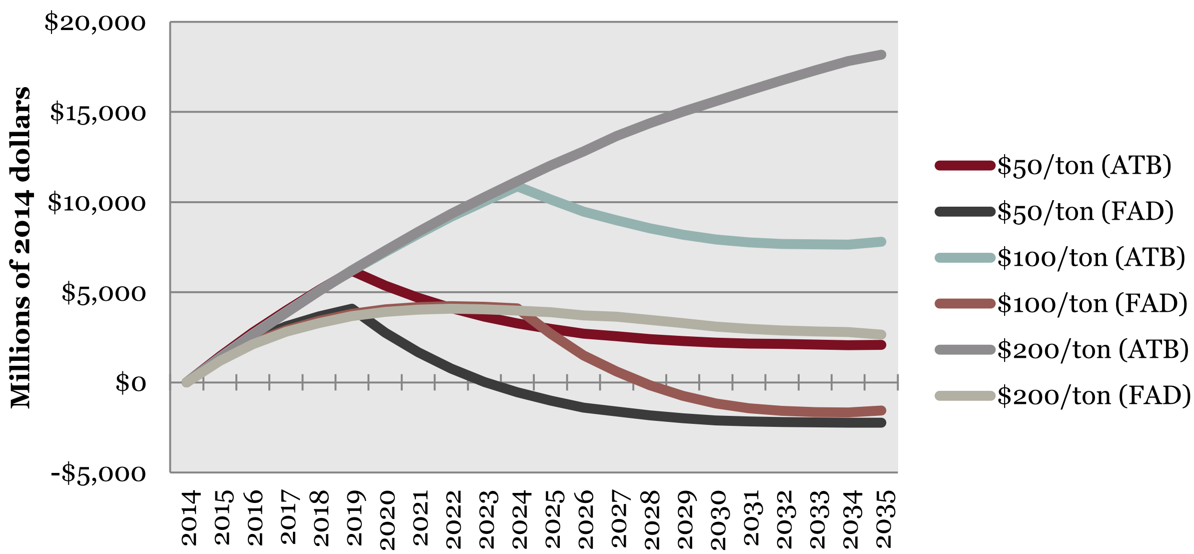
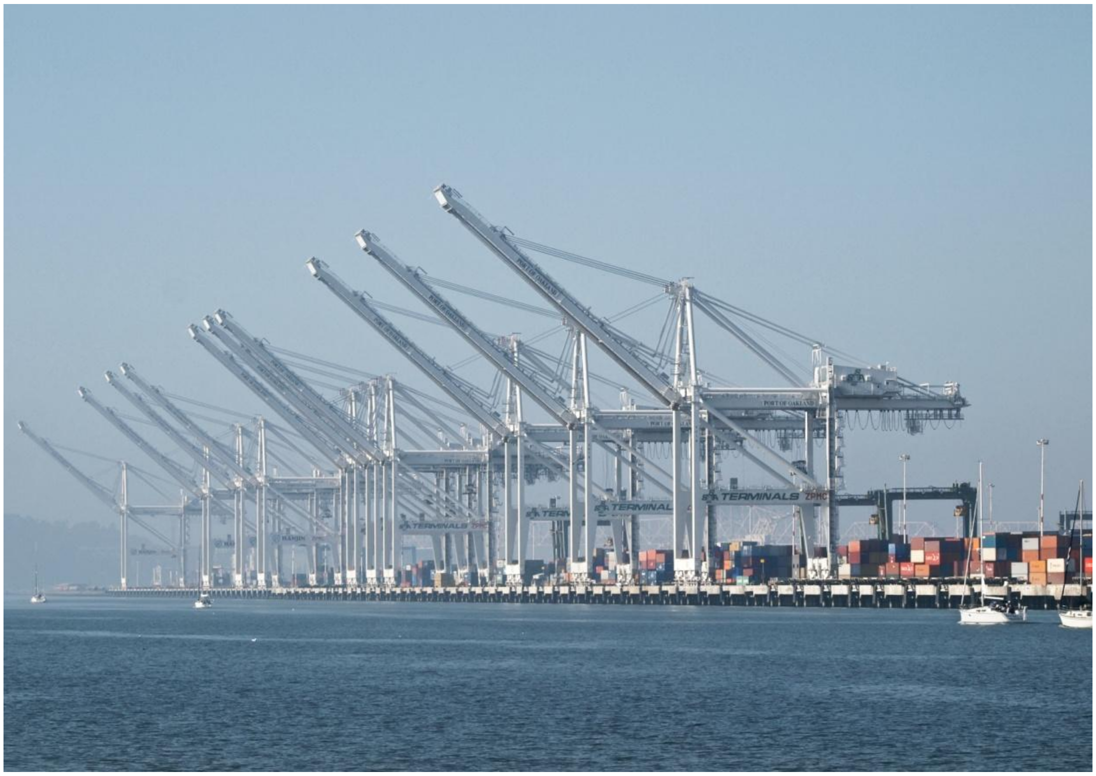


Figure 3.2 – Depending on the scenario, ***the state's level of economic activity (as measured by GDP) stands to be higher under environmental tax reform.*** *One case shows this as much as $18 billion/year and even the negative cases represent diminutive loses of less than $3 billion/year within the tax swaps described.*



Job growth and GDP are interrelated, though not always in a one-to-one manner, as *Figure 3.1* and *Figure 3.2* demonstrate on ATB, FAD, and their respective merits for economic impacts. By design, a carbon tax raises the price of energy in a jurisdiction to incentivize energy consumers to use less of it. This would include raising the price of electricity, natural gas, and petroleum products for commercial and industrial firms—the price of energy by type and sector. The former pairing and prices for the residential sector are variables in PI^{+}. These costs form elements of cost of doing business in the state, which PI^{+} would then use to determine the competitiveness of California in terms of attracting firms, business retention, and how fast exiting ones will grow. **Increasing the cost of energy with a carbon tax without offset, such as tax relief in the ATB scenarios, means reducing the competitiveness of Californian firms.** This means less business for those firms and a smaller economy. Therefore, in the ATB scenarios, which create an improvement in the cost of doing business, California has a larger economy, but one that looks essentially the same as the current one—just larger. The FAD scenarios, which do not offset costs, imply a smaller economy, but one more focused on consumer spending (due to an increase in incomes from the dividend) and with an increased share of personal income and less a locus on exports and business investments. Each has its relative merits for leaders to consider when designing policies. Additionally, industries associated with the former (retail, wholesale, services) tend to generate more jobs than those associated with the latter (manufacturing, power, and extraction). These adjustments move at differing speeds, which is why jobs and GDP do not always march in time with each other in the results.

ADDITIONAL GROSS DOMESTIC PRODUCT (CUMULATIVE)

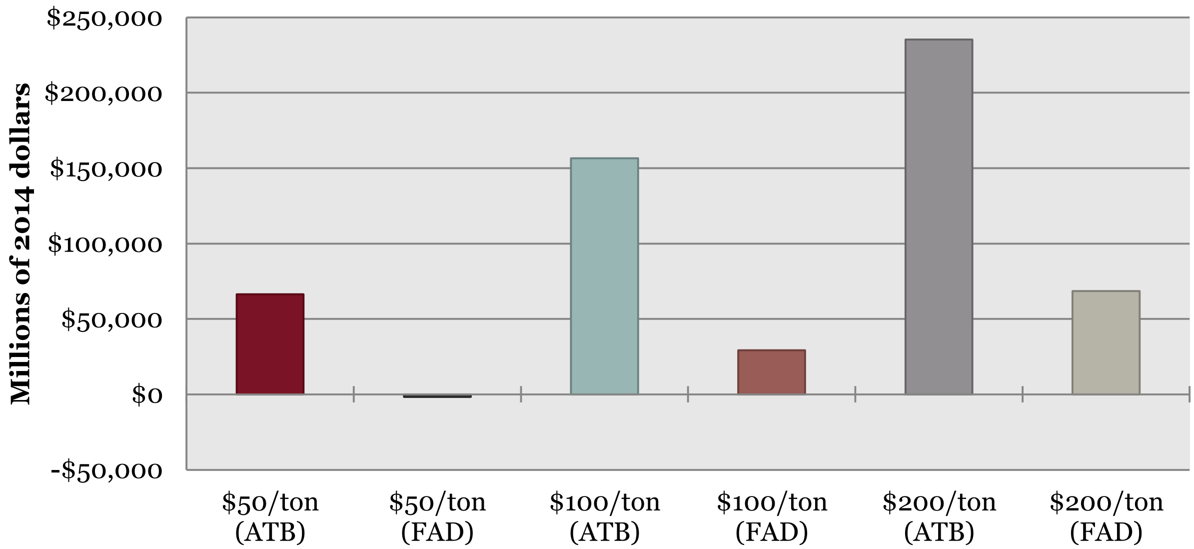


Figure 3.3 – This repackages the information to show the cumulative (horizontal sum) impact to GDP in the six scenarios. Only the $50/ton FAD simulation has a negative impact to GDP over the next twenty years, though it is nearly indistinguishable from the baseline Californian economy of the future. Others are appreciably positive.

The next subsection adds detail in breaking out the above macroeconomic indicators on the impact to jobs and GDP for portions of the economy by industry and by occupation. This illustrates the standing of each of the industries under a carbon tax swap as well as the socioeconomics when dividing jobs between industry and employment. In terms of industries, PI+ utilizes the North American Industrial Classification System (NAICS); NAICS is the standardized categorization of the U.S. Census on what constitutes a group of firms engaged in an industry and market competition.[30] Dow and DuPont each might operate a plant of some sort in the same county for access to natural gas mainlines—to the NAICS, however, the chemical plants, the jobs, and the production are all "325."[31] On the occupation side, an industry may be in one part of the supply-chain, but individual firms hire a broad swath of differing sorts of workers. For instance, those chemical plants would hire engineers, managers, mechanics, accountants, IT, security, sales representatives, maintenance personnel, and a number of additional trades. PI+ uses the Standard Occupational Classification (SOC) from the Bureau of Labor Statistics (BLS) to describe the actual job that workers do.[32]

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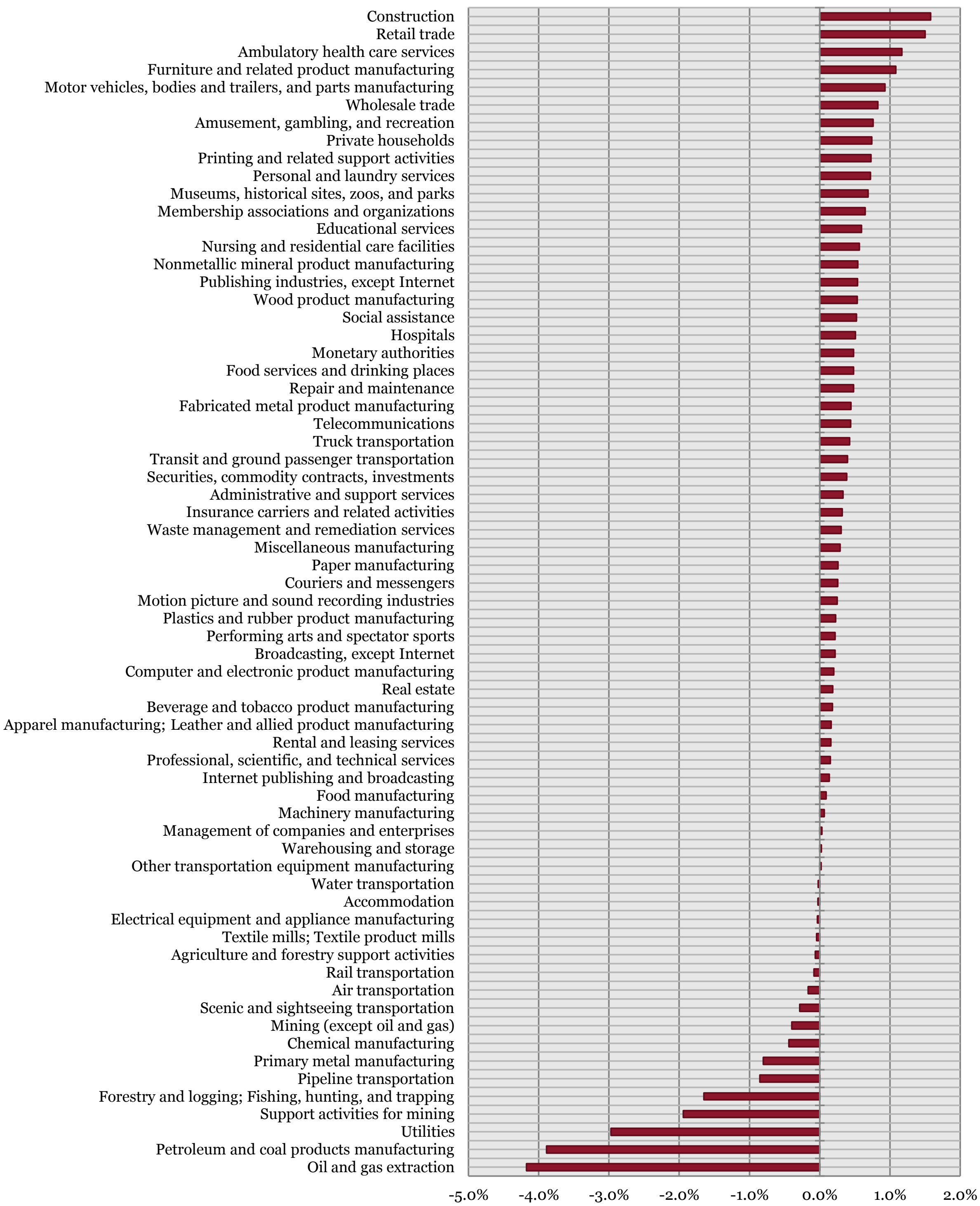
[30] "North American Industrial Classification System," *U.S. Census*, <http://www.census.gov/eos/www/naics/>
[31] "325 Chemical Manufacturing," *U.S. Census*, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=325&search=2012%20NAICS%20Search>
[32] "Standard Occupational Classification," *Bureau of Labor Statistics*, <http://www.bls.gov/soc/>

FIGURE 3.4 – ANNUAL OUTPUT BY INDUSTRY ($200/TON, ATB)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$1.0	-$17.9	-$41.4	-$62.8	-$80.7
Agriculture and forestry support activities	$0.0	-$1.8	-$4.7	-$7.0	-$8.4
Oil and gas extraction	-$50.6	-$410.3	-$721.9	-$854.1	-$781.6
Mining (except oil and gas)	$0.0	-$6.8	-$17.5	-$28.8	-$39.6
Support activities for mining	-$5.6	-$79.2	-$167.2	-$233.9	-$278.7
Utilities	-$212.1	-$1,225.3	-$2,140.5	-$2,751.8	-$3,012.3
Construction	$345.4	$2,169.4	$3,773.9	$4,884.5	$5,479.5
Wood product manufacturing	$6.3	$35.7	$56.0	$65.3	$65.6
Nonmetallic mineral product manufacturing	$12.6	$64.0	$93.6	$103.8	$98.8
Primary metal manufacturing	$0.5	-$49.6	-$133.2	-$209.8	-$266.5
Fabricated metal product manufacturing	$31.1	$168.8	$253.3	$303.9	$326.1
Machinery manufacturing	$6.4	$27.4	$27.8	$24.8	$20.7
Computer and electronic product manufacturing	$67.7	$348.8	$505.0	$646.6	$773.7
Electrical equipment and appliance manufacturing	$7.6	$25.4	$9.4	-$24.2	-$67.6
Motor vehicles, bodies and trailers, and parts manufacturing	$15.4	$92.3	$146.7	$182.5	$200.0
Other transportation equipment manufacturing	$7.2	$25.5	$20.6	$5.7	-$13.2
Furniture and related product manufacturing	$16.9	$87.7	$124.4	$134.2	$124.4
Miscellaneous manufacturing	$19.2	$86.9	$109.9	$125.4	$134.2
Food manufacturing	$16.9	$68.2	$95.8	$116.4	$127.9
Beverage and tobacco product manufacturing	$8.2	$44.6	$75.3	$98.8	$110.2
Textile mills; Textile product mills	$2.2	$5.8	$1.6	-$7.6	-$14.1
Apparel manufacturing; Leather and allied product manufacturing	$3.0	$14.7	$14.4	$17.4	$16.8
Paper manufacturing	$5.7	$25.4	$33.8	$35.4	$32.2
Printing and related support activities	$10.3	$61.0	$97.8	$121.4	$133.4
Petroleum and coal products manufacturing	-$482.0	-$4,211.3	-$8,056.2	-$11,420.3	-$14,113.5
Chemical manufacturing	$50.8	-$17.0	-$316.4	-$687.3	-$1,055.5
Plastics and rubber product manufacturing	$15.7	$62.4	$67.9	$51.1	$21.5
Wholesale trade	$198.8	$1,286.3	$2,286.0	$3,117.6	$3,749.7
Retail trade	$286.3	$2,061.1	$3,802.7	$5,253.5	$6,361.9
Air transportation	$3.1	$3.9	-$22.9	-$64.0	-$109.7
Rail transportation	$0.0	-$2.2	-$6.1	-$10.7	-$15.1
Water transportation	$0.5	$1.1	-$0.4	-$3.1	-$5.9
Truck transportation	$19.4	$121.6	$209.3	$276.1	$323.9
Couriers and messengers	$5.8	$33.3	$55.9	$72.9	$85.2
Transit and ground passenger transportation	$2.6	$13.5	$22.7	$30.4	$36.2
Pipeline transportation	-$1.3	-$9.6	-$17.3	-$21.0	-$21.0
Scenic and sightseeing transportation	-$2.2	-$26.8	-$58.9	-$94.4	-$131.1
Warehousing and storage	$2.0	$7.5	$5.7	$0.0	-$7.3
Publishing industries, except Internet	$57.6	$375.6	$645.7	$868.3	$1,047.9
Motion picture and sound recording industries	$32.2	$149.1	$244.7	$321.8	$380.5
Internet publishing and broadcasting	$11.8	$58.6	$90.0	$113.7	$133.2
Broadcasting, except Internet	$10.1	$51.9	$78.7	$96.9	$111.7
Telecommunications	$51.1	$296.1	$517.9	$722.2	$908.2
Monetary authorities	$127.7	$660.5	$1,054.7	$1,326.8	$1,509.8
Securities, commodity contracts, investments	$54.2	$265.3	$390.3	$443.9	$454.7
Insurance carriers and related activities	$36.7	$193.1	$301.4	$359.0	$375.1
Real estate	$121.4	$594.0	$964.8	$1,221.9	$1,349.1
Rental and leasing services	$27.1	$122.4	$176.7	$210.0	$242.1
Professional, scientific, and technical services	$129.0	$564.4	$753.3	$828.4	$891.1
Management of companies and enterprises	$15.0	$51.1	$39.9	$10.8	-$18.8
Administrative and support services	$56.1	$293.3	$458.7	$584.6	$703.7
Waste management and remediation services	$5.9	$30.0	$48.6	$63.2	$74.1
Educational services	$21.7	$144.8	$271.1	$381.4	$461.2
Ambulatory health care services	$210.7	$1,174.8	$1,950.3	$2,575.6	$3,100.0
Hospitals	$48.8	$272.3	$483.5	$695.0	$906.1
Nursing and residential care facilities	$15.0	$87.9	$161.8	$234.0	$299.2
Social assistance	$12.9	$86.1	$163.9	$236.8	$295.2
Performing arts and spectator sports	$8.9	$51.0	$87.4	$118.4	$142.7
Museums, historical sites, zoos, and parks	$2.3	$16.0	$30.4	$43.5	$53.9
Amusement, gambling, and recreation	$14.0	$77.8	$131.0	$175.3	$213.2
Accommodation	$12.3	$19.3	-$10.4	-$42.2	-$44.4
Food services and drinking places	$47.0	$301.2	$567.0	$820.5	$1,038.5
Repair and maintenance	$20.8	$114.8	$195.8	$263.6	$314.8
Personal and laundry services	$26.4	$136.7	$204.1	$246.5	$278.9
Membership associations and organizations	$21.3	$136.4	$252.4	$354.1	$426.9
Private households	$4.0	$22.5	$35.4	$44.8	$54.4
TOTAL FOR ALL INDUSTRIES =	$1,614.8	$7,231.4	$10,474.1	$12,505.4	$13,903.5

FIGURE 3.5 – INDUSTRY OUTPUT (%, $200/TON, ATB, 2015-2035)

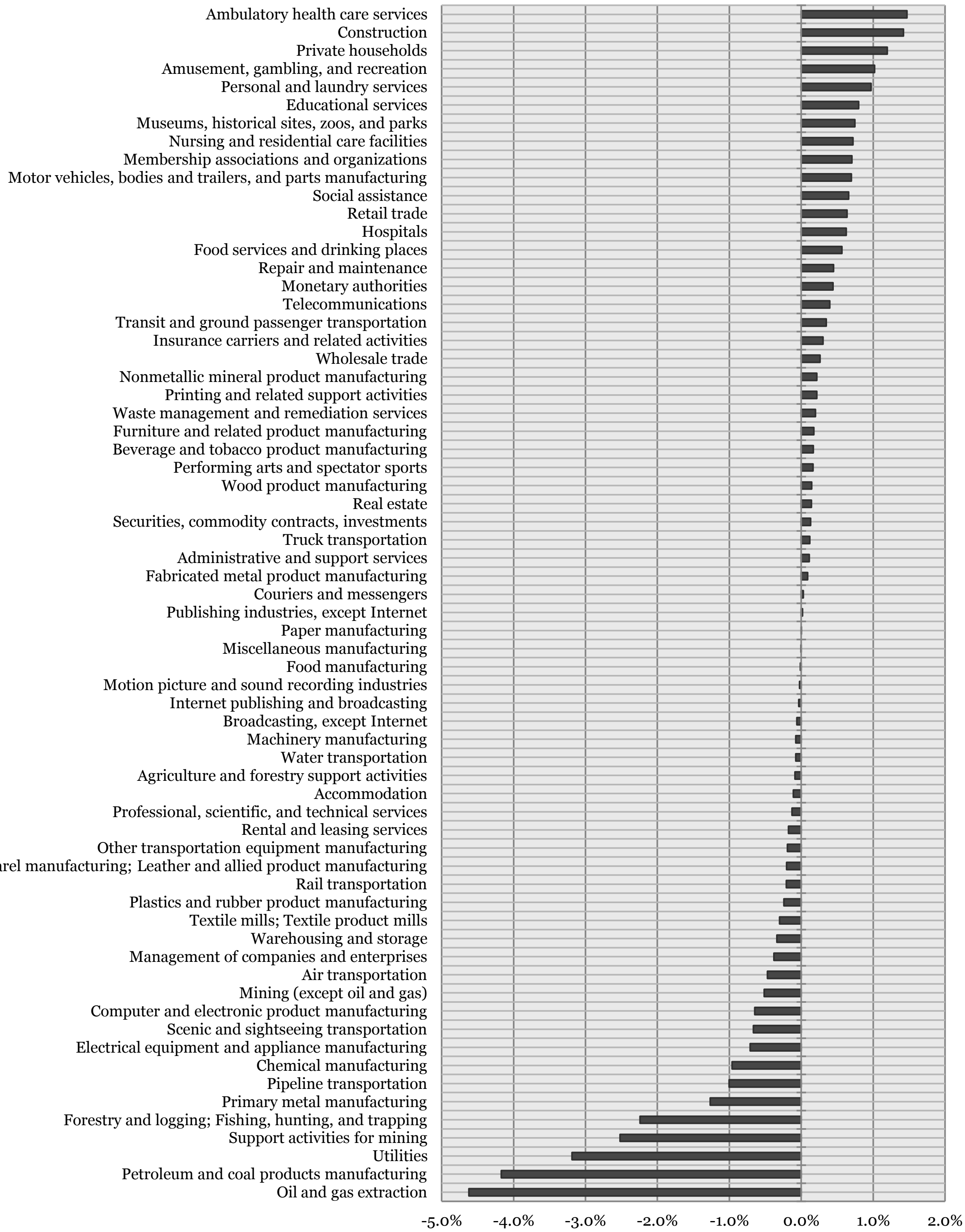


This reorganizes the table of change in industry outputs into their percentage changes by industry. As per the intuition, most sectors can grow faster under a carbon tax (sans the oil and gas supply-chain, which shrink slightly).

FIGURE 3.6 – ANNUAL OUTPUT BY INDUSTRY ($200/TON, FAD)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$1.3	-$24.3	-$55.9	-$83.5	-$104.6
Agriculture and forestry support activities	$0.0	-$2.7	-$7.0	-$10.1	-$11.6
Oil and gas extraction	-$52.3	-$431.7	-$763.8	-$906.2	-$833.5
Mining (except oil and gas)	-$0.1	-$9.1	-$22.9	-$36.9	-$49.4
Support activities for mining	-$6.7	-$99.6	-$212.1	-$297.2	-$352.4
Utilities	-$208.3	-$1,254.1	-$2,225.4	-$2,880.3	-$3,162.1
Construction	$352.1	$2,059.7	$3,416.3	$4,375.3	$5,005.6
Wood product manufacturing	$4.5	$16.9	$17.4	$12.4	$6.6
Nonmetallic mineral product manufacturing	$10.3	$37.7	$40.4	$32.4	$21.4
Primary metal manufacturing	-$3.0	-$91.7	-$213.8	-$316.9	-$385.4
Fabricated metal product manufacturing	$22.4	$71.8	$59.0	$30.2	$2.2
Machinery manufacturing	$5.1	$3.4	-$25.4	-$55.6	-$79.1
Computer and electronic product manufacturing	-$11.7	-$575.9	-$1,524.5	-$2,492.9	-$3,290.0
Electrical equipment and appliance manufacturing	$2.4	-$27.0	-$88.8	-$153.2	-$209.6
Motor vehicles, bodies and trailers, and parts manufacturing	$14.6	$76.2	$111.4	$131.9	$141.9
Other transportation equipment manufacturing	$2.0	-$35.0	-$110.6	-$190.3	-$257.1
Furniture and related product manufacturing	$9.1	$31.0	$25.4	$9.5	-$8.4
Miscellaneous manufacturing	$13.8	$35.1	$5.0	-$24.8	-$46.0
Food manufacturing	$19.0	$29.5	-$9.1	-$45.5	-$67.6
Beverage and tobacco product manufacturing	$11.8	$50.4	$71.2	$83.9	$88.4
Textile mills; Textile product mills	$1.0	-$2.1	-$10.2	-$19.5	-$26.5
Apparel manufacturing; Leather and allied product manufacturing	$1.0	-$3.5	-$19.8	-$30.1	-$37.6
Paper manufacturing	$3.9	$8.0	$1.7	-$5.4	-$11.1
Printing and related support activities	$6.3	$24.5	$29.4	$30.8	$32.4
Petroleum and coal products manufacturing	-$493.5	-$4,336.4	-$8,306.4	-$11,758.9	-$14,492.4
Chemical manufacturing	$21.5	-$262.1	-$795.5	-$1,338.4	-$1,797.6
Plastics and rubber product manufacturing	$9.1	$1.7	-$47.7	-$103.1	-$151.4
Wholesale trade	$98.9	$479.7	$745.7	$927.2	$1,064.9
Retail trade	$123.4	$860.0	$1,598.0	$2,246.6	$2,837.2
Air transportation	$2.5	-$20.9	-$87.1	-$166.7	-$242.8
Rail transportation	-$0.3	-$6.9	-$16.5	-$26.1	-$34.0
Water transportation	$0.7	$0.2	-$3.6	-$8.7	-$13.4
Truck transportation	$10.9	$46.4	$61.3	$66.0	$71.1
Couriers and messengers	$3.6	$10.8	$8.7	$2.7	-$3.1
Transit and ground passenger transportation	$3.4	$14.0	$20.2	$25.0	$29.3
Pipeline transportation	-$1.4	-$11.0	-$20.2	-$24.6	-$24.8
Scenic and sightseeing transportation	-$6.4	-$66.4	-$140.5	-$217.9	-$290.9
Warehousing and storage	$0.2	-$13.9	-$39.1	-$66.0	-$89.7
Publishing industries, except Internet	$24.3	$75.8	$35.1	-$22.8	-$48.3
Motion picture and sound recording industries	$7.9	$4.1	-$20.3	-$50.2	-$77.7
Internet publishing and broadcasting	$10.3	$7.6	-$26.4	-$50.8	-$54.0
Broadcasting, except Internet	$7.2	$8.5	-$15.8	-$45.0	-$67.1
Telecommunications	$64.8	$303.9	$472.4	$620.8	$769.6
Monetary authorities	$167.8	$712.6	$995.6	$1,130.3	$1,195.5
Securities, commodity contracts, investments	$68.3	$211.8	$174.5	$60.5	-$58.8
Insurance carriers and related activities	$49.5	$213.2	$290.1	$315.0	$310.8
Real estate	$200.7	$690.8	$794.5	$737.6	$631.4
Rental and leasing services	$18.4	-$14.6	-$152.3	-$324.6	-$476.2
Professional, scientific, and technical services	$108.9	$40.1	-$497.9	-$1,100.6	-$1,545.4
Management of companies and enterprises	$5.1	-$95.9	-$298.4	-$527.6	-$737.2
Administrative and support services	$56.7	$184.6	$175.9	$126.8	$102.0
Waste management and remediation services	$7.2	$26.3	$33.1	$35.0	$35.7
Educational services	$35.9	$214.0	$373.6	$504.2	$597.0
Ambulatory health care services	$304.3	$1,565.4	$2,503.6	$3,238.2	$3,845.6
Hospitals	$77.5	$379.0	$612.6	$831.9	$1,056.6
Nursing and residential care facilities	$23.7	$124.2	$211.4	$290.6	$361.2
Social assistance	$19.7	$119.5	$212.3	$294.1	$358.5
Performing arts and spectator sports	$10.7	$48.1	$68.2	$79.9	$87.0
Museums, historical sites, zoos, and parks	$3.0	$19.1	$33.9	$46.4	$55.7
Amusement, gambling, and recreation	$22.6	$112.4	$179.2	$232.0	$276.4
Accommodation	$20.1	$20.7	-$46.0	-$118.6	-$152.1
Food services and drinking places	$73.3	$401.8	$684.3	$931.2	$1,142.9
Repair and maintenance	$26.4	$120.4	$184.8	$236.4	$278.5
Personal and laundry services	$42.2	$195.8	$277.8	$325.3	$359.4
Membership associations and organizations	$29.9	$163.0	$279.0	$376.5	$448.3
Private households	$7.5	$37.9	$58.2	$72.6	$85.3
TOTAL FOR ALL INDUSTRIES =	$1,462.2	$2,472.5	-$941.6	-$5,039.8	-$7,990.0

FIGURE 3.7 – INDUSTRY OUTPUT (%, $200/TON, FAD, 2015-2035)



This is the same illustration as *Figure 3.5* only for the FAD program instead of ATB. The energy sector itself sees a contraction of between 2.5% and 5.0% and industries related to consumption (such as retail or services) improve over ATB's results.

The general economy might stand to gain from environmental tax reform and a carbon tax. In particular, it can gain in certain industries that create large numbers of jobs while most lost output comes from industries without much labor-intensity that share a close tie with energy production. Every industry's "profile" in terms of the carbon tax differs depending on its preexisting haul of output, its competitiveness, its current utilization of energy resources, its current tax apportionments, how close it is to direct consumer spending, and how it fits into other B2B transactions.

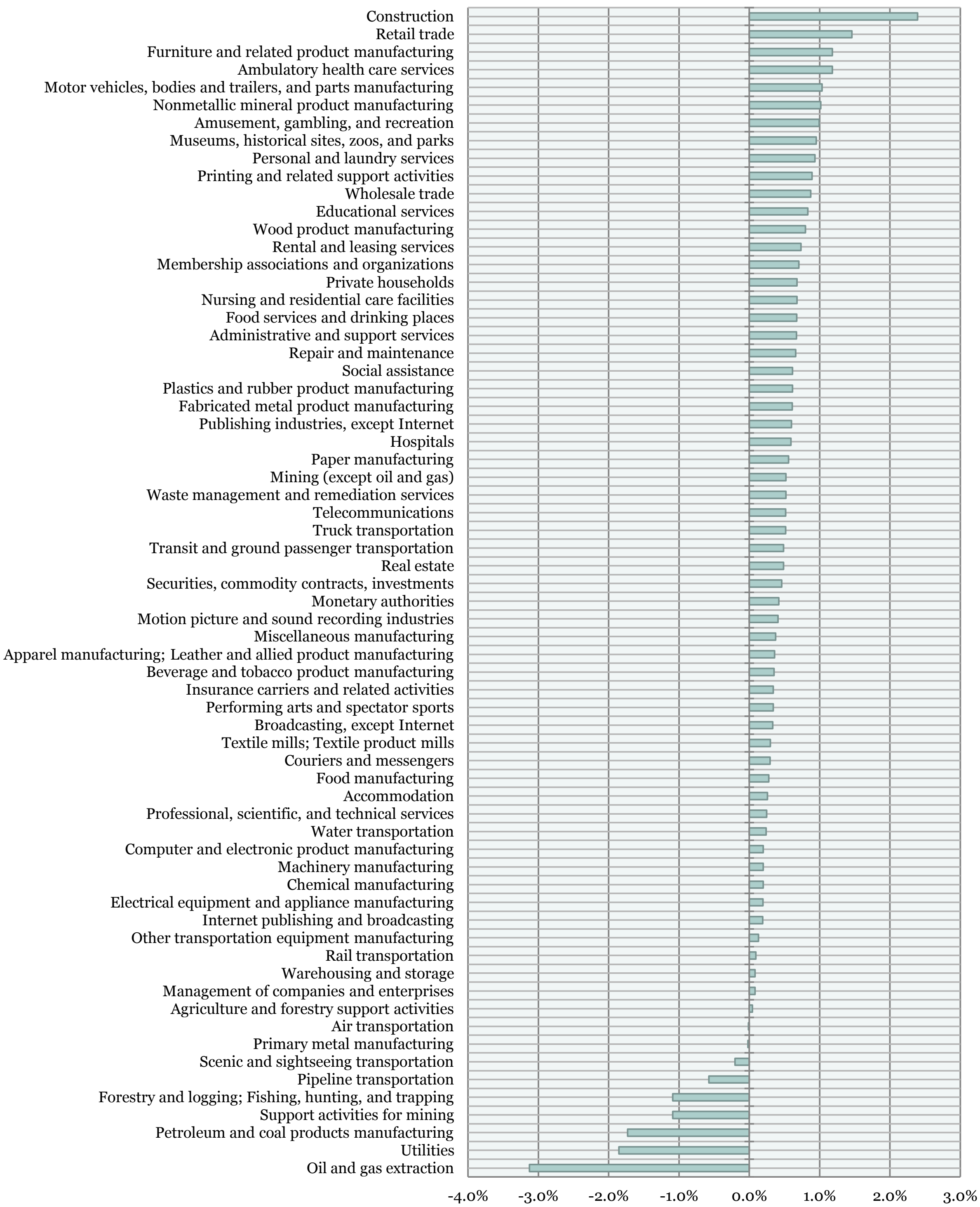
The uppers and downers in the industry list offer interesting cases. Some of the "losers" (though percentage changes are fairly miniature in simulations, most less than 2% and all less than 5%) include **petroleum and coal products** (which includes petroleum refining), **utilities**, **chemical manufacturing** (energy-intensive and a feedstock to refining), **oil and gas extraction**, and **primary metal manufacturing** (for steel products such as pipelines). FAD adds **computers and electronic products** and **professional and technical services** (which are big industries within California and competitive on the national and international market, with San Jose and Los Angeles competing with firms in Seoul, Shanghai, and London). Conversely, the "winners" are a numerous collection. They involve localized, labor-intensive industries with direct ties to households and their spending such as **construction**, **retail trade**, **food service and drinking places**, **financial services**, and **healthcare**. Some specialized sectors in manufacturing, such as **furniture**, **wood products**, **paper**, and **motion pictures and sound recording**—this being California—see benefits, too, given the reduction in cost available to them under the ATB case and their light use of electrical power and fossil energy compared to heavy manufacturing.

The difference in impacts on industry output between ATB and FAD lies in the natures of the various industries' customers. Under FAD, industries such as **healthcare** and **education services**, **entertainment and gaming**, and **personal services** would do better because their customers are the individuals and families receiving checks from the carbon tax dividend. ATB delivers benefits or neutral impacts to more industries. **Computers and electronics** is perhaps a representative case for the difference between the two. **Computers and electronics** gain under ATB because of their relatively low usage of energy resources and the highly competitive nature of the market shares in question—any change in their cost of doing business, cost of capital, and taxes can lead to bigger swings. However, with FAD, **computers** see a decline in output for equal (though opposite) reasons. The industry itself is far enough back in the production supply-chain and exports too much of its product out of California to feel much of a demand surge from the dividends, and its responsiveness to business costs and the competitive nature of the industry between regions leads to a decline in output. The general effect is still positive, and the job results in the next sections show what begins to happen on the labor market within California.

FIGURE 3.8 – EMPLOYMENT BY INDUSTRY ($200/TON, ATB)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-4	-66	-136	-187	-224
Agriculture and forestry support activities	7	43	91	139	173
Oil and gas extraction	-109	-787	-1,322	-1,544	-1,486
Mining (except oil and gas)	3	35	88	148	208
Support activities for mining	-13	-145	-239	-257	-230
Utilities	-177	-808	-1,153	-1,216	-1,092
Construction	3,051	21,106	38,761	51,975	60,612
Wood product manufacturing	29	185	316	398	436
Nonmetallic mineral product manufacturing	47	289	496	638	716
Primary metal manufacturing	5	3	-9	-12	-8
Fabricated metal product manufacturing	117	687	1,106	1,398	1,580
Machinery manufacturing	22	116	163	195	210
Computer and electronic product manufacturing	97	426	544	613	648
Electrical equipment and appliance manufacturing	24	94	84	41	-13
Motor vehicles, bodies and trailers, and parts manufacturing	36	195	276	301	289
Other transportation equipment manufacturing	15	80	130	174	213
Furniture and related product manufacturing	89	455	640	681	627
Miscellaneous manufacturing	68	295	374	423	450
Food manufacturing	42	269	502	695	822
Beverage and tobacco product manufacturing	15	110	213	296	340
Textile mills; Textile product mills	13	62	78	54	54
Apparel manufacturing; Leather and allied product manufacturing	35	207	255	314	328
Paper manufacturing	17	92	147	175	182
Printing and related support activities	63	359	533	593	576
Petroleum and coal products manufacturing	-33	-182	-243	-248	-227
Chemical manufacturing	62	164	164	128	78
Plastics and rubber product manufacturing	53	277	428	515	555
Wholesale trade	903	5,541	9,288	11,815	13,211
Retail trade	3,499	22,793	38,119	47,227	51,221
Air transportation	9	30	6	-31	-63
Rail transportation	0	5	11	19	26
Water transportation	1	9	20	34	51
Truck transportation	141	918	1,642	2,228	2,684
Couriers and messengers	45	254	425	554	651
Transit and ground passenger transportation	41	229	408	566	693
Pipeline transportation	-2	-11	-14	-12	-9
Scenic and sightseeing transportation	-15	-153	-289	-392	-458
Warehousing and storage	24	102	122	116	107
Publishing industries, except Internet	114	598	848	929	906
Motion picture and sound recording industries	87	453	741	957	1,108
Internet publishing and broadcasting	20	96	137	152	148
Broadcasting, except Internet	25	137	225	294	349
Telecommunications	82	448	729	922	1,031
Monetary authorities	271	1,223	1,754	1,976	2,022
Securities, commodity contracts, investments	369	1,764	2,591	2,956	3,064
Insurance carriers and related activities	133	715	1,145	1,386	1,476
Real estate	394	2,797	5,448	7,721	9,349
Rental and leasing services	127	676	1,071	1,321	1,460
Professional, scientific, and technical services	865	4,248	6,531	8,224	9,707
Management of companies and enterprises	71	241	244	221	212
Administrative and support services	975	6,510	11,957	17,026	21,244
Waste management and remediation services	26	162	304	440	559
Educational services	339	2,645	5,361	7,858	9,685
Ambulatory health care services	1,620	9,167	15,566	20,781	25,184
Hospitals	312	1,854	3,416	4,923	6,270
Nursing and residential care facilities	225	1,438	2,795	4,148	5,356
Social assistance	273	1,952	3,889	5,744	7,253
Performing arts and spectator sports	114	757	1,416	2,012	2,496
Museums, historical sites, zoos, and parks	16	126	247	354	429
Amusement, gambling, and recreation	246	1,515	2,733	3,784	4,627
Accommodation	118	494	790	1,128	1,561
Food services and drinking places	799	5,704	10,976	15,578	18,799
Repair and maintenance	211	1,278	2,322	3,222	3,883
Personal and laundry services	405	2,118	3,174	3,805	4,234
Membership associations and organizations	264	1,736	3,260	4,568	5,471
Private households	481	2,494	3,600	4,165	4,661
TOTAL FOR ALL INDUSTRIES =	17,202	106,624	185,295	245,149	286,475

FIGURE 3.9 – INDUSTRY EMPLOYMENT (%, $200/TON, ATB, 2015-2035)



Most industries see gains in employment with a carbon tax under ATB, though some see more than others do. Construction and the services-related sectors, in particular, see more jobs than direct and indirect relations to extraction do.

FIGURE 3.10 – EMPLOYMENT BY INDUSTRY ($200/TON, FAD)

NAICS Industries	2015	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-6	-96	-197	-266	-307
Agriculture and forestry support activities	7	20	46	91	135
Oil and gas extraction	-113	-832	-1,410	-1,652	-1,599
Mining (except oil and gas)	3	27	72	129	190
Support activities for mining	-17	-194	-334	-372	-345
Utilities	-171	-818	-1,189	-1,260	-1,129
Construction	3,104	20,389	36,523	49,068	58,284
Wood product manufacturing	21	111	174	216	246
Nonmetallic mineral product manufacturing	39	213	356	468	553
Primary metal manufacturing	-1	-57	-113	-134	-130
Fabricated metal product manufacturing	86	373	531	662	787
Machinery manufacturing	19	64	68	79	95
Computer and electronic product manufacturing	-24	-614	-1,142	-1,342	-1,289
Electrical equipment and appliance manufacturing	9	-34	-120	-184	-221
Motor vehicles, bodies and trailers, and parts manufacturing	30	145	197	214	210
Other transportation equipment manufacturing	5	-23	-66	-79	-61
Furniture and related product manufacturing	49	181	187	145	90
Miscellaneous manufacturing	50	153	138	150	186
Food manufacturing	49	227	385	533	651
Beverage and tobacco product manufacturing	21	126	227	309	356
Textile mills; Textile product mills	7	24	23	1	2
Apparel manufacturing; Leather and allied product manufacturing	15	51	10	34	64
Paper manufacturing	12	57	89	113	127
Printing and related support activities	40	188	267	302	308
Petroleum and coal products manufacturing	-34	-190	-256	-262	-238
Chemical manufacturing	32	-48	-190	-279	-313
Plastics and rubber product manufacturing	33	107	125	138	159
Wholesale trade	463	2,376	3,860	4,964	5,768
Retail trade	1,544	10,201	17,701	22,836	26,146
Air transportation	8	-26	-126	-219	-281
Rail transportation	0	-3	-1	5	13
Water transportation	1	8	16	29	45
Truck transportation	82	437	748	1,048	1,366
Couriers and messengers	29	99	126	148	183
Transit and ground passenger transportation	55	243	391	526	651
Pipeline transportation	-2	-13	-17	-15	-10
Scenic and sightseeing transportation	-45	-407	-755	-1,012	-1,164
Warehousing and storage	4	-115	-306	-471	-577
Publishing industries, except Internet	56	200	222	227	243
Motion picture and sound recording industries	30	185	342	508	673
Internet publishing and broadcasting	18	46	52	65	80
Broadcasting, except Internet	18	53	62	78	108
Telecommunications	103	468	705	870	977
Monetary authorities	347	1,259	1,578	1,629	1,596
Securities, commodity contracts, investments	464	1,483	1,522	1,254	1,038
Insurance carriers and related activities	176	787	1,147	1,338	1,420
Real estate	612	3,271	5,687	7,759	9,408
Rental and leasing services	111	492	706	832	915
Professional, scientific, and technical services	760	1,424	199	-809	-839
Management of companies and enterprises	26	-303	-790	-1,125	-1,261
Administrative and support services	1,008	5,167	8,608	12,011	15,195
Waste management and remediation services	31	154	262	367	468
Educational services	540	3,644	6,889	9,733	11,806
Ambulatory health care services	2,334	12,140	19,836	25,939	31,058
Hospitals	489	2,490	4,179	5,725	7,145
Nursing and residential care facilities	350	1,956	3,513	4,977	6,277
Social assistance	413	2,641	4,923	7,006	8,694
Performing arts and spectator sports	132	756	1,342	1,888	2,369
Museums, historical sites, zoos, and parks	21	146	271	375	447
Amusement, gambling, and recreation	387	2,091	3,556	4,765	5,732
Accommodation	182	532	620	776	1,122
Food services and drinking places	1,208	7,215	12,753	17,322	20,528
Repair and maintenance	272	1,426	2,462	3,376	4,103
Personal and laundry services	646	2,997	4,245	4,905	5,305
Membership associations and organizations	370	2,079	3,642	4,940	5,862
Private households	912	4,202	5,946	6,794	7,355
TOTAL FOR ALL INDUSTRIES =	17,420	91,351	150,517	198,186	236,775

FIGURE 3.11 – INDUSTRY EMPLOYMENT (%, $200/TON, FAD, 2015-2035)

The results for FAD are similar, although a couple manufacturing sectors (in chemicals, electrical capital, primary metal, and computers) have slightly more negative impacts to their employment compared to ATB and the baseline.

There are two concepts that help in reading the impacts to jobs in contrast to impacts on industry output. One is labor productivity, and the other is "factor substitution." Labor productivity is the amount of production associated with a unit of labor. For example, if an aircraft production line produces 100 units per year and each one of the planes sells for $200 million, the output of the line is $2 billion/year. In 2012, California's output in **aerospace products** approached $35 billion, so a line like this would be about 6% of the industry. Suppose the line employs 5,000 workers—this implies a labor productivity of $400,000, which is the $2 billion in output over 5,000 labor units. Technology and manufacturing firms tend to have high labor productivity. They rely on automation and capital, and some enterprises (such as petroleum refining and related activities) have millions of dollars in output for one worker. Other industries are more "labor-intensive" in the sense their production processes, their nature in the service sector, and their technology mean they require more workers to create the same amount of output. Sectors like this include **retail**, **construction**, **healthcare**, **education**, and **food service**—all industries primarily benefiting under a carbon tax swap. This is why the employment results are "higher" than that of GDP.

$$\textit{Output} = \textit{Labor Units} * \textit{Labor Productivity}$$

Another, lesser issue is factor substitution. To a limited degree, firms can substitute different input types for each other when designing an optimal way to produce a good or a service. For instance, imagine a wholesaler is relying on a software product to do its payroll. The firm finds the software, which is a type of capital requiring an investment, outdated and clunky, and requires a significant number of hours from HR staff to make it work. The company has an option to upgrade to a modern system; however, the cost of the new system (new capital) is prohibitive and potentially disruptive to other legacy products. Sticking with the old system and its implication for higher labor inputs is an implicit choice by the company to rely on labor before capital in this instance. The same process can happen in other industries between labor and capital, as well as between labor, capital, and fuel types (electricity, natural gas, and petroleum products). The PI$^+$ model intrinsically handles the substitution amid factors in the regular architecture of its structure. This means labor productivity can change in the model, and therefore an industry could lose some output in the simulations while still gaining some amount of employment. An industry like **construction**, with its variety of production processes, would be a chief candidate for factor substitution.

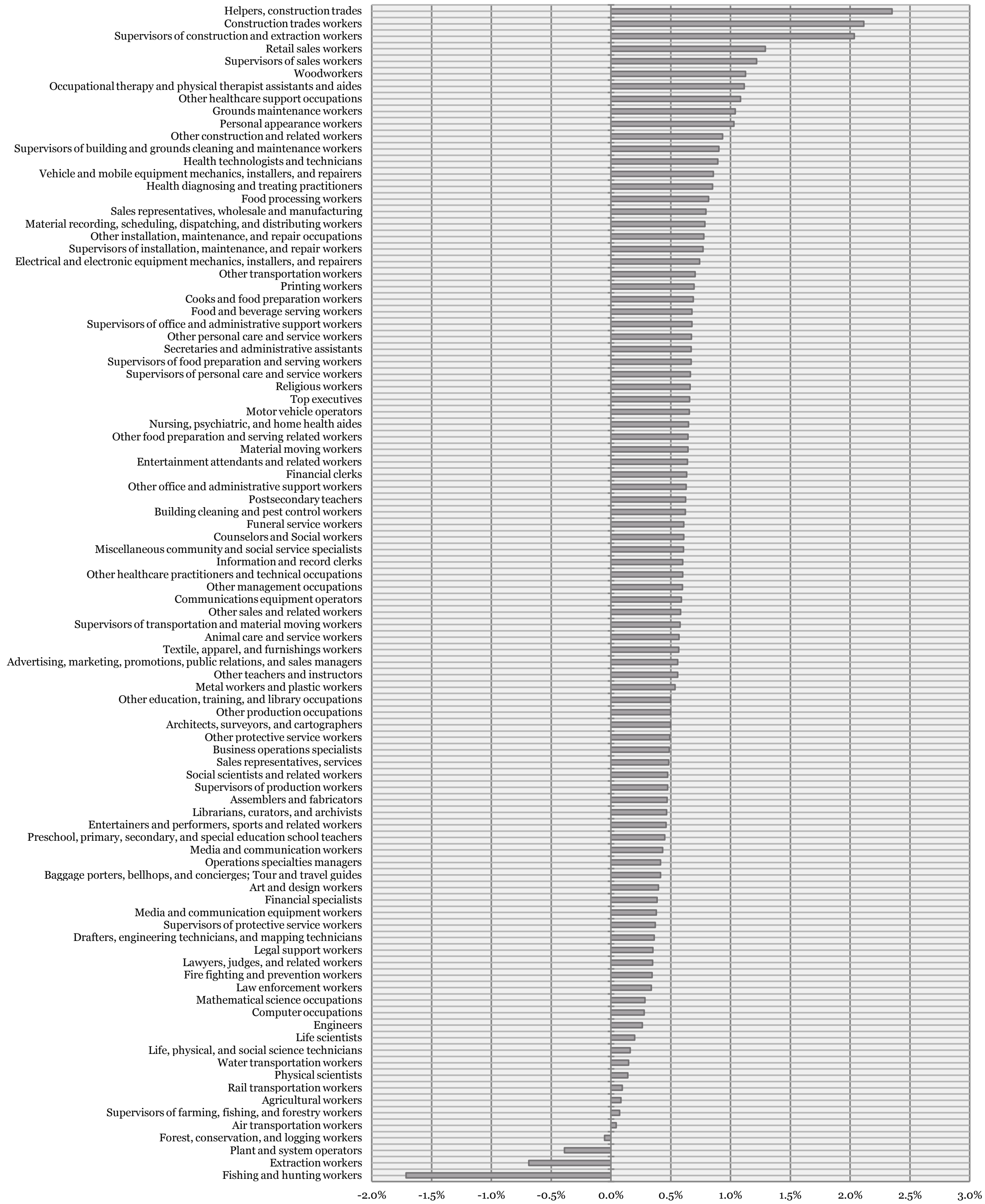
The greatest job gains in the simulations are in labor-intensive, service-based sectors like **construction**, **retail**, **food, drinking places**, **education**, and **healthcare**. The impact here is double owing to their labor-intensity and sensitivity to general tax cuts (ATB) and additions to consumer spending (FAD). The actual types of jobs arising out of environmental tax reform reflect this in the numbers above.

Figure 3.12 – Employment by Occupation ($200/ton, ATB)

SOC Occupations	2015	2020	2025	2030	2035
Top executives	297	1,729	2,917	3,743	4,231
Advertising, marketing, promotions, public relations, and sales managers	81	470	777	988	1,115
Operations specialties managers	149	805	1,303	1,653	1,883
Other management occupations	270	1,712	3,099	4,215	5,002
Business operations specialists	406	2,422	4,152	5,481	6,431
Financial specialists	317	1,667	2,652	3,303	3,707
Computer occupations	286	1,501	2,343	2,910	3,303
Mathematical science occupations	9	43	67	82	91
Architects, surveyors, and cartographers	25	142	240	324	398
Engineers	99	501	799	1,079	1,354
Drafters, engineering technicians, and mapping technicians	61	319	510	664	789
Life scientists	19	90	137	174	204
Physical scientists	14	52	75	103	138
Social scientists and related workers	22	121	206	274	326
Life, physical, and social science technicians	16	70	108	147	188
Counselors and Social workers	114	709	1,303	1,829	2,239
Miscellaneous community and social service specialists	69	445	828	1,168	1,426
Religious workers	2	15	29	42	52
Lawyers, judges, and related workers	60	301	466	559	594
Legal support workers	35	181	286	350	380
Postsecondary teachers	148	1,005	1,910	2,695	3,242
Preschool, primary, secondary, and special education school teachers	273	1,581	2,743	3,628	4,178
Other teachers and instructors	72	456	837	1,156	1,374
Librarians, curators, and archivists	20	119	208	276	317
Other education, training, and library occupations	108	653	1,169	1,586	1,863
Art and design workers	82	460	741	934	1,055
Entertainers and performers, sports and related workers	70	452	836	1,176	1,440
Media and communication workers	82	476	814	1,082	1,276
Media and communication equipment workers	33	184	306	400	469
Health diagnosing and treating practitioners	643	3,751	6,487	8,762	10,641
Health technologists and technicians	421	2,521	4,386	5,917	7,144
Other healthcare practitioners and technical occupations	13	75	131	180	219
Nursing, psychiatric, and home health aides	199	1,278	2,447	3,604	4,647
Occupational therapy and physical therapist assistants and aides	34	204	357	487	604
Other healthcare support occupations	337	1,859	3,076	3,999	4,729
Supervisors of protective service workers	16	86	139	174	193
Fire fighting and prevention workers	19	97	155	191	207
Law enforcement workers	69	356	568	702	763
Other protective service workers	166	967	1,625	2,122	2,480
Supervisors of food preparation and serving workers	79	535	998	1,387	1,658
Cooks and food preparation workers	261	1,746	3,237	4,483	5,344
Food and beverage serving workers	572	3,933	7,413	10,409	12,542
Other food preparation and serving related workers	110	728	1,359	1,893	2,263
Supervisors of building and grounds cleaning and maintenance workers	46	346	683	1,014	1,289
Building cleaning and pest control workers	486	2,743	4,509	5,845	6,903
Grounds maintenance workers	326	2,626	5,317	8,055	10,397
Supervisors of personal care and service workers	25	139	236	313	371
Animal care and service workers	44	277	476	631	747
Entertainment attendants and related workers	78	459	810	1,104	1,334
Funeral service workers	4	21	35	44	48
Personal appearance workers	188	1,026	1,568	1,928	2,212
Baggage porters, bellhops, and concierges; Tour and travel guides	10	56	99	137	168
Other personal care and service workers	418	2,521	4,342	5,863	7,159
Supervisors of sales workers	312	2,013	3,377	4,223	4,634
Retail sales workers	1,865	12,082	20,318	25,410	27,849
Sales representatives, services	217	1,169	1,883	2,357	2,650
Sales representatives, wholesale and manufacturing	280	1,734	2,926	3,759	4,256
Other sales and related workers	154	992	1,784	2,412	2,847
Supervisors of office and administrative support workers	208	1,205	2,020	2,603	2,988
Communications equipment operators	18	84	124	137	131
Financial clerks	506	2,891	4,832	6,221	7,137
Information and record clerks	711	3,991	6,579	8,428	9,693
Material recording, scheduling, dispatching, and distributing workers	501	2,991	4,866	5,952	6,414
Secretaries and administrative assistants	595	3,442	5,873	7,696	8,953
Other office and administrative support workers	534	3,142	5,363	7,000	8,084
Supervisors of farming, fishing, and forestry workers	1	6	10	14	16
Agricultural workers	18	110	194	259	299
Fishing and hunting workers	-1	-18	-37	-51	-61

Forest, conservation, and logging workers	1	-1	-5	-7	-9
Supervisors of construction and extraction workers	195	1,339	2,460	3,308	3,871
Construction trades workers	1,640	11,288	20,688	27,737	32,355
Helpers, construction trades	132	945	1,762	2,399	2,841
Other construction and related workers	58	367	647	852	984
Extraction workers	-14	-125	-198	-199	-147
Supervisors of installation, maintenance, and repair workers	60	395	709	952	1,116
Electrical and electronic equipment mechanics, installers, and repairers	79	489	838	1,086	1,243
Vehicle and mobile equipment mechanics, installers, and repairers	241	1,565	2,762	3,660	4,235
Other installation, maintenance, and repair occupations	404	2,709	4,964	6,775	8,067
Supervisors of production workers	45	244	379	467	515
Assemblers and fabricators	138	728	1,101	1,329	1,449
Food processing workers	67	427	727	920	1,015
Metal workers and plastic workers	132	745	1,191	1,505	1,704
Printing workers	35	192	286	324	325
Textile, apparel, and furnishings workers	89	464	653	751	790
Woodworkers	41	233	361	423	433
Plant and system operators	-21	-117	-162	-155	-115
Other production occupations	206	1,109	1,755	2,178	2,412
Supervisors of transportation and material moving workers	43	269	464	611	712
Air transportation workers	5	19	16	7	-1
Motor vehicle operators	445	2,774	4,828	6,363	7,389
Rail transportation workers	1	3	7	11	15
Water transportation workers	2	11	20	31	43
Other transportation workers	52	295	487	620	704
Material moving workers	497	3,019	5,085	6,524	7,403
TOTAL FOR ALL OCCUPATI/ONS =	**18,295**	**112,251**	**194,251**	**256,157**	**298,366**

FIGURE 3.13 – JOBS BY OCCUPATION (%, $200/TON, ATB, 2015-2035)



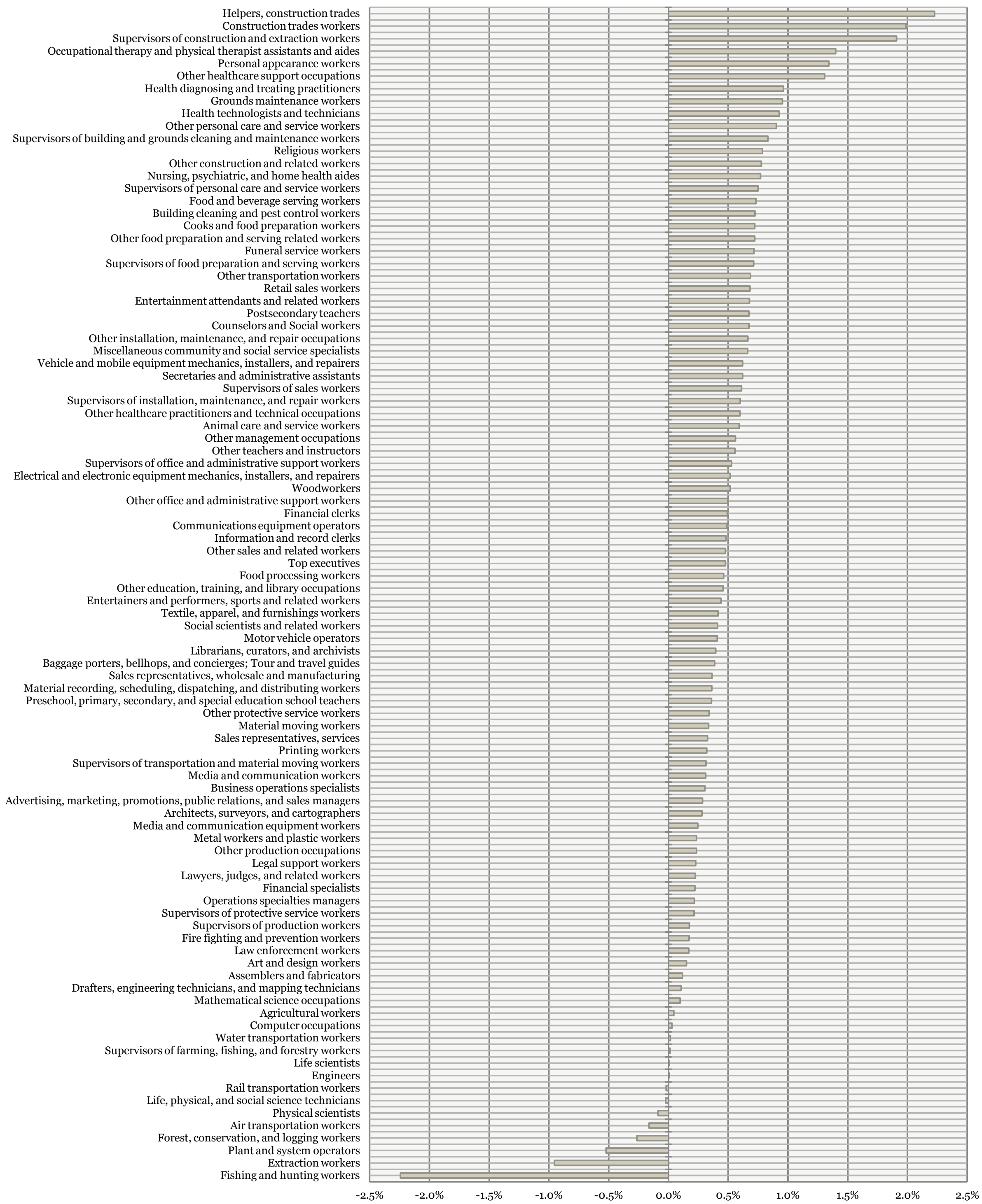
While industries might contract, occupations are more robust. Individuals are more able to shift and churn between industries with their same skill set to similar responsibilities that might be with another firm yet in a wholly dissimilar NAICS.

FIGURE 3.14 – EMPLOYMENT BY OCCUPATION ($200/TON, FAD)

SOC Occupations	2015	2020	2025	2030	2035
Top executives	277	1,314	2,071	2,643	3,075
Advertising, marketing, promotions, public relations, and sales managers	63	264	384	479	565
Operations specialties managers	139	500	656	784	934
Other management occupations	319	1,704	2,887	3,866	4,646
Business operations specialists	386	1,709	2,560	3,251	3,906
Financial specialists	347	1,226	1,507	1,639	1,807
Computer occupations	217	455	202	42	142
Mathematical science occupations	8	24	23	20	21
Architects, surveyors, and cartographers	23	98	137	167	204
Engineers	65	69	-49	-57	82
Drafters, engineering technicians, and mapping technicians	46	126	133	161	230
Life scientists	16	24	-2	-16	-7
Physical scientists	10	-12	-61	-86	-78
Social scientists and related workers	26	116	178	228	275
Life, physical, and social science technicians	13	5	-28	-39	-21
Counselors and Social workers	153	838	1,446	1,975	2,408
Miscellaneous community and social service specialists	94	521	909	1,246	1,513
Religious workers	3	19	35	48	59
Lawyers, judges, and related workers	67	238	300	322	331
Legal support workers	40	145	187	204	214
Postsecondary teachers	196	1,153	2,063	2,847	3,428
Preschool, primary, secondary, and special education school teachers	297	1,382	2,180	2,810	3,292
Other teachers and instructors	88	482	833	1,129	1,352
Librarians, curators, and archivists	22	108	176	229	267
Other education, training, and library occupations	125	637	1,062	1,414	1,684
Art and design workers	52	196	265	332	415
Entertainers and performers, sports and related workers	78	445	793	1,113	1,385
Media and communication workers	78	361	570	756	924
Media and communication equipment workers	27	121	190	254	318
Health diagnosing and treating practitioners	868	4,488	7,357	9,706	11,727
Health technologists and technicians	523	2,741	4,540	6,026	7,303
Other healthcare practitioners and technical occupations	16	80	131	175	214
Nursing, psychiatric, and home health aides	296	1,660	2,951	4,175	5,293
Occupational therapy and physical therapist assistants and aides	49	269	450	602	737
Other healthcare support occupations	470	2,346	3,716	4,730	5,543
Supervisors of protective service workers	16	60	80	92	102
Fire fighting and prevention workers	17	62	78	85	91
Law enforcement workers	64	225	285	314	338
Other protective service workers	171	761	1,120	1,387	1,626
Supervisors of food preparation and serving workers	107	614	1,068	1,440	1,707
Cooks and food preparation workers	343	1,964	3,413	4,601	5,460
Food and beverage serving workers	786	4,597	8,069	10,965	13,090
Other food preparation and serving related workers	161	896	1,538	2,055	2,420
Supervisors of building and grounds cleaning and maintenance workers	57	341	628	916	1,168
Building cleaning and pest control workers	750	3,512	5,303	6,553	7,553
Grounds maintenance workers	395	2,567	4,878	7,275	9,415
Supervisors of personal care and service workers	35	170	269	345	403
Animal care and service workers	58	309	497	642	757
Entertainment attendants and related workers	99	516	860	1,148	1,387
Funeral service workers	6	27	41	50	54
Personal appearance workers	299	1,443	2,075	2,440	2,702
Baggage porters, bellhops, and concierges; Tour and travel guides	14	60	93	120	147
Other personal care and service workers	697	3,655	5,907	7,661	9,104
Supervisors of sales workers	162	977	1,654	2,127	2,450
Retail sales workers	983	6,124	10,487	13,556	15,609
Sales representatives, services	242	948	1,274	1,462	1,626
Sales representatives, wholesale and manufacturing	163	815	1,305	1,692	2,007
Other sales and related workers	169	866	1,441	1,922	2,316
Supervisors of office and administrative support workers	211	1,001	1,557	1,973	2,309
Communications equipment operators	20	74	101	109	105
Financial clerks	528	2,426	3,719	4,680	5,462
Information and record clerks	776	3,483	5,217	6,480	7,544
Material recording, scheduling, dispatching, and distributing workers	268	1,376	2,185	2,730	3,108
Secretaries and administrative assistants	699	3,392	5,384	6,914	8,130
Other office and administrative support workers	554	2,659	4,196	5,383	6,336
Supervisors of farming, fishing, and forestry workers	1	1	1	3	5
Agricultural workers	13	58	100	143	179
Fishing and hunting workers	-2	-23	-49	-66	-78

Forest, conservation, and logging workers	0	-11	-24	-32	-34
Supervisors of construction and extraction workers	198	1,277	2,284	3,078	3,673
Construction trades workers	1,661	10,787	19,260	25,866	30,745
Helpers, construction trades	134	909	1,653	2,255	2,720
Other construction and related workers	58	320	534	694	813
Extraction workers	-16	-160	-268	-285	-233
Supervisors of installation, maintenance, and repair workers	56	312	541	734	892
Electrical and electronic equipment mechanics, installers, and repairers	69	353	572	743	884
Vehicle and mobile equipment mechanics, installers, and repairers	191	1,111	1,953	2,658	3,207
Other installation, maintenance, and repair occupations	428	2,410	4,186	5,704	6,969
Supervisors of production workers	29	99	127	160	202
Assemblers and fabricators	83	234	246	283	363
Food processing workers	41	235	401	522	604
Metal workers and plastic workers	92	352	488	630	790
Printing workers	23	95	128	142	148
Textile, apparel, and furnishings workers	90	370	466	521	564
Woodworkers	26	120	165	183	187
Plant and system operators	-21	-141	-212	-219	-181
Other production occupations	150	566	784	977	1,165
Supervisors of transportation and material moving workers	32	153	245	324	395
Air transportation workers	5	-4	-41	-74	-95
Motor vehicle operators	344	1,781	2,953	3,918	4,733
Rail transportation workers	0	-2	-3	-2	2
Water transportation workers	2	2	0	2	10
Other transportation workers	63	304	472	591	675
Material moving workers	337	1,632	2,584	3,341	3,977
TOTAL FOR ALL OCCUPATI/ONS =	**18,434**	**94,912**	**155,020**	**203,086**	**241,995**

FIGURE 3.15 – JOBS BY OCCUPATION (%, $200/TON, FAD, 2015-2035)



Both ATB and FAD display similar patterns where close to all occupations might have an increase over the baseline. Even the "worst" occupation for **fishing and hunting** loses less than 2.5% of its total jobs (against baseline) out to 2035.

Personal Consumption Expenditure (PCE)-Price Index

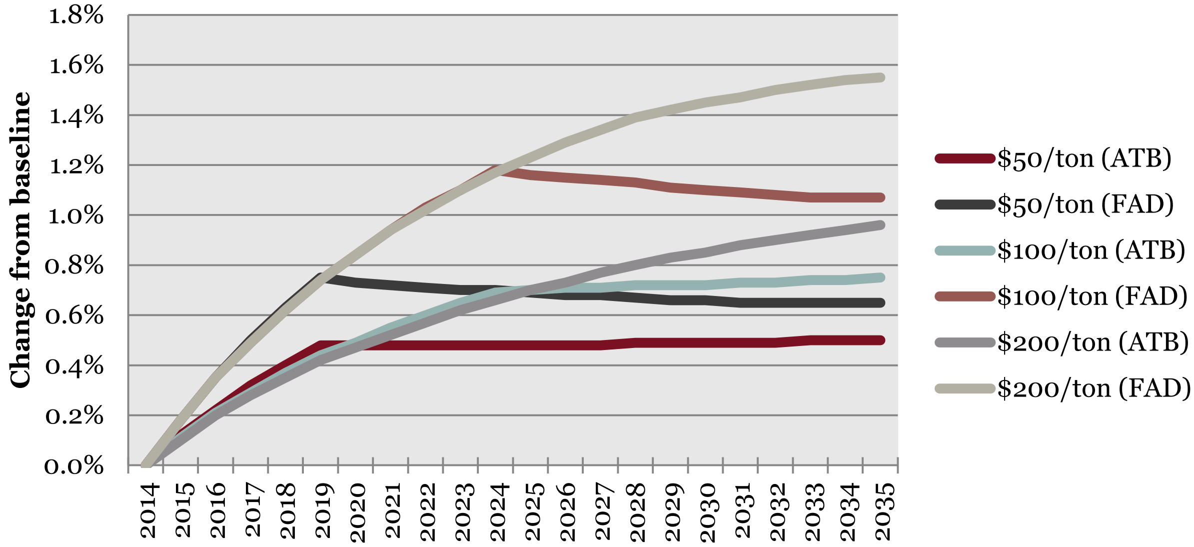


Figure 3.16 – The PCE-Index is the PI+ measurement of the average cost of living in a region. It is similar to the Consumer Price Index (CPI), which attempts to measure monetary inflation, though it is a more comprehensive, specific figure that includes major consumption items like fuel and housing—unlike the CPI. The figures are not cumulative—they represent a less than 2% change in the cost of living relative to the baseline, a vector "one-time" adjustment upwards, and not a change in the rate.

PCE-Price Index by Income Quintile

$200/ton, ATB	2015	2020	2025	2030	2035
Lowest 20%	0.11%	0.48%	0.71%	0.86%	0.98%
Low-Middle 20%	0.11%	0.49%	0.72%	0.88%	0.99%
Middle 20%	0.11%	0.48%	0.71%	0.87%	0.98%
High-Middle 20%	0.10%	0.47%	0.69%	0.84%	0.95%
Highest 20%	0.10%	0.45%	0.66%	0.81%	0.91%

$200/ton, FAD	2015	2020	2025	2030	2035
Lowest 20%	0.18%	0.85%	1.25%	1.47%	1.57%
Low-Middle 20%	0.18%	0.86%	1.26%	1.48%	1.58%
Middle 20%	0.18%	0.85%	1.25%	1.47%	1.57%
High-Middle 20%	0.18%	0.83%	1.22%	1.43%	1.53%
Highest 20%	0.17%	0.81%	1.19%	1.40%	1.49%

Figure 3.17 – One concern with carbon taxes is the potential to injure low-income families disproportionally because of their reliance on fossil fuels. When examining the simulations, however, the difference in the impact to the cost of living by quintile is negligible. Higher incomes mean larger homes, more vehicles, and more travel, all of which increases their energy consumption (and therefore their carbon tax). The sales tax reductions in the ATB scheme allow some relief to low-income earners, as well.

Changes in Energy Prices (from Baseline)

PI+ has seventy-five consumption categories ranging from cars to nondurable goods, to food and fuels, transportation, insurance of all descriptions, hospitals, personal services, and tourism. Changing these (fuel prices upwards for the carbon tax, and items eligible for the California state sales tax downwards for the revenue-neutrality) is how the model simulates the direct impact of environmental tax reform on the residential sector of the economy. Importantly, **these are adjustments from the baseline and one-time, not a forecast of anticipated growth rates for energy prices in California sometime in the future.** This shows the impact of the tax, which might actually be against a baseline of declining prices for energy due to the newfound development of nonconventional fossil sources and efficiency gains in the electricity markets from new renewable power, storage, or other future technologies.

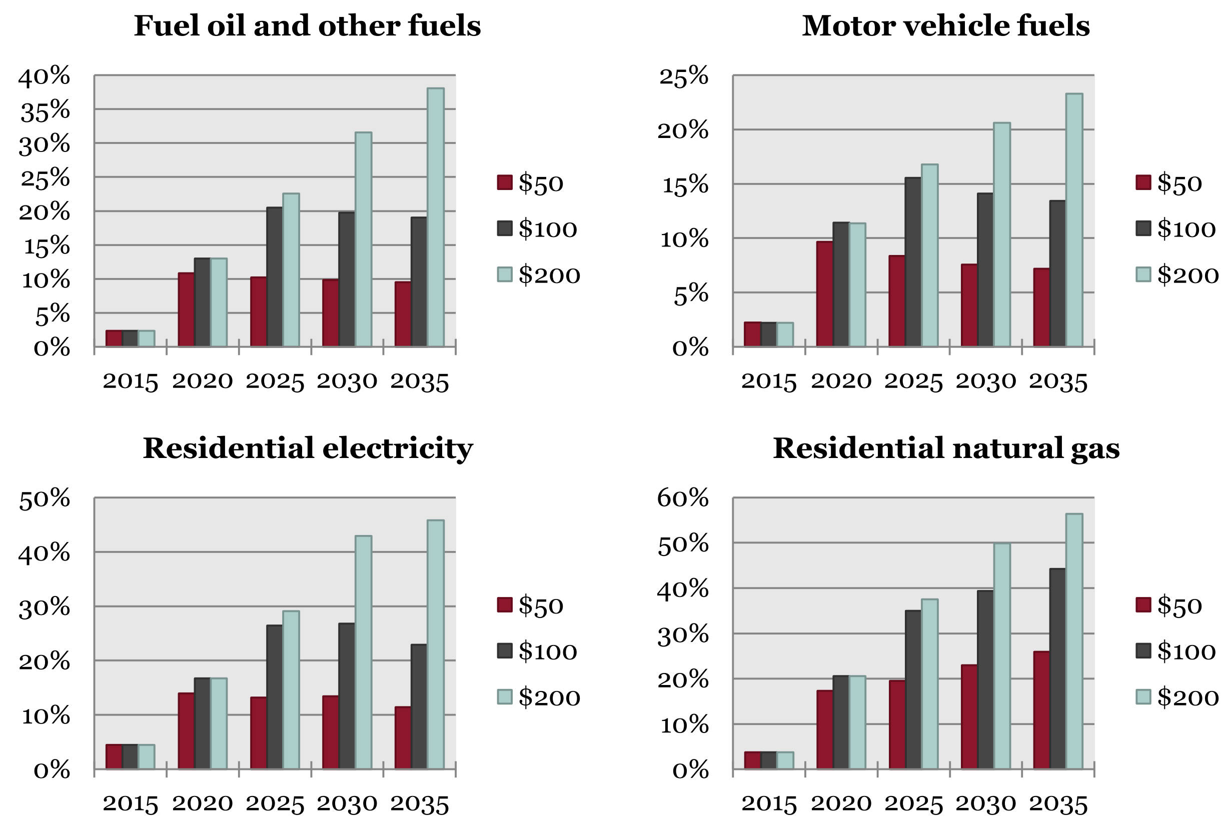
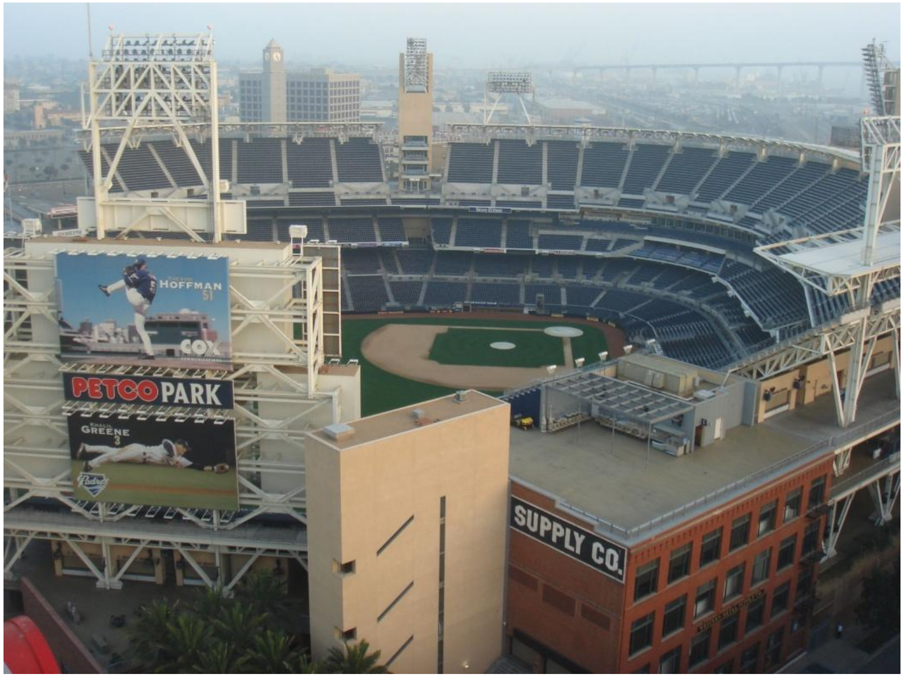


Figure 3.18 – These four categories show the effect on residential prices for energy from carbon tax. The effect between the ATB and FAD approaches are very similar; therefore, the average between the two is what is above. PI+ and CTAM technically report separate retail and wholesale prices for energy in the commercial and industrial sectors, but these are, again, not too dissimilar from the impact to the residential sector, so the numbers above approximate impacts to businesses.



ADDITIONAL REAL DISPOSABLE PERSONAL INCOME[33] (ANNUAL)

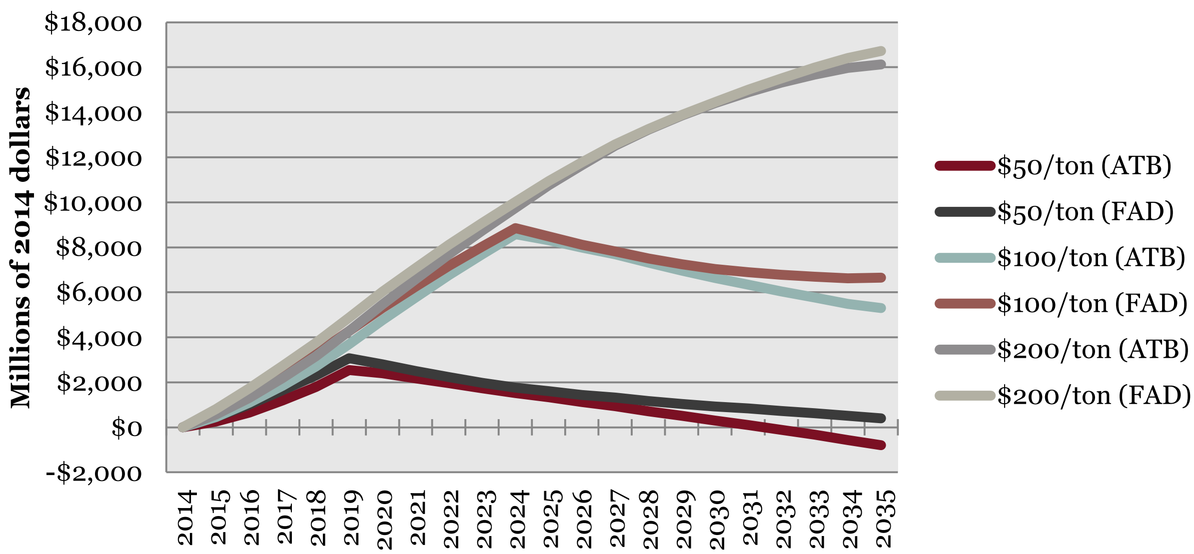


Figure 3.19 – The above is the aggregate impact to after-tax income for California households because of the carbon tax and recycling. A few factors drive the trends: the quality of the labor market (changing wages and number of jobs), changes to the cost of living (the PCE-Index above), GDP growth, the size of annual dividend, and the population of the state. The impact is a net positive for most of the cases.

33 PI+ calculates real disposable personal income (RDPI) in a comprehensive manner as total, after-tax income received by households, including wages and salaries, investment returns, rents, transfer receipts from all levels of government, adjustments for costs of living, and minus all taxes

ADDITIONAL REAL DISPOSABLE INCOME (CUMULATIVE)

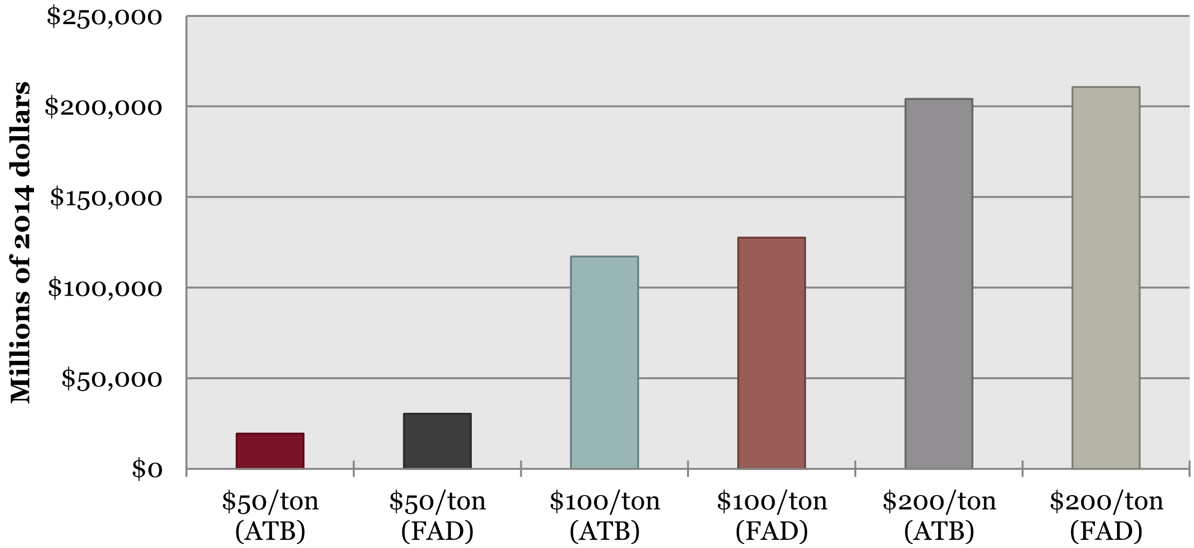
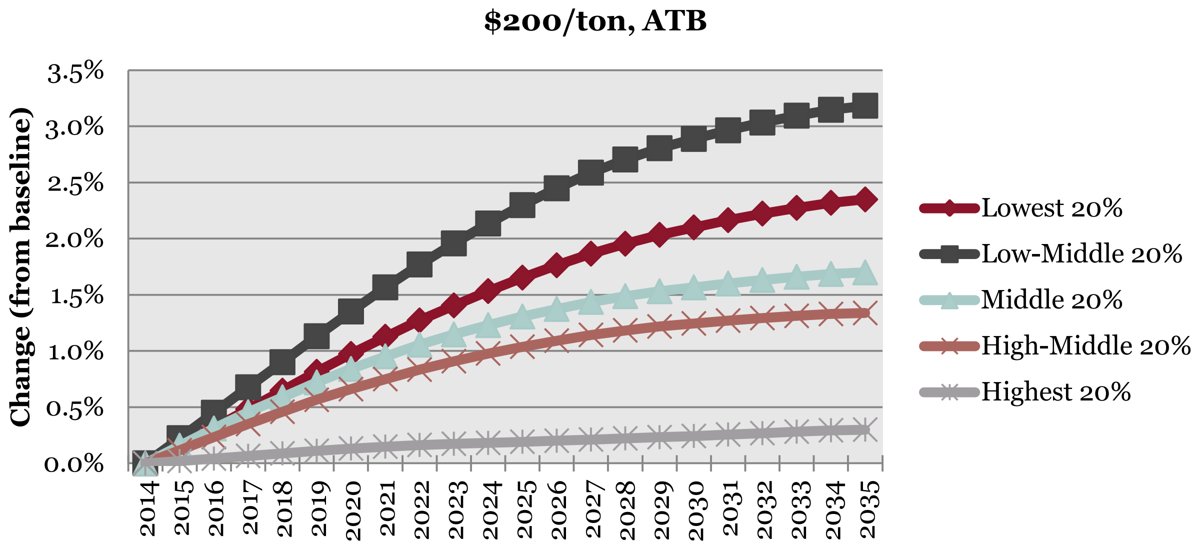


Figure 3.20 – While ATB has an advantage in lowering business costs and taxes in a complementary manner with carbon tax, FAD has superiorities in creating a greater boost to real incomes. The state economy is larger in the former, but actual paid wages to Californian households are more momentous for the latter. Complicating this issue is the change in population and the potential distributional impacts of the policy.

INCOME BY QUINTILE



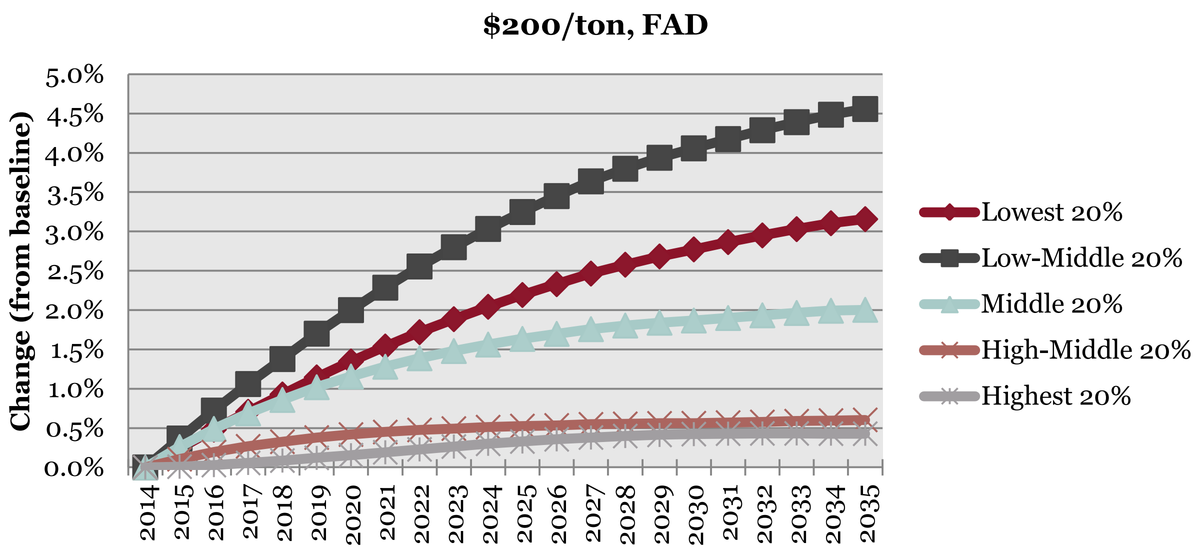
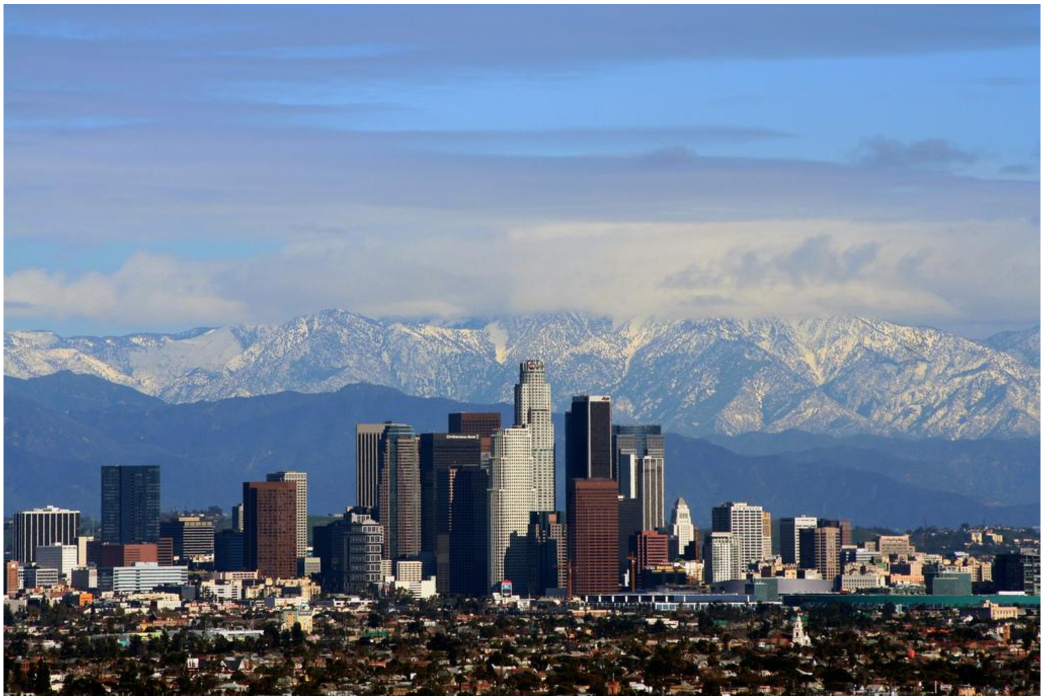


Figure 3.21 – The two graphs relate the $200/ton simulation (to show the maximum impact) and by 20% increments. One surprising aspect of carbon tax simulation is its propensity to generate jobs and income in the lowest 60% of households in the state. Many of the jobs created through environmental tax reform and revenue-neutrality are in the service sector, which tends to be steady employment for the middle class and dependable income. Many of these families spend a larger share of their money on sales tax-eligible goods and have children, which increases their potential annual dividend. In contrast, the top 40% tends to work in technology and skilled trades that have less of a change in ATB and FAD. They also spend more of their money on services and investments, which means a sales tax cut does them less aid.



CHANGE IN POPULATION (FROM BASELINE)

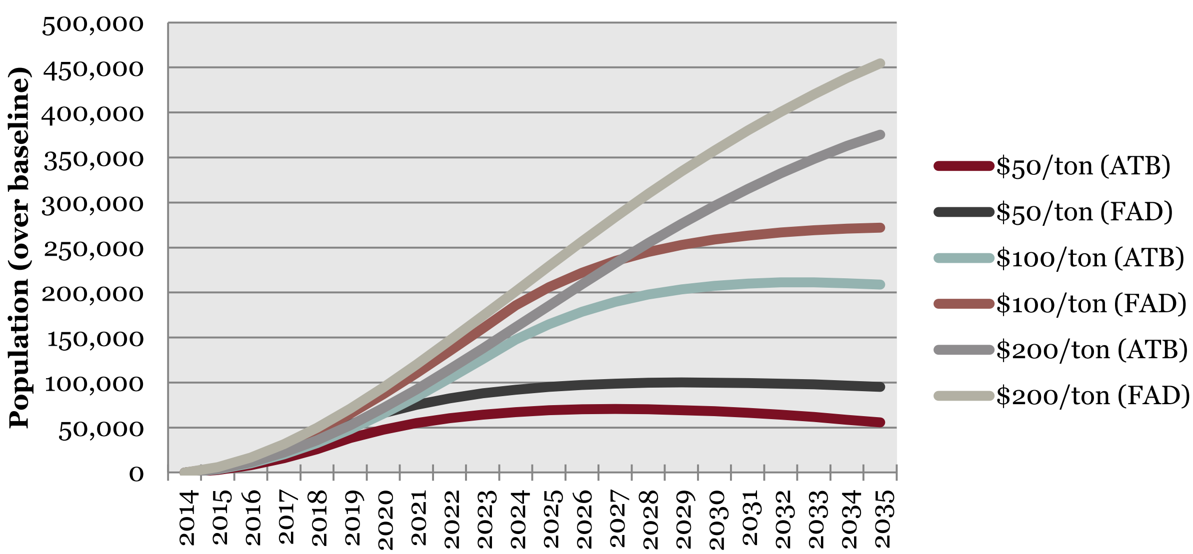


Figure 3.22 – The state's population increases in all simulations due to a number of factors. Those include the improved availability of jobs on the labor market, lower taxes (under ATB), and future prospects for the annual dividend (under FAD). The difference in population under the two recycling options is due to their divergent impacts on these factors—ATB generates jobs and GDP and lowers taxes, but FAD has a similar amount of jobs and higher personal income. Households tend to look at the latter two when making location decisions, which thereby draws them into California at a slightly higher rate for the FAD scenario than inside of ATB.

ACROSS-THE-BOARD V. FEE-AND-DIVIDEND

As demonstrated in the results, each of these options has strengths and weaknesses in how to use the money coming into the state budget from under the new carbon tax. This subsection discusses them and compares how they rate on various metrics—and against the baseline, to give goodly sense of sensibility and of proportion. All of the data below is for the $200/ton carbon tax to use the maximum case in making comparisons, though the aggregate results are similar for any other tax level.

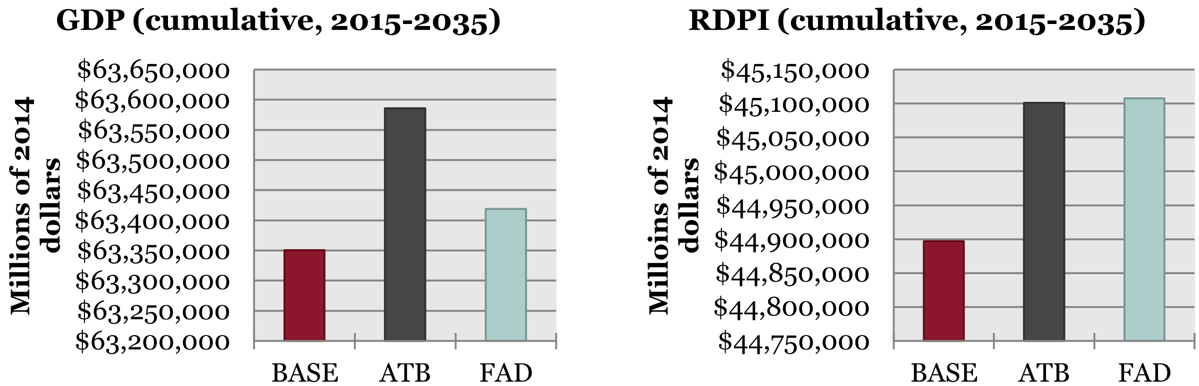


Figure 3.23 – This shows the total GDP and real disposable personal income over the simulation period for the two options chosen here and the baseline. ATB generates a larger economy (as measured by GDP) via investments and exports, while FAD slightly increases the quantity of household income from 2015 out to 2035.

LABOR SHARE OF INCOME[34]

BASE = 70.87%; ATB = 70.93%; FAD = 71.13%

All portions of the economy would pay a robust, comprehensive carbon tax (including commercial and industrial enterprises), which means **returning the revenues only to households would increase the labor share of GDP**. However, with private industry less competitive under FAD than under ATB, the higher share is of a smaller economic "pie," which means the difference in impacts to absolute household income between the two is minimal. Population increases in both, though more migrants come into the state with FAD than ATB. The impact to per capita GDP and income thus is rather close to zero. Improvements in individual incentives to move to a region (such as lower unemployment rates, higher pay, cheaper cost of living) mean new migrants will "rush" into the area to balance the market. They fill jobs, take wages, and thereby return California closer to national averages. This keeps the per capita "return" on work and living in the state much the same between scenarios.

[34] Calculated as real disposable personal income divided by gross domestic product

CARBON TAX REVENUES (ANNUAL)

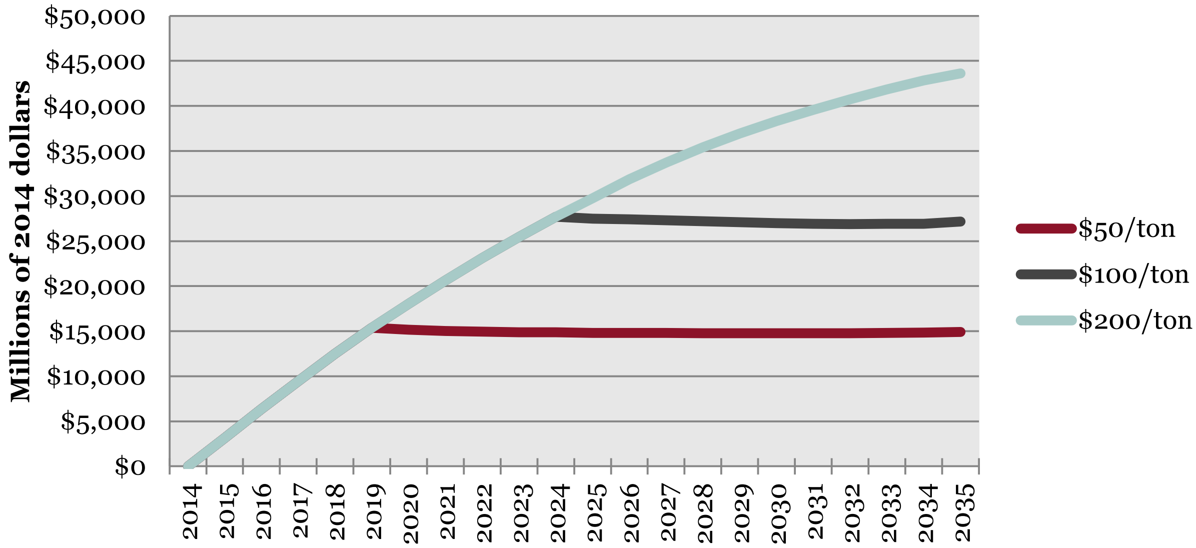


Figure 3.24 –The revenues out of CTAM increase during the $10/year phase-in period, though they are actually rather stable once they achieve maximums. This is because of the "smoothness" of long-term macroeconomic forecasts (nobody tries predicting the business cycle in the 2020s or 2030s), growth in state population and GDP, and increased energy efficiency—the net of the two canceling one and other out.

CARBON TAX REVENUES (CUMULATIVE)

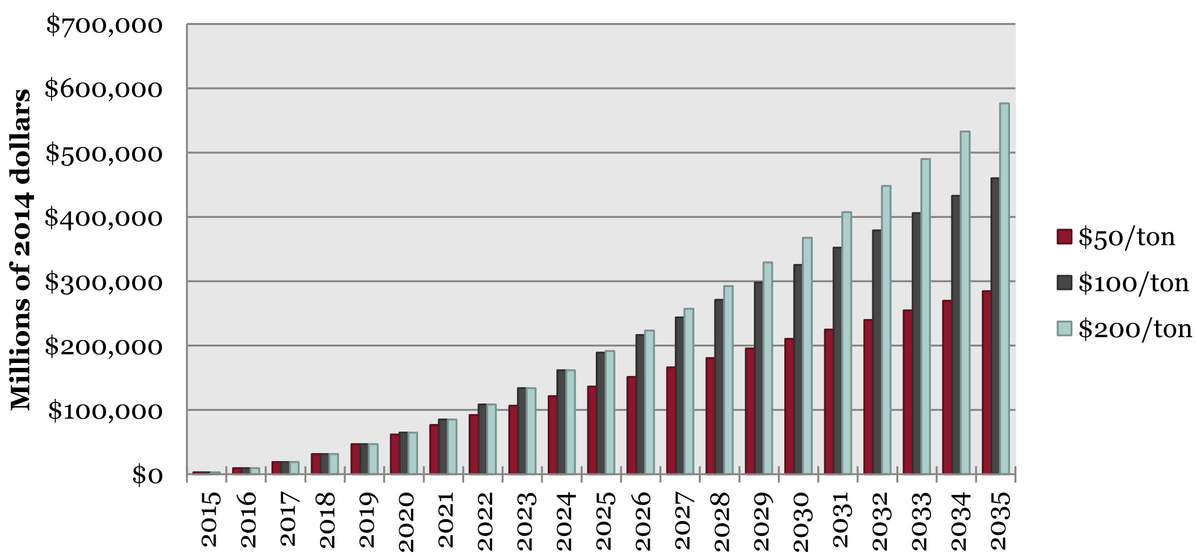


Figure 3.25 – This shows the total summed over time. Results for both ATB and FAD are very similar. Hence, only the average of the two methodologies merits inclusion on the state revenue impacts and the impact on carbon dioxide emissions out of CTAM.

CARBON TAX PAID BY SECTOR (NON-GOVERNMENT)

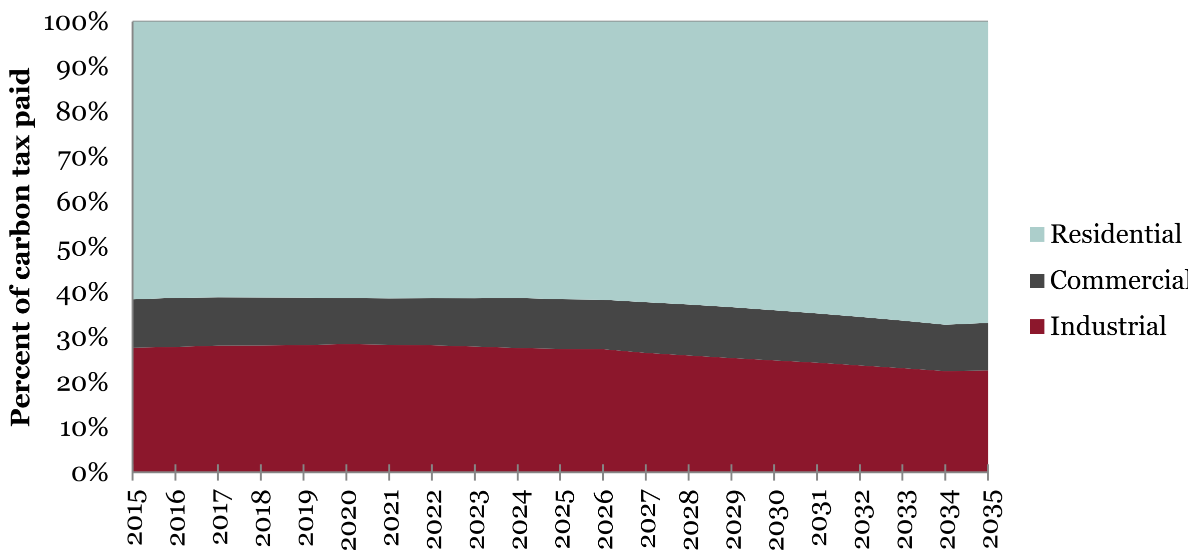


Figure 3.26 – The area chart shows the share of carbon taxes paid into the state by broad sectors of the economy (counted here as residential households, commercial enterprises, and industrial operations). Households pay the lion's share of the carbon fee due to their reliance on motor gasoline. Gasoline for cars is as much as 40% of the carbon tax (and carbon dioxide) in some years in the state. This graph shows that the ATB share of funds returned to business, which is somewhere between 25% and 50% with lowered corporation taxes and the $4 billion/year renewable fund, is roughly similar to the initial share paid by private industry in carbon pricing.

FORECASTED ANNUAL DIVIDEND CHECK (PER CAPITA)

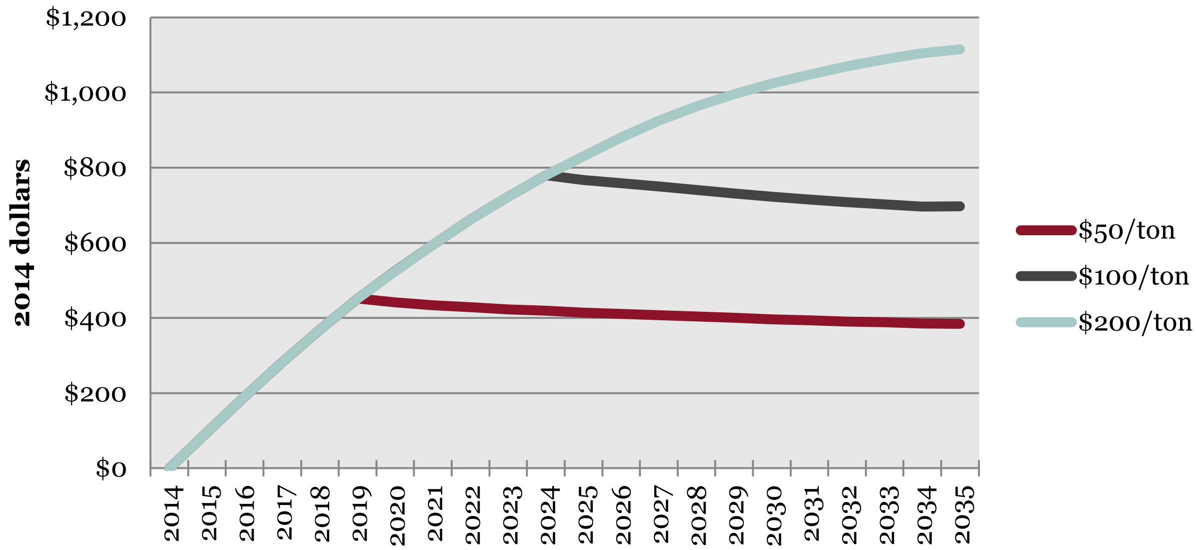


Figure 3.27 – This shows the estimated size of the carbon dividend paid to Californian households based on a few parameters. It involves taking the annual tax revenues from CTAM and dividing them by the population forecast in the simulations of PI+. The Alaska Permanent Fund has a list of requirements for their dividend—this includes at least a year of state residency and no felony convictions.[35] *Results assume an 85% eligibility rate in the state. Approximately 35 million people relocate in the United States every year,*[36] *and more than 5.75 million Americans have a felony record.*[37] *Further data reveals California is not much different from national averages.*[38] *The two together give a rough estimate of 85% eligibility in California under the Alaska criteria, though Sacramento is free to pick its own.* ***Quantities above represent an annual rebate that scales with family size.*** *To give one example, in 2020, a family of four could receive $2,000 (in 2014 dollars) inside their annual check.*

35 "Eligibility Requirements," *Alaska Department of Revenue*, <https://pfd.alaska.gov/Eligibility/EligibilityRequirements>

36 "Figure A-1. Number of Movers and Mover Rate: 1948-2013," *U.S. Census*, <http://www.census.gov/hhes/migration/data/cps/historical/Figure%20A-1.1.png>

37 Michael McLaughlin, "Felon Voting Laws Disenfranchise 5.85 Americans with Criminal Records," *Huffington Post*, July 12, 2012, <http://www.huffingtonpost.com/2012/07/12/felon-voting-laws-disenfranchise-sentencing-project_n_1665860.html>

38 "State-to-State Migration Flows," *U.S. Census*, <https://www.census.gov/hhes/migration/data/acs/state-to-state.html>

CARBON DIOXIDE EMISSIONS (ANNUAL FORECAST)

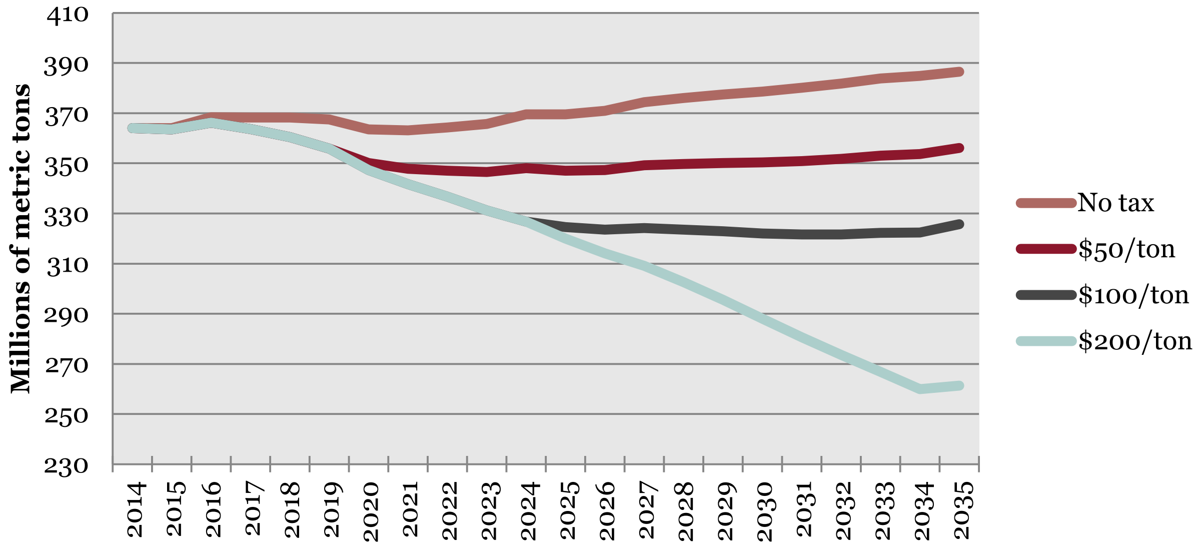


Figure 3.28 – This is the carbon portion and environmental impact of tax reform. The difference between ATB and FAD is minor—hence, only the average between the two is present. California emits between 350 million and 410 million metric tons per year (depending on fluctuations in weather, GDP growth, plant shutdowns, and other factors).[39] *The data and assumptions for this forecast come out of the Annual Energy Outlook (AEO) from EIA,*[40] *which serves as the baseline for energy consumption and prices in CTAM and PI+. With no carbon ax and assuming no federal law, EIA has California's emissions slowly increasing in the 2020s and early 2030s. The incentives behind a carbon tax would encourage this to decline. Additionally, CTAM analyses the demand for electricity and does not include any power switching beyond what is already present in the AEO baseline. California right now generates much of its power from gas, nuclear plants, and hydroelectric dams, however, which would make this effect muted compared to the central and southern parts of the United States.*

[39] "State Energy CO2 Emissions," *U.S. Environmental Protection Agency*, <http://epa.gov/statelocalclimate/resources/state_energyco2inv.html>
[40] "Annual Energy Outlook 2013," *U.S. Energy Information Administration*, <http://www.eia.gov/forecasts/aeo/IF_all.cfm>

CARBON DIOXIDE EMISSIONS (CUMULATIVE DIFFERENCE)

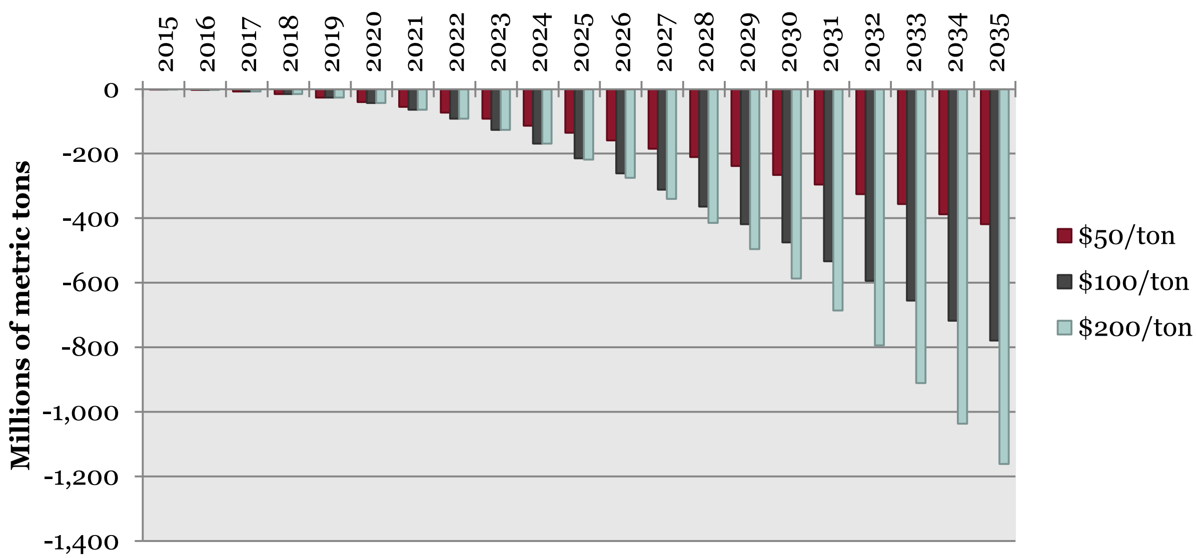


Figure 3.29 – This is the same information as the previous figure now presented as the cumulative savings over time. California emits more carbon dioxide than any other state. These figures show reduced emissions from the Golden State by as much as a billion tons.[41] Do notice, as well, the marginal improvement to savings declines at higher levels of taxation. The first $50/ton saves over 400 million tons. Multiplying that by four would give you 1.6 billion tons, though CTAM reports only 1.1 billion tons of savings for a $200/ton tax. This is because energy consumers will adopt the most obvious efficiencies first—"low-hanging fruit"—and decreasing emissions more and more becomes difficult the more you do it. This does not reduce the effectiveness of the policy; however, it does mean the response in demand from consumers is less under higher-and-higher carbon taxes than the lower initial rates.

[41] 2,204,622,620,000 pounds, the equivalent to 112,480,746,000 gallons of gasoline, which is approximately 80% of current annual consumption in the United States

Carbon Dioxide Emissions (1990 Benchmark)

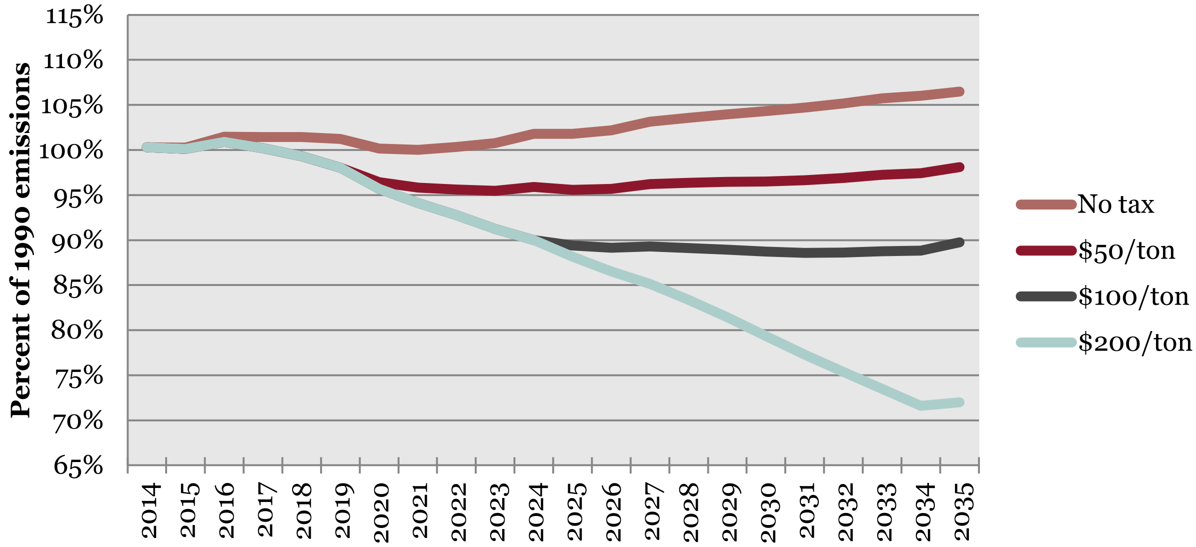
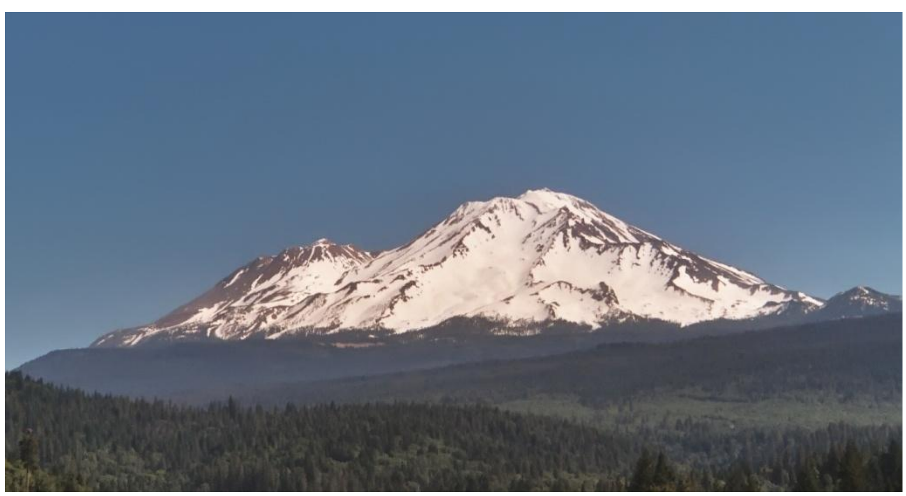


Figure 3.30 – This shows California's "progress" in terms of its current and forecasted emissions relative to levels in 1990. The 1990 benchmark is arbitrary from an economic and environmental standpoint, but it is a common rule of thumb given its importance in the Kyoto Protocol and its goals for reducing emissions by keeping them at or below the amounts from 1990.[42] *In 1990, California emitted 363 million metric tons of carbon; in 2011, the most recent year of historical data from EPA, California emitted almost exactly the same amount at 360 million metric tons. The carbon tax helps to "bend the curve" downwards in the future, with $100/ton bringing 90% of 1990 emissions by 2025 and $200/ton potentially meaning a dip below 75% of Kyoto Protocol permitted emissions by the end of the NEMS analysis period in 2035.*



[42] "Kyoto Protocol," *United Nations Framework Convention on Climate Change*, <https://unfccc.int/kyoto_protocol/items/2830.php>

ASSEMBLY BILL 32 (AB32)

In 2006, California became unique in the United States for passing the Global Warming Solutions Act, otherwise known as AB32 legislatively and in terms of its final programs. AB32 implements a "cap-and-trade" system in the state, which differs from a carbon tax principally in means—not goals. California is not the only state or region working on cap-and-trade. The Regional Greenhouse Gas Initiative (RGGI) is also a cap-and-trade, which covers nine Northeastern states (with Pennsylvania and three Canadian provinces as "observers").[43] RGGI, however, covers only emissions from the generation of power from facilities over 25 megawatts in capacity—AB32 will cover not only electrical power generation (starting in 2013 and 2014), but also natural gas and vehicle fuels (out to 2020). This covers 85% of emissions from California. **Retail carbon taxes, as modeled, would not compete with the implementation or goals of AB32, but rather would enhance them by serving as an enforcement mechanism.** A carbon tax and a cap-and-trade approach the same problems from two different sides.[44] In essence, a carbon tax chooses a price for emissions based on carbon content and allows the price incentives of higher energy costs to "pick" a new quantity of emissions out on the market. Cap-and-trade allows the statehouse or Congress to choose a specific quantity of emissions and, in an auction, markets "pick" the allowance price necessary to incentivize consumers to the point they only would emit that amount.[45] Emissions decline either way; one selects a price and arrives at a quantity, and one selects quantity and then settles at a price. Consider simplified supply and demand curves for energy and the mutual interactions of these two policies:

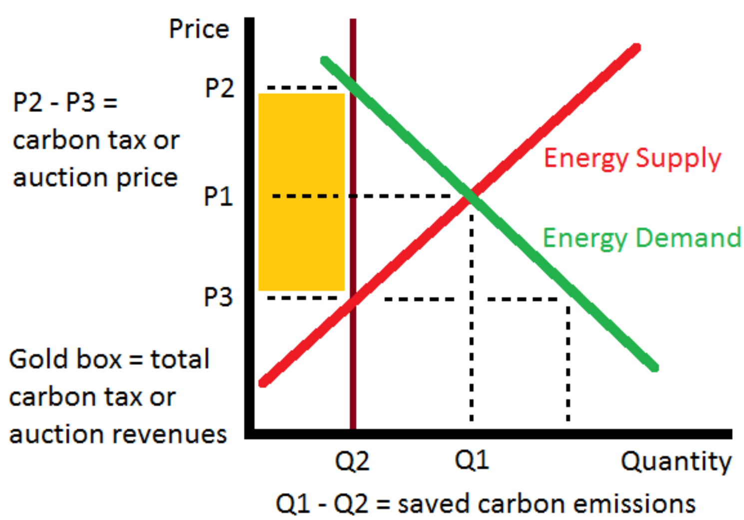


Figure 4.1 – The supply and demand curves to the left show the microeconomic foundations of cap-and-trade against the carbon tax. Carbon taxes set the difference between P2 and P3 and allow the market to find a new Q2; cap-and-trade sets Q2 and allows the market to find the necessary auction price (still P2 minus P3) to incentivize consumers to cut back. The area of Q2 times P2 minus P3 is the total quantity of carbon tax or auction revenues paid.

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43 "Welcome," *Regional Greenhouse Gas Initiative*, <http://www.rggi.org/>

44 "Climate Policy Memo #1: Cap-and-Trade v. Taxes," *Pew Center on Global Climate* Change, March 2009, <http://www.c2es.org/docUploads/Policy-Memo-1-CapTradevTax.pdf>

45 For more explanation, please see, "Carbon Tax v. Cap-and-Trade," *Environmental Economics*, <http://www.env-econ.net/carbon_tax_vs_capandtrade.html>

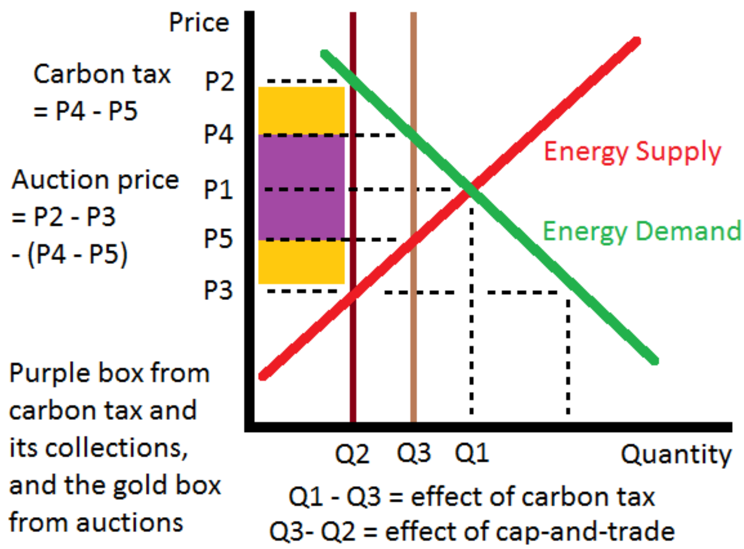

Figure 4.2 – This illustrates the situation of an "incomplete" carbon tax. The tax is enough to incentivize emissions of Q3. This is shy of the eventual goal of Q2, so the cap-and-trade auction price adds the difference. The auction brings in the gold area (the auction price times Q2) while the carbon tax brings in the purple area in the middle of the block. Thus, final energy prices change by P2 minus P3 and final emissions fall to Q2, which is the same as before.

Cap-and-trade and carbon taxes can be symbiotic, and, as shown above, both interact to further the goals of reducing emissions—which is anything less than Q1 in *Figure 4.1* and *Figure 4.2* (eventually Q2 in each). Lawrence H. Goulder and Andrew R. Schein of Stanford University described this as, "If covered firms are cost-minimizing, they will reduce emissions up to the point where, at the margin, the costs of emissions abatement equals the emissions price. **The two policies thus tend to bring about equality of marginal abatement**."[46] They also advocated "hybrid" systems where a combination of carbon taxes, cap-and-trade, and price floors or caps for auction prices would give policymakers the most options for avoiding price volatility, adjusting to the business cycle and new technological developments, and interfacing with regional- or national-level pricing schemes.[47] Imagining a situation where AB32 and a carbon tax are active at the same time is not hard. For instance, presume a wholesaler was looking to sell fuel this quarter, but AB32 required it to purchase permits along with the fuel. Prior to the auction, however, a retail carbon tax would reduce the demand at the pump for gasoline and other fuels in the first place, meaning the wholesaler would need a reduced quantity of allowances. Many wholesalers across the state would face the same situation, which implies a reduction in demand at the auction and a correspondingly lower permit price (under AB32). Such a system would spread out the "direct" impact of policy meant to reduce emissions, and it would give options for policymakers to modify their plans. Furthermore, households and firms involved in this paradigm would receive tax relief elsewhere, leaving the net impact, at the macro-level, on their cost of living and cost of doing business totality at a minimum.

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[46] Lawrence H. Goulder and Andrew R. Schein, "Carbon Taxes v. Cap-and-Trade: A Critical Review," *Stanford University*, August, 2013, p. 4, <http://www.stanford.edu/~goulder/Papers/Published%20Papers/Carbon%20Taxes%20vs%20Cap%20and%20Trade%20-%2015%20Aug%20%2713.pdf>

[47] Ibid., p. 36, **emphasis added**

REGIONAL ECONOMIC MODELS, INC. (REMI)

REMI is an economic and policy analysis firm specializing in services related to regional modeling. REMI's headquarters is in Amherst, Massachusetts, though its research and consulting practice reside in Washington, DC. It first began as a research project by a professor at the University of Massachusetts-Amherst named George Treyz. In the late 1970s, Dr. Treyz developed an economic model to assess the impact of expanding the "MassPike" (I-90 through central Massachusetts from Boston to Worcester, Springfield, and connecting to the New York State Thruway in Albany out to Syracuse, Rochester, and Buffalo). He generalized the methodology to all counties and incorporated the firm in 1980. REMI provides data, software, support, and issue-oriented consulting across the country and the globe. There are users of the REMI data, models, or studies in every state (and the District of Columbia) and foreign nations in North America, Europe, Asia, and the Middle East.[48] Typical REMI clients work for state and local governments, the federal or regional agencies of an area, consulting firms, universities, trade associations, labor unions, or non-profits. REMI's list of clients in California is extensive. It includes California Department of Finance (CalFinance),[49] California Department of Resources, Recycling, and Recovery (CalRecycle),[50] South Coast Air Quality Management District (SCAQMD),[51] Southern California Association of Governments (SCAG),[52] Los Angeles County Metropolitan Transit Authority (LACMTA),[53] and Los Angeles World Airports (counting LAX, the sixth-busiest airport in the world).[54] Others include the Sol Price School of Public Policy (at the University of Southern California)[55] and the Office of the Comptroller of the city and county of San Francisco.[56] By itself, California is one of the ten largest economies in the world (ahead of South Korea and behind Italy), and REMI has always held an important part in its policymaking discussion.

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[48] "Clients," *REMI*, <http://www.remi.com/clients>

[49] "Major Regulations," *California Department of Finance*, <http://www.dof.ca.gov/research/economic_research_unit/SB617_regulation/view.php>

[50] "Cost-Benefit Analysis and Distributional Impacts of Used Oil Management Policy Scenarios," *California Department of Resources, Recycling, and Recovery*, July 30, 2013, <http://www.calrecycle.ca.gov/Publications/Documents/1466%5C20131466.pdf>

[51] Sue Lieu, Shah Dabirian, and Greg Hunter, "Socioeconomic Report 2012," *South Coast Air Quality Management District*, <http://www.aqmd.gov/aqmp/2012aqmp/Final/FinalSocioeconomicReport.pdf>

[52] Marlon G. Boarnet, Wallace Walrod, and Scott Nystrom, "Economic Benefit from Accelerating Transportation Infrastructure Investment," *Southern California Association of Governments*, <http://economy.scag.ca.gov/Economy%20site%20document%20library/2012EconomicSummit_BenefitsTransInvest.pdf>

[53] "State Route 138 Avenue 'T' to Route 18," *Los Angeles County Metropolitan Transit Authority*, <http://media.metro.net/projects_studies/cmia/images/P%20138T%20Web.pdf>

[54] "Economic Impacts of Los Angeles International Airport and the LAX Master Plan Alternatives on the Los Angeles Regional Economy," *Hamilton, Rabinovitz, & Alschuler*, January 2001, <http://ourlax.org/docs/draft_eir_NE/T05_LR.pdf>

[55] Cristy Lytal, "Going Green Good for the Economy," *University of Southern California*, <http://priceschool.usc.edu/newsletter/march-2010/climate/>

[56] Ted Egan, "The Economic Impact of San Francisco's Nightlife Businesses," *San Francisco*, March 5, 2012, <http://sfcontroller.org/Modules/ShowDocument.aspx?documentid=2953>

PI+

REMI used a 1-region, 70-sector PI+ model of the state of California to commence this analysis in concert with a California-level CTAM model ("CACTAM"). PI+ is the software branding of the "base" REMI model for economic and demographic modeling. It is the foundation for other products, which include such "expansion packs" as TranSight (for transportation analysis), Tax-PI (for deeper budgetary analysis), Metro-PI (for analysis of sub-county geographies), and eREMI (an Internet-based tool for data analytics and forecasting). California has fifty-eight counties, and they range in population from about 10 million (Los Angeles County) to just under 2,000 (Alpine County, the county seat at the little town of Markleeville, California). PI+ can break the state down into any county or any set of counties, though this analysis concentrates on the statewide impact to all the counties—an agglomeration of 58-regions into a lonely 1-region. The 70-sectors in these simulations approximate 3-digit NAICS.[57] This provides a strong balance between depth of study (a 23-sector model does not break out the manufacturing industries, for

[57] "Industries for PI+ v. 1.4 Models," *REMI*, <http://www.remi.com/download/documentation/pi+/pi+_version_1.4/NAICS_Industries_for_PI+-Hierarchical_v1.4.pdf>

example) and quality (a 160-sector model has more issues with data suppression at the county- or state-level). The result is a computerized, multiregional, and multiyear model within a Microsoft Windows-based graphic user interface (GUI) of the state's economy and demographics. The PI+ model relies on four methodologies, which highlights their strengths while complimenting for their weaknesses:

1. **Input/output** tabulation (I/O) – At the core of the PI+ model is an input-output table (sometimes called a Social Accounting Matrix, or SAM), which captures the structure of the regional or national economy in terms of business-to-business transactions, wages, consumption, and "multipliers." To provide an example, an automobile assembly plant in Michigan will have a lengthy supply-chain behind it, with parts manufacturers in Wisconsin, steel mills in Indiana, railroads based in Nebraska, and Great Lakes boats from Ohio for ore from the Mesabi Range in northern Minnesota. I/O models are strong when following the path of a dollar through supply-chains in the computational sense, though they have several key weaknesses. These include their "before" and "after" nature (everything happens instantaneously), no scarcity of labor or capital, no concept of competitiveness, and no adjustments to the structure of the economy in response to incentives. REMI and PI+ include other modeling techniques to deepen the representation of the structure over time and transcend this transactional accounting.

2. **Computable general equilibrium** (CGE) – CGE models are a broad class of programs that rely on the principles of equilibrium economics. In essence, the utilization of CGE principles in PI+ adds market-level concepts to its economic and demographic structure. The standard supply-and-demand graph illustrates what is called a partial equilibrium—a point where demand and supply balance at a given price and quantity. A general equilibrium is when all markets "clear" in interrelation to each other. For example, say a new turbine parts manufacturer moved into Kings County, California (which has a population of 150,000 and its county seat in Hanford, California). If the plant employs 5,000 workers then, in all likelihood, the local labor market could not absorb it all alone. Demand for workers would bid-up the price of labor, and many workers with training for technical occupations would move to Kings County from other parts of California and the rest of the United States, which would increase the cost of housing and needs for government service. Still others would commute to the area from other metropolitan areas like Visalia, California in Tulare County and Fresno County. An I/O model would only see a multiplier effect from the plant, but the CGE model simulates the effects on all of the markets above—those for housing, labor, taxes, government spending, commuting, and others. CGE concepts allow PI+ to take account of long-term incentives when describing impacts.

3. **Econometrics** – REMI uses historical data to determine those parameters necessary to make the model work mathematically. This includes the estimation of elasticity (the slope of supply and demand curves), strengths of responses, and "time-lags" on how long it takes individual markets to adjust. Some markets, such as those for labor, tend to work relatively quickly as people and firms look for work and labor. Other markets, like that for housing, tend to need more time as individuals and existing capital work to catch-up to the new set of incentives on the market. This allows the I/O and CGE components of the model to work together and maintain a truly dynamic structure.

4. **New Economic Geography** – Economic geography is the study of the idea of cities and concentrated industries as engineers of economic growth. PI+ uses this approach to illustrate how specialization in labor pools and industry clusters give a region a competitive advantage. For instance, on the labor-side, the selection of trained cardiologists in cities known for their medical centers and universities (some examples including metropolitan areas resembling Boston, Massachusetts or Minneapolis/St. Paul and Rochester, Minnesota) is high compared to that in smaller Mountain West cities (such as Missoula, Montana). All else the same, a hospital in Cleveland or Houston is able to find the productive, qualified worker it needs easier than a hospital in Las Cruces, New Mexico, which tends to make the industry more competitive in areas with labor specialized to its needs. The same would be true with other endeavors, such as scientific research in Raleigh, North Carolina or software in Silicon Valley. The same concept holds for manufacturing when thinking about supply-chains instead of labor input. Appropriate examples of concentrated supply-chains would include the textiles and furniture industries in the Southeast, commercial aircraft in Washington, agribusiness in Nebraska and Iowa, and shipbuilding in Virginia Beach, Virginia and the Gulf Coast. The strength of these clusters is monumental to the growth of any regional economy. Different cities and parts of the United States tend to specialize in different things economically, which makes a handful of main industries the cornerstone of their economic wellbeing. PI+ constantly assesses the "health" of these clusters in light of new policies like environmental tax reform.

The methodology and underlying equations to PI+ are peer-reviewed and available to publically.[58] The initial publications by Dr. Treyz and the research team appeared in such publications as the *Journal of Regional Science*, the *Review of Economics and Statistic*s (describing the econometrics of the migration equation for predicting labor mobility and household relocations in the United States),[59] and the *American Economic*

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[58] "PI+ v. 1.5 Model Equations," *REMI*, <http://www.remi.com/resources/documentation>
[59] George I. Treyz, Dan S. Rickman, Gary L. Hunt, and Michael J. Greenwood, "The Dynamics of U.S. Internal Migration," *Journal of Economics and Statistics*, May 1993, <http://tinyurl.com/ltfhthc>

Review.[60] PI+ relies on public data from statistical agencies like the Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), U.S. Census, EIA,[61] the Department of Defense (DOD), and other bodies. Beyond the regions, trends in the macroeconomic and global economy come from the BLS forecast and the Research Seminar in Quantitative Economics (RSQE) at the University of Michigan-Ann Arbor.[62] This provides much of the background data for building the software harnessed for the simulations in this report—and all simulations in all REMI models.

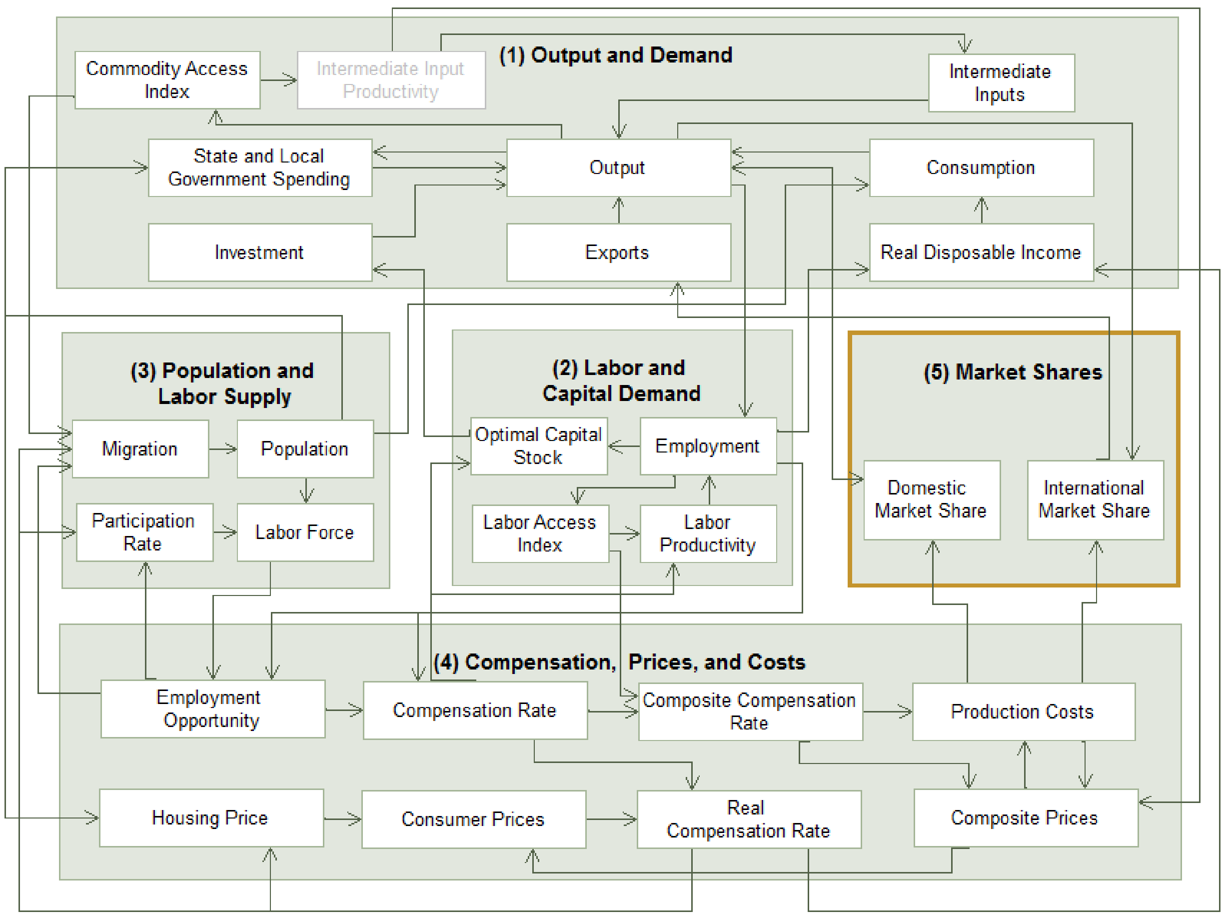

Figure 5.1 – This shows the equation structure of the PI+ model. Current prices, preferences, income, and technology form the overall economy in Block 1, which then goes to firms making production decisions in Block 2. Households reside in Block 3; it includes demographics, consumption, participation rates, and labor supply. Block 4 includes marketplaces for house, labor, and capital, costs of living, and the costs of doing business, which lead into regional imports and exports out of Block 5.

60 Note 58, p. 53
61 "Data Sources and Estimation Procedures," *REMI*, <http://www.remi.com/resources/documentation>
62 "RSQE specializes in economic forecasting of the U.S. and Michigan economies," *Research Seminar in Quantitative Economics*, <http://rsqe.econ.lsa.umich.edu/>

Simulating the net impact of carbon taxes and ATB or FAD in PI+ involved the usage of four variable sets of *Figure 5.1* of the model's structure. Under the four "rectangles" are variables to change costs or incentives in the economy, or simply to add more money to a portion, depending on the variable in question:

- **Consumer prices** – The consumer price variables include price indices for the seventy-five consumption categories in the model. Modeling the downside of the carbon tax on the residential sector requires increasing the cost of fuels by the categories, which increases household costs and reduces their purchasing power elsewhere. The upside of sales tax cuts goes into the model by lowering the cost of consumption categories eligible for the state sales tax.

- **Output** – This was the destination of the $4 billion/year fund for increasing the level of investments into renewable energy in California. PI+ involved this as an incremental increase in statewide construction activity. REMI did not trigger the generic construction industry but rather relied on research into how investments in wind and solar differ from the general industry.[63]

- **Production costs** – This increased the costs of electricity, natural gas, and that of petroleum products for commercial and industrial sectors in California. This, by itself, leads to a decline in market shares (an increase in the state's imports and a decrease in its exports). It also includes the reduction in corporation taxes, which yields opposite effects. The exact impact on a specific industries depended on the nature of its marketplaces, how much fuel it burns, how much tax it pays, and how much it might feel a boost in direct consumption from low state income taxes, state sales taxes, or the annual carbon dividend.

- **Real disposable personal income** – RDPI is the end of a process for the PI+ model. The model calculates total wages paid based on the fundamentals of the labor market in terms of supply and demand, the number of jobs, and nominal wages. After that, the model takes out taxes and includes capital income and net transfer payments. Then, lastly, it uses the PCE-Index to determine what those dollars really mean in terms of actual purchasing power. ATB meant lowering the taxes taken out (and therefore increasing household savings and spending), and FAD meant adding another layer of "non-wage" income in the form of an annual transfer from the state government—the carbon tax dividend. Both lead to more consumer spending and growth in the related industries.

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[63] Scott Nystrom and Zilin Cui, "A Multiregional Macroeconomic Framework for Analyzing Energy Policies," *USAEE Dialogue*, <http://dialogue.usaee.org/index.php/volume-20-number-1-2012/56-a-multiregional-macroeconomic-framework-for-analyzing-energy-policies>

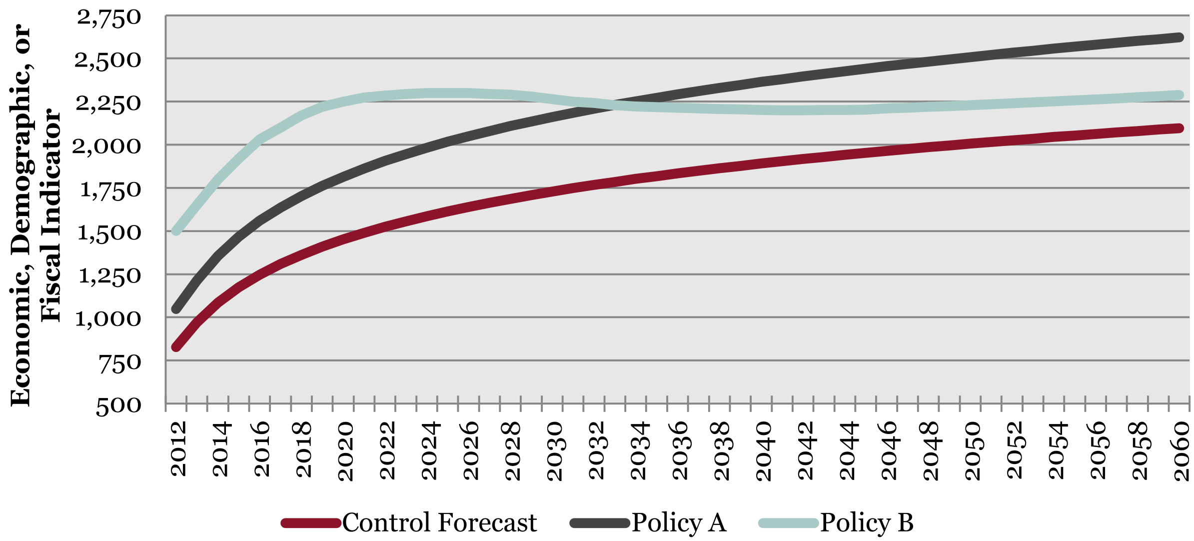
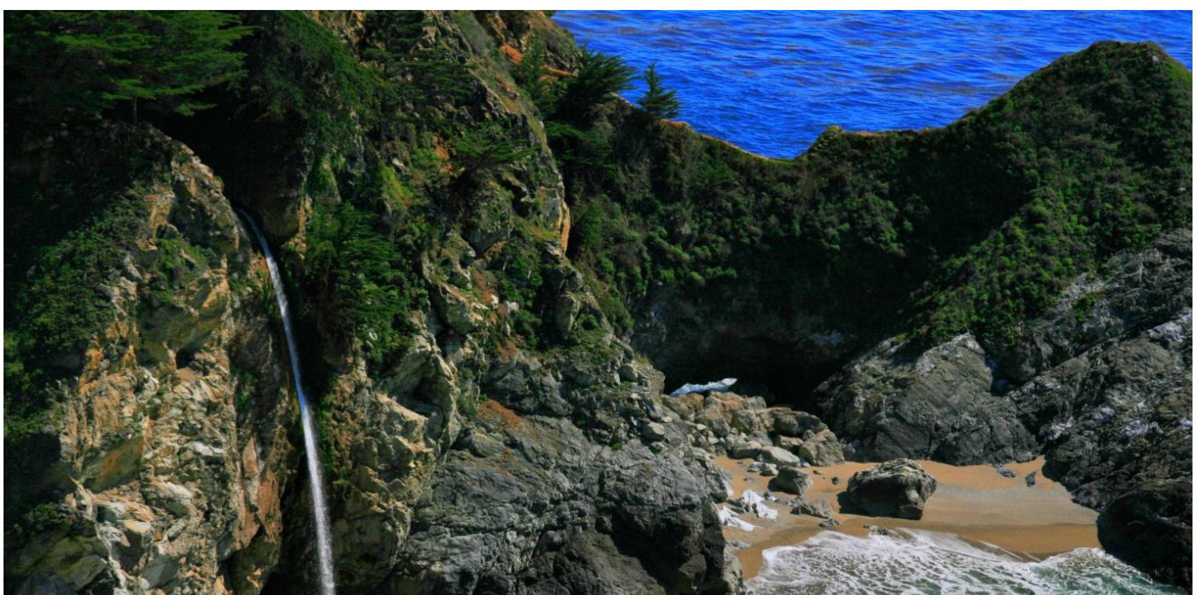


Figure 5.2 – This shows the most basic process of simulation and analysis in REMI models. The control forecast, in crimson, is the "do-nothing" scenario of no impact to any variables. It is the "general drift" of the economy as forecasted by REMI out of regional and national trends and changing economic structures and relationships. From there, the analyst changes variables—like those on the previous page—and the model re-simulates the economy. Most of the actual work is in comparing the vertical difference between the lines, or the "impact," as it was in much of this report.



CARBON TAX ANALYSIS MODEL (CTAM)

CTAM is an open-source, Microsoft Excel-based model designed to forecast state-level carbon dioxide emissions and potential revenues under different levels of carbon tax.[64] The spreadsheet document is available online.[65] CTAM uses projections from the AEO of the EIA (which, in turn, comes from NEMS) on the anticipated energy usage by type and sector for 9-regions of the United States out to 2035. The forecast in the AEO is usually only in thermal quantities, such as quadrillions of BTUs, though sometimes they have volumetric measurements like gallons or short tons of coal used for power. CTAM uses parameters on the chemical relationships between heat, fuel, and carbon to build a "shell" on NEMS to forecast the carbon emissions implied by EIA's outlook. From there, CTAM relates this data within energy to fiscal concepts such as the carbon tax. NEMS only has a "Pacific" region and not one for California. The Pacific region includes the Pacific Rim states of Alaska, California, Hawaii, Oregon, and Washington. Creating the shares down to California involves using historical data on fuel consumption levels by state and making allocations from there. Consumer responses in CTAM come from price elasticity by fuel type—*Figure 6.1* illustrates the exact process in the model.

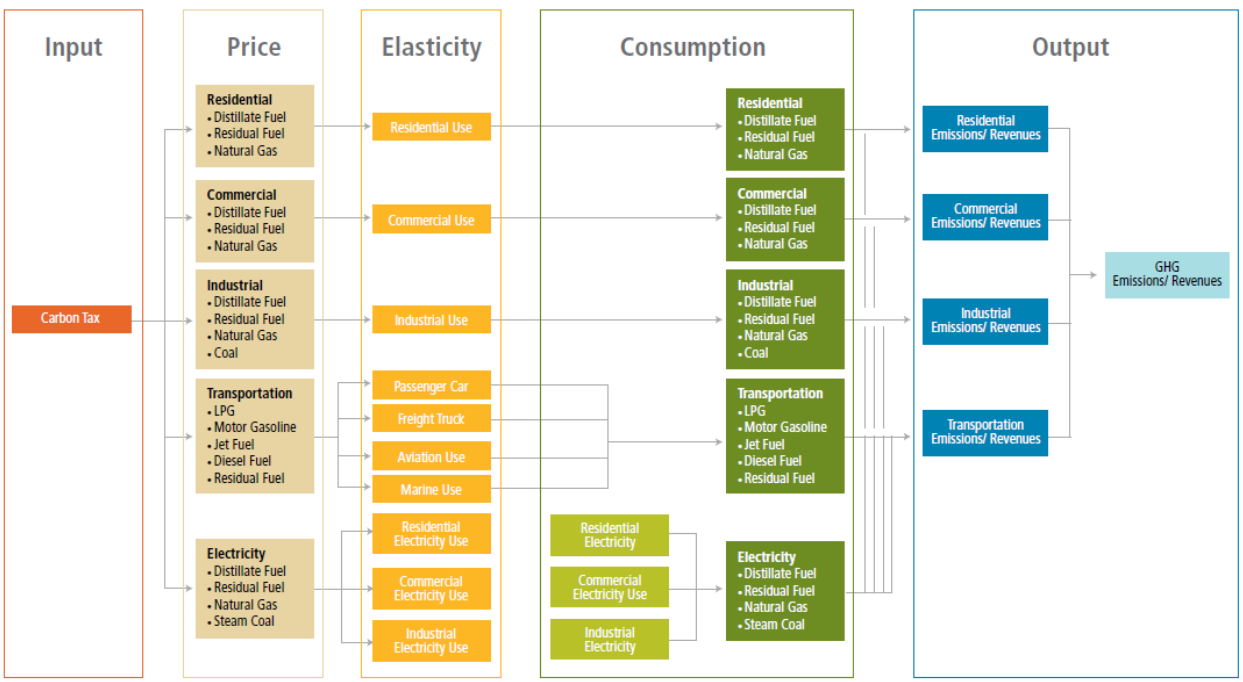


Figure 6.1 – This shows the calculations in CTAM to estimate how much emissions go down because of a carbon price. Mori estimated price elasticity from meta-studies, and this study uses the same figures as his originals in the CACTAM calibration.

[64] Keibun Mori, "Washington State Carbon Tax: Fiscal and Environmental Impacts," *University of Washington*, <http://www.commerce.wa.gov/Documents/Washington-State-Carbon-Tax.pdf>
[65] 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/>

INTEGRATING PI⁺ AND CTAM

Bridging the two models involves lining their various dimensions up with one another. Both models are annual, so both can use the same set of years from 2015 to 2035[66] in the simulation of carbon policies. CTAM has four main sectors of fuel demand and of carbon emissions: residential, commercial, industrial, and transportation. These four groupings all have an analogous concept in PI^+ as a consumer price or production cost. CTAM has some more granularities in terms of fuel than PI^+. Agglomerating the CTAM fuel types upwards into the three fuel classifications in PI^+, which are electricity, natural gas, and petroleum products, is the approximate way to deal with this. The table below shows how to associate the rows of carbon tax revenues from CTAM (by sector and fuel type) with the related policy variables in the PI^+ model structure:

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

Figure 6.2 – Data in the second-column from CTAM, as sorted by sector in the first, corresponds to the explicit variables in PI^+ on the right. The variables above are applicable for a state-level (or any other 1-region) simulations because adding more regions requires using data in PI^+ to break CTAM into sub-state groupings. These models work in a symbiotic way; they are both inherently dynamic and regional.

[66] The most recent last forecast year in the AEO, though it will soon change to 2040

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Scott Nystrom[67] received his B.A. history, B.S. economics (*summa cum laude*), and M.A. economic history from Iowa State University in Ames, Iowa. He has worked at REMI since 2011, and he is the head of software training, technical support, and economic consulting in its Washington, DC office. Mr. Nystrom works on a daily basis with clients all over the United States and the world in state and local governments, federal agencies, provincial authorities, regional councils, consulting firms, academic institutions, and non-profits research organizations. Major projects have included impact analyses of the federal "fiscal cliff" and sequestration, the TransCanada Keystone XL Pipeline, the $500 billion Southern California Association of Governments (SCAG) transportation plan, Medicaid expansion in North Carolina, and studies on carbon taxes in Massachusetts, Washington, and King County, Washington (Seattle and its major suburbs). His other responsibilities include research on integrating energy models into a macroeconomic framework, modeling the impacts of intermodal transportation projects, and business development and traveling throughout North America.

Ali Zaidi[68] is an assistant economist and research associate in REMI's Washington, DC office. He holds his B.A. economics from the University of Massachusetts-Amherst. He performed the calibration of the California version of CTAM model this project (as well as MACTAM and WACTAM for Massachusetts and Washington, respectively). His other work has included aiding on analyses of federal immigration reform and integrating regional models with agent-based systems to look at national security scenarios, border closures, and international capital flows. Mr. Zaidi's research plans include helping to develop tools for analyzing diverse infrastructure types as one system.

67 <http://www.linkedin.com/pub/scott-nystrom/5b/274/337>
68 <http://www.linkedin.com/in/lucrosmc>

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