The Economic, Climate, Fiscal, Power, and Demographic Impact of a National Fee-and-Dividend Carbon Tax

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[1] All images courtesy of *Wikimedia* and out of the public domain

Executive Summary

This report examines the economic, climate, budgetary, power generation, and demographic impacts of implementing a revenue-neutral carbon tax for nine regions of the United States. The carbon tax would begin in 2016 with a rate of $10 per metric ton of carbon dioxide and escalate in a linear manner at $10 per year. The point of assessment for this tax would be extraction, although, after significant pass-through of the cost from upstream producers to downstream consumers, everyone in the energy supply chain would feel the influence from the carbon tax. Every dollar—100% of proceeds—from the carbon tax would enter into a "fee-and-dividend" (FAD) system that refunds the money to all American households with checks or direct deposits on a monthly basis. Every household would receive its share based on the number of adults (over 18) living there with dependent children (under 18) counting half as much as adults (and two being the maximum). The policy would also include a border adjustment to correct for carbon leakage outside of American borders and preserve competitiveness.

The results of the study demonstrate that there are probable benefits to taxing carbon dioxide emissions and returning the money to consumers through FAD. The following are highlights of the national level results of the study in 2025.

- 2.1 million more jobs under the FAD carbon tax than in the baseline
- 33% reduction in carbon dioxide emissions from baseline conditions
- 13,000 premature deaths saved from improvements in air quality

These principal results are not to say the outcome is universally positive, and there are certain industries and regions in the United States that may do better or worse under a carbon pricing system. For example, the industries tied directly to households, such as healthcare, retail, and housing construction, tend to do well because FAD increases the overall level of consumer spending. There are other important results in 2025. The FAD rebates return nearly $400 billion to households—or almost $300 per month for a family of four, and the carbon tax aids in retirements of coal plants and accelerates investments in wind, solar, and nuclear power. The impact to the total cost of living is less than 3% from the baseline, and gross domestic product (GDP) increases between $80 billion and $90 billion.

This study integrates three models with different, important perspectives on the economy and energy. The first is ReEDS (Regional Energy Deployment System) built by the National Renewable Energy Laboratory (NREL) and run by Synapse Energy Economics, Inc. from Cambridge, Massachusetts. The ReEDS model predicts the type of power generation in use (such as coal, gas, nuclear, wind, or solar) in different parts of the country after implementing a carbon tax. The second is the Carbon Analysis Tool (CAT), which draws its assumptions from the Annual Energy Outlook (AEO) produced by the Energy Information Administration (EIA). CAT forecasts carbon dioxide emissions and revenues from the carbon tax. The third is PI^+, a dynamic, multiregional model of subnational units of the United States economy. PI^+ includes variables describing the changing energy prices, investments, and air quality and produces an impact study with results on job creation, GDP, income, and the differential impacts between different income groups, industries, and regions.

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"Just the Facts"

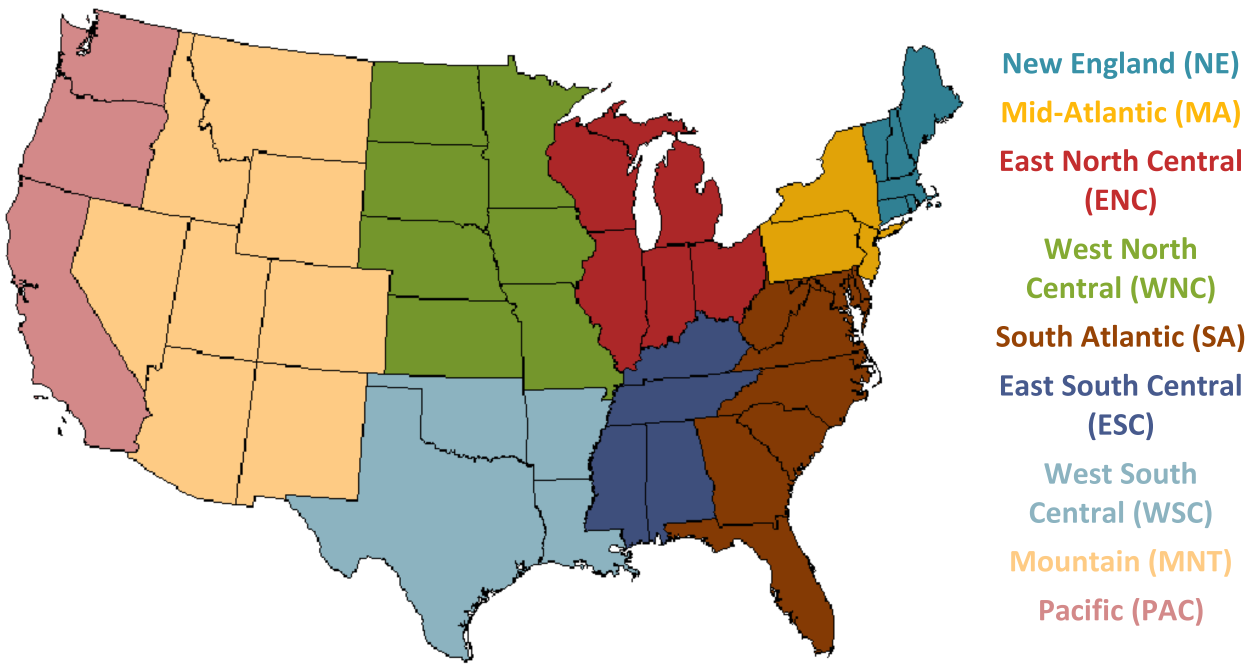
Policy Design

This white paper examines the economic, climate, budgetary, electrical power, and demographic implications of a carbon tax at the national level for nine regions of the United States and its economy. Those nine regions are the "U.S. Census" regions used in a number of federal data sources and in the energy forecasts from the Energy Information Administration (EIA). The carbon tax under study here supposes a tax rate of $10 per metric ton of carbon dioxide in 2016 and then increasing at a linear rate upward of $10 per year. The tax would be at the point of extraction and entrance to the economy, but the interconnectivity of the energy supply chain would mean a significant amount (if not the whole weight) of the carbon tax would eventually make its way to end-use consumers in the residential, commercial, and industrial sectors of the economy. This policy design would take 100% of the revenues and send them into a "fee-and-dividend" (FAD) system in which all proceeds would return to households in the form of monthly checks or direct deposits. Rebate eligibility would be on a per capita basis for adults (over 18) with half-credit for dependent children in each household (under 18) up to a maximum of two. This would keep the system revenue-neutral and require no other changes to the tax code or expenditures by the federal government. The policy would also include a "border adjustment" based on the carbon dioxide emitted during the production of any goods or services for importation into the United States. This border adjustment would help prevent the leakage of emissions outside of the country, aid in preserving the competitiveness of American industry on the world market, and encourage other countries to adopt a similar policy.

Methodology

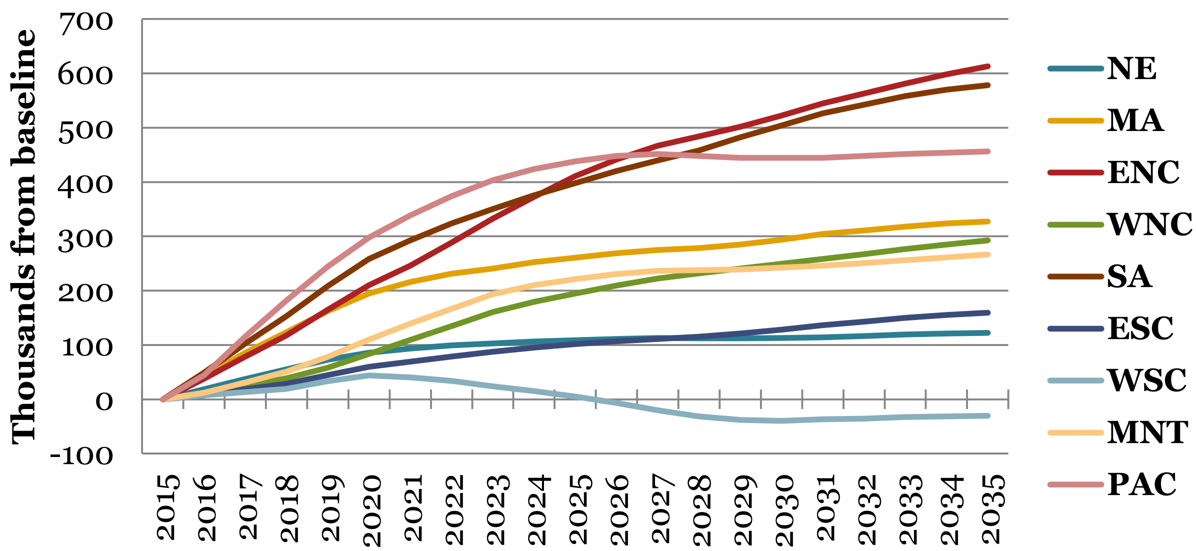
This study integrates three models with different perspectives on the economy and energy markets. They are (1) the Regional Energy Deployment System (ReEDS) built by the National Renewable Energy Laboratory and ran by Synapse Energy Economics; (2) the Carbon Analysis Tool (CAT) built from the Annual Energy Outlook (AEO) from the EIA; and (3) REMI PI+, a dynamic model of subnational units of the United States' economy. The ReEDS model shows potential future investment patterns for power generation capacity by technology type. A carbon tax might influence earlier retirements of coal plants and earlier or additional investments in low- or zero-carbon power sources such as nuclear, natural gas with carbon sequestration, or wind and solar—ReEDS explicitly models such power switching. CAT takes its data and its assumptions from the AEO in order to have a baseline of energy consumption in the United States by region and sector. CAT adjusts this forecast downwards based on the price elasticity of demand for energy commodities after the tax and a pass-through in the energy supply chain increases end-use energy costs. CAT uses this process to generate an alternative energy demand forecast with saved carbon dioxide emissions and revenues from carbon taxes to have fiscal results. CAT also includes concepts on power investments from ReEDS, air quality, the revenues from the border adjustment, and changing American exports of fossil fuel resources. PI+ combines input data from ReEDS and CAT in order to perform an economic impact study of the FAD carbon tax in its dynamic, multiregional structure, including the impacts on job creation, gross domestic product (GDP), personal income, the cost of living, and long-term regional demographics as households respond to new incentives.

This map shows the nine regions in this study (Alaska and Hawaii are in the Pacific region).



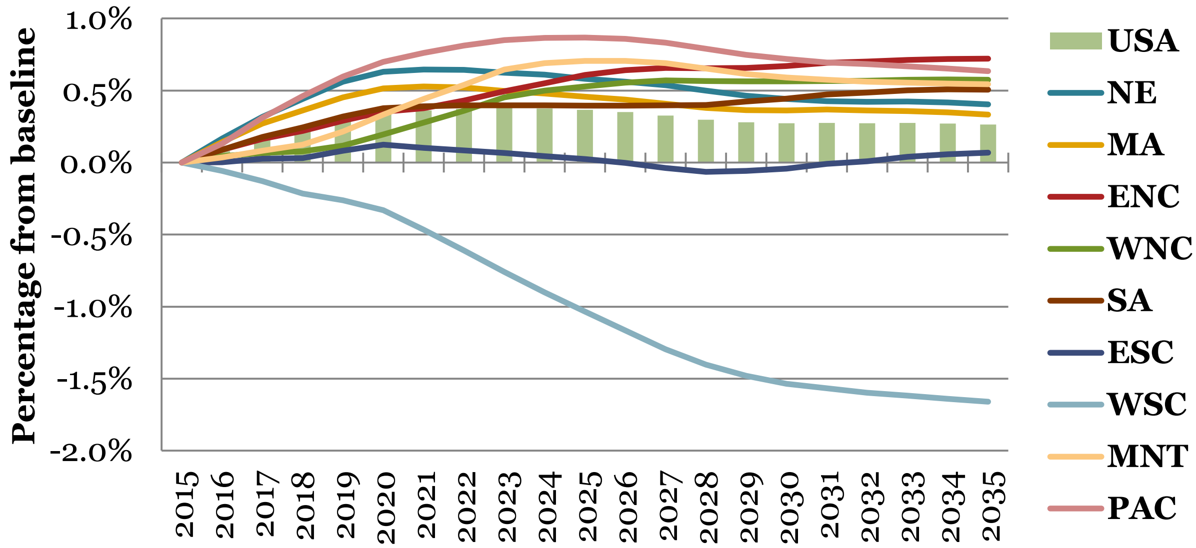
Economic Impact Results

Total Employment (regional level)



Almost all regions experience a positive impact to job creation relative to the baseline from the FAD carbon tax, and even the energy production-intensive WSC region (which includes Texas) has close to a net zero impact to total employment levels. The FAD carbon tax tends to generate jobs in labor-intensive industries like healthcare and retail, which helps explain these results of 2.1 million jobs in 2025 and 2.8 million jobs by 2035.

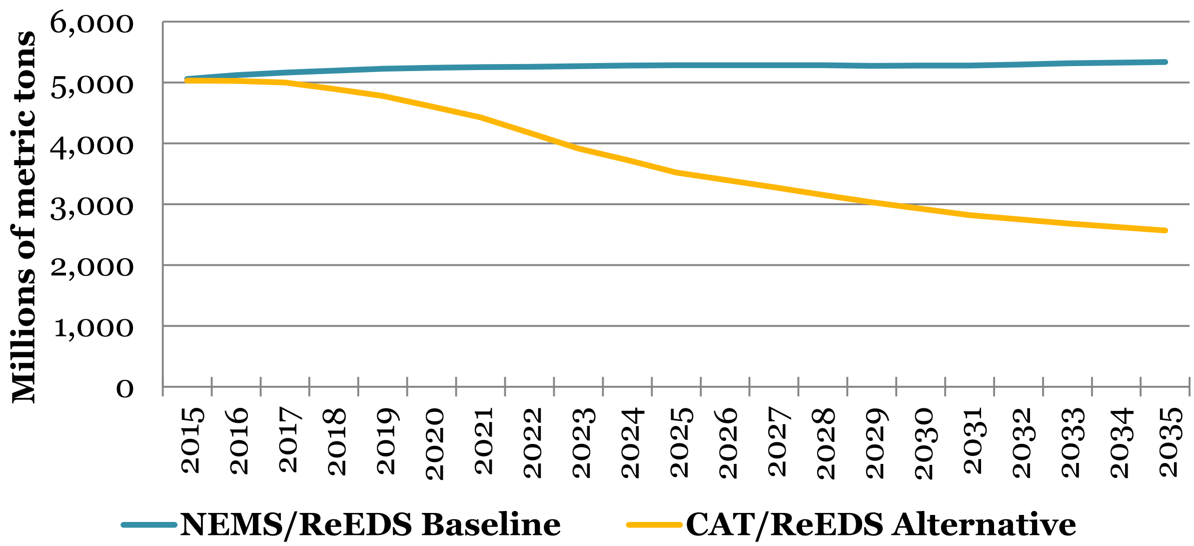
Gross Regional Product (GRP) and Gross Domestic Product (GDP)



The sum of GRP for all regions is the same as GDP for the nation. Most regions have a positive impact to total output, though WSC does decline because of reduced output in capital-intensive sectors like oil and gas extraction, pipeline transportation, and petroleum refining. Job creation in WSC is still not significantly different from the baseline, however, and the net national result in 2025 is an additional $80 billion to $90 billion in GDP.

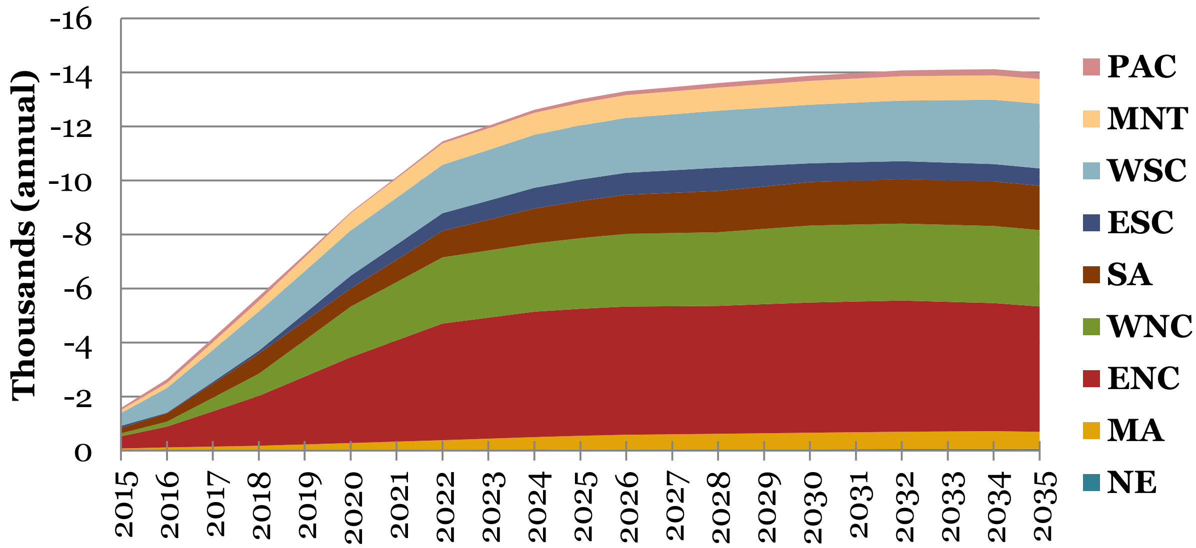
Climate Impact Results

Carbon Dioxide Emissions (annual forecast from baseline, national level)



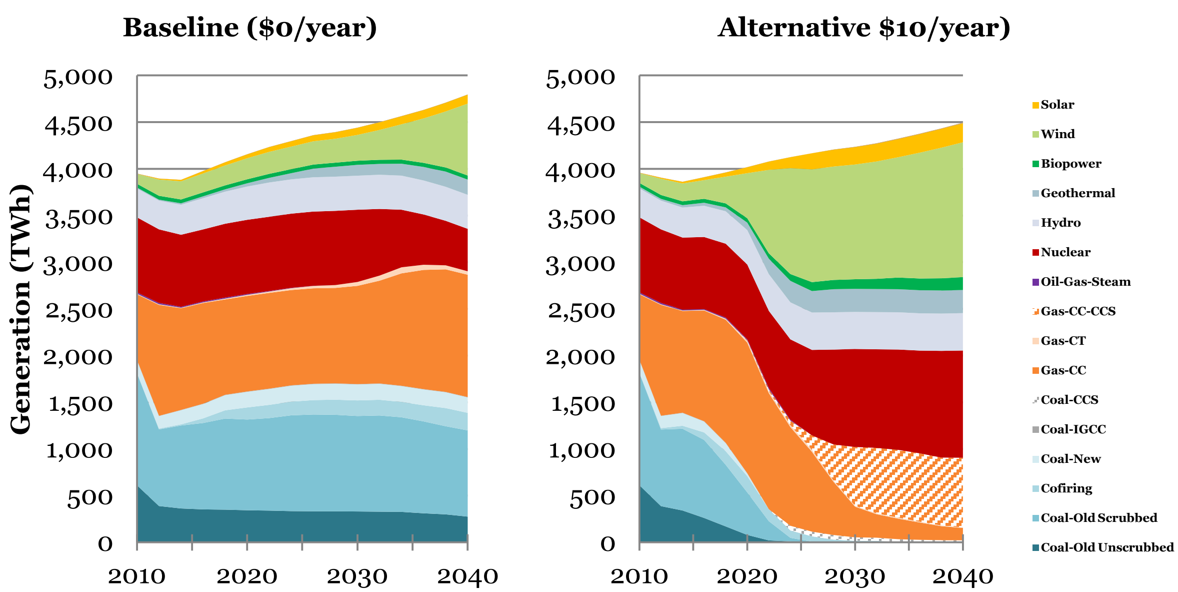
A $10 per metric ton carbon tax starting in 2016 and increasing at $10 per year would have a large influence on future carbon dioxide emissions, engendering a 33% decrease from baseline emissions by 2025 and a 52% decrease from baseline in 2035.

Saved Premature Deaths (annual, regional level)



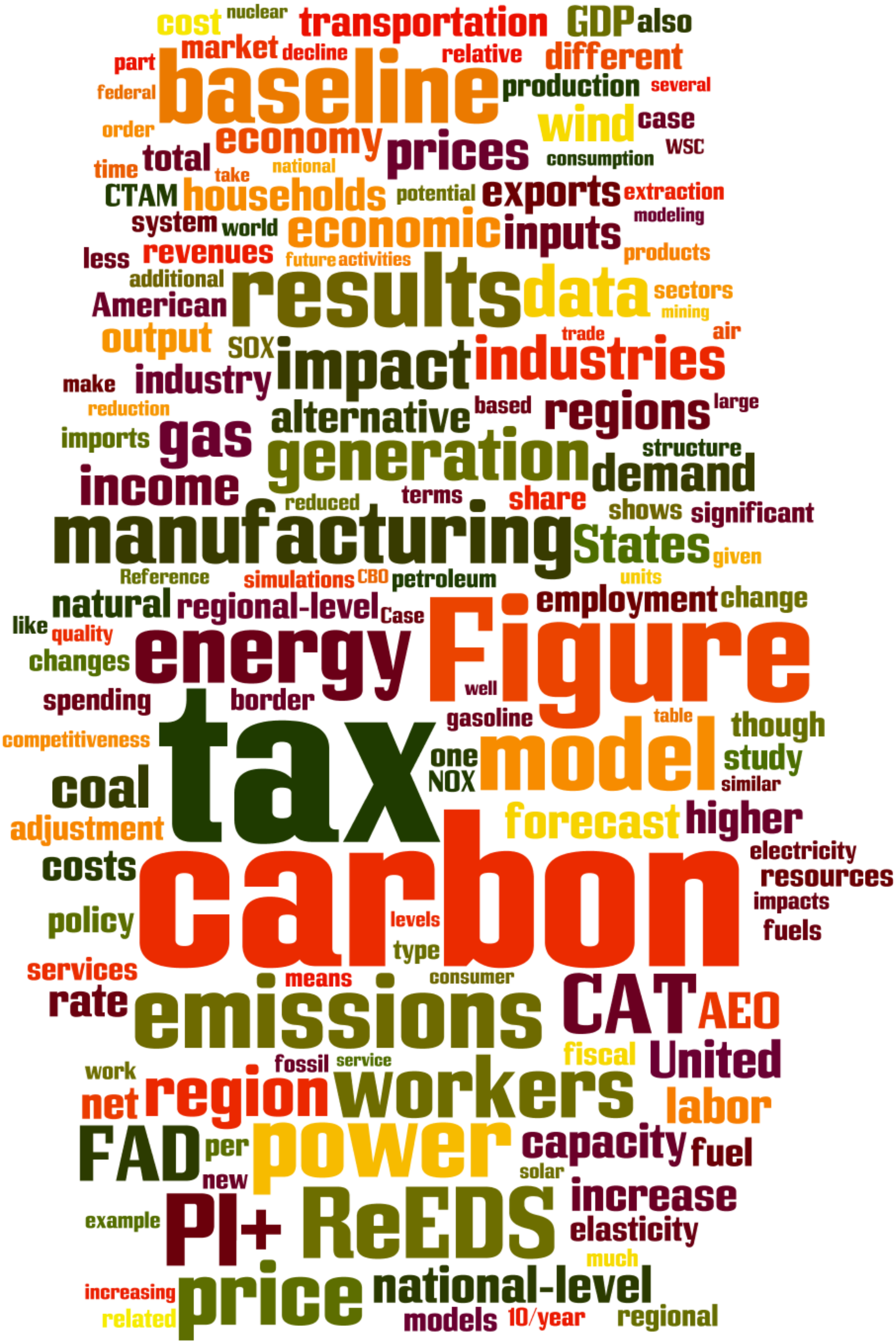
Reducing emissions of carbon dioxide (mostly from vehicles and power plants, as shown below) also indirectly reduces the emissions of noxious air pollutants such as mono-nitrogen oxides (or NO_X) and sulfur dioxide (SO_X). According to the U.S. Environmental Protection Agency (EPA), both these compounds can cause respiratory problems and hospitalizations. The above results calculate saved premature deaths from reducing NO_X and SO_X emissions in a way consistent with guidelines from EPA and other federal agencies.

Electrical Power Generation (national level)



Baseline power generation continues to include a significant amount of coal and gas, while the alternative with the carbon tax reduces generation and emissions (of carbon, NO_X, and SO_X) from coal and gas while encouraging nuclear, solar, and wind power.

Word Cloud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Introduction

This research takes a detailed look at the impacts to the United States' economy, emission, federal budget, power generation capacity, and demographics from implementing a national system for a "fee-and-dividend" (FAD) carbon tax starting in 2016. To provide a synopsis, this system would apply a fee to the extraction or removal of any carbon dioxide-emitting fuels—such as petroleum, natural gas, or coal—from the Earth. Objectives include the discouragement of their usage in order to preserve future resource endowments, reduce emissions, and provide an income base for a monthly rebate check of any proceeds from the carbon tax to all American households.[2] Such a carbon tax would begin at $10 per metric ton in 2016 and escalate in a linear fashion at $10 per year upward, although this study's timeline ends with the models' horizon in 2035. Carbon taxes are a form of a sales tax—they introduce an extra charge paid to the government during a regular market transaction that raises the price of the good or service and renders the buyer less likely to consume it.[3] Carbon taxes are expressly "Pigouvian" in the sense they mean to help markets internalize the negative externalities unrealized by the parties directly involved in the transaction, such as the potential harm done to the atmosphere when combusting fossil fuels.[4] However, a carbon tax's nature as a fee and sales tax and its service as a revenue source for a governmental jurisdiction or a rebate fund make it a fiscal issue and therefore an appropriate topic for scrutiny with the traditional "tools of the trade" for economic and fiscal impact analysis. These include, in short, price elasticity of demand, network and dispatch modeling of electrical power generation, and regional impact modeling. This study integrates the three perspectives to allow a comprehensive portrait of a FAD carbon tax—what it means as budget, fiscal, and tax reform at the federal level. This includes implications on the national and regional economies, emissions by type, the federal budget, the electrical grid, and long-term industrial competitiveness and quality of life.

The fundamental objective of a price on carbon dioxide is to incentivize households and businesses to consider the total cost of carbon dioxide emission during prosaic purchasing decisions. Carbon dioxide, while harmless in dilute quantities and produced during normal respiration by many living organisms, may produce damages (an external social cost) when emitted in tremendous quantities across the globe. There is no shortage of literature postulating that higher atmospheric concentrations may disrupt existing human activities through rising sea levels, changing weather patterns, increase in the overall frequency and intensity of storms, and other factors.[5] **This analysis does not depend on a motive for why the United States may wish to reduce its emissions.** The net of the benefits and costs from global warming or climate change are immaterial in examining carbon taxes and FAD as a sort of "mundane" budget or tax reform, and impacts on climate and air quality are truly secondary, indirect effects

[2] For a full introduction to the fee-and-dividend (FAD) system for a carbon tax under consideration here, please see, <http://citizensclimatelobby.org/wp-content/uploads/2014/04/Carbon-Fee-and-Dividend-April-2014.pdf>, particularly the section **"Therefore the following legislation"**

[3] For a longer introduction to the basics of carbon taxes, please see, <http://www.carbontax.org/issues/>, and especially this slideshow, <http://www.slideshare.net/kea/ctc-slide-show-5-sept-2007>

[4] Named for Arthur Cecil Pigou, a British economist of the early Twentieth-Century and a founding figure of welfare economics who noted that markets did not account for public costs with issues such as littering and pollution, please see, <http://www.econlib.org/library/Enc/bios/Pigou.html>

[5] For a summary to the research and controversy about carbon externality and "climate change," please see the UN Intergovernmental Panel on Climate Change (IPCC), <http://www.ipcc.ch/>

in this type of modeling and policy design. To offer an example on the functioning of a carbon tax, a gallon of gasoline at retail weighs about 6.3 pounds on average. Those 6.3 pounds produce approximately 19.6 pounds of carbon dioxide in combustion when combining hydrocarbons with the oxygen in the air.[6] After undertaking unit conversion,[7] a $1 per metric ton carbon tax is the equivalent to a $0.009 per gallon excise tax on retail gasoline (literally "at the pump"). The exercise is the same for different fuels based on the inherent chemical "carbon content" of the fuel at whatever typical unit of sale at whatever point on the energy supply chain (such as extraction, first sale, refinement, wholesale, or retail). Many major corporations—including ExxonMobil, Wal-Mart, Microsoft, General Electric, Walt Disney, Wells Fargo, DuPont, Duke Energy, Google, and Delta Airlines—already make similar calculations of the potential carbon tax on their energy usage in expectation of future carbon pricing policies at the regional or national level.[8] These expectations help motivate and contribute to the research into the potential net impact of such a carbon tax with an FAD algorithm.

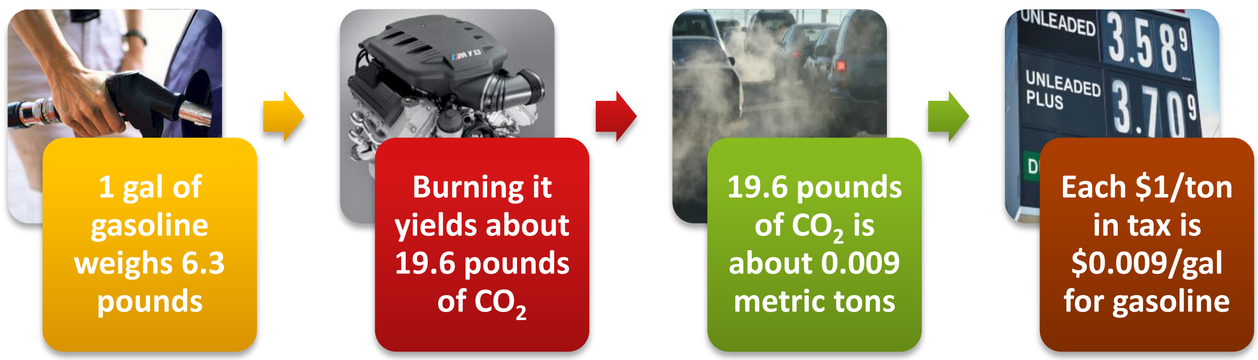

Figure 1.1 – This process chart shows the basics of calculating a carbon tax once passed down through the energy supply chain to retail and end-use consumers. Chemistry determines the "carbon content" of a fuel or energy type, which becomes part of its price with an excise tax within a transaction to discourage its use and garner revenues for a rebate fund.

Citizens' Climate Lobby (CCL), private citizens based in Coronado, California, engaged Regional Economic Models, Inc. (REMI) and its Washington, DC office to examine these issues and their interrelationships through the lens of modeling. This study uses three tools: the Regional Energy Deployment System (ReEDS), the Carbon Analysis Tool (CAT), and PI$^+$. The ReEDS model, built by the National Renewable Energy Laboratory (NREL) in Golden, Colorado, but ran in this study by Synapse Energy Economics, Inc. of Cambridge, Massachusetts,[9] is a long-term capacity deployment and investment tool for modeling the power sector in the United States.[10] CAT is an evolution of the Carbon Tax Analysis Model (CTAM) initially developed by Keibun Mori for

6 Depending on the specific blend with ethanol, <http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11>
7 1 pound = 0.00045359237 metric tons
8 In fact, these companies already factor in a future price on carbon in their strategic planning and their long-term investment decisions, please see Coral Davenport, "Large Companies Prepared to Pay Price on Carbon," *New York Times*, December 5, 2013, <http://www.nytimes.com/2013/12/05/business/energy-environment/large-companies-prepared-to-pay-price-on-carbon.html>
9 For more background on Synapse, please see their webpage, <http://www.synapse-energy.com/>
10 For an introduction to ReEDS, please see the NREL website, <http://www.nrel.gov/analysis/reeds/>, the technical appendix has more information on its specific application for this research

Washington[11] and later adapted by REMI for analyses in Massachusetts,[12] the state of Washington, King County, Washington,[13] and California.[14] CAT takes CTAM and its construction on top of the Reference Case of the Annual Energy Outlook (AEO)[15] from the National Energy Modeling System (NEMS)[16] of the Energy Information Administration (EIA)[17] and adds new emissions concepts for NO_X and SO_X, international imports and exports of energy, multiple regions, power switching (from ReEDS), and a fuller integration with REMI PI^+. PI^+ is a dynamic, multiregional, and integrated economic, demographic, and fiscal model inside of a Microsoft Windows-based software package of subnational units of the United States used to produce economic impact results from exogenous policy simulations such as the FAD carbon tax. The models work in tandem. ReEDS describes how the power grid and generation might respond to a carbon tax with fossil energy sources being more expensive relative to zero-carbon alternatives and CAT takes data from ReEDS and the AEO to forecast a baseline and alternative for emissions and carbon tax revenues. PI^+ simulates the net impact of higher end-use energy prices versus increased consumer spending from FAD, investments in different power sources, and various other factors. This integrated approach highlights each model's strengths in its core area (such as power generation in ReEDS and long-term demographics in PI^+) before moving to the next step; the outputs from one model become the inputs for the next before finishing the chain inside of PI^+ with economic impact analysis.

The results in this white paper cover several dimensions and topics, the era from 2016 to 2035 of twenty years, and a nine region subnational breakout of different segments of the United States. The broad areas include macroeconomic indicators, a baseline forecast and alternative for carbon dioxide emission from ReEDS and CAT, fiscal considerations for the federal budget and FAD system, the impact to the cost of living and socioeconomics, changes in the power generation profile, and any long-term changes to American demographics at the regional level on account of these policies. Macroeconomic indicators include employment and job creation, gross regional product (GRP) or gross domestic product (GDP),[18] and distribution of jobs and

[11] Please see the original article by Keibun Mori, "Washington State Carbon Tax: Fiscal and Environmental Impacts," from the Evans School of Public Affairs at the University of Washington, <http://www.commerce.wa.gov/Documents/Washington-State-Carbon-Tax.pdf>, and see additional information on the construction of CTAM and CAT in the technical appendix

[12] Scott Nystrom and Ali Zaidi, "Modeling the Economic, Demographic, and Climate Impact of a Carbon Tax in Massachusetts," July 11, 2013, <http://www.committeeforagreeneconomy.com/>; Erin Ailworth, "Environmentalists Call for Massachusetts Carbon Tax," *Boston Globe*, June 23, 2013, <http://www.bostonglobe.com/business/2013/06/23/group-seeks-carbon-tax-combat-climate-change/EGvlBc9ltLUCskJPgad0fL/story.html>

[13] Technically a 2-region study of King County and the rest of the state, please see Scott Nystrom and Ali Zaidi, "The Economic, Demographic, and Climate Impact of Environmental Tax Reform in Washington and King County," <http://etr-us.org/wp-content/uploads/2014/01/etr-wa-remi-dec-13-2013.pdf>

[14] Including a similar policy design to the FAD approach here, please see Scott Nystrom and Ali Zaidi, "Environmental Tax Reform in California: Economic and Climate Impact of a Carbon Tax Swap," <http://citizensclimatelobby.org/wp-content/uploads/2014/03/REMI-CA-Carbon-Tax.pdf>

[15] This study used the AEO reference case for 2013, found here, <http://www.eia.gov/forecasts/aeo/>

[16] For an introduction to NEMS, please see, <http://www.eia.gov/oiaf/aeo/overview/>

[17] For the EIA homepage, please see, <http://www.eia.gov/>

[18] Sometimes called "value-added," the market value of goods and services produced by labor and property in a region (GRP) or the United States (GDP) regardless of the nationality of its ownership

GRP across different industries,[19] occupations,[20] and regions. The climate results involve a baseline forecast, a "$0 per ton" future case, contrasted with the $10 per year case to 2035 and potential emissions savings in power generation, the use of liquid and gaseous fuels, and reduced fossil fuel exports. Fiscal data includes a forecast of total carbon tax revenues, which is the anticipated remaining emissions multiplied by the rate in any given year, as well as the anticipated size of any annual or monthly rebate checks per capita or per household. The socioeconomics of the study look at changes to cost of living indices, energy and commodity prices, and changes by income strata in the labor market and the prospects of FAD serving as a nascent "guaranteed income." Results for power include the anticipated capacity and generation for each technology type in each case and by year and by region. The power results combine with data from CAT on transportation-related emissions in order to consider the impact of improved air quality via reduced emissions of mono-nitrogen oxides (NO_X),[21] sulfur dioxide (SO_X),[22] and the benefit-cost of health outcomes. Quality of life, the labor market, and cost of living adjusts the demographic forecast in PI+ through migration between regions in the model. The dynamic results for several categories on the impact of a FAD carbon tax offer a comprehensive portrait of the implications of fiscal and climate policy.

There are two appendices to the report. The first describes the technical foundation of the ReEDS model, CAT, PI+, and the integration between the three. The second has a surfeit of detailed tables on selected model results at the regional level. While this is a national level study of a proposed change in federal tax policy, the workings of the models are "bottom-up" for running at the regional level before agglomerating upward to the national whole. The United States' economy and demographics total over $16 trillion in annual GDP and 318 million individuals. This is approximately the size of the whole European Union (EU) in terms of GDP (though with around 190 million fewer people). Just as in Europe between different countries, there is considerable variation within the United States. Energy is perhaps a quintessential example of regional inimitability. For instance, California produces almost no power from coal and instead relies on natural gas, nuclear, renewable power, and its uneven topography and adequate rivers to site hydroelectric dams.[23] At the national level, on the other hand, coal-fired

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[19] By 70 sectors that approximate the 3-digit NAICS (North American Industrial Classification System) codes, the U.S. Census' standard definition of what constitutes the hierarchy of industrial sectors in the economy, please see, <http://www.census.gov/eos/www/naics/>

[20] By the Standard Occupational Classification (SOC) codes from the Bureau of Labor Statistics (BLS), a similar concept to NAICS that instead looks at the type of job and tasks performed by the worker instead of the final product produced by the firm, please see, <http://www.bls.gov/soc/>

[21]According to the "health" page of the U.S. Environmental Protection Agency (EPA), "Current scientific evidence links short-term exposures to SO_2, ranging from five minutes to twenty-four hours, with an array of adverse respiratory conditions including bronchial construction and increased asthma symptoms… these effects are particularly important for asthmatics at elevated ventilation rates (e.g., while exercising or playing)," <http://www.epa.gov/airquality/sulfurdioxide/health.html>

[22] According to EPA, "Current scientific evidence links short-term NO_2 exposures, ranging from thirty minutes to twenty-four hours, with adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma… breathing elevated short-term NO_2 concentrations, and increased visits to emergency departments and hospital admissions for respiratory issues, especially asthma," <http://www.epa.gov/air/nitrogenoxides/health.html>

[23] California still imports electricity that may come from coal-fired generation in the western United States, although its internal power generation is nearly all gas and zero-carbon sources, please see, <http://www.eia.gov/state/?sid=ca#tabs-4>

generation produces between 35% and 40% of all electricity.[24] Thus, the modeling here of region-to-region has several advantages over a purely macroeconomic or "one region" setup—it takes into account of regional differences in industry mixtures, energy supply and demand, and provides results from the FAD carbon tax in terms of geographic units. It does not use "one number" to cover all the inherent heterogeneity and variability of the United States' economy.[25] The results presented in this study are the same as the nine regions of the NEMS model and the EIA data for the sake of consistency with federal sources.

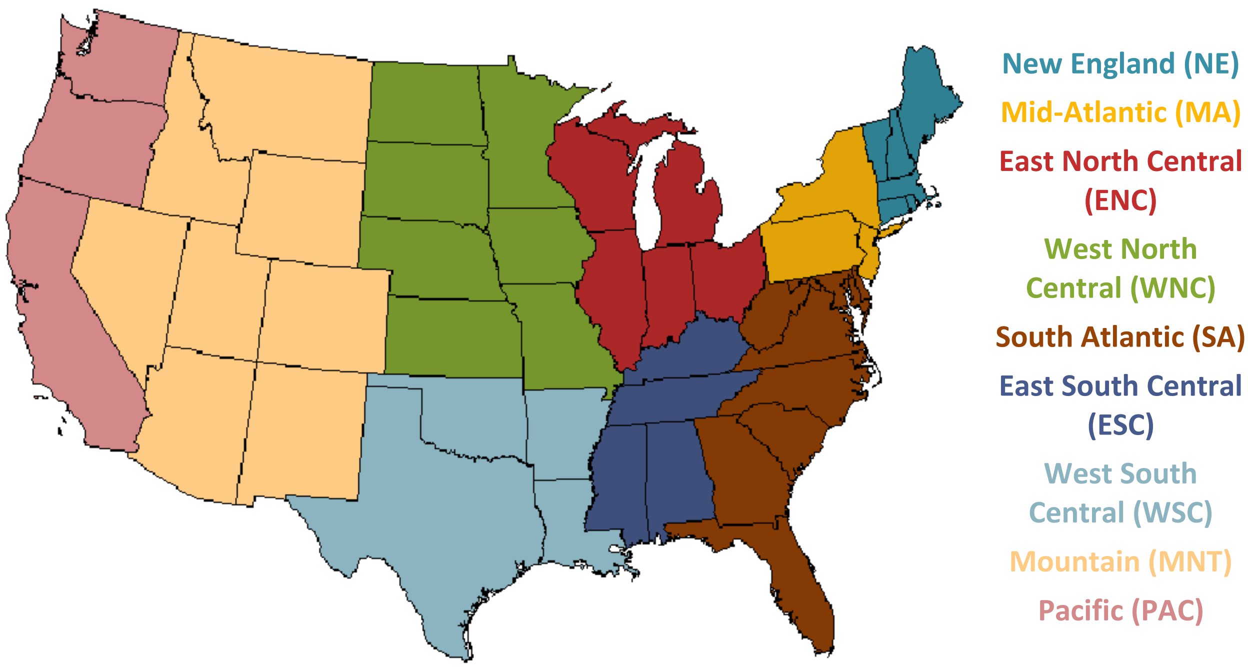

Figure 1.2 – This map shows the nine regions in the PI⁺ model simulations for this work.[26] The colors above are consistent with the coloration of the results tables and appendices. The states of Alaska and Hawaii are part of the PAC region with California, Oregon, and Washington. Each region has its own reaction to the FAD carbon tax before becoming part of the national whole through simple addition. For instance, the heavy concentration of coal-fired power plants in ENC and WNC (the Great Lakes and Great Plains states, respectively) make their economies more susceptible to switching from coal power to nuclear power than NE or PAC, neither of which have comparably much in terms of coal. On the other hand, ENC and WNC have potential for wind power given all their cheap, open land. ***These regions have their idiosyncrasies—these models specifically exist to take account of them.***

[24] According to EIA, please see, <http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3>
[25] There is always considerable variability between regions in response to policy, and some states can grow rapid while others are in recession—for example, in 2012, national real GDP grew at 2.5%, but ten states grew at 3.3% or faster (and North Dakota at 13.4%) while nine states grew less than 1.2% (with a small recession in Connecticut of -0.1%) according to the Bureau of Economic Analysis (BEA), <http://www.bea.gov/newsreleases/regional/gdp_state/gsp_newsrelease.htm>
[26] The regions above are the same as those in the NEMS modeling data and the same as the subnational units used by the U.S. Census in many of its data releases at the "Census Divisions" granularity, please see, <https://www.census.gov/geo/reference/gtc/gtc_census_divreg.html>

Policy Design

The results consider a primary scenario of a FAD carbon tax starting in 2016 at $10 per metric ton of carbon dioxide and increasing at a linear rate of $10 per year assessed at the point of extraction of any carbon dioxide-emitting fuels.[27] The initial rate above is in 2016 dollars, and the tax rate would have indexing from the outset in order to prevent the divergence from its real value due to inflation. The rate per metric ton is an important consideration with a carbon tax because it captures market-based incentives toward switching out of carbon-intensive power generation, business practices, and item purchases and toward a trajectory for lower emissions. The linear, consistent increase in the tax rate sends a clear, predictable message to households, businesses, and investors about future costs and incentivizes them to investigate different ways of doing things. The embedded simplicity and expectedness of this system removes all ambiguity about future prices for any purchasing decisions—up from individuals doing straightforward benefit-cost analysis on things like appliance purchases to multinational corporations and their strategic plans. Assuming the carbon tax rate would continue increasing at $10 per year past 2035 and to at least 2040 is part of the illustration of the point. The ReEDS model runs to 2040 and has a structure that implicitly assumes the investors in electrical power capacity make rational decisions about cost competitiveness of plants and infrastructure not only now but in the future. "Investors" in 2035 will look for a return on investment (ROI) from 8% to 12% over the lifespan of a project, which means anticipated higher carbon prices in 2035 will matter for decisions made in the 2020s and the 2030s.

Fee-and-Dividend (FAD)

The other main part of a carbon tax is considering of the final disposition of the revenues. This can have considerable influence on the final regional and macroeconomic impacts of the policy (given that the sums involved often total a few percentage points of GDP). The revenues from a carbon tax could see utilization in an infinite number of ways toward replacing current revenue sources, refunds, deficit reduction, or financing new expenditures. Nevertheless, the governing principle for this design is **revenue-neutrality and the fee-and-dividend alone—all of monies paid into the U.S. Department of the Treasury from the carbon tax must return to households in the form of a monthly check or direct deposit.** There would be limited eligibility requirements, and household size would determine each household's share of the total, national dividend. To quote, "Equal, monthly, per-person dividend payments made to all American households (one-half payment per child under eighteen with a limit of two per household), and the total value of all monthly dividend payments shall represent 100% of the total carbon fees collected in each month."[28] A monthly check (as opposed to annual) assists families living "hand to mouth" in any transitional periods, prevents households from needing to carry a net loss from higher energy prices longer than thirty-one days, and makes it an easier part of family budget planning along with monthly car payments, mortgages, and similar fixed costs. Revenue-neutrality through FAD has several advantages from a policy design and a political standpoint. Revenue-neutrality implies there is no appreciable net increase in the level

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[27] For an outline of the full legislative proposal by CCL, please see, <http://citizensclimatelobby.org/wp-content/uploads/2014/04/Carbon-Fee-and-Dividend-April-2014.pdf>
[28] This matters in the economic simulations, as well, given it helps determine some of the distribution of the impacts between regions of the country due to differing fertility rates and family sizes

of total federal spending, which means the fiscal and climate issues behind the carbon tax are separate from any debates on the most appropriate or efficient level of spending relative to tax revenues, population, or GDP. The FAD approach avoids entanglement in ongoing debates about tax reform,[29] individual income tax rates, corporate taxes, tax expenditures,[30] capping deductions,[31] or "base broadening" because FAD works as a separate system from general fiscal policy and the regular tax code. It also does not influence the structure, functioning, or financing of social entitlement programs, such as Social Security, Medicare, Medicaid, or unemployment insurance.[32] These are all issues with infinite complications of their own, but FAD combined with revenue-neutrality leaves them as separate matters.

Border Adjustment

Another feature of this design is its inclusion of a "border adjustment" on the potential carbon dioxide of any fuels or the emissions behind the production of goods brought into the United States for sale. It charges the same rate on manufactured goods, agricultural products, and fossil fuel imports as that charged domestic producers. The tariff would also apply to American exports of fossil fuels. The goal of the adjustment is to prevent the "leakage" of emissions for American consumption to foreign production, maintain competitiveness, and place upward pressure on the world price of coal, natural gas, and petroleum and incentivize other nations to design their own carbon pricing. The United States is a large country and an enormous energy producer, and therefore a higher cost for domestic resource extraction would have some effect on the world price for energy, although the scale of that effect is not part of the modeling. The border adjustment aids in preventing the movement of production lines and their emissions out of the United States in order to avoid the tax before exporting the goods back into the American market. For instance, consider an automobile assembly plant in Ontario or Chihuahua in competition with a similar one in Michigan or Alabama. Without a border tariff and *ceteris paribus*, the foreign lines could freely emit while domestic ones pay carbon taxes. However, the border adjustment means Canadian and Mexican producers pay a border tax comparable to the prevailing one in the United States. This design could have complications with international trade law, the World Trade Organization (WTO), and its goals of encouraging international commerce via lower tariffs. The models here presume any issues with the WTO have a happy resolution; there is an abundance of literature on possible routes.[33] Revenues from the border adjustment would still meet revenue-neutrality criteria, but they would have a different

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[29] Perhaps the most important one at the moment is that of Representative Dave Camp, for a summary, please see, Martin Sullivan, "25 Interesting Features of Chairman Camp's New Tax Reform Plan," *Forbes*, March 3, 2014, <http://www.forbes.com/sites/taxanalysts/2014/03/03/twenty-five-interesting-features-of-chairman-camps-new-tax-reform-plan/>

[30] For an introduction to tax expenditures, the largest one being the deduction for employer-provided insurance, please see, "The Distribution of Major Tax Expenditures in the Individual Income Tax System," *Congressional Budget Office* (CBO), May 29, 2013, <http://www.cbo.gov/publication/43768>

[31] An approach favored by such economists at Dr. Martin Feldstein at Harvard and a favorite of Governor Mitt Romney during the presidential campaign of 2012, please see, Martin Feldstein, "It's time to cap deductions," *Washington Post*, March 12, 2013, <http://www.washingtonpost.com/opinions/its-time-to-cap-tax-deductions/2013/03/12/af05081c-8a63-11e2-8d72-dc76641cb8d4_story.html>

[32] Some proposals imagine a carbon price supplementing or replacing current payroll taxes

[33] For example, please see, Joost Pauwelyn, "Carbon Leakage Measures and Border Tax Adjustments Under WTO Law," *Graduate Institute of International and Development Studies* (IHEID), March 21, 2012, <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2026879>

treatment than domestic carbon tax revenues into the FAD system. Revenues from the tariff adjustment would go into a separate "jar" than the general FAD and help to rebate back the tax's value to American manufacturers in order to support their ability to compete on international markets. This would assist in buttressing American competitiveness and reducing leakage of carbon emissions for American-consumed goods to foreign production locations or other nations without an analogous carbon dioxide pricing arrangement.

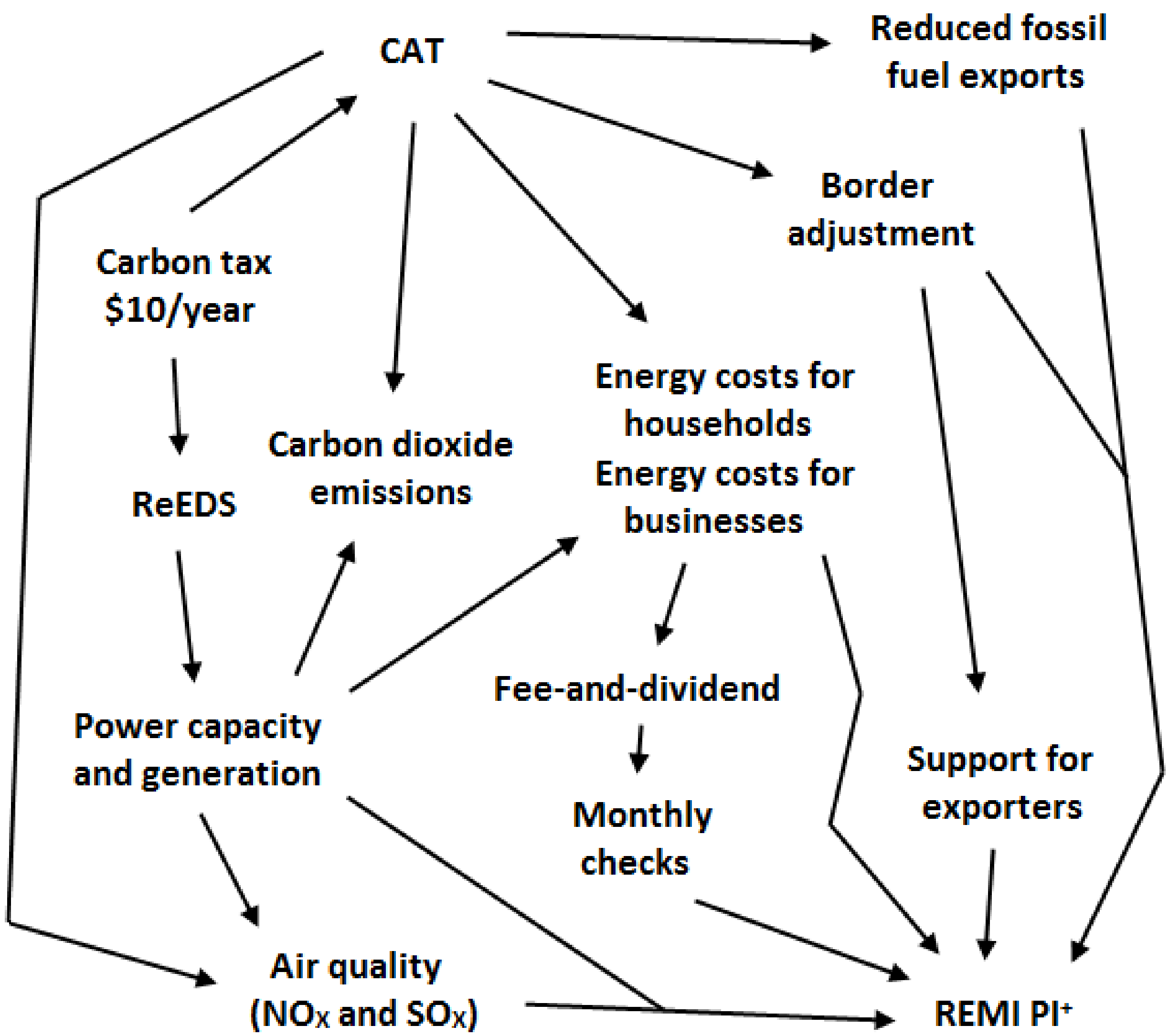

Figure 2.1 – This is an arc-and-node representation of the logical superstructure of the policy and the data involved in the model. The carbon tax rate in the upper left informs the initial simulations in ReEDS and CAT, which in turn generate results on power generation and capacity, air quality, carbon dioxide emissions, energy costs, the border adjustment, and fossil fuel exports. These serve as inputs to the economic study in PI^+ in the bottom right.

Simulation Results

The results of the simulations in ReEDS, CAT, and PI^+ cover the economic, climate/emissions, federal fiscal, electrical power, and demographic implications of a national, FAD carbon tax starting at $10 per year in 2016 (in 2016 dollars) and increasing linearly at $10 per year through 2035. As per FAD, all revenues gained from the carbon tax return to American households in the form of a monthly check in a system roughly similar to the Alaska Permanent Fund of annual rebates to individual taxpayers of state royalties and excise taxes on oil and gas extraction and mining.[34] The results include simulation inputs for the border adjustment, as well. All the results below are against a "do-nothing" or "business as usual" baseline presuming no other changes to the economy, energy prices, or the tax code. The baseline represents the general drift of the United States' economy by region into the future based on long-term trends within the economy, technological development, and demographics. **The models simulate the net impact of implicitly higher end-use energy costs from the carbon tax versus the benefit of increased consumer spending (via FAD) with changing investments in power generation capacity and the border adjustment.** It accounts for both the negatives and the positives of this potential policy with a *ceteris paribus* condition against the "null hypothesis" baseline. For the most part, results are against this baseline, although there are instances where a direct comparison between the baseline and alternative is appropriate rather than just the difference (or "delta") between them.

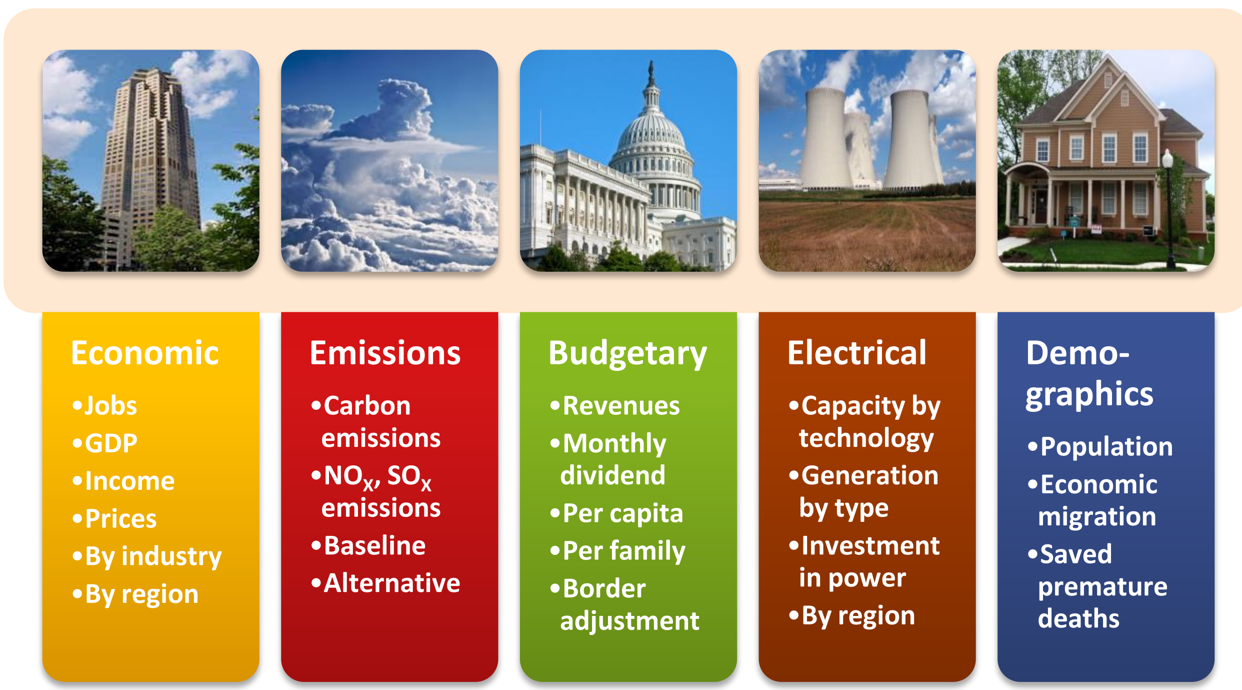

Figure 3.1 – This summarizes the broad categories of the results, starting on the left with economic impacts and eventually ending with changing long-term demographics.

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[34] The Alaska Permanent Fund (or the "oil check") serves as inspiration for CCL's conception of a FAD system with a few differences, including narrower eligibility requirements for state residency and the existence of a permanent, interest-bearing sovereign wealth fund in Alaska, while FAD would carry no balance and immediately refund all revenues, please see, <http://pfd.alaska.gov/Home/index>

Total Employment (regional level)

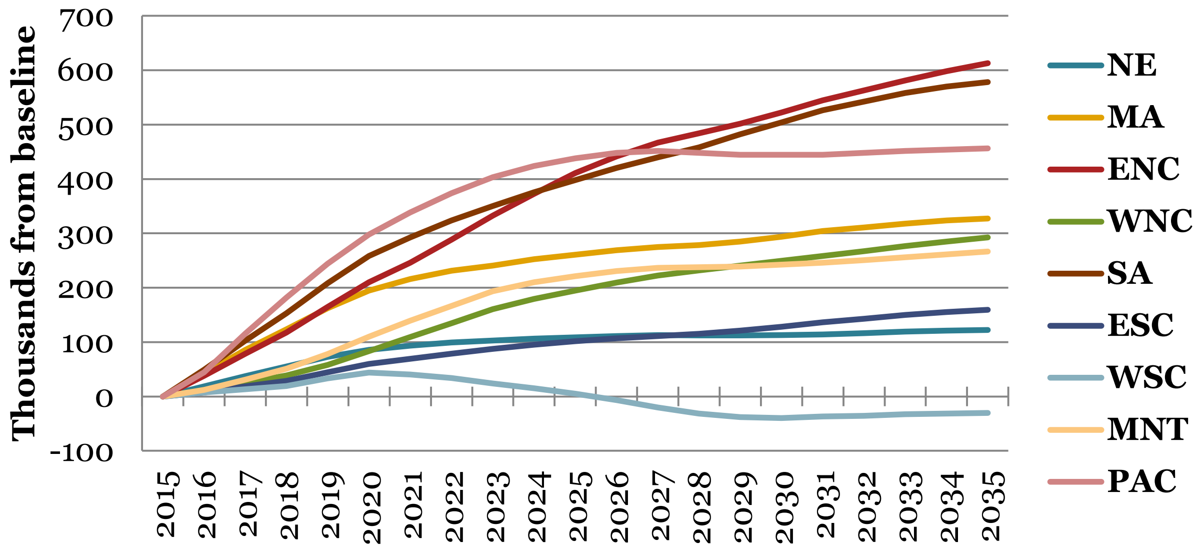

Figure 3.2 – This represents the net change in employment by region. The results are, again, consequences of the inputs built around conditions described in the policy design section and previous page. Speaking relative to the baseline, the net effect on job creation and employment is positive in most years and regions, and even the export-oriented and energy production-intensive WSC region has close to a net zero impact on its employment levels.

Total Employment (national level)

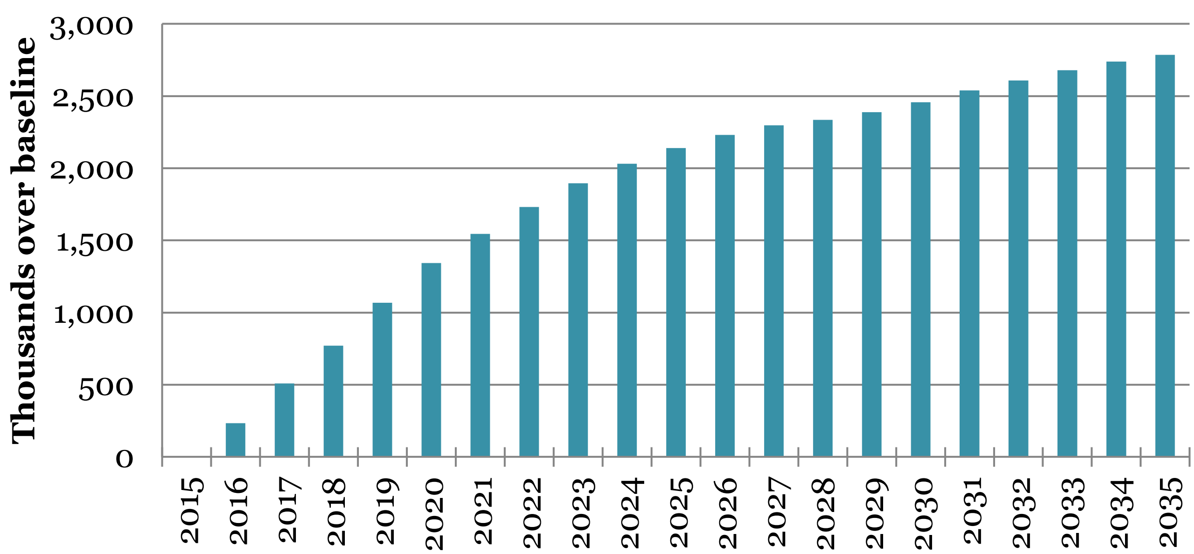

Figure 3.3 – This is the same data as that in Figure 3.2 agglomerated up from the regions to the nation. Thus, net employment levels at the national level from the FAD carbon tax are between 2 million and 3 million over baseline (approximately a 1% increase) when counting higher energy costs versus rebates to households and changed investments.

Gross Regional Product (GRP)

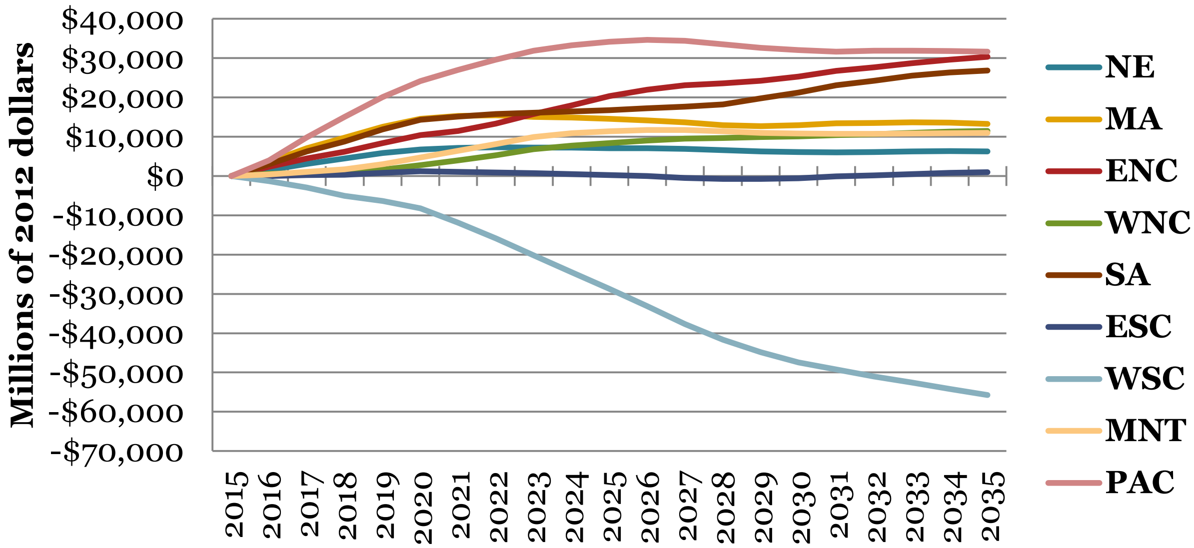

Figure 3.4 – This shows the impact to GRP for the nine regions from the FAD carbon tax. Most regions see a slight expansion in their economic output, although the ESC and WSC regions have either a neutral or a negative impact. This is a natural extension of the large energy production cluster present in the WSC's economy. Its ability to maintain the same level of employment in the face of falling GRP involves a change in its industry mixture.

Gross Domestic Product (GDP)

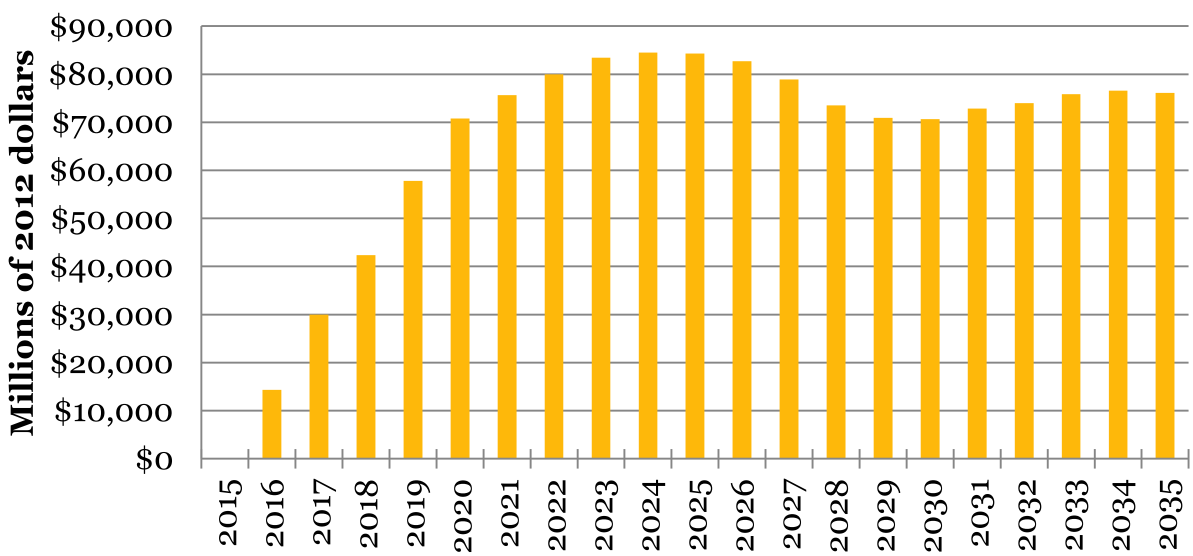

Figure 3.5 – This is the sum of the regions' GRP, which equals the United States' GDP. The impact is still a net positive, although less so than the impact to employment in percentage terms—the above is a difference of 0.35% to 0.65% from baseline GDP. The difference in the scale of the impact between the two again comes down to the industry mixture.

Total Employment (percentage change)

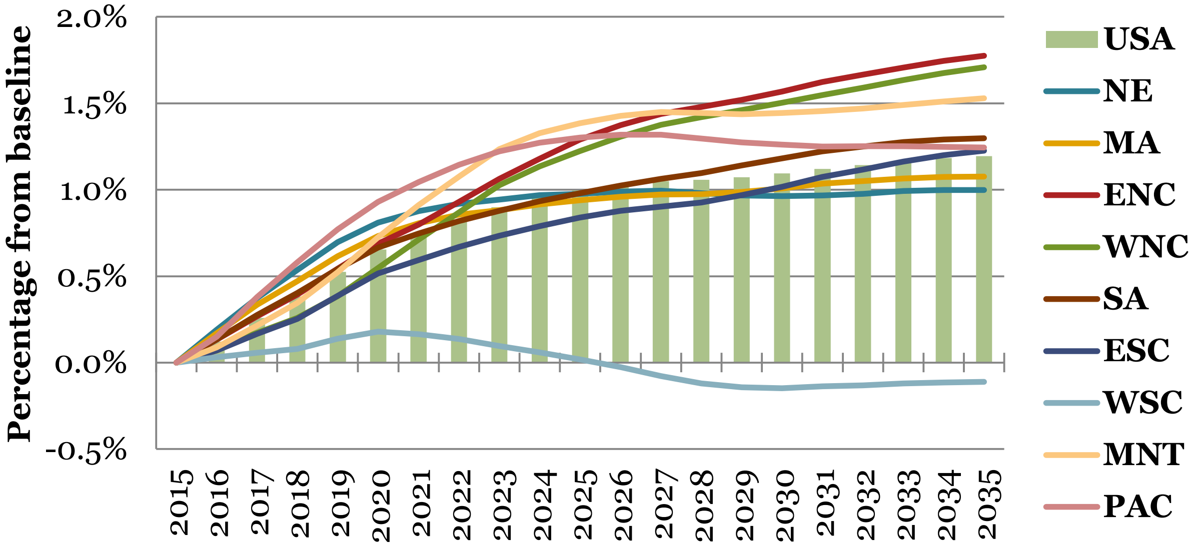

Figure 3.6 – The above displays the percentage change from the baseline implied by the results in Figure 3.2 and Figure 3.3. The FAD carbon tax has a positive effect on employment in most regions, although over the scope and scale of the United States economy the impact in even the "best" region (PAC, MNT, or ENC) is still less than a 2% difference from the baseline.

Gross Regional/Domestic Product (percentage change)

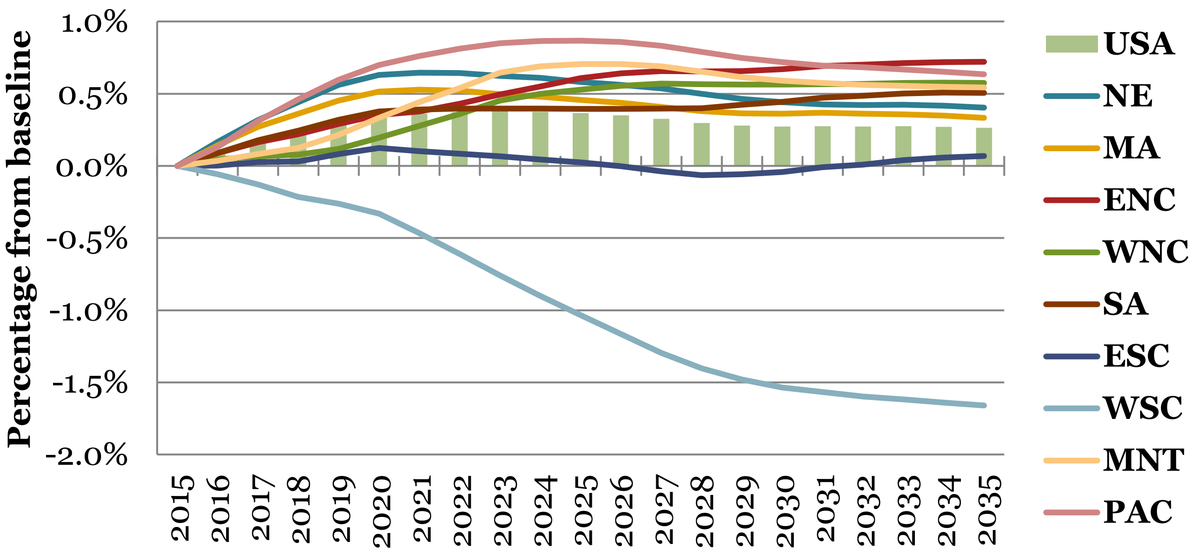

Figure 3.7– The percentage changes in GRP and GDP are less than that in the changes to total employment because of the labor-intensity of the industries tied to consumer spending and the FAD system in Figure 3.8. Most regions add GRP save WSC but, even then, the impact to GRP in the WSC region is less than 2% by 2035, which is a small change from baseline.

GDP by Major Industries (national level)

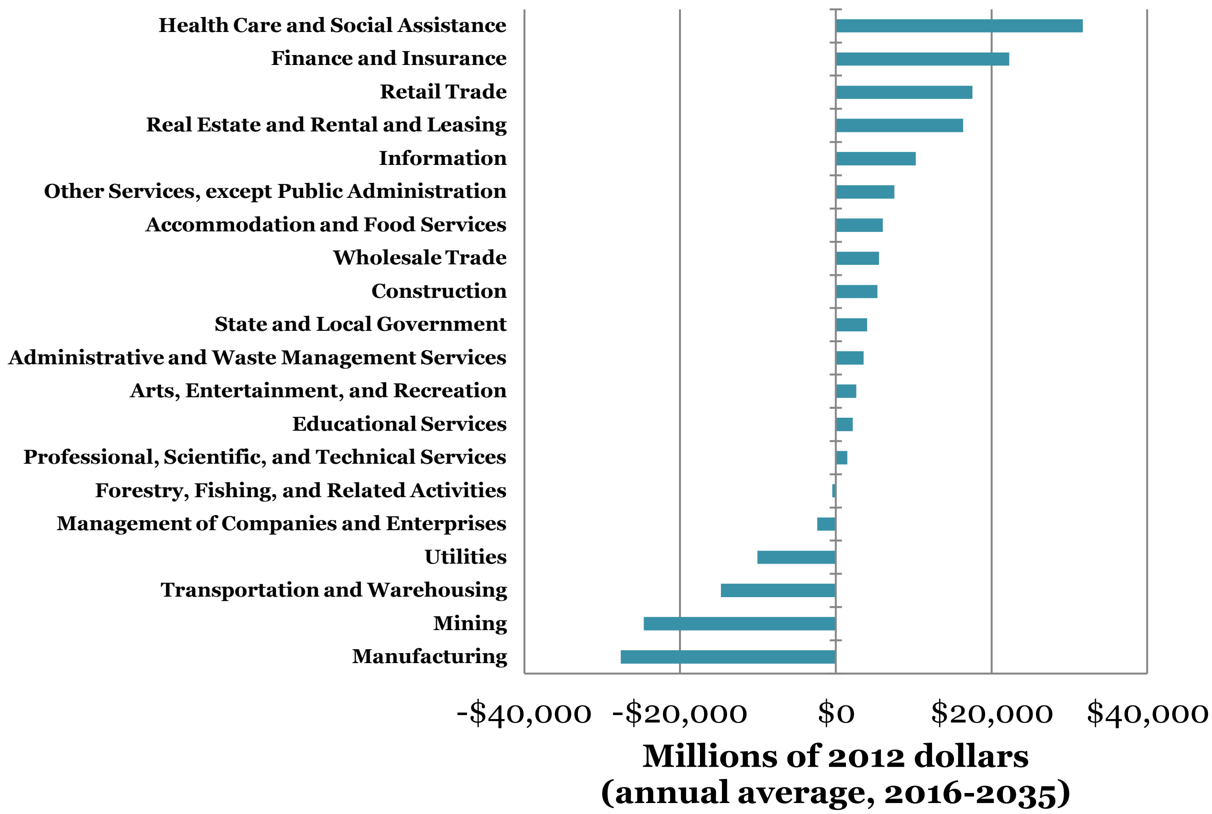

Figure 3.8 – This distributes the impacts to national GDP between the 19 private sector industries that make the two-digit NAICS codes as well as state and local government. As in Figure 3.6 and Figure 3.7, most of this represents a small change versus the baseline of between 1% and 2% of total output over two decades for the service sectors and under a 10% decrease in mining output. ***Manufacturing has important patterns in Figure 3.9.***

The FAD carbon tax renders the national economy larger than the one in the baseline, but perhaps just as vital is the composition of GDP under the policy. The above shows higher energy prices cause a decline in the value-added of the sectors directly related to energy production and distribution, such as mining or utilities, as well as energy-intensive sectors like manufacturing and transportation/logistics. This is an expected outcome of taxing those industries' products or inputs via the carbon tax in order to incentivize a reduction in the consumption of carbon dioxide-emitting fuels, goods, and services. On the other hand, FAD increases demand from households for consumer staples like healthcare, food and drinks, electronics, media, entertainment, and housing. The industries in the blend at the top of the distribution all have close, direct, or indirect linkages with the consumption component ("C") of GDP, and its expansion in the simulation due to the rebate increase their output and value-added. Carbon pricing would not yield a positive impact on all sectors or regions no matter its structure, and the results for the WSC region in *Figure 3.4* and industries in *Figure 3.8* reflect the expectation. The net is overwhelmingly positive, however, and there are trends within manufacturing and in *Figure 3.8* that reflect higher national and regional employment levels.

GDP by Manufacturing Industries (national level)

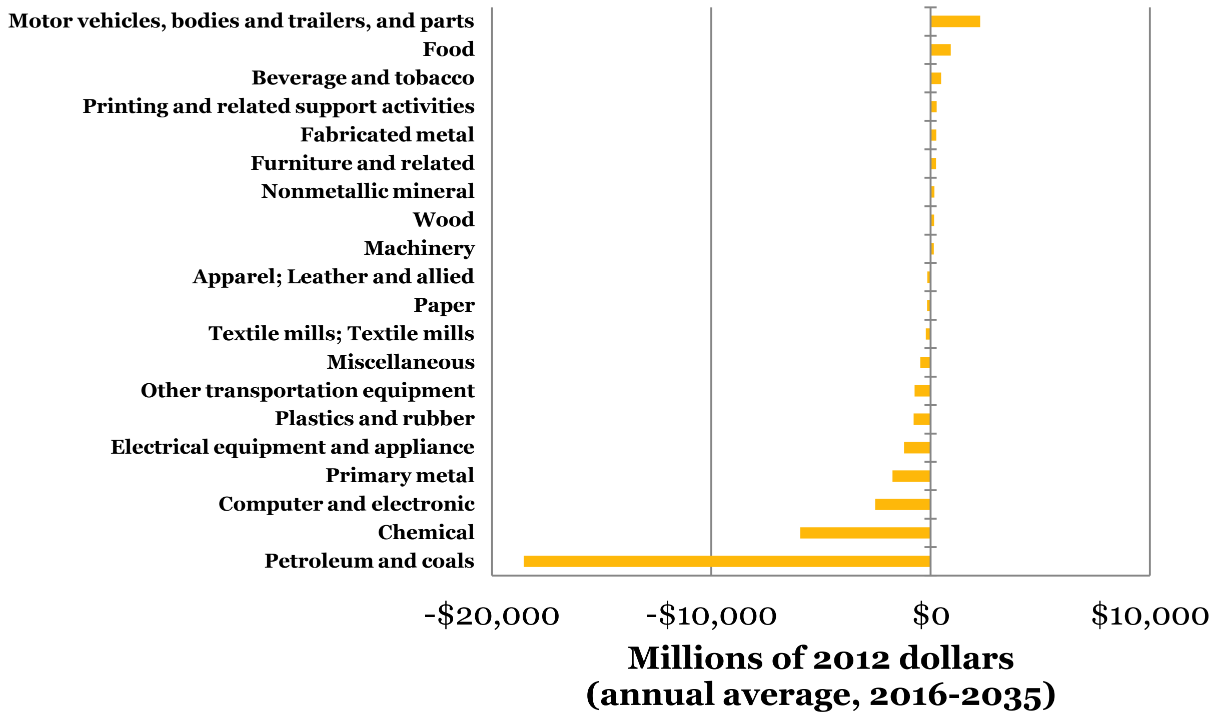

Figure 3.9 – This is the same data as the manufacturing agglomeration in the previous figure subdivided into the three-digit manufacturing sectors in the NAICS codes. As before, most of these changes represent a marginal difference from the baseline of a few percentage points.

There are several key trends in the complicated picture for American manufacturing under the FAD carbon tax. Most sectors have close to a neutral impact, though some break this pattern. The largest losses are in "petroleum and coals," which is an industry made up mostly of petroleum refineries.[35] Declining output for this industry relative to the baseline is a natural expectation from a measure like a carbon tax. A price on emissions raises upstream costs of inputs and, after a "pass-through" in market prices, the downstream cost of its final products in wholesale and retail markets. Its decline is a significant loss in output but, as *Figure 3.10* on the next page depicts, it does not represent a very significant loss in employment compared to the gains in other industries. The other industries at the bottom, including chemicals and primary metals (which produce steel and pipes), have a direct relationship to the decline in refinery output for being part of that industry's supply chain. Conversely, manufacturing subsectors with a strong connection to consumers—such as automobiles, food products, printing, fabricated metals (mostly car parts), and furniture—increase their output relative to the baseline. **In fact, if one subtracts petroleum and chemical manufacturing, the net change in the combined output under the FAD carbon tax from all of the other, "non-energy" American manufacturing sectors is close to zero.**

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[35] This sector, which is NAICS 324, mostly involves refinement of crude petroleum; please see, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=324&search=2012%20NAICS%20Search>

Employment by Major Industry (national level)

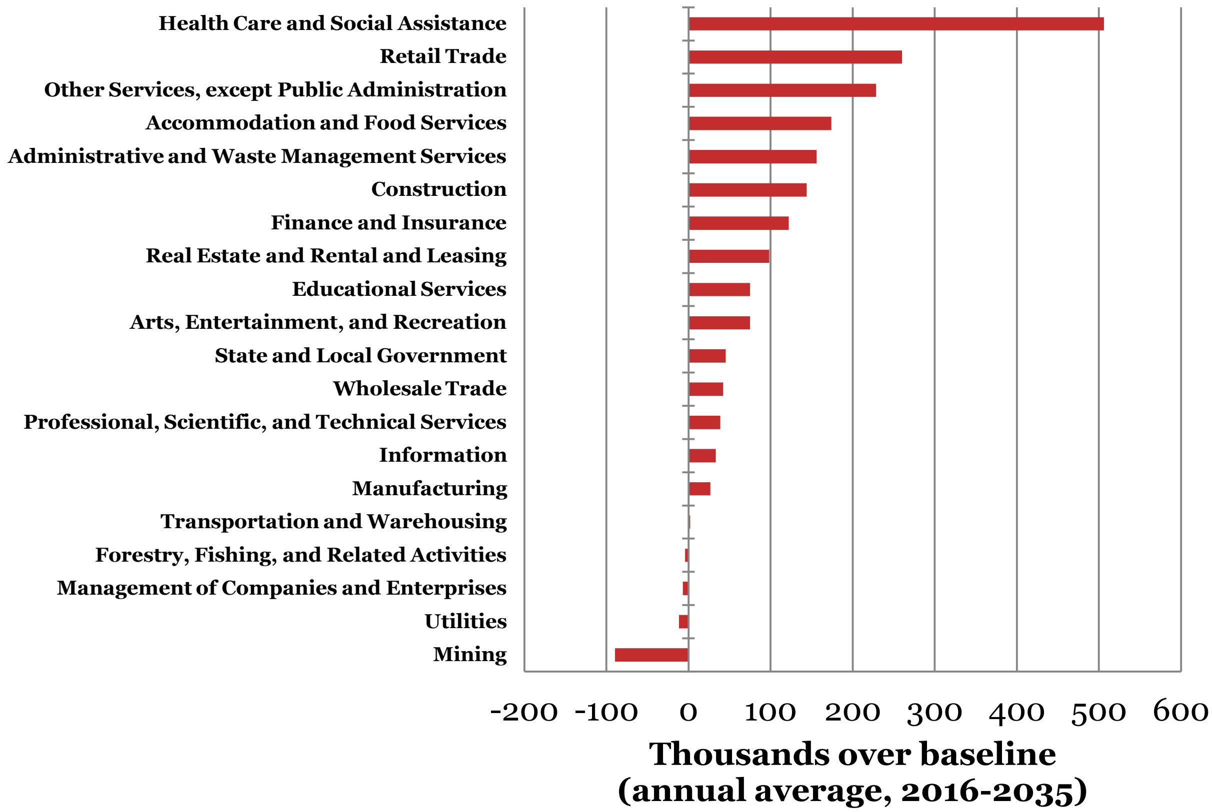

Figure 3.10 – This chart recasts the total employment by region and nationally from previous figures into the difference in jobs by industry relative to the baseline. Most sectors, with the exception of mining and utilities, have a positive impact to their employment levels.

The main factors in the results for *Figure 3.2*, *Figure 3.3*, *Figure 3.4*, and *Figure 3.5* on the regional and macroeconomic impacts to jobs, GDP, and GRP from FAD carbon tax are changes in demand by industry and labor productivity. As described, demand relates to the incentives inherent to the carbon tax. Labor productivity is a concept of the necessary labor units needed to perform a task—for instance, if a software company requires 50 workers for two years to complete a $20 million contract, this implies a labor productivity of $200,000 per worker every year.[36] Technology and the nature of the production process for each industry determine the relative "labor-intensity," or to what degree labor inputs and wages play a role in its operational enterprise. The positive results to employment levels under the carbon tax owe much to this policy's propensity to shift output away from industries with low labor-intensity (such as petroleum refining, mining, transportation, and utilities) and toward consumer-centric industries that require larger labor inputs. The healthcare and retail sectors, in particular, receive many of the extra dollars and their labor-intensity means they create an outsized portion of the net new jobs. This explains why total employment can be positive or neutral in the face of stagnant or declining GRP or GDP in the model simulations.

[36] 50 workers * 2 years * $200,000 per worker = $20 million worth of completed project

Figure 3.11 – GDP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$156	-$430	-$646	-$794
Agriculture and forestry support activities	-$11	-$42	-$64	-$74
Oil and gas extraction	-$6,344	-$13,923	-$19,207	-$20,603
Mining (except oil and gas)	-$3,380	-$10,396	-$15,971	-$16,872
Support activities for mining	-$1,101	-$1,422	-$1,366	-$1,121
Utilities	-$9,932	-$11,462	-$11,075	-$11,060
Construction	$1,814	$6,292	$7,806	$10,390
Wood manufacturing	$139	$212	$170	$156
Nonmetallic mineral manufacturing	$165	$237	$167	$177
Primary metal manufacturing	-$613	-$1,790	-$2,680	-$3,066
Fabricated metal manufacturing	$921	$332	-$226	$394
Machinery manufacturing	-$145	$438	$358	-$148
Computer and electronic manufacturing	-$504	-$2,538	-$4,314	-$4,970
Electrical equipment and appliance manufacturing	-$335	-$1,163	-$1,925	-$2,470
Motor vehicles, bodies and trailers, and parts manufacturing	$1,264	$2,314	$3,081	$3,876
Other transportation equipment manufacturing	-$179	-$693	-$1,190	-$1,557
Furniture and related manufacturing	$338	$347	$201	$38
Miscellaneous manufacturing	$58	-$467	-$875	-$1,022
Food manufacturing	$944	$1,114	$983	$857
Beverage and tobacco manufacturing	$483	$583	$532	$456
Textile mills; Textile mills	-$20	-$208	-$401	-$459
Apparel manufacturing; Leather and allied manufacturing	-$35	-$170	-$230	-$236
Paper manufacturing	$91	-$120	-$364	-$532
Printing and related support activities	$247	$318	$310	$316
Petroleum and coals manufacturing	-$8,199	-$18,210	-$27,028	-$35,033
Chemical manufacturing	-$1,016	-$5,341	-$9,824	-$13,374
Plastics and rubber manufacturing	-$40	-$640	-$1,339	-$1,879
Wholesale trade	$4,633	$6,327	$6,517	$7,582
Retail trade	$9,893	$18,138	$23,935	$30,480
Air transportation	-$3,937	-$10,395	-$17,408	-$23,916
Rail transportation	-$288	-$647	-$1,028	-$1,234
Water transportation	-$44	-$125	-$219	-$300
Truck transportation	$492	$517	$277	$219
Couriers and messengers	$222	$193	$24	-$122
Transit and ground passenger transportation	$176	$237	$243	$261
Pipeline transportation	-$508	-$838	-$979	-$988
Scenic and sightseeing transportation; Support activities for transportation	-$869	-$2,232	-$3,788	-$5,438
Warehousing and storage	$168	$162	$83	$49
Publishing industries, except Internet	$1,389	$2,019	$2,271	$2,738
Motion picture and sound recording industries	$1,301	$2,161	$2,875	$3,715
Internet publishing and broadcasting; ISPs, search portals, and data processing	$616	$803	$810	$880
Broadcasting, except Internet	$387	$536	$569	$643
Telecommunications	$3,437	$5,408	$6,561	$7,767
Monetary authorities - central bank; Credit intermediation and related activities	$9,636	$14,491	$16,689	$18,807
Securities, commodity contracts, investments	$3,847	$5,189	$5,381	$5,641
Insurance carriers and related activities	$3,813	$5,268	$5,425	$5,374
Real estate	$13,816	$22,972	$27,708	$32,174
Rental and leasing services; Leasing of nonfinancial intangible assets	-$1,164	-$4,245	-$7,656	-$10,299
Professional, scientific, and technical services	$3,453	$2,614	$120	-$978
Management of companies and enterprises	-$106	-$1,953	-$4,133	-$5,837
Administrative and support services	$2,733	$3,753	$3,864	$4,288
Waste management and remediation services	$277	$362	$353	$375
Educational services	$1,516	$2,386	$2,849	$3,177
Ambulatory health care services	$14,727	$23,715	$29,217	$34,358
Hospitals	$3,872	$6,195	$7,672	$9,001
Nursing and residential care facilities	$1,322	$2,142	$2,642	$3,075
Social assistance	$1,071	$1,704	$2,073	$2,384
Performing arts and spectator sports	$689	$1,067	$1,260	$1,481
Museums, historical sites, zoos, and parks	$105	$174	$217	$253
Amusement, gambling, and recreation	$972	$1,608	$1,977	$2,297
Accommodation	$1,543	$2,587	$3,187	$3,731
Food services and drinking places	$2,428	$3,944	$4,746	$5,405
Repair and maintenance	$1,238	$1,864	$2,112	$2,379
Personal and laundry services	$2,494	$4,052	$4,934	$5,649
Membership associations and organizations	$985	$1,525	$1,802	$2,020
Private households	$411	$737	$936	$1,092
State and local government	$4,422	$5,021	$3,991	$3,966
TOTAL OF ALL SECTORS =	$65,623	$72,609	$52,993	$53,536

Figure 3.12 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-1	-3	-4	-5
Agriculture and forestry support activities	0	-2	-2	-2
Oil and gas extraction	-25	-56	-80	-91
Mining (except oil and gas)	-13	-36	-47	-43
Support activities for mining	-4	-3	-1	0
Utilities	-15	-14	-10	-7
Construction	62	170	209	245
Wood manufacturing	3	5	6	7
Nonmetallic mineral manufacturing	3	5	7	9
Primary metal manufacturing	-1	-2	-3	-2
Fabricated metal manufacturing	8	7	6	12
Machinery manufacturing	0	2	2	1
Computer and electronic manufacturing	-2	-7	-9	-8
Electrical equipment and appliance manufacturing	-1	-4	-6	-7
Motor vehicles, bodies and trailers, and parts manufacturing	7	9	10	10
Other transportation equipment manufacturing	0	-1	-2	-2
Furniture and related manufacturing	5	5	4	2
Miscellaneous manufacturing	1	-1	-2	-1
Food manufacturing	10	14	15	15
Beverage and tobacco manufacturing	1	2	2	2
Textile mills; Textile mills	0	-2	-4	-5
Apparel manufacturing; Leather and allied manufacturing	-1	-3	-3	-2
Paper manufacturing	2	2	2	2
Printing and related support activities	3	5	4	4
Petroleum and coals manufacturing	-2	-3	-3	-3
Chemical manufacturing	1	-2	-4	-4
Plastics and rubber manufacturing	2	0	-2	-3
Wholesale trade	34	49	52	56
Retail trade	172	289	342	387
Air transportation	-14	-32	-48	-59
Rail transportation	-1	-1	-1	0
Water transportation	0	1	2	3
Truck transportation	14	29	45	65
Couriers and messengers	5	9	13	18
Transit and ground passenger transportation	6	10	13	17
Pipeline transportation	-1	-1	-1	-1
Scenic and sightseeing transportation; Support activities for transportation	-8	-19	-28	-37
Warehousing and storage	4	5	5	6
Publishing industries, except Internet	6	8	8	8
Motion picture and sound recording industries	6	9	11	12
Internet publishing and broadcasting; ISPs, search portals, and data processing	2	3	3	2
Broadcasting, except Internet	2	3	3	4
Telecommunications	10	14	15	16
Monetary authorities - central bank; Credit intermediation and related activities	34	47	48	49
Securities, commodity contracts, investments	44	58	57	57
Insurance carriers and related activities	28	38	38	37
Real estate	62	105	121	130
Rental and leasing services; Leasing of nonfinancial intangible assets	6	7	6	5
Professional, scientific, and technical services	43	49	38	37
Management of companies and enterprises	0	-7	-13	-15
Administrative and support services	101	168	199	226
Waste management and remediation services	3	4	5	6
Educational services	46	81	101	115
Ambulatory health care services	190	311	387	459
Hospitals	57	95	118	136
Nursing and residential care facilities	35	61	77	91
Social assistance	42	71	89	103
Performing arts and spectator sports	16	24	27	30
Museums, historical sites, zoos, and parks	2	3	4	5
Amusement, gambling, and recreation	32	54	67	76
Accommodation	23	38	46	50
Food services and drinking places	91	155	185	201
Repair and maintenance	18	29	33	37
Personal and laundry services	56	88	101	110
Membership associations and organizations	34	55	66	74
Private households	49	82	96	104
State and local government	53	57	43	41
TOTAL OF ALL SECTORS =	1,344	2,140	2,458	2,785

The data in *Figure 3.13* examines the impact from the FAD carbon tax to the labor market at the national level not from the perspective of industry-by-industry but rather by each "occupation." An occupation is a task or type of worker that may work in different industries depending on qualifications; all industries employ a number of occupations. For instance, a commercial bank in a city like Charlotte, North Carolina or Seattle, Washington will employ executives, analysts, records clerks, managers and supervisors, IT and HR professionals, sales representatives, receptionists, and maintenance personnel of any buildings and grounds. All these occupations have differing backgrounds in terms of education, position in the corporate hierarchy, and wages—hence, an examination of the impact by occupation is one means for approaching the socioeconomic aspects of PI+ analysis. In addition, occupation-by-occupation impacts are often a more accurate way to measure the net impacts on labor attributable to a policy than industry level impacts. After all, for most workers, finding a job or good pay is more important to them than the NAICS code of their employer. Some industries have a decline in their total level of employment relative to the baseline in *Figure 3.12*, but very few of the occupations have a similar result. These numbers represent small changes against a baseline over a long horizon, which implies hiring and natural attrition over time are the more likely means for the changes below to take place (rather than any surges in direct hiring or layoffs). For example, in the scenario of FAD carbon tax, a young engineering graduate or a certified welder is slightly more likely to find work in the automotive sector, in construction (of housing or commercial square footage), or in wind power instead of with mining, oil and gas extraction, or petroleum refining. Still other engineers might find themselves using their education to move into another quantitative occupation such as financial analysis, computer programming, research and development, professional sales, or management where jobs would be marginally more plentiful than in the baseline within several industries. This helps allow the economy and labor market to absorb these small changes over a decade's experience.

Figure 3.13 – Employment by Occupation (thousands over baseline)

95-occupation SOC	2020	2025	2030	2035
Top executives	18	27	29	31
Advertising, marketing, promotions, public relations, and sales managers	5	8	8	9
Operations specialties managers	11	14	13	14
Other management occupations	21	34	39	44
Business operations specialists	28	41	43	47
Financial specialists	32	43	43	45
Computer occupations	17	19	16	15
Mathematical science occupations	1	1	1	1
Architects, surveyors, and cartographers	0	0	0	0
Engineers	-3	-8	-13	-15
Drafters, engineering technicians, and mapping technicians	0	0	-1	-1
Life scientists	1	1	1	1
Physical scientists	-1	-2	-4	-4
Social scientists and related workers	2	3	3	4
Life, physical, and social science technicians	0	-1	-2	-2
Counselors and Social workers	13	21	26	30
Miscellaneous community and social service specialists	8	13	16	19
Religious workers	0	1	1	1
Lawyers, judges, and related workers	4	5	4	4
Legal support workers	2	3	3	2
Postsecondary teachers	15	25	29	33
Preschool, primary, secondary, and special education school teachers	21	29	31	34
Other teachers and instructors	7	11	12	14
Librarians, curators, and archivists	2	2	2	3
Other education, training, and library occupations	9	14	16	18
Art and design workers	5	7	7	7

Entertainers and performers, sports and related workers	8	13	15	17
Media and communication workers	8	12	13	14
Media and communication equipment workers	3	4	4	5
Health diagnosing and treating practitioners	78	128	158	186
Health technologists and technicians	46	75	93	109
Other healthcare practitioners and technical occupations	1	2	2	3
Nursing, psychiatric, and home health aides	32	54	68	81
Occupational therapy and physical therapist assistants and aides	4	7	9	11
Other healthcare support occupations	37	60	74	85
Supervisors of protective service workers	1	1	1	1
Fire fighting and prevention workers	1	1	1	1
Law enforcement workers	3	4	3	3
Other protective service workers	13	20	23	25
Supervisors of food preparation and serving workers	9	14	17	19
Cooks and food preparation workers	28	46	55	60
Food and beverage serving workers	63	107	128	141
Other food preparation and serving related workers	13	21	25	27
Supervisors of building and grounds cleaning and maintenance workers	6	11	13	15
Building cleaning and pest control workers	52	87	102	112
Grounds maintenance workers	43	80	100	116
Supervisors of personal care and service workers	3	5	6	6
Animal care and service workers	5	8	9	10
Entertainment attendants and related workers	9	15	18	20
Funeral service workers	1	1	1	1
Personal appearance workers	30	48	57	64
Baggage porters, bellhops, and concierges; Tour and travel guides	1	1	1	1
Other personal care and service workers	52	89	108	124
Supervisors of sales workers	17	27	32	36
Retail sales workers	102	170	201	225
Sales representatives, services	23	32	33	33
Sales representatives, wholesale and manufacturing	11	16	17	18
Other sales and related workers	15	24	28	31
Supervisors of office and administrative support workers	17	25	29	32
Communications equipment operators	1	2	2	2
Financial clerks	40	61	67	74
Information and record clerks	64	94	104	114
Material recording, scheduling, dispatching, and distributing workers	23	34	37	41
Secretaries and administrative assistants	51	80	91	103
Other office and administrative support workers	43	66	73	80
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	1	1	1	1
Fishing and hunting workers	0	-1	-1	-1
Forest, conservation, and logging workers	0	0	0	-1
Supervisors of construction and extraction workers	3	8	9	11
Construction trades workers	34	89	108	129
Helpers, construction trades	3	8	10	12
Other construction and related workers	2	3	4	4
Extraction workers	-11	-22	-28	-28
Supervisors of installation, maintenance, and repair workers	3	5	6	7
Electrical and electronic equipment mechanics, installers, and repairers	4	6	7	7
Vehicle and mobile equipment mechanics, installers, and repairers	12	19	21	24
Other installation, maintenance, and repair occupations	23	41	47	54
Supervisors of production workers	2	1	1	1
Assemblers and fabricators	7	8	8	9
Food processing workers	6	9	10	11
Metal workers and plastic workers	5	4	3	5
Printing workers	2	3	2	2
Textile, apparel, and furnishings workers	5	6	5	5
Woodworkers	2	3	3	3
Plant and system operators	-3	-5	-6	-6
Other production occupations	12	14	14	15
Supervisors of transportation and material moving workers	2	4	4	5
Air transportation workers	-5	-13	-19	-24
Motor vehicle operators	30	52	68	88
Rail transportation workers	0	-1	-1	0
Water transportation workers	0	0	0	1
Other transportation workers	4	6	6	6
Material moving workers	25	35	37	45
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	1,344	2,140	2,458	2,785

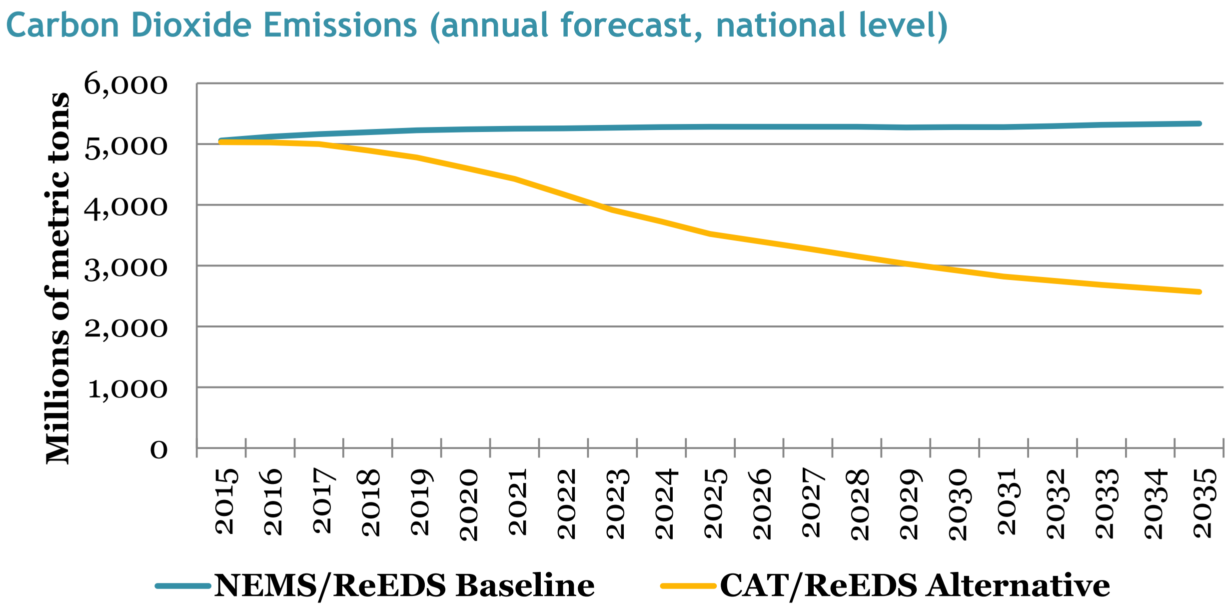

Figure 3.14 – These lines illustrate a baseline for emissions without the tax from the Reference Case in the AEO and ReEDS (blue). The alternative (gold) after a $10 per year tax, price elasticity of demand in CAT, and grid optimization in ReEDS represents a significant reduction in emissions—of 52% by 2035. The baseline is not exactly the same as the one in the AEO because this projection uses ReEDS for the power generation portion of the emissions forecast. They are rather close, however. AEO 2013 projects a 2.4% increase in national emissions from 2015 to 2035 while the blue line above projects a 5.5% total increase.

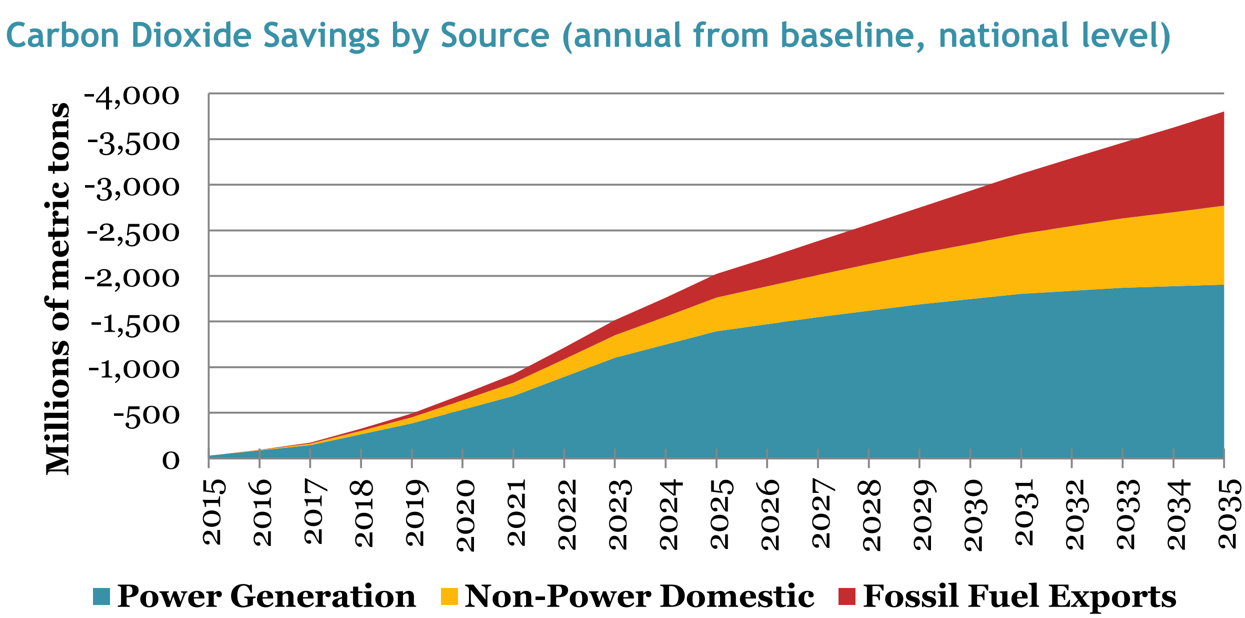

Figure 3.15 – This shows the savings in carbon dioxide emissions by major source broken out into power generation, non-power domestic fuels, and reduced fossil fuel exports.

The data in *Figure 3.15* reveals trends about the disposition of the economy, technology, and their ability to find savings. The power sector, in particular, illustrates the initial likelihood to save emissions. There are full details in a later section. However, in summary, a relatively low tax rate in the 2010s and 2020s (of $50 per year to $100 per year) and the certainty of a higher rate in the 2030s (within the lifespan of any investments) means a large reduction in coal-fired generation and its replacement with gas, nuclear, and renewable sources. This greatly reduces emissions from power "early" in policy life. Reductions from residential or business consumers of natural gas and petroleum products (especially motor gasoline) are slower given changes in end-use prices and the relatively inelastic price responses.[37] The response is slower when the impact to gasoline prices is less than $1 per gallon, although it does accelerate later when it approaches $2 per gallon. "Blue" and "gold" in *Figure 3.15* represent mostly a net reduction in American and world emissions—**the "red" section, however, shows only the implied savings from reduced exports of coal, natural gas, and petroleum products. "Red" does not necessarily represent a net world reduction, however, given that foreign production of fossil fuels (from the Middle East, Australia, or other regions) may increase to make up for reduced American exports.**

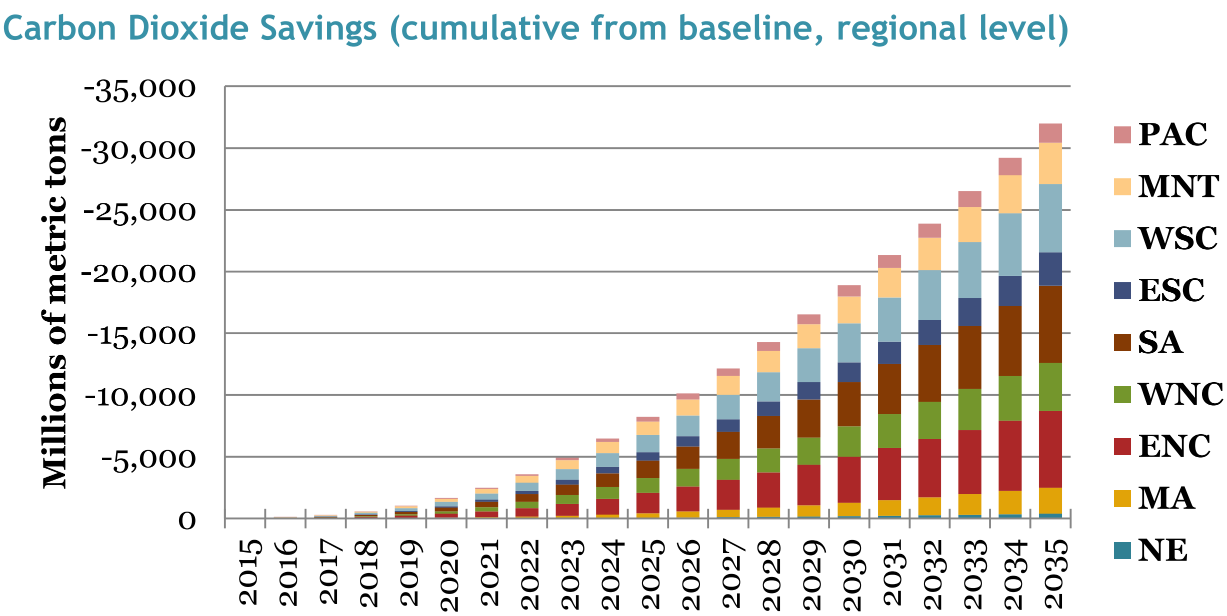

Figure 3.16 – This shows the cumulative savings from Figure 3.14 of reduced domestic emissions from power generation or fuel by region. A reduction of emissions of over 30 billion metric tons over two-decades is as if six years of baseline emissions from 2015 to 2035 no longer enter the atmosphere. Most savings occur in the late 2020s and early 2030s after the economy has a chance to adjust to carbon pricing. In terms of regions, larger regions with the majority of power generation from coal and natural gas (ENC, WNC, and SA) and heavy rates of gasoline purchases (SA, WSC) see the largest share of emissions reductions. Smaller regions without much fossil fuel usage (such as NE), on the other hand, contribute much less.

[37] For example, the average price elasticity of demand in this study for motor gasoline from the original CTAM and PI+ is -0.62, which means a 1% in gasoline prices only reduces demand by 0.62%

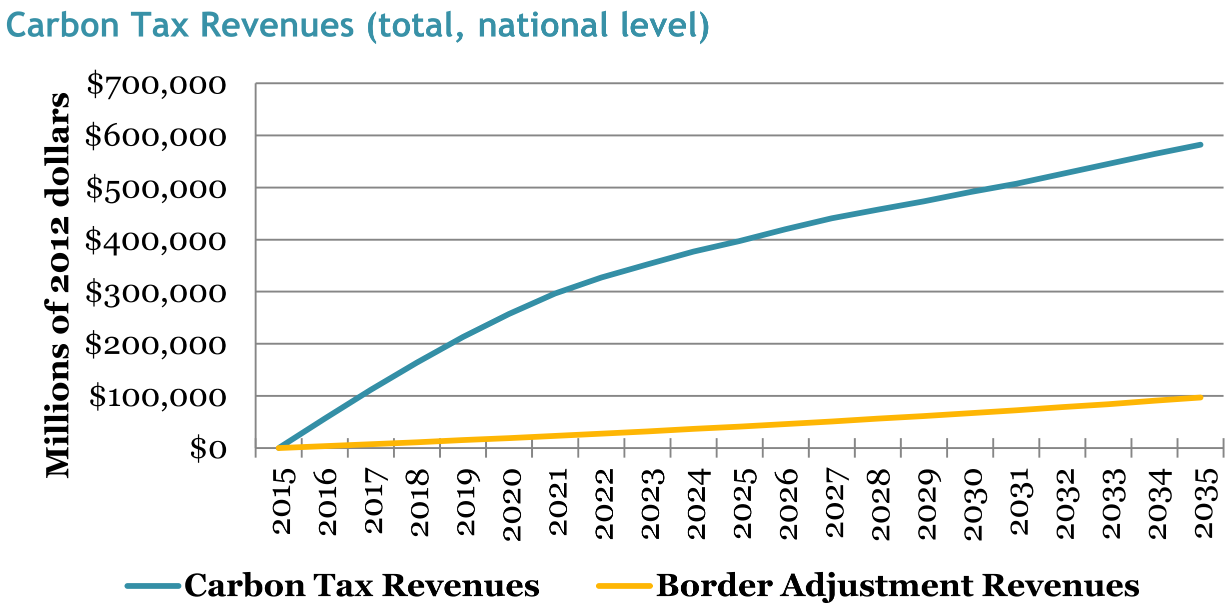

Figure 3.17 – The results above are for the revenues from the carbon tax in blue and receipts from the border adjustment in gold. These revenues are significant and robust despite a decline in emissions in CAT and ReEDS in the late 2020s and 2030s—the increasing tax rate keeps revenues robust through at least the two-decade window. For context, federal revenue in 2012 came in at $2.45 trillion (and corporate income tax receipts at $242.3 billion).[38]

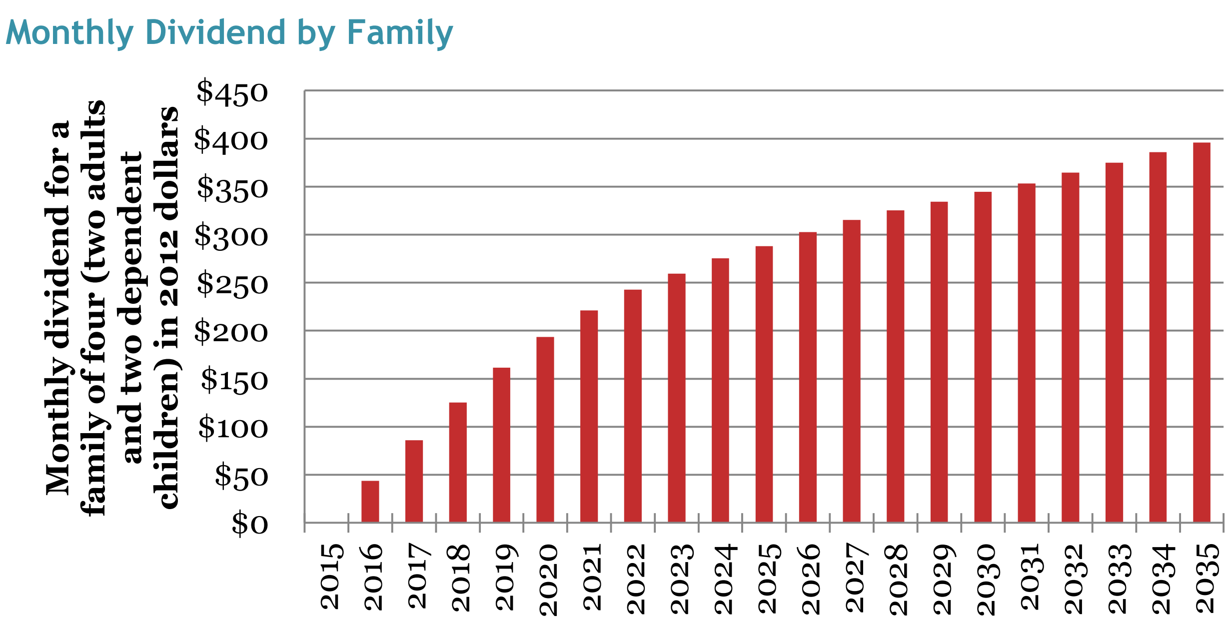

Figure 3.18 – This divides the "blue" general carbon tax revenue in Figure 3.17 across all American households for their projected share of the monthly carbon tax dividend.

[38] From CBO data, please see, <http://www.cbo.gov/publication/45249>

Cost of Living (regional level)

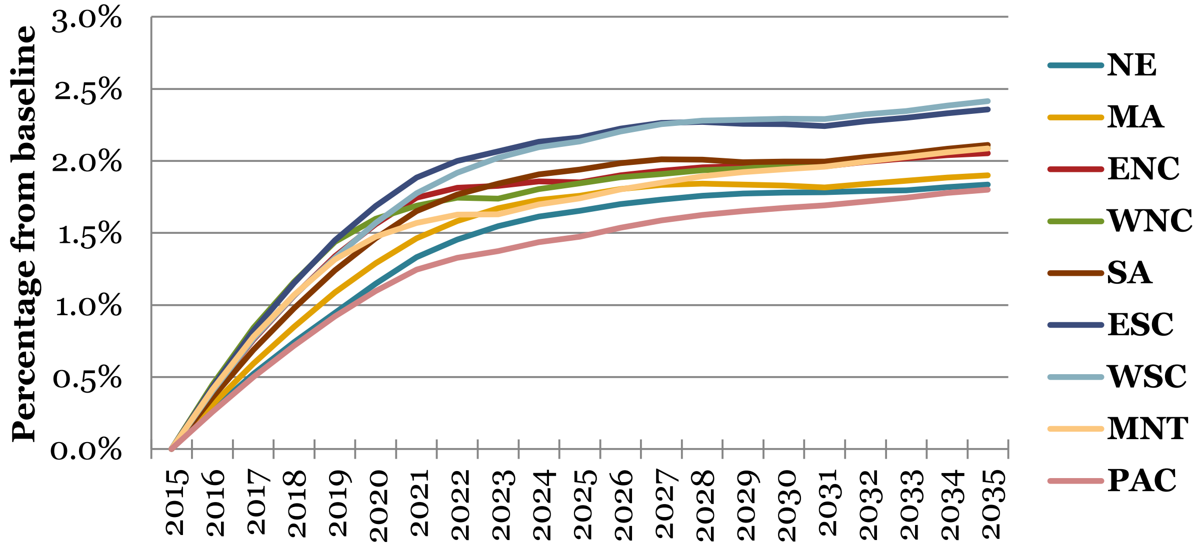

Figure 3.19 – This represents the change in the cost of living for households in PI+ from higher energy costs and any pass-through of higher prices from businesses because of a higher cost of production. PI+ utilizes an internal Personal Consumption Expenditure (PCE) index, which is similar to the Consumer Price Index (CPI) though different in some of its treatment of housing and local taxes. The carbon tax does elevate the cost of living in the model in every one of the nine regions. Energy-intensive regions such as ESC and WSC have the largest impacts while less energy-intensive regions like NE and PAC have smaller results. However, the above is a modest, "one-time" vector adjustment of less than 3% over a twenty-year period. This is the equivalent to adding one "extra" year of inflation between 2016 and 2025 before achieving price stability relative to the "do-nothing" baseline sometime in the late 2020s.

The next section and *Figure 3.20* describe the average impact to energy prices by commodity attributable to the carbon tax. The results on average electricity prices are out of ReEDS, and the results for petroleum products and natural gas are the calculated differences in CAT based on the inherent carbon dioxide content of the fuels, the tax rate, and the price forecasts in the Reference Case of the AEO. The difference in natural gas prices are especially high in the results because the absolute price forecast for natural gas is lower than for petroleum products in the EIA data.[39] The numbers, as in *Figure 3.19*, represent a one-time adjustment against the baseline and not any projected or assumed growth rate in energy prices of the future. In fact, retail energy prices might fall in the future if NEMS finds a market solution where such results are feasible. Most of the impacts by region are not divergent to any significant degree—a $1 per ton carbon tax still corresponds to an excise tax on retail gasoline of $0.009 per gallon anywhere in the country (given that chemistry does not vary between MA, SA, MNT, or other regions). Higher prices do have a negative impact by themselves. Contextualizing them with the cost of living in *Figure 3.19* and the macroeconomic results in the previous section implies the total economy offsets some of the potential harms below.

[39] In energy-equivalent units (such as dollars per MMBTU or other thermal measurements)

Energy Commodity Prices (national level)

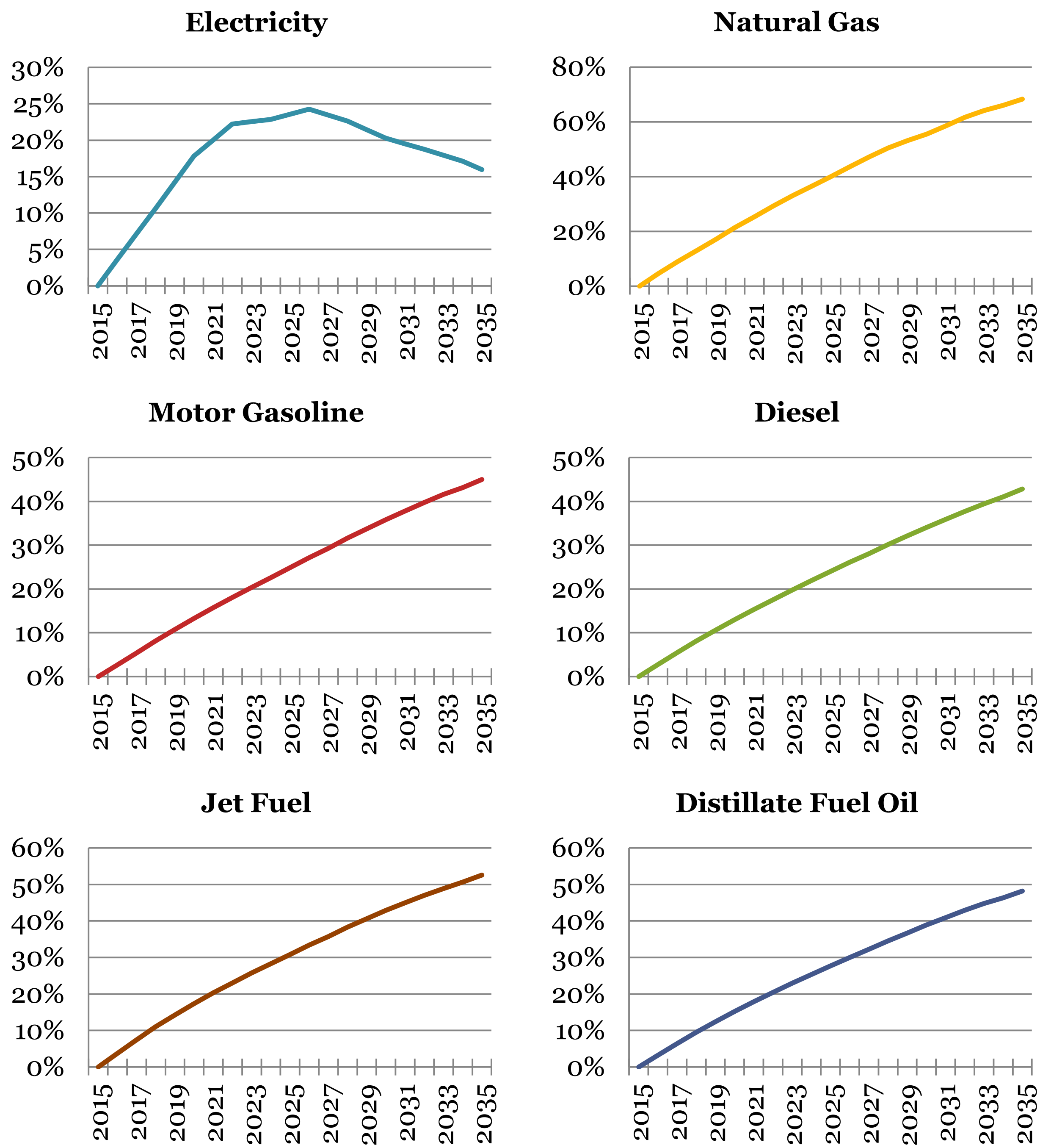

Figure 3.20 – Most commodities see a linear increase in their prices relative to the baseline with the national level, linear increase in the rate. Electricity, on the other hand, can switch out of carbon-intensive coal and natural gas and into zero-carbon nuclear, wind, and solar, which reduces the impact in the 2020s and 2030s. All these have a negative effect, but the macroeconomic balance is positive, and it does generate revenues for the FAD and incentivize the significant reduction of national and regional level emissions.

Cost of Living (by quintile, national level)

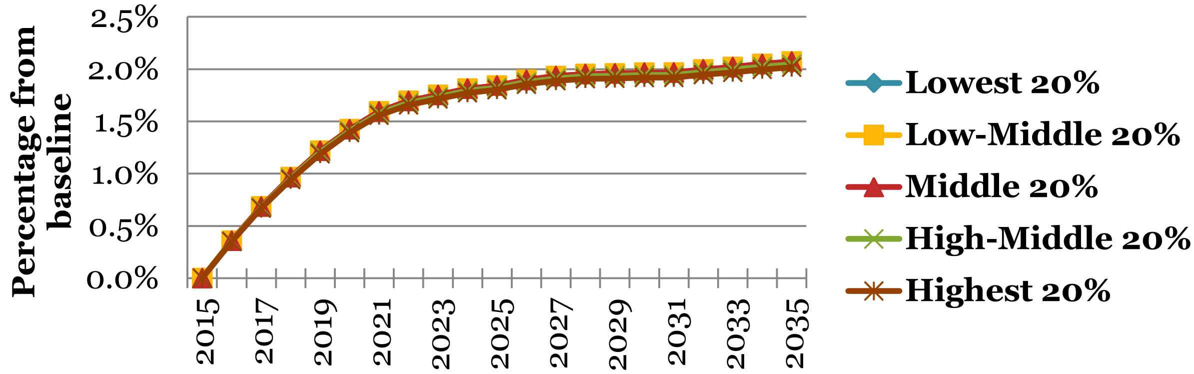

Figure 3.21 – This adapts the data in Figure 3.19 to display by income quintile (the 20% increments) instead of by region.[40] ***The impact to the cost of living between different quintiles is nearly indistinguishable in the modeling's net results.***

A critical concern with a carbon tax is that it may behave regressively—cost of living spikes for low-income households disproportionately more than that for earners and households higher in the income spectrum. There is a bevy of literature on the topic.[41] The general theory is such that lower-income households have much less flexibility with their spending and, unlike wealthier households, cannot cutback on luxury purchases (electronics, travel, and new vehicles) in order to cover the costs of necessities like food and fuel. This logic is sensible; however, consumption of energy is "income elastic" as wealthier people tend to live in larger dwellings, own more cars, use public transportation less, travel by air, and have more appliances and electronics. This aids in "leveling" the share of income for energy purchases across income quintiles. Other aspects of this policy help to equalize its socioeconomics. As demonstrated in *Figure 3.22* ahead, the occupational mixture of new jobs over the baseline from FAD carbon tax tend to be in the lower 60% of the distribution. Increasing the quality of the labor market for workers—in terms of employment opportunity and wages—helps offset any of the negative effects from higher energy costs. The Congressional Budget Office (CBO) assessed a FAD-like idea (a refundable income tax rebate) as a means for offsetting the cost of higher energy prices for lower-income households under a carbon tax, concluding, "A refundable tax rebate of a fixed dollar amount would be progressive, providing greater relief as a percentage of income to low-income households."[42] Furthermore, "Based on earlier CBO work, fully offsetting the additional cost that a carbon tax

[40] Above calculations in PI+ based on the Consumer Expenditure Survey 2011 by the BLS, <http://www.bls.gov/cex/csxstnd.htm>, for the methodology of the calculations, please see, <http://www.remi.com/download/documentation/pi+/pi+_version_1.3/Income_Distribution.pdf>

[41] There is some disagreement, although most "static" studies on this question look only at prices and not macroeconomic feedbacks in markets like in PI+, for example, please see Corbett A. Grainger and Charles D. Kolstad, "Who Pays a Price on Carbon," *National Bureau of Economic Research* (NBER), NBER Working Paper #15239, August 2009, <http://www.nber.org/papers/w15239>

[42] CBO has a full discussion of the pros and cons of a refundable income tax credit (which has similar incentives to FAD though with a different structure, being nested in the existing tax code) on pp. 8-9 of Terry Dinan, "Offsetting a Carbon Tax's Cost on Low-Income Households," *Congressional Budget Office* (CBO), November 2012, <http://www.cbo.gov/sites/default/files/cbofiles/attachments/11-13LowIncomeOptions.pdf>

would impose on households in the lowest income quintile would take roughly 12% of the gross revenue."[43] The FAD would approximate this distribution of the funds. Household size is not uniform across the spectrum, and, on average, more members for a household means there are more adults available for full-time employment and adolescents for part-time work. The median household with an income under $25,000 per year has less than two members, the median one from $25,000 per year to $100,000 per year has two to three, and the median household over $100,000 per year has three or more.[44] **If the average family has around 2.0 or 3.0 shares of the FAD (two adults and two children) and the average low-income family has 1.5 or 2.0 (two adults or one adult and one child), then low-income households would receive between 10% and 15% of FAD funds—satisfying CBO's criteria to "make whole" the bottom 20%.** A FAD design would also create an implicit "guaranteed income" system in the same way as the Alaska Permanent Fund, which would complement and supplement existing welfare benefits.[45]

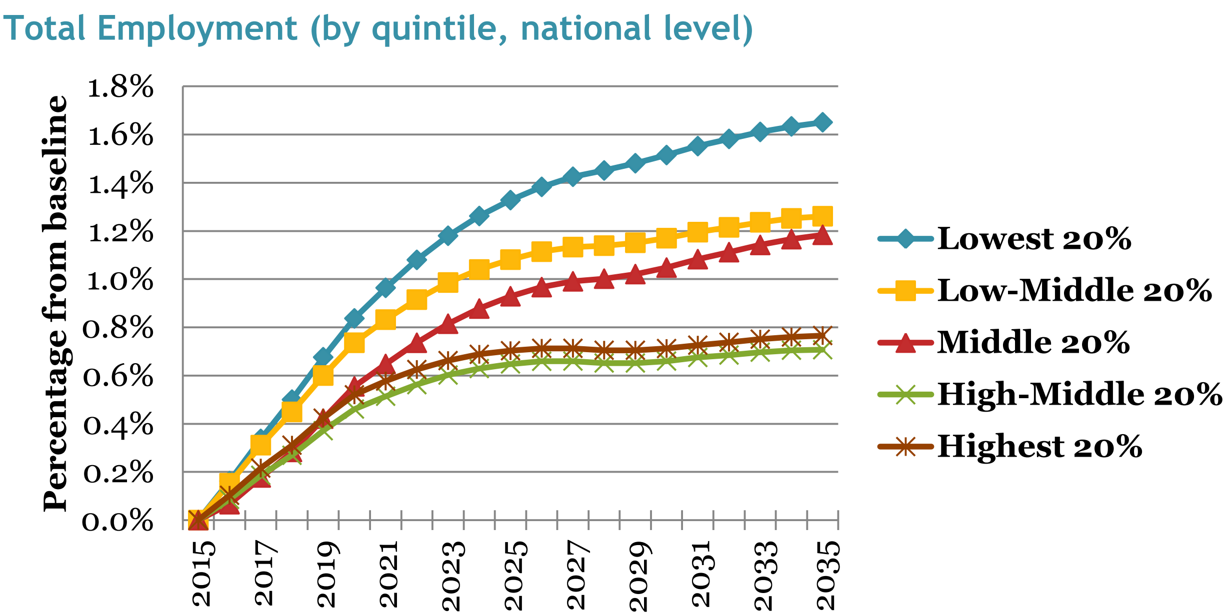

Figure 3.22 – This figure shows the percentage change to total employment levels by occupational quintile against the baseline. While all quintiles see an increase in the total number of jobs, the bottom 60% actually has a disproportionate share. This is due to the carbon tax and FAD's propensity to generate jobs in labor-intensive service sectors, which require large quantities of labor inputs but typically offer wages below the median.

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43 Ibid., p. 13

44 For the raw data table from the U.S. Census on household size and income expectation, please see, <https://www.census.gov/hhes/www/income/data/historical/household/2011/H09AR_2011.xls>

45 Please see Megan McArdle, "They'll Pay You to Live in Switzerland," *Bloomberg*, November 15, 2013, <http://www.bloomberg.com/news/2013-11-15/they-ll-pay-you-to-live-in-switzerland-.html>; Annie Lowrey, "Switzerland's Proposal to Pay People for Being Alive," *New York Times*, November 12, 2013, <http://www.nytimes.com/2013/11/17/magazine/switzerlands-proposal-to-pay-people-for-being-alive.html?pagewanted=all&src=ISMR_AP_LO_MST_FB&_r=2&>

Real Disposable Personal Income (regional level)

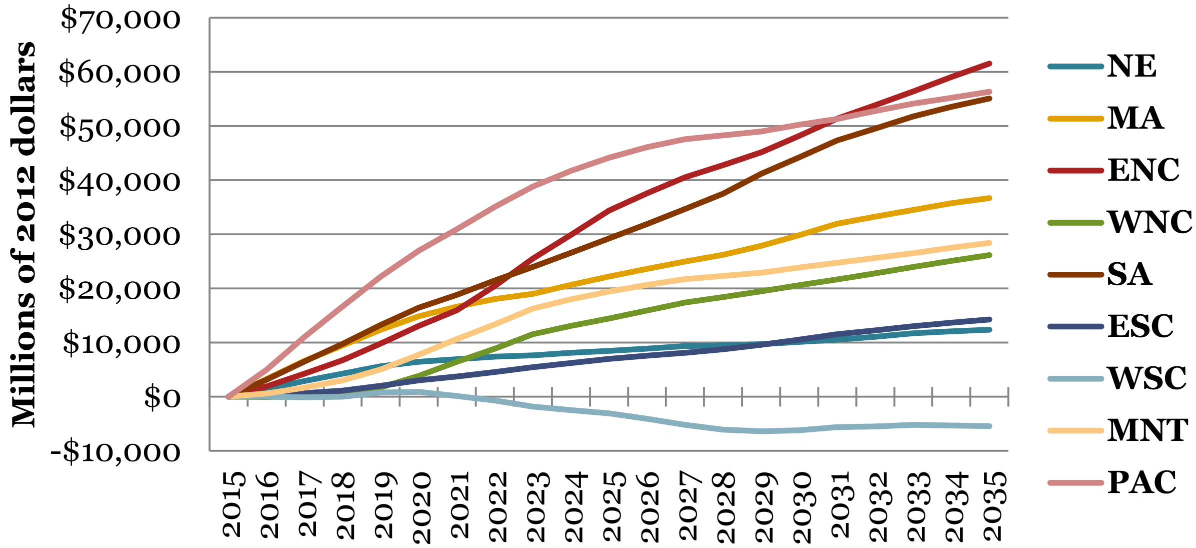

Figure 3.23 – This is the regional level impact to aggregate personal income. For example, if a hypothetical region had five income-earners each making $100,000 per year, then total real disposable personal income (RDPI) in the region would be $500,000 per year. Given that the above is real income, this means it is the net of increasing the number of jobs available and wages, the FAD rebates to households, and any negative impact from higher energy prices reflected in the price index in Figure 3.19. Most regions have a positive impact, although the WSC region has a neutral/slightly negative impact (with a smaller population).

Real Disposable Personal Income (national level)

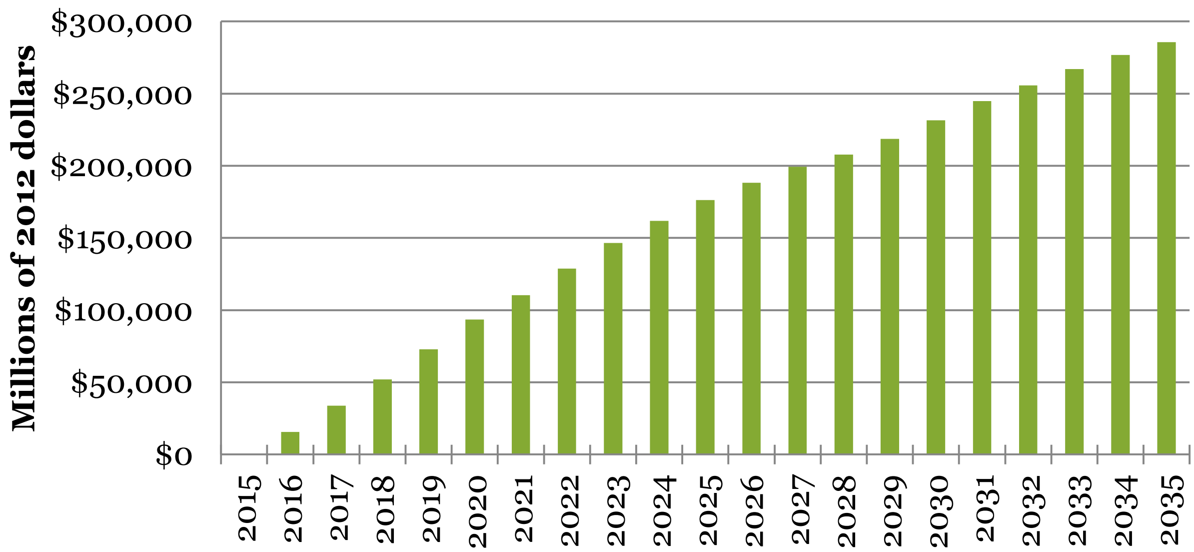

Figure 3.24 – Total RDPI at the national level increases between $150 billion and $300 billion depending on the year, which is as much as 1.25% more than levels in the baseline.

Real Disposable Personal Income (per capita, regional level)

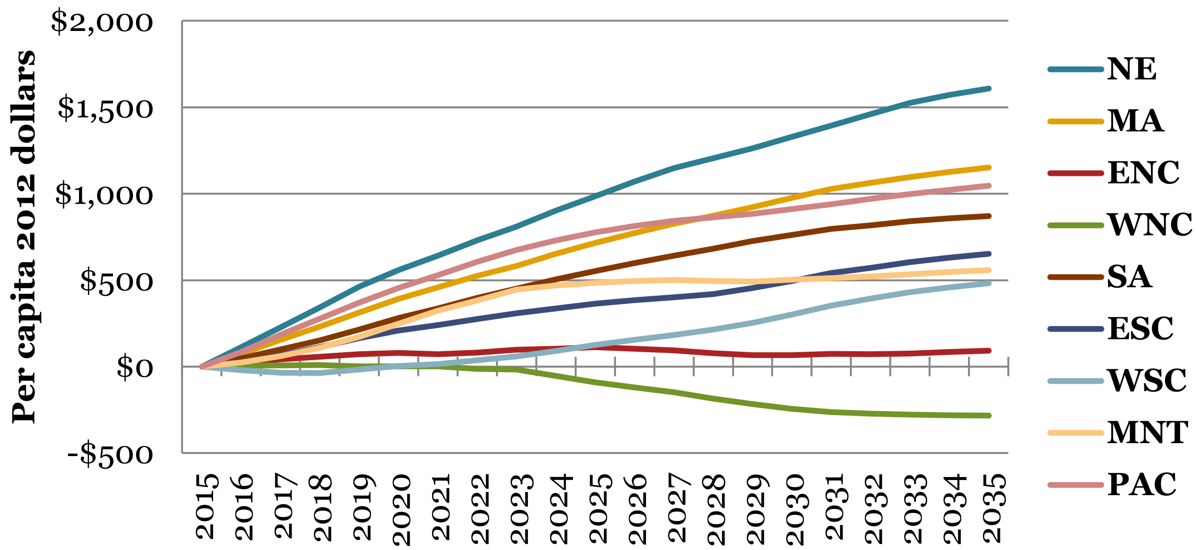

Figure 3.25 – This recasts the results from Figure 3.23 in per capita terms. This means the above results take account of not only changes in RDPI—the net of the impact to the labor market, FAD checks, and energy prices—but also to population and demographic trends. For instance, the Midwestern regions, ENC and WNC, add $60 billion and $25 billion to annual RDPI by 2035, respectively, although here their per capita impact is close to zero. Therefore, each region must have experienced a large increase in its population relative to baseline, which is the happenstance under the FAD carbon tax simulations here.

Real Disposable Personal Income (per capita, national level)

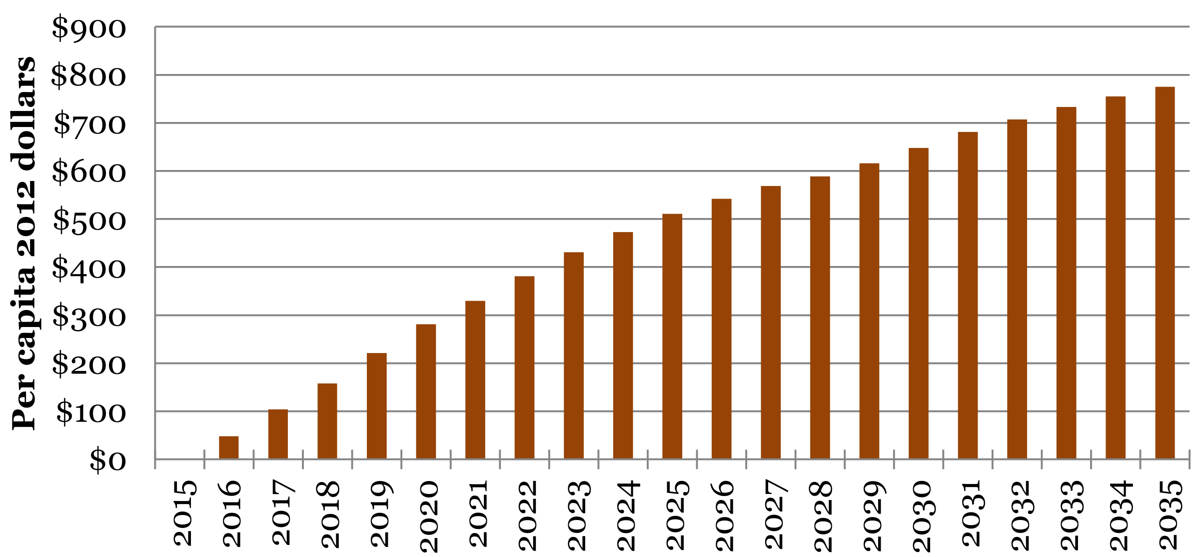

Figure 3.26 – This aggregates the regional level results to the national level. Real per capita income is $500 more by 2025 and almost $800 more by the models' sunset in 2035.

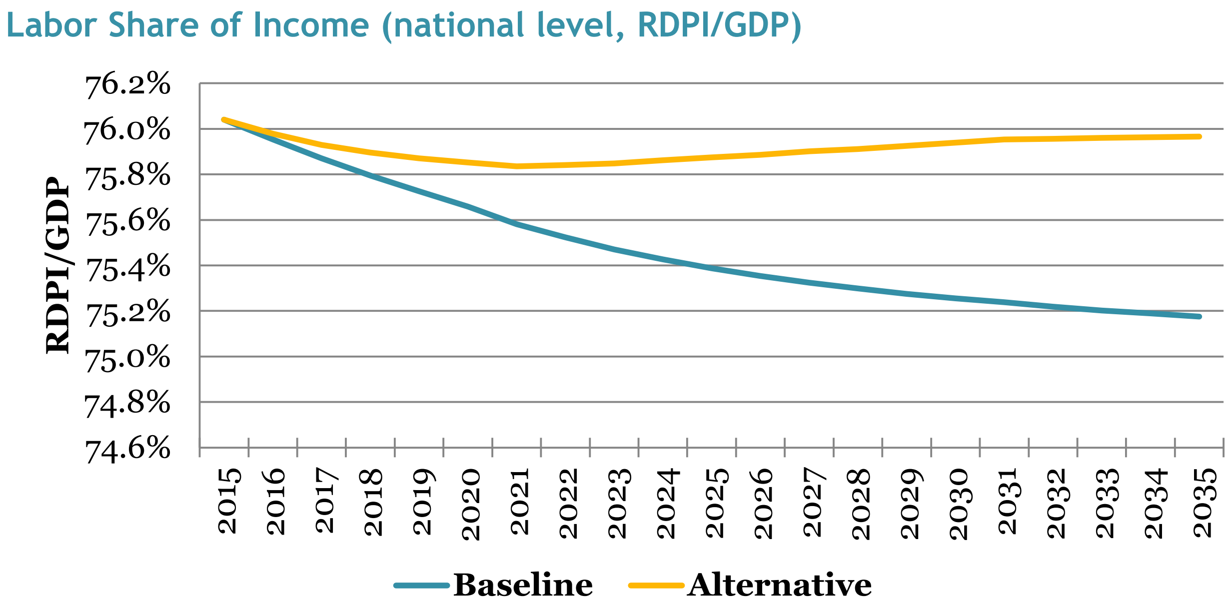

Figure 3.27 – Finishing the conversation at this time on the distributional aspects of carbon tax, this shows the labor share of income in the PI+ model—defined as the ratio of real disposable personal income to GDP here. The baseline has a decline in the labor share from around 76% in 2016 down to near 75% by 2035, but the alternative policy reverses this.

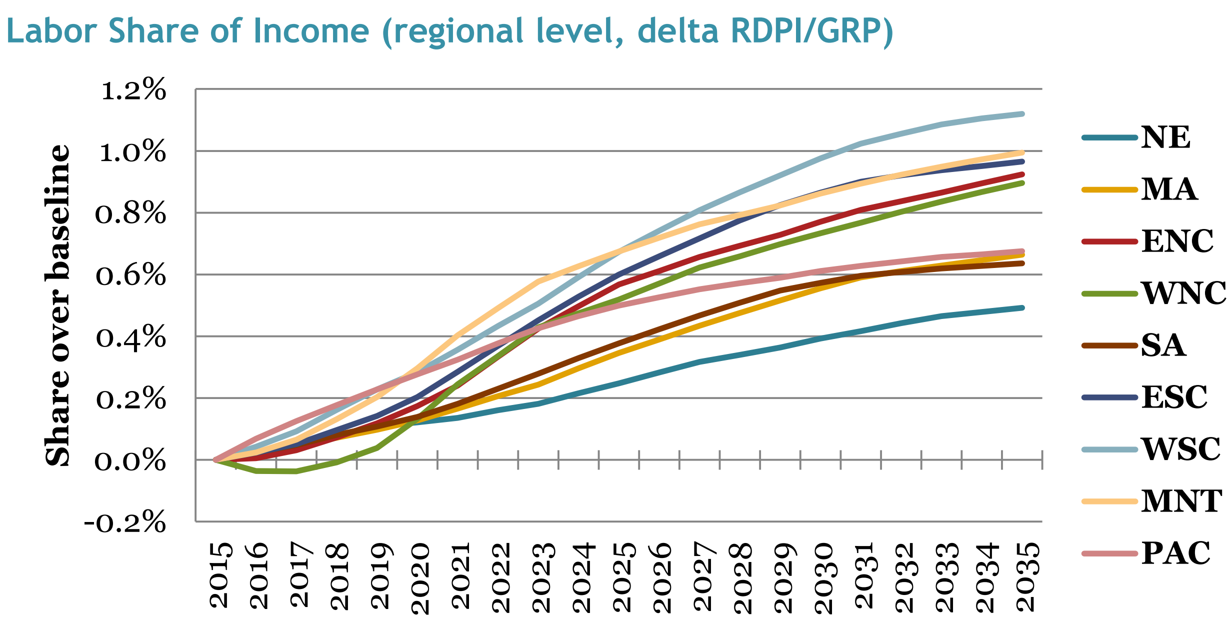

Figure 3.28 – This shows the "delta" to the labor share of income, RDPI/GRP, by region (the equivalent to the difference between "blue" and "gold" in Figure 3.27). All of the regions have an increase in their labor share of income relative to the baseline in the simulations. The increase in WSC is the most because it maintains a neutral level of employment (in the consumer-centric and labor-intensive service sectors) in the face of a decline in GRP.

Electrical Power Capacity (national level)[46]

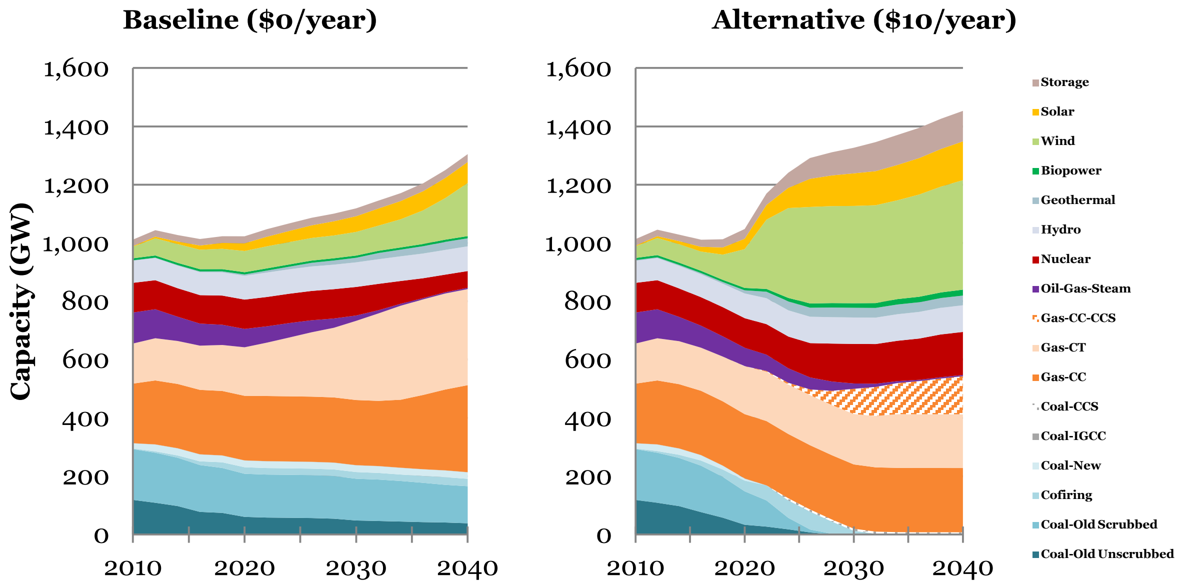

Figure 3.29 – This shows the total installed capacity by technology type at the national level from ReEDS. Power capacity and generation results for the nine regions are in the appendix.

Electrical Power Generation (national level)

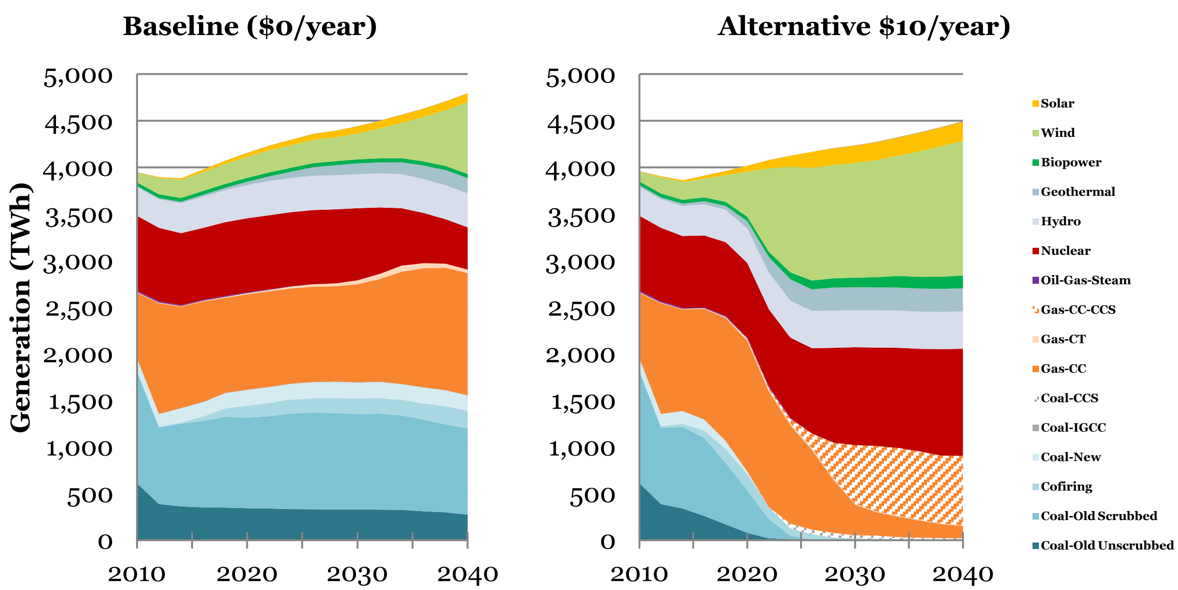

Figure 3.30 – This is also from ReEDS on national level generation. Results run to 2040 because ReEDS is "forward-looking" in its capacity installments vis-à-vis future prices.

46 Gas-CC-CCS = combined cycle-carbon capture and storage, Gas-CT = combustion turbine, Gas-CC = combined cycle, Gas-CCS = carbon capture and storage

Several trends in *Figure 3.29* and *Figure 3.30* help drive the further economic, climate, fiscal, and demographic results elsewhere.[47] The most notable trend is that a carbon tax at $10 per year starting in 2016 eliminates coal-related capacity and generation by the late 2020s. When assuming thermal equivalence, coal is a carbon-intensive resource—one MMBTU of energy from coal releases between 93.28 kilograms and 103.69 kilograms of carbon dioxide into the atmosphere.[48] Natural gas, in contrast, averages 53.06 kilograms per MMBTU, which makes gas approximately twice as "carbon-efficient" as coal for energy.[49] Aside from the carbon dioxide reductions of less coal, coal plants are also large sources of NO_X and SO_X emissions,[50] which influence air quality, quality of life, and amenity. Coal-derived capacity and generation gives way to some additional natural gas in the short- and medium-term in the model. However, ReEDS looks at anticipated future prices when making decisions about new investments, which means even natural gas seem less competitive in the future when optimizing for the higher tax rate in the late 2020s and 2030s. Some natural gas does remain for base-load purposes, however, and especially gas with carbon capture and carbon sequestration at scales in the 2030s. Replacing coal and natural gas on the grid are, to degrees, nuclear power, biomass, geothermal, wind, and solar. Gas-CT capacity also expands to meet needs for a few peak hours each year. As these plants see use so infrequently, little overall generation from them appears in *Figure 3.30*. Hydroelectricity is present and significant in both the baseline and the alternative, and especially in the MNT and PAC regions of the western United States. The paucity of major rivers with steep elevation changes that still lack a dam in North America prevents the hydroelectric sector from expanding much even with a carbon price. The baseline trend for nuclear power is such that the existing fleet ages in place before eventually retiring in the next few decades, its replacement being a mixture of gas and renewable energy.[51] The carbon price helps in establishing price competitiveness for nuclear in the medium- and long-term. Instead of a decline, nuclear renews itself or even expands in the 2030s. Wind farms experience the greatest impact, and the additional wind replaces much of the decline in coal, although not in an equal manner. Solar follows in a similar direction for increasing as fossil-based generation declines. Additionally, the uptick for renewable power in the $10 per year alternative increases the total capacity in the United States for power generation—the intermittency of wind and solar means there needs to be more generation capacity and storage to make up for it. Generation in the alternative is less than that in the baseline, however, because of a price response to higher wholesale and retail electricity pricing. With carbon pricing, scale wind and solar would assume

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47 Supplementary discussion to these results available in the technical appendix

48 According to the EPA table on fuel emissions factors by source, typically in kilograms per MMBTU, <http://www.eia.gov/oiaf/1605/excel/Fuel_Emission_Factors.xls>

49 This white paper considers only the impact of taxing carbon dioxide and not that of fugitive methane lost in natural gas extraction or deployment—the second is an important issue, although quantifying the total "leakage" from the system (including landfills) is much more uncertain at this point than working on carbon alone, and other EPA regulations are starting to address the issue, please see James Bradbury, Michael Obeiter, Laura Draucker, Amanda Stevens and Wen Wang, "Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems," *World Resources Institute* (WRI), April 2013, <http://www.wri.org/publication/clearing-air>

50 Over 65% of SO_X emissions are from utility generation, particularly coal, for example

51 For example, please see Matthew D. Wald, "Economics Forcing Some Nuclear Plants into Retirement: Aging and Expensive, Reactors Face Mothballs," *New York Times*, October 23, 2012, <http://www.nytimes.com/2012/10/24/business/energy-environment/economics-forcing-some-nuclear-plants-into-retirement.html?_r=0>

a comparable role to each other on the grid in providing variable generation during sunny and windy hours. Different cost assumptions on the relative cost of wind[52] versus solar[53] would lead to the "lime green" for wind and the "gold" for solar trading share with each other in the graphs in *Figure 3.29* and *Figure 3.30*. In the alternative, by 2035, the ReEDS model shows nearly all American power generations coming from zero- or low-carbon sources such as solar, wind, geothermal, hydro, nuclear, and captured gas.

The next section covers improvements in air quality from changing sources in power generation and reduced combustion of transportation fuels. Specifically, it includes two compounds—NO_X and SO_X emissions—that are part of the ReEDS and CAT models. These emissions play no direct part in the carbon pricing of $10 per year, but they are implied, indirect effects of the emissions and power generation effects elsewhere. Social costs of NO_X and SO_X are the same here as those in REMI TranSight, the transportation-oriented version of PI+, which monetizes the social costs of emissions in a manner consistent with EPA guidelines.[54] **The values are $0.005 per gram for NO_X and $0.0025 per gram for SO_X (in 2012 dollars).**

Improved Air Quality (regional level)

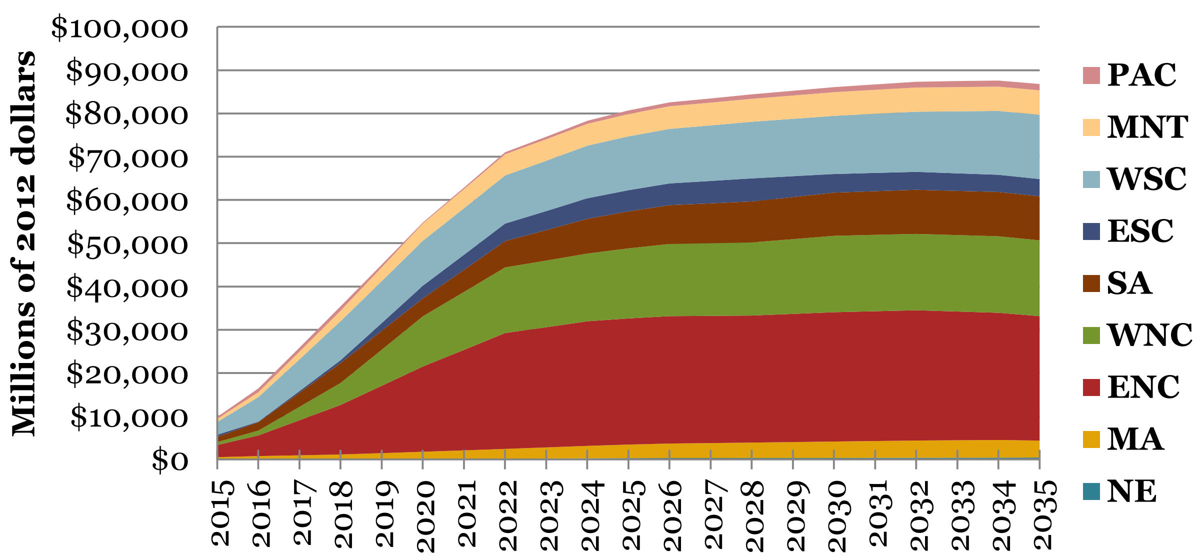

Figure 3.31 – This illustrates the value of reduced NO_X and SO_X emissions from power generation, gasoline, and diesel. The lions' shares of savings are in the ENC and the WNC, which have the heaviest proportion of coal-fired generation in the United States. Regions with a smaller share of coal power generation, such as NE or PAC, have less of an impact.

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52 The source for the long-term cost assumptions about wind power in ReEDS is the ongoing research from U.S. Department of Energy (USDOE), "A New Vision for United States Wind Power," <http://energy.gov/eere/wind/new-vision-united-states-wind-power>

53 Long-term solar cost assumptions for ReEDS also come from an ongoing USDOE research project, "Sunshot Vision Study," <http://energy.gov/eere/sunshot/sunshot-vision-study>

54 Based on methodologies developed by Mark Delucchi at University of California-Irvine, please see, <www.remi.com/download/documentation/transight/transight_version_2.1/TranSight_User_Guide_and_Model_Doc_v2.1.pdf>

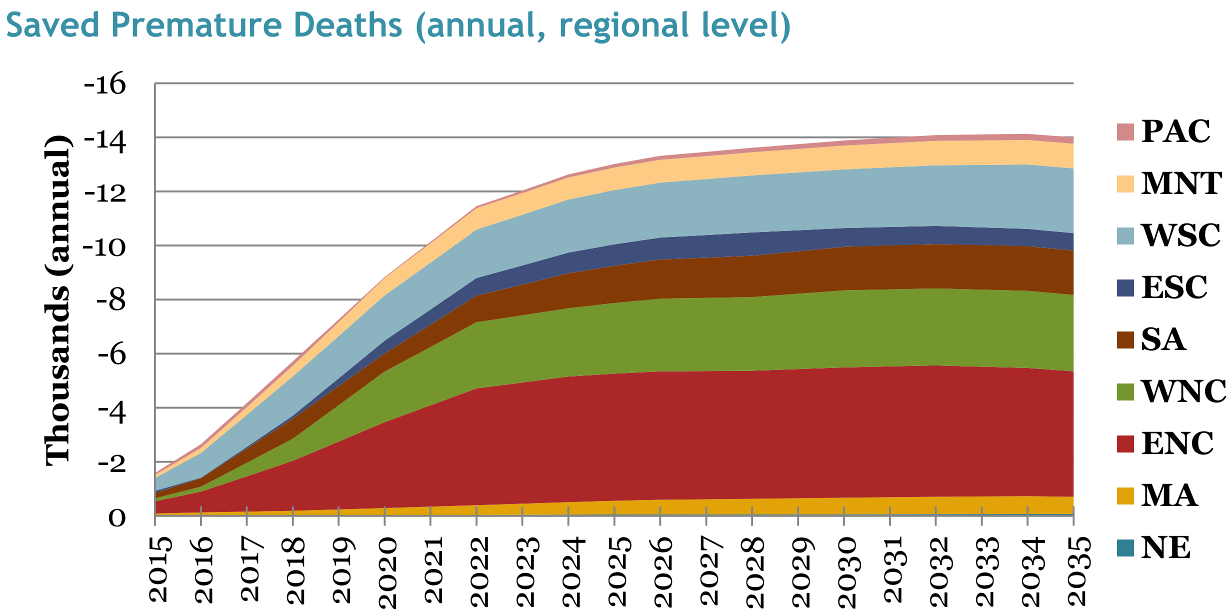

Figure 3.32 – In continuation of the benefit-cost, the above is Figure 3.31 ***divided by $6.2 million for the average social cost of a premature death*** *for air quality-related conditions or reduced quality of life. The exact figure for this calculation varies between federal sources;[55] the $6.2 million is the "unadventurous" figure usually required by the U.S. Department of Transportation (USDOT) in accounting for air quality benefits.*

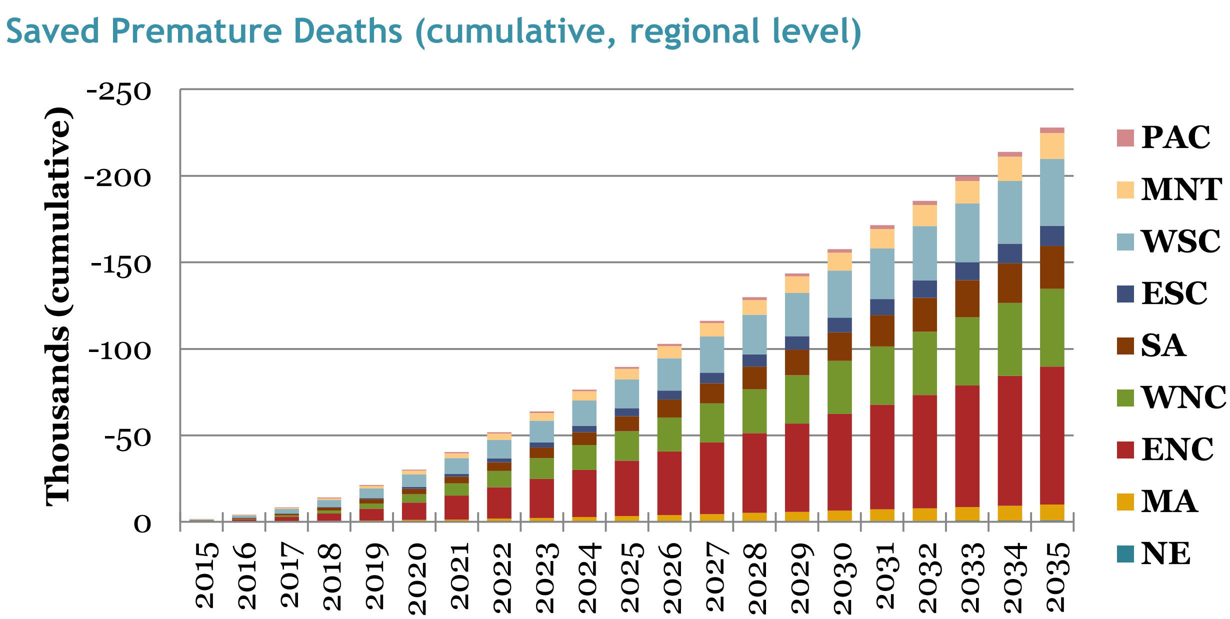

Figure 3.33 – These are annual saved lives summed over time to 230,000 in twenty years.

[55] For a discussion of some of the values used by EPA and USDOT, please see Binyamin Appelbaum, "As U.S. Agencies Put More Value on a Life, Businesses Fret," *New York Times*, February 16, 2011, <http://www.nytimes.com/2011/02/17/business/economy/17regulation.html?pagewanted=all&_r=0>

Population (regional level)

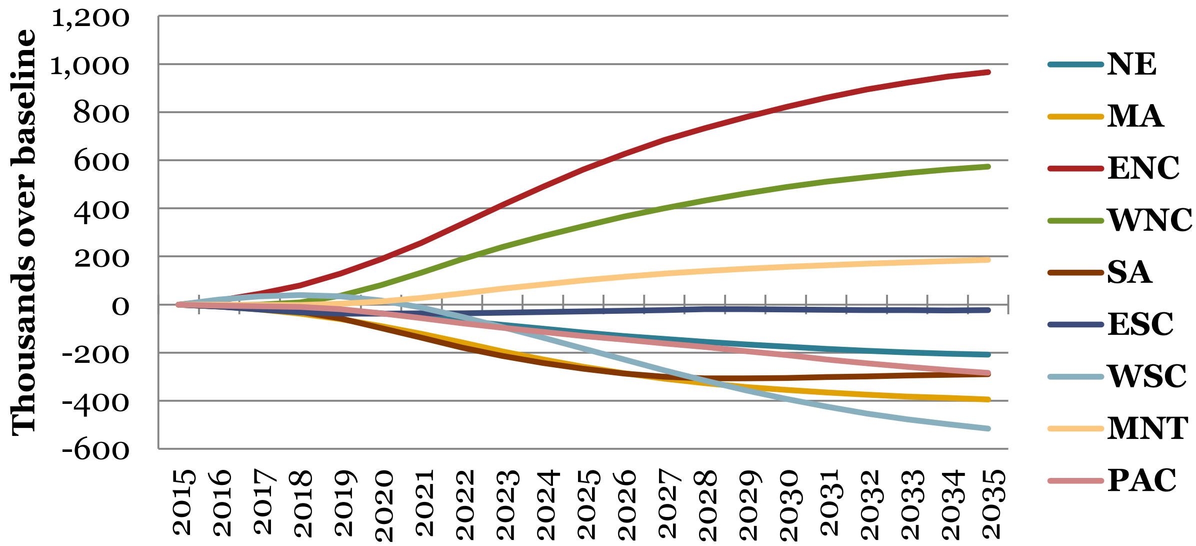

Figure 3.34 – This is the net change in population, over or under the baseline, for the nine regions after migration due to changes in the labor market, the regional cost of living, and quality of life/amenity benefits. The increase in population in ENC and WNC is from their large share of the improved air quality and quality of life, as Figure 3.35 demonstrates.

Economic Migration Determinants (regional level)

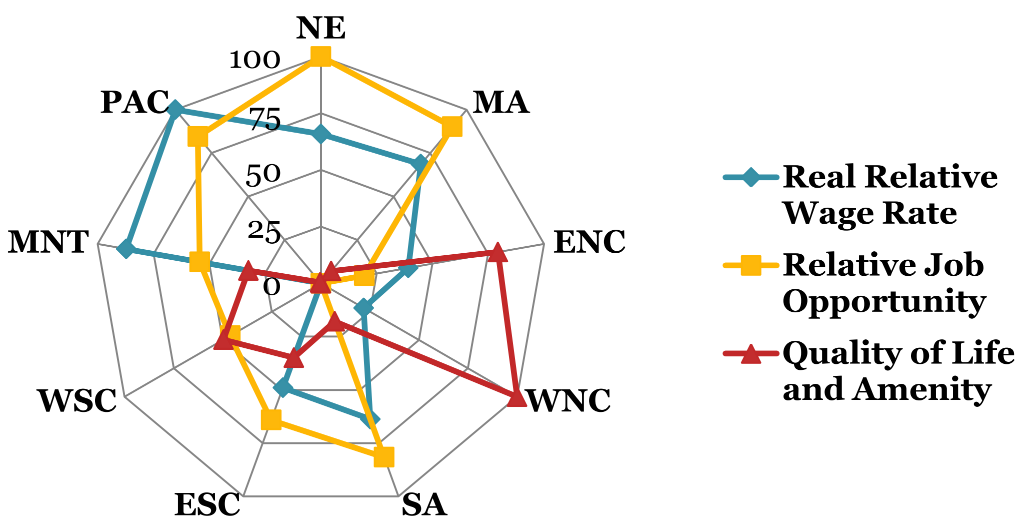

*Figure 3.35 – This radar chart displays the determinants for economic migration and population. **The factors are not of equal strength—amenity ("red") is the strongest and dominates the results with the population increase in ENC and WNC.** The regions are on a 100-point scale with the "best" region equal to 100, the relative "worst" at 0, and a hypothetical "average" region at 50 with the others scaled in the middle.*

Alternative Fiscal Case: "Across-the-Board" (ATB) Tax Cuts

Dedicating the funds from a revenue-neutral carbon tax to a FAD system is just one of countless policy options, and the nature of the allocation of the revenues has strong implications for the net economic and demographic impacts. This alternative fiscal case, which means to test the models' responsiveness and economy's sensitivity, looks at the "most simple" of those options—an across-the-board (ATB), revenue-neutral tax cut to the largest federal revenue categories that are up for revision during tax reform periods. This considers the three categories that are the largest revenue items for the budget: (1) the personal income tax, (2) the payroll tax/FICA, and (3) the corporate income tax. Modifying the simulations to cover a contrasting utilization of the revenues from a carbon tax has little significant impact on the climate and air quality results above—the price incentive of $10 per year is still the same in coal, electricity, gas, and petroleum markets, after all—so the difference examined here is the economic impact. The comparison looks at three "headline" results of employment, GDP, and RDPI.

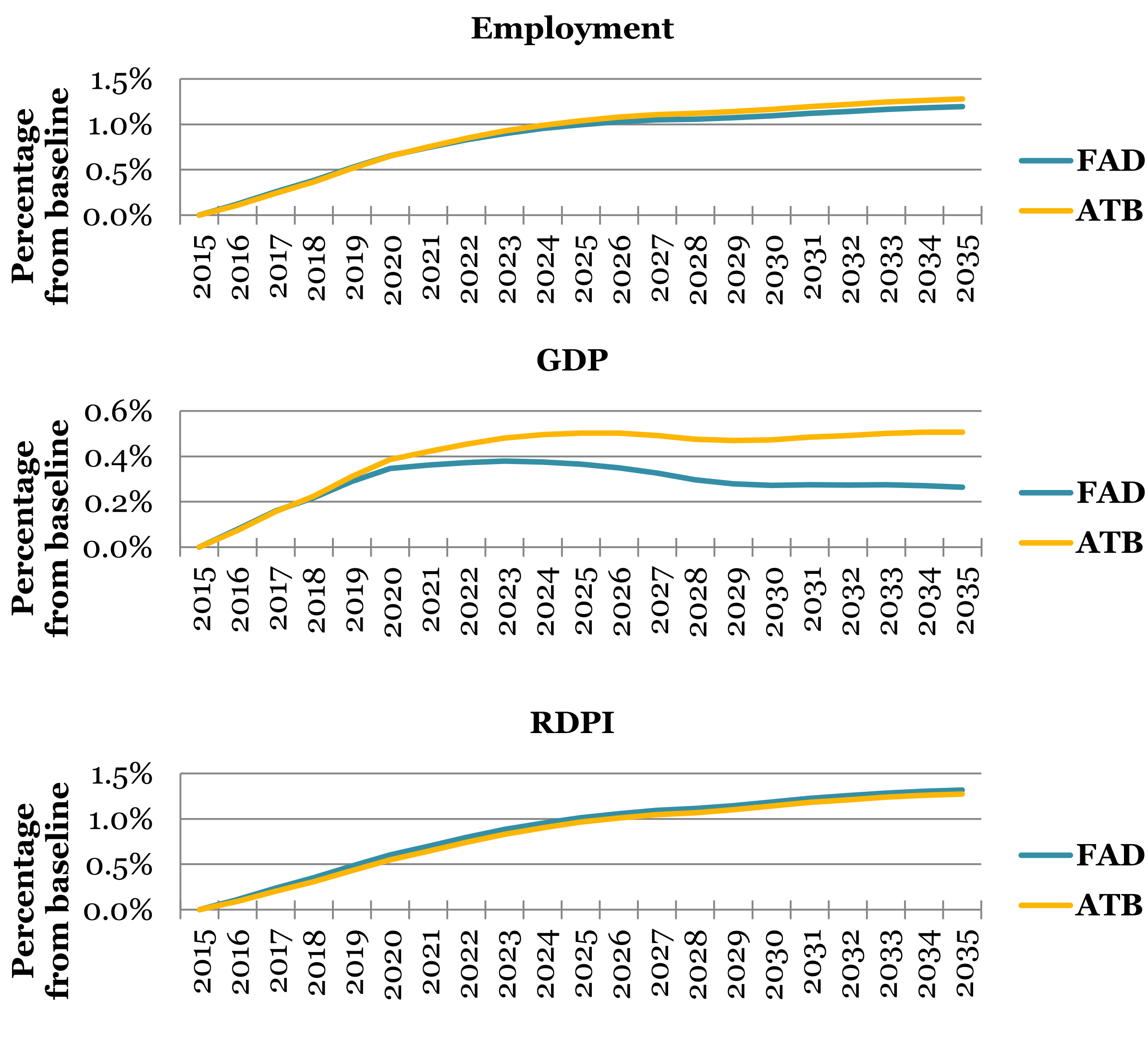

Figure 4.1 – The incentives for work and investment under ATB produce employment and GDP, although the rebates of FAD keep RDPI higher than in the alternative fiscal case.

The results in *Figure 4.1* follow from the economic reasoning inherent in the models. Increasing the return to labor and capital by lowering taxes on income and business entities encourages work and investment, although such a program has less influence on consumer spending (at least initially) compared to FAD. Reducing some business costs through cuts to the corporate income tax, however, increases the rate of investment in the United States, improves the trade balance by reducing imports and increasing exports, and expands GDP over time relative to the baseline and FAD. This result brings about the higher percentage impact to employment with ATB given the increased GDP encapsulates increased labor demand. Conversely, the FAD system, for reserving more of the funds for direct rebates to households and eventual consumer spending, has advantages in boosting spending in labor-intensive, localized industries, which keep the overall impact to employment roughly parallel amid the cases. It also increases the total household share of national income/GDP. Despite the differences in *Figure 4.1*, neither case is wholesale different from the other on a national scale. The economic models and general intuition of higher prices reducing energy demand, changing power investments away from fossil fuels, improving air quality, reducing the level of economic activity associated with the capital-intensive energy production and distributional supply chain, and increasing the output of relative labor-intensive, consumer-related industries holds for both. Relative to each other, ATB describes a slightly larger economic "pie" with more exports, although with a smaller share for households of national income. FAD illustrates a slightly smaller economy from ATB (not the baseline) with more consumer spending and overall RDPI for households. Each simulation has its respective story on a growing, less carbon-intensive economy.

Congressional Budget Office (CBO)

In May 2013, the CBO released a report and literature review on several of the possible policy options regarding carbon taxes for Congress and the White House and likely economic, fiscal, and environmental effects.[56] The study did not attempt to quantify the potential impacts of a carbon tax from either deficit reduction ("CBO has not estimated how a carbon tax combined with a deficit reduction policy would affect output")[57] nor revenue-neutrality ("CBO has not quantified the effects of a tax swap").[58] The overall directions of the results in this white paper are, nonetheless, broadly consistent with CBO's finding and the literature. Most notably, CBO says that apt fiscal reform to the general tax code in combination with carbon pricing could potentially increase output or GDP. To quote, "However, various studies that have looked at different types of tax swaps have concluded that a well-designed swap would significantly lower the economic costs of a carbon tax, and a few studies have concluded that a tax swap could lead to a net increase in output."[59] Such a statement fits this study into the latter category where returning the funds to households to engender consumer spending leads to a net increase in employment and GDP from the tax swap or rebate. The main difference between the CBO research and this study is that CBO considered only marginal tax rate changes, while the prime

[56] Available online, please see "Effects of a Carbon Tax on the Economy and Environment," *Congressional Budget Office* (CBO), May 22, 2013, <http://www.cbo.gov/publication/44223>

[57] Ibid., p. 10

[58] Ibid., p. 11

[59] Ibid., p. 10

simulations here looked at a refund system.[60] Both of the approaches would lead to an increase in consumption, but the guaranteed income of FAD would lose some of the positive incentives that come with changes to marginal rates. Adapting a CBO statement on lump-sum payments to lower-income households to adjust for their welfare losses, which is similar to the FAD, "Those payments would not increase people's incentives to work or invest, and thus would not lead to greater economic productivity."[61] After all, if the "rebate" from the carbon tax goes to households only through lower income tax rates, then individuals would be more likely to "seek the benefit" by participating in the labor force or working longer hours. PI+ captures some of these differences in the results of *Figure 4.1*. Adjusting marginal rates leads to higher GDP and productivity (essentially the same quantity of labor for additional output) than relying on FAD by itself. The feedbacks in PI+, not necessarily present in other models at the same level of regional or industrial detail or with the same exact structure, lead to the "wash" in the results for employment and RDPI. Cutting marginal income taxes and FAD have differences in their welfare effects and short- and long-term incentives; yet, each still leads to a massive jump in aggregate consumer spending that dictates much of the macroeconomic results with a boost to the output of labor-intensive and service sectors.

CBO generally concurs with the other crucial results of CAT and PI+ on climate and economic impacts from carbon pricing. Foremost, CBO's description of the likely industries to see a decline in their output match those in *Figure 3.9* with coal mining, oil and gas, other types of metallic and nonmetallic mineral product mining, refining, chemical manufacturing, and other heavy manufacturing.[62] With climate, CBO's hypothetical $20 per ton carbon tax (with a 5.6% annual increase in the rate) would reduce national emissions in the first decade by 8%.[63] Given adjustments take time, the emissions reduction in the final year of the decade window would have to be somewhat more than 8%. This is more than the 6% reduction from the CAT baseline in 2018 (the year of $30 per ton), although this reduction would be closer to 10% to 12% if it were a plateau and had more time to adjust, thus making it consistent with CBO numbers. Regarding fiscal implications, CBO comments, "Because rising tax rates would lead to a decline in emissions, the amount of revenues generated by a carbon tax would eventually decline, as well."[64] To continue, "However, if the tax rate grew slowly, it could produce rising revenues for many decades and allow the economy to adjust gradually to less emission-intensive ways of producing goods and services." This statement is consistent with the results in *Figure 3.15* and *Figure 3.16* of a carbon tax phased at $10 per year serving as a robust revenue item for the federal government or FAD "trust" through at least 2035. The money would be enough to return significant amounts of cash to every household or even replace major revenue items such as the corporate income tax or much of FICA for Social Security, Medicare, and other programs. The results here have many more details, and they report the distributional aspects of this policy between regions and industries in a way not typical to CBO analyses.

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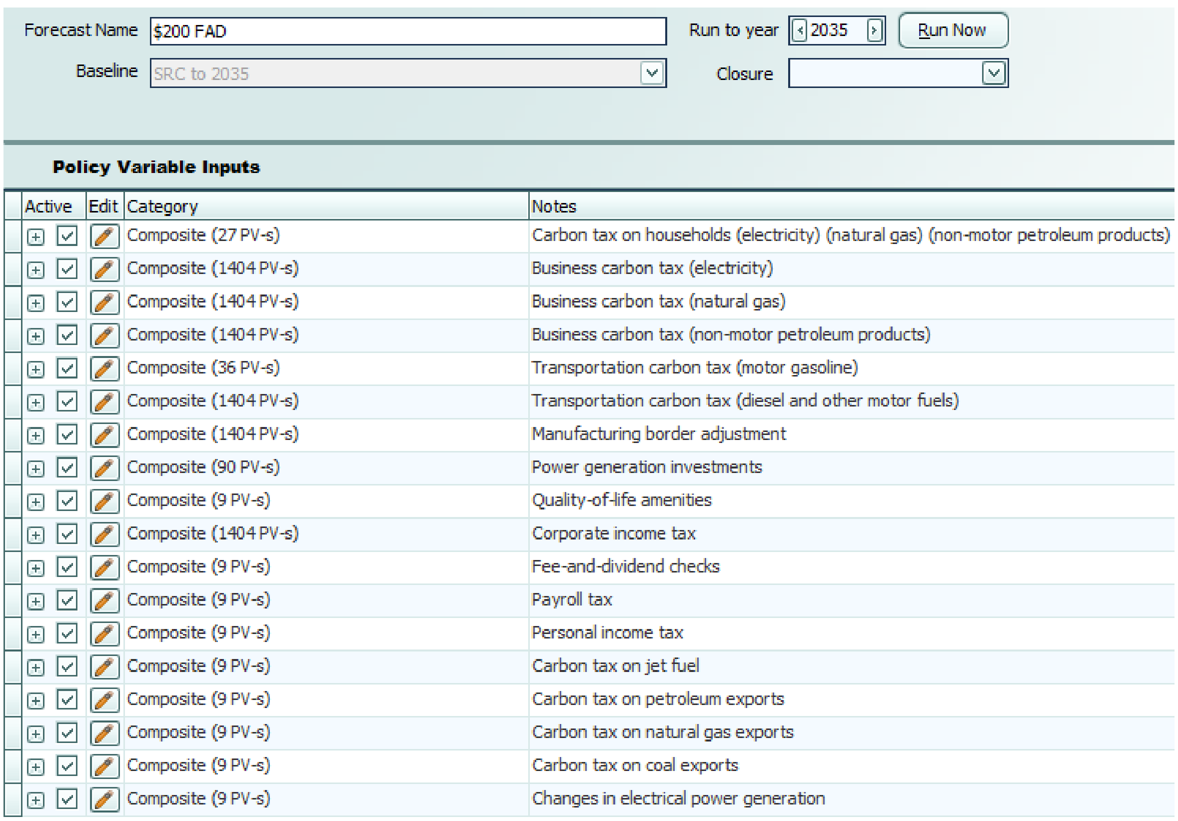
[60] "A well-designed tax swap would cut marginal tax rates (the rates on an additional dollar of income), thereby raising the after-tax returns that people receive from work or investment and leading to increases in those activities," Ibid., p. 10
[61] Ibid., p. 12
[62] Ibid., p. 9
[63] Ibid., p. 3
[64] Ibid., p. 3

Technical Appendix

This section describes the details behind the quantification and the modeling of the results at the heart of this report. The descriptions are "input-oriented," looking mostly at how the input variables and assumptions to ReEDS, CAT, and PI^+ came out with references to the general documentation for the original construction of ReEDS and PI^+. This technical appendix starts with the ReEDS model, inputs, assumptions, and how it generates the power technology data and information reported in this study. The portion on CAT covers the original methodology from CTAM and the additions made to CAT to take account of power switching (from ReEDS), NO_X and SO_X emissions, multiple regions, the border adjustment, and the integration of this data into the policy simulation in PI^+. The PI^+ partition covers the basics of the model, its dynamic structure, and how each of the data inputs to policy variables influence the simulation and the results of the white paper. The final simulation looked at 160 sectors, twenty years, and nine regions, which is 28,800 potential results even before looking at the type of results (such as total employment, GDP, or income). This gives a comprehensive accounting of the potential impacts of a FAD carbon tax from many variable inputs.


Forecast Name: $200 FAD
Run to year: 2035
Run Now
Baseline: SRC to 2035
Closure:

Policy Variable Inputs

Active	Edit	Category	Notes
✓		Composite (27 PV-s)	Carbon tax on households (electricity) (natural gas) (non-motor petroleum products)
✓		Composite (1404 PV-s)	Business carbon tax (electricity)
✓		Composite (1404 PV-s)	Business carbon tax (natural gas)
✓		Composite (1404 PV-s)	Business carbon tax (non-motor petroleum products)
✓		Composite (36 PV-s)	Transportation carbon tax (motor gasoline)
✓		Composite (1404 PV-s)	Transportation carbon tax (diesel and other motor fuels)
✓		Composite (1404 PV-s)	Manufacturing border adjustment
✓		Composite (90 PV-s)	Power generation investments
✓		Composite (9 PV-s)	Quality-of-life amenities
✓		Composite (1404 PV-s)	Corporate income tax
✓		Composite (9 PV-s)	Fee-and-dividend checks
✓		Composite (9 PV-s)	Payroll tax
✓		Composite (9 PV-s)	Personal income tax
✓		Composite (9 PV-s)	Carbon tax on jet fuel
✓		Composite (9 PV-s)	Carbon tax on petroleum exports
✓		Composite (9 PV-s)	Carbon tax on natural gas exports
✓		Composite (9 PV-s)	Carbon tax on coal exports
✓		Composite (9 PV-s)	Changes in electrical power generation

Figure 5.1 – This is a screen capture from the PI^+ software including all of the exogenous variables used for the final economic and demographic impact simulation. Many of those inputs—such as power generation investments or quality of life amenities—are significant results for their own sake and reported here from ReEDS and CAT. The fiscal inputs include the personal income tax, the payroll tax, and the corporate income tax for alternative fiscal cases, though, for the most part, those inputs were zero and all funds went into the FAD. Every variable set represents its own set of benefits and costs to the regional economies.

The ReEDS Model

This subsection provides a high-level overview of the costs and technology characteristics of the ReEDS model runs. A comprehensive outline of the methodology behind the model is available from NREL;[65] the Renewable Electricity Future study thoroughly documents all assumptions at current inside the modeling system.[66]

The ReEDS model is a long-term capacity expansion and dispatch model of the electrical power system in the United States developed by NREL. It has a high-level of renewable resource detail with numerous wind and solar resource regions, each with availability by resource class and unique grid connection costs. Model outputs include generation, total capacity, transmission expansion, total system costs, electricity prices, and emissions of carbon dioxide, NO_X, SO_X, and mercury (Hg). The model operates out to 2050 in 2-year steps, with each 2-year period divided into 17 time slices representing morning, afternoon, evening, and night in each of the four seasons, plus an additional summer peak. The ReEDS model includes data on the existing fossil fuel facilities in each of the model's 134 Power Control Areas (PCAs) based on data reported in EIA's Form 860 Annual Electric Generator Report.[67] Under a carbon tax, ReEDS will change both the dispatch of existing units and the build of new units, as well as transmission additions and interregional transfers. The resulting scenarios are a product of many input assumptions, several of which have definitions here.

Technology Data

Most technology parameters come from the EIA's AEO 2013.[68]

	Capital Costs (1000$/MW)	Fixed O&M ($/MW-year)	Variable O&M ($/MWh)	Heat Rate (MMBTU/MWh)
Hydro	$3,719	$14	$3	9.63
Gas-CT	$817	$7	$13	9.89
Gas-CC	$962	$14	$3	6.59
Gas-CC-CCS	$2,088	$32	$3	7.41
Goal-Pulverized	$2,924	$32	$4	8.66
Coal-IGCC	$3,771	$51	$7	8.17
Coal-CCS	$5,211	$66	$4	10.95
Oil-Gas-Steam	$965	$24	$4	10.50
Nuclear	$4,767	$93	$2	10.31
Geothermal	$6,050	$112	$0	9.62
Biomass	$4,098	$106	$5	13.31
Landfill Gas	$8,492	$388	$9	13.46
Wind (onshore)	$1,759	$48	$0	N/A
Wind (shallow offshore)	$4,436	$125	$0	N/A
Wind (deep offshore)	$5,732	$160	$0	N/A
Utility PV	$3,173	$16	$0	N/A
CSP (no storage)	$5,022	$52	$0	N/A

Figure 5.2 – These values provide technology costs and performance characteristics.

65 Please see, <http://www.nrel.gov/analysis/reeds/documentation.html>
66 Please see M.M. Hand, S. Baldwin, E. DeMeo, J.M. Reily, T. Mai, D. Arent, G. Porro, M. Meshek, D. Sandor, eds., "Renewable Electricity Futures Study," 4 vols., NREL/TP-6A20-52409, National Renewable Energy Laboratory (NREL), <http://www.nrel.gov/analysis/re_futures/>
67 Please see, <http://www.eia.gov/electricity/data/eia860/>
68 Assumptions for wind in *Figure 6.2* are for Class-3 resource and do not include the cost of interconnection, and hydro and geothermal costs represent the baseline costs for a new facility—costs will increase from this level for power control areas with resources harder to access

	LBS/MMBTU				LBS/MWh (2015)			
	NO_X	SO_X	Hg	CO_2	NO_X	SO_X	Hg	CO_2
Gas-CT	0.1	0.0	0.0	119	0.9	0.1	0.0	1,194
Gas-CC	0.0	0.0	0.0	119	0.2	0.0	0.0	795
Gas-CC-CCS	0.0	0.0	0.0	18	0.3	0.0	0.0	134
Coal-Old Scrubbed	0.1	0.2	0.0	205	1.1	1.9	0.0	2,047
Coal-Old Unscrubbed	0.1	1.2	0.0	205	1.1	12.8	0.0	2,103
Coal-New	0.1	0.1	0.0	205	1.0	0.5	0.0	1,800
Coal-IGCC	0.1	0.1	0.0	205	0.7	0.5	0.0	1,698
Coal-CCS	0.1	0.1	0.0	31	0.9	0.5	0.0	341
Oil-Gas-Steam	0.2	0.3	0.0	137	1.8	0.6	0.0	1,459
Biomass	0.0	0.1	0.0	0	0.0	3.2	0.0	0
Cofiring	0.1	0.2	0.0	205	1.2	1.1	0.0	2,202
Landfill Gas	0.0	0.0	0.0	-250	0.0	2.0	0.0	-3,408
Nuclear	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Geothermal	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Solar	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Wind	0.0	0.0	0.0	0	0.0	0.0	0.0	0

Figure 5.3 – These are the electricity emissions rates (in 2015, national level averages).

	LBS/MMBTU				LBS/MWh (2015)			
	NO_X	SO_X	Hg	CO_2	NO_X	SO_X	Hg	CO_2
Gas-CT	0.9	0.1	0.0	119	0.9	0.1	0.0	1,131
Gas-CC	0.2	0.0	0.0	119	0.2	0.0	0.0	781
Gas-CC-CCS	0.3	0.0	0.0	18	0.3	0.0	0.0	134
Coal-Old Scrubbed	1.1	1.9	0.0	205	1.1	1.9	0.0	2,047
Coal-Old Unscrubbed	1.1	12.8	0.0	205	1.1	12.8	0.0	2,103
Coal-New	1.0	0.5	0.0	205	1.0	0.5	0.0	1,792
Coal-IGCC	0.7	0.5	0.0	205	0.7	0.5	0.0	1,527
Coal-CCS	0.9	0.5	0.0	31	0.9	0.5	0.0	286
Oil-Gas-Steam	1.8	0.6	0.0	137	1.8	0.6	0.0	1,459
Biomass	0.0	3.2	0.0	0	0.0	3.2	0.0	0
Cofiring	1.2	1.1	0.0	205	1.2	1.1	0.0	2,202
Landfill Gas	0.0	2.0	0.0	-250	0.0	2.0	0.0	-3,408
Nuclear	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Geothermal	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Solar	0.0	0.0	0.0	0	0.0	0.0	0.0	0
Wind	0.0	0.0	0.0	0	0.0	0.0	0.0	0

Figure 5.4 – These are the electricity emissions rates (in 2050, national level averages).

Much of the benefits in this report are from moving out of capacity types at the top of the above distribution and toward the bottom in *Figure 5.3* and *Figure 5.4*. The renewable, zero-carbon dioxide sources also have reduced NO_X and SO_X emissions.

Load Data

The ReEDS model only covers the electrical power sector, and thus it takes its energy and peak load requirements from AEO 2013. There is no endogenous capability to add energy-efficient (EE) resources or capital, although it is likely that additional EE would come at the carbon tax levels under discussion here.[69] *Figure 5.5* shows the growth patterns assumed in the baseline from AEO 2013 and the alternative based on implicit price elasticity.

[69] This would have some influence on the economic impact results, but they would be small compared to the gross results of placing a price on energy and recycling the revenue with FAD

Load Profile for Tax Cases (national level)

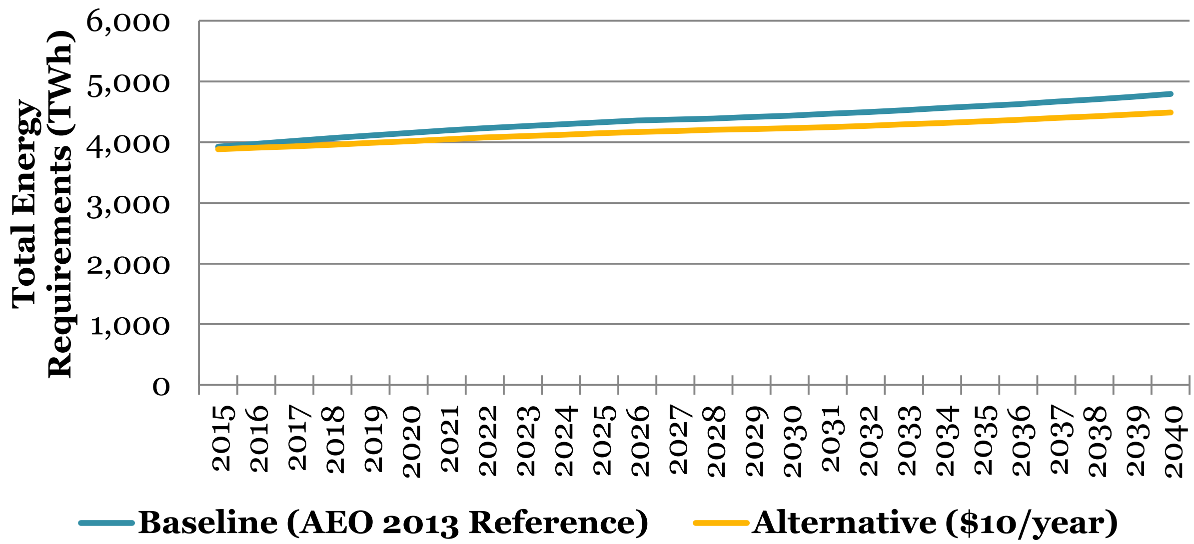


Figure 5.5 – These are the national level load requirements on the ReEDS model for the baseline—which is the same as in the Reference Case as the AEO 2013—and an alternative that assumes low load from reduced energy purchases due to higher electricity prices. Each has internal growth of around 4.0 TWh needed in 2014 to nearly 5.0 TWh needed by 2040.

Resource Assumptions

"Renewable Electricity Futures: Volume 2" has detailed resource supply curve assumptions, and there is a summary of the methodology here for reference.[70]

Wind

The ReEDS system models onshore wind, shallow offshore wind, and deep offshore resources. For each type, the model has data on five resource classes for wind power in every one of the 356-regions across the country. These resources come from GIS analysis of high-resolution wind speed data with exclusions for land-use, topographical constraints, and wildlife habitats. A stepwise supply curve accounts for the cost of connection individual wind sites to the existing power distribution and transmission grid.

Concentrating Solar Power (CSP)

The ReEDS model considers CSP without storage and CSP with at least 5-hours of storage. Similar to wind, five resource classes are in each of the 356-regions for CSP based on a detailed GIS analysis—although most resources are in the Southwest and West.[71]

Utility-Scale and Distributed Rooftop Photovoltaic (PV)

Characteristics for utility-scale resources are in each of the 134 PCAs with costs from the 2012 Sunshot Vision study.[72] Generation profiles are averages from satellite data from 1998 to 2009.

[70] Please see, <http://www.nrel.gov/analysis/re_futures/>
[71] Portions of ENC, WSC, MNT, and PAC in the nine region breakout
[72] Please see, <http://energy.gov/eere/sunshot/sunshot-vision-study>

Distributed rooftop photovoltaic deployments and performance are from another NREL model, SolarDS,[73] and inputs exogenously into ReEDS. **All scenarios use distributed rooftop deployment consistent with a 50% cost reduction from 2010 to 2020.** This level does not change across the scenarios, although more aggressive cost reductions may take place at higher tax levels given further investments and research.

Biomass

There are both dedicated biomass power plants and cofired power plants supplied with biomass in each of the 134 PCAs. Their supply curves come from the USDOE study, "U.S. Billion-Ton Update" from 2011, which estimated the potential biomass supplies within the contiguous United States based on assumptions about both sustainable residue biomass levels and new, dedicated feedstock that might come online in the future.[74]

Geothermal

The ReEDS model includes supply curves for conventional geothermal, as well as near-field enhanced geothermal (EGS) and deep EGS. Near-field EGS resources are hot enough for electricity production but still relatively shallow, so they are substantially less expensive than deep EGS resources. A typical ReEDS run will allow conventional and near-field EGS, but exclude deep EGS due to substantial uncertainty with the technology.

Hydroelectricity

NREL is in the process of updating hydroelectric resources based on recent work by Oak Ridge National Laboratory (ORNL). This work will explore the potential to add power production at existing non-powered dams as well as original research for the ongoing "Hydro Vision" study paired with the wind and solar research projects by USDOE.[75]

Retirements

The ReEDS model retires existing conventional power plants based on assumed lifetimes. Fossil units can also have endogenous retirements. The assumptions are such that coal units under 100MW have a 65-year life and ones larger than that continue to operate for 75-years. Natural gas units have a 55-year life. Fossil units retire endogenously in the model if they do not see utilization beyond a minimum capacity for more than 4-years. Nuclear plants built before 1980 retire after 60-years. For those built after 1980, the model allows them two license renewals—that results in them having a *de facto* lifespan of 80-years.

Integrating Renewable Resources

In addition to accounting for the cost to bring renewable power onto the grid, the model also accounts for several operational parameters of variable resources. The ReEDS model calculates

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[73] For an introduction and methodology to this additional modeling system, please see Paul Denholm, Easan Drury, and Robert Margolis, "The Solar Deployment System (SolarDS) Model: Documentation and Sample Results," *National Renewable Energy Laboratory* (NREL), September 2009, <http://www.nrel.gov/docs/fy10osti/45832.pdf>

[74] Please see "U.S. Billion-Ton Update: Biomass Supply for a Bio-energy and Bio-products Industry," *U.S. Department of Energy* (USDOE), August 2011, <http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf>

[75] For an introduction, please see, <http://energy.gov/eere/water/water-power-program>

curtailed energy, firm capacity value, storage resources, and the additional included operation reserve requirements (due to forecast errors) from variable resources.

Supplemental Discussion

Total capacity grows substantially in the alternative, $10 per year case to meet both rising peak demand and to compensate for the reduced capacity contribution from intermittent resources, such as wind and solar, as compared to traditional fossil fuel generation. Nationally, capacity starts at 1,000 GW in 2010 and by 2040 grows to 1,300 GW in the baseline and 1,440 GW in the $10 per year case. This alternative case reflects a few key trends.

Between 2020 and 2030, most coal undergoes either conversion into co-fire with biomass or outright retirement. Natural gas and wind meet the need for capacity, and they appear the most economical resource to replace retiring coal plants and meet the underlying, baseline growth in demand over time. Due to reduced capacity contributions from wind resources, total nameplate capacity in the alternative case remains similar to or higher than the baseline despite reduced energy demand overall in the $10 per year carbon tax.

Integrating intermittent resources requires increasingly flexible capacity resources to meet load in periods where renewable output falls (or, conversely, to reduce their load when renewable output surges). The model endogenously determines the capacity value of wind and solar each year, which declines with increasing levels as increasingly marginal sites come online. For example, in the $10 per ton tax case the median percentage of wind capacity counted as “firm” decreases from 18% in 2010 to 7% in 2040. Additional wind and solar also require new, flexible, responsive reserve resources to guard against errors in the output forecast. By 2040, this results in building an extra 60 GW of dispatch reserve requirements. Toward the end of the study period, the demands placed on the system by increasingly intermittent resources—coupled with increasingly large carbon taxes—result in the reintroduction, beginning, and then the significant expansion of low-carbon base-load technologies such as nuclear plants and natural gas with carbon capture and storage (CCS) at an industrial scale.

Nationally, wind and solar represent about 5% of 2014 generation and, by 2040, this grows to 37% in the alternative case. Nuclear, which mostly retires in the baseline, expands from 20% at current to around 25% of total generation. Coverage for the remainder of the balance from the reductions in coal is from a combination of geothermal, hydroelectricity, and natural gas combined-cycle units (gas-CC, and many gas-CCS). The model can build coal with carbon capture and sequestration technology and retrofit old plants to the same standard; however, even with an assumed capture rate of 85%, the emissions from coal-CCS would still be high enough those hypothetical plants are uneconomical with these prices. While storage plays an important role, it is a net negative generation technology due to imperfect efficiency, and it does not appear on the generation chart to any significant degree.

The carbon tax results in a dramatic reduction in carbon dioxide emissions. In the baseline, emissions rise slowly, concurrent with the increase in the load, resulting in cumulative electrical-derived emissions of 85 gigatons from 2010 to 2050. With the $10 per year price, cumulative emissions by 2050 are closer to 27 gigatons, which is a 68% reduction over the period. As the tax level increases between scenarios, it quickly becomes clear the marginal cost of additional carbon abatement is rising rapidly. For example, a $15 per year carbon tax from 2016 to 2050 only results in 11% fewer emissions than $10 per year with a 50% increase in the cost for emitters throughout the whole of the economy.

A carbon tax represents a large departure from the current power system, resulting in significant turnover and replacement of many of today's plants in the next twenty-five years. The rapid investment in resources in these scenarios—particularly wind—may seem difficult to imagine given today's energy sector. However, a society that implements a significant carbon tax would presumably commit to solving the complex logistical, manufacturing, and regulatory challenges necessary to reduce emissions to this degree.

The results vary at the regional level, and the second appendix has the exact data. To discuss some basic trends in the baseline and alternative, however, most regions continue to use a substantial amount of coal out to 2040 without the carbon tax. Large portions of the existing nuclear fleet retire, and its replacement is either natural gas or wind. The $10 per ton case is sufficient to drive out coal in all regions. Those with limited wind resources, such as ESC, tend to replace coal with nuclear, while WNC (the farmlands of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) builds the largest amount of wind and couples it with base-load renewable power and transmission for balancing.

The CAT Model

CAT is an evolution of CTAM for state carbon analysis to add dimensions and additional inputs for economic and fiscal models to its simulations. This section will cover the basic methodology of CTAM, its integration with ReEDS, and the added features to make it into the CAT system. A summary slide deck is available online,[76] as well as a Microsoft Excel-based copy of the original CTAM for the state of Washington.[77]

The "core" of CTAM and CAT is an exogenous case, typically the Reference Case, from the AEO. This study used the Reference Case from AEO 2013 because the full AEO 2014 only became available late in this research's projected timeline (on May 7, 2014 versus a planned release of the white paper in early June). The current NREL calibration of the ReEDS uses AEO 2013 and, for the sake of consistency between the models, this paper stays with AEO 2013. The most important table is "A2" for total energy consumption by sector and source.[78] This table is also available at the regional level, which was a direct influence on the choice of the nine regions for assessment (and not, initially, states or cities, which PI+ can do, as well).[79] The AEO baseline is

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[76] Please see Keibun Mori, Roel Hammerschlag, and Greg Nothstein, "Carbon Tax Modeling for Washington State," *2013 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>

[77] Please see, <http://daily.sightline.org/files/2011/08/Washington-State-Carbon-Tax-Analysis-Model.xls>

[78] Please see, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=2-AEO2013&table=2-AEO2013&region=1-0&cases=ref2013-d102312a>

[79] Here is, for example, table A2 for New England (NE), please see, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=2-AEO2013&table=2-AEO2013&region=1-1&cases=ref2013-d102312a>

in thermal units (quadrillions of BTUs), but an emissions factor allows these energy units to undergo conversion into carbon dioxide emissions.[80] For example, the Reference Case forecast in AEO 2013 for NE has residential consumption of propane totaling 0.036 quadrillion BTUs. From the EPA table, the combustion of enough propane to release one MMBTU of energy[81] emits 63.07 kilograms of carbon dioxide into the air. The 0.036 quadrillion BTUs in the AEO forecast is 36,000,000 MMBTUs. When multiplied by the EPA emissions factor, this means the AEO forecast implies carbon dioxide emissions from this sector, this source, and in this year equal about 2,270,000,000 kilograms. This is 2,270,000 metric tons and 2.270 million metric tons when converting by first thousands (10^3) and then millions (10^6). Finding carbon tax revenues by sector/source/year/region is a multiplication of the rate by the forecast, which would be $113.5 million in this case at $50 per ton.[82] This "static" calculation off the Reference Case is not the whole story on how CTAM and CAT work, however, given this simple calculation fails to take account of any cutbacks in energy purchases by consumer because of higher prices. Without a price response, emissions in the baseline and alternative are the same and the implicit price elasticity of demand is zero—perfectly inelastic, there is no possible price change large enough to induce a change in spending habits. To deal with this involves another data set from AEO and another set of calculations off the baseline.

The main mechanism in CTAM and CAT to determine the impact to emission, and thereby to carbon tax revenues, is price elasticity of demand. The AEO also provides a price forecast for energy by sector and source in table A3.[83] This forecast is in dollars per MMBTU. In order to find an alternative price, the model works backwards—it calculates the carbon tax per MMBTU of fuel by type from the EPA data and then adds the additional cost on top of the baseline one from the Reference Case. For example, one MMBTU of gasoline averages 71.26 kilograms of carbon dioxide.[84] A carbon tax of $30 per ton would charge $2.13 per MMBTU of gasoline (which is 0.0713 metric tons multiplied by $30 per ton).[85] The Reference Case has the price of gasoline in the MA region at $25.64 (in 2012 dollars) in 2018. The case's carbon tax rate in that year is $30 per ton in 2016 dollars—or $28.66 per ton in 2012 dollars. [86] Finding the adjusted price for a simulation involves adding the carbon price ($2.04 per MMBTU in 2012 dollars)[87] to the baseline price ($25.64 per MMBTU) to give an adjusted price of $27.68 per MMBTU. This is a 7.96% change in the market price from alternative to baseline, which factors into the price elasticity response. CTAM and CAT each include exogenous parameters for the price elasticity of demand for different fuel types—how much does a 1% increase in market prices decrease consumer spending. In the original CTAM, Mori included a literature survey of econometric analyses and meta-studies of price elasticity by fuel type, averaged them, and then included them as adjustable parameters. REMI either evaluated these parameters as probable or adjusted

[80] Please see, <http://www.eia.gov/oiaf/1605/excel/Fuel_Emission_Factors.xls>
[81] 1 gallon of propane = 91,600 BTUs, so 1 MMBTU of propane would be approximately 10.92 gallons, or about 2.31 times the size of standard 4.73 gallon refillable steel tanks for backyard cooking
[82] The primary case's rate in 2020 was $50/ton, so $50/ton * 2,270,000 = $113.500 million
[83] Please see, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=3-AEO2013&table=3-AEO2013&region=1-0&cases=ref2013-d102312a>
[84] 1 gallon of gasoline, depending on the exact blend or mixture, averages 0.114 MMBTU of energy
[85] $2.14/MMBTU * 0.114MMBTU/gallon = $0.27 gallon (adjusted for rounding)
[86] $1.00 in 2016 is about $0.955 in 2012 according to the price index in PI+
[87] $2.13/MMBTU (the rate before adjusting for the price index) * (0.955/1.00) from the previous note

them for consistency with the preexisting price elasticity of demand in research for PI+ and its treatment of energy.[88] The critical one is gasoline, which this study kept from Mori at -0.62 (a 1% increase in price engenders a 0.62% decline in consumption) phased over a decade. Price response is not instantaneous but dynamic in order to give a more realistic sense of the time it takes consumers to adjust to new prices and for old, energy-intensive capital items to wear-out and see replacement by newer, more efficient equipment for final utilization. Transportation fuels take ten years to phase and non-transportation fuels take twenty years. To return to the example, a 7.96% increase in the cost of gasoline would reduce demand for the commodity by 4.94%.[89] The new demand forecast becomes the factor in CAT's forecast of emissions versus a baseline and, after multiplying it by the carbon tax rate, the potential fiscal effects in the economic model. **Neither CTAM nor CAT include cross price elasticity for switching between liquid and gaseous fuel types where possible (such as the replacement of a fuel oil boiler with natural gas heating or a car powered by an internal combustion engine with an electric vehicle).** There would be some of this switching on the margin, but the size of the effect would be diminutive compared to the overall response to higher prices. Price elasticity of demand would still handle the overall change in demand even with switching and, in light of inelasticity, in an analytically conservative manner.

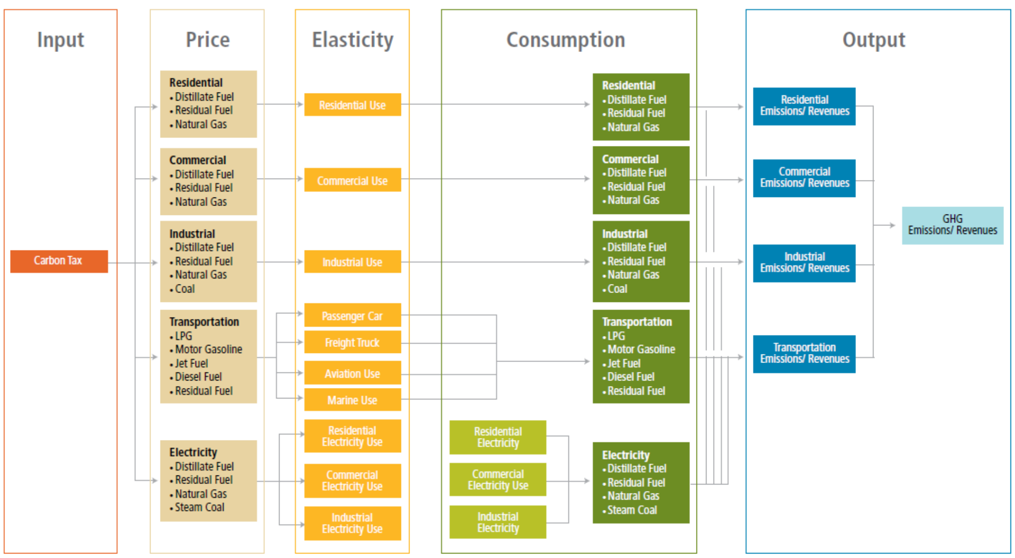

Figure 5.6 – This is the structure of the original CTAM in a graphic designed by the Northwest Economic Research Council (NERC) at Portland State University.[90] Much of the above remains intact in CAT, although a few changes to its structure and assumptions allow it to go "further back" in the energy supply chain, integrate electricity data from ReEDS, and take account of other effects like border adjustments, exports, and air quality concepts. Changes in these areas allow CAT to bring more to the analytical inputs to the economic impact model.

88 For a description of the estimation procedure of consumption elasticity in PI+, please see, <http://www.remi.com/download/documentation/pi+/pi+_version_1.0/Consumption_Elasticities.pdf>
89 7.96% * -0.62 = -4.94%
90 Please see Jeff Renfro and Jenny Liu, "Carbon Tax and Shift: How to make it work for Oregon's economy," Northwest Economic Research Council (NERC), March 1, 2013, <http://www.pdx.edu/nerc/sites/www.pdx.edu.nerc/files/carbontax2013.pdf>

CTAM has strong concepts for price elasticity of demand, emissions forecasting, tax revenues, and the grounding of the AEO forecast, but there are several limitations to its approach at the national scale. First, because it uses only price elasticity off the Reference Case, CTAM has no concept of power switching from coal/gas toward wind/solar/nuclear. It can reduce aggregate demand for electricity in the forecast but not adjust for the carbon content of the power over time in response to price incentives for utilities and investors. For instance, if the baseline has 25% coal-derived generation in the AEO and, by extension CTAM, then 25% of the generation in the alternative will still come from coal, even though the ReEDS runs here show coal is unlikely to persist with a significant tax. In order to improve on this, the CAT model takes output data from ReEDS on power generation and capacity by type and adjusts the carbon tax on electricity to the changing levels of carbon-intensity in power generation, which ReEDS simulates in detail. The structure of CTAM alone makes it best for examining the fiscal and climate effects of a low carbon tax assessed at retail in a state or region with little in terms of power generation or resource extraction. States like Massachusetts or the rest of New England would be ideal for this sort of policy design and modeling. NE has little coal-based generation to switch away. The area's status as a hydrocarbon importer with almost no extraction of its own would favor a retail tax because assessing the tax at the point of extraction would miss imports (nearly all of their energy), and taxing interstate trade of MMBTUs would have implementation problems and might conflict with the Commerce Clause. CTAM describes situations like this well, although the power switching in ReEDS and CAT are necessary to handle other parts of the country. **CAT keeps CTAM's original methodology of adjusting consumption, emissions, and revenues based on the price elasticity of demand for liquid and gaseous fuels, though, for electricity, it entirely replaces price elasticity and data from AEO with everything from ReEDS.** This change along with others described below allow for CAT to conceive of the carbon tax at the point of extraction with an assumption of a "perfect," 100% pass-through of energy prices down to end-use consumers in residencies, commerce, and industry. Reality would be more complicated as dynamic markets adjust to the carbon tax. The modeling here does take account of the aggregate, economy-wide effects after pass-through, and CAT illustrates how all energy consumers (the end-use above as well as utilities via ReEDS and exports) react to the price incentives of a tax early in the supply chain. **CAT gives results for the downstream. Unlike CTAM, however, it does not miss on incorporating incentives for producers, which makes it analogous to assessing an upstream tax with a heavy or complete pass-through to consumers.**

Besides accounting for endogenous power switching from ReEDS, here is a list of additional features in the CAT model intended as PI^+ inputs.

- *Border Adjustment*
- *Electrical Power Investments*
- *NO_X and SO_X Emissions*
- *Fossil Fuel Exports*

The next subsection describes the methodology in CAT behind each of these before moving on to the PI^+ model and the inputs into it from *Figure 5.1.* Overall, these processes aim to develop additional inputs for the economic model, PI^+, for simulations.

Border Adjustment

Assessing the fiscal and economic impact of a border adjustment requires two inputs: (1) a robust forecast of imports to the United States by type and (2) a way to transform the import forecast into an explicit forecast of the carbon dioxide emissions behind any imports. From there, the next step is to multiply the carbon content of the imports by the tax rate and feed this back into the economic model. The adjustment decreases competitiveness of carbon-intensive imported goods on the American market and, using the funds gained at the port of entry, it increases the competitiveness of American exports to the rest of the world. This requires several data sources and the baseline forecast in the PI^+ model.

PI^+ includes a detailed forecast of imports by region, year, and industry, quantified in the form of all monetary value of the trade. Thus, this took care of step one, and the next step was to somehow change those dollar values into carbon quantities. For this, the resource was a report by the U.S. Department of Commerce on the ratio of the output of various NAICS industries to their carbon emissions.[91] It reported, for example, that amongst the manufacturing industries the most "carbon-intensive" (defined as the ratio of output to carbon dioxide emissions) manufacturing sector was nonmetallic mineral products (NAICS 327)[92] with 1.613 million metric tons of carbon dioxide emitted for $1 billion of output in 2006. The least carbon-intensive manufacturing sector was leather and allied products (NAICS 316)[93] with 0.072 million metric tons for $1 billion in output. Unfortunately, detailed information on the carbon-intensity of imports from every other nation of the world and dozens of industries probably does not exist at the current time. Instead, the estimation procedure utilized the import forecast from PI^+ (increasing monetary values of imports with a growing world economy and increasing levels of connectedness) with a few assumptions. The first is that foreign imports now have the same carbon intensity as American production from 2002, which is the median case from the data in the U.S. Department of Commerce report. The second is that the carbon-intensity of foreign imports improves at the same rate as the carbon-intensity of the American economy improves according to the AEO forecast.[94] This places the average exporter to the United States a decade behind this country in terms of efficiency but gaining at the same technological rate as American industry. While an imperfect estimation, this does create a "stable" forecast of revenues from the border adjustment where increasing import volumes and the decreasing carbon-intensity of those imports "wash" each other out, and the increase in the carbon tax rate does mean a gentle, upward, linear slope in anticipated adjustment revenues to 2035.

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[91] Please see, "U.S. Carbon Dioxide Emissions and Intensities Over Time: A Detailed Accounting of Industries, Government and Households," U.S. Department of Commerce (USDOC), September 10, 2010, <http://www.esa.doc.gov/Reports/u.s.-carbon-dioxide>

[92] "The nonmetallic mineral product manufacturing subsector transforms mined or quarried nonmetallic minerals, such as sand, gravel, stone, clay, and refractory materials, into products for intermediate or final consumption," please see, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=327&search=2012%20NAICS%20Search>

[93] "Establishments in the leather and allied product manufacturing subsector transform hides into leather by tanning or curing and fabricating the leather into products for final consumption," please see, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=316&search=2012%20NAICS%20Search>

[94] The year-over-year growth rate in the energy-intensity row of this table, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=5-AEO2013&table=18-AEO2013&region=0-0&cases=ref2013-d102312a>

Electrical Power Investments

One of the important economic development implications of a carbon tax is the potential for an expansion of the installation and maintenance of alternative energy resources in different areas of the country. Wind and solar projects, in addition, might be more labor-intensive or localized during the construction phase than the existing coal, natural gas, and nuclear fleets. Changing over from fossil-based generation to renewable power will require a number of requirements and an increased rate of new builds to make up for the difference, as well. The calculation involved looking at the year-to-year change in net capacity added or subtracted by region from the ReEDS results. The data in *Figure 5.2* allowed for the conversation of electrical capacities into dollars based on the capital costs of a megawatt of different technology types. Regarding operations and maintenance expenses, the calculation was similar on multiplying the current difference in net capacity between the baseline and alternative and monetizing it with the information from *Figure 5.2*. It was the same for the variable cost (mostly fuel inputs) from the ReEDS data and results. The transaction data does not cover power generation beyond its generic type; the industry accounting data from the Bureau of Economic Analysis (BEA),[95] for example, only goes down to the three-digit NAICS.[96] Some concepts go to 388-industries, but even this does not cover the six-digit NAICS where different types of power generation make themselves at home.[97] Hence, the simulations used the NAICS industries the most analogous to the unique sorts of production and economic activity associated with each of the power types. Natural gas vectored toward oil and gas extraction,[98] coal toward coal mining,[99] nuclear and hydroelectricity toward construction and custom turbine installation,[100] wind power toward industrial wind turbine manufacturers,[101] and solar panel power toward semiconductor manufacturing.[102] **The exact variable in PI⁺ was the "demand" for production from these industries, which is an important distinction from directly increasing the "output" of these sectors in the model.** Demand is the purchase or utilization of a good and not its production. This means actual production could be local or it could take the form of imports from another region. PI⁺ can illustrate this difference with the preexisting trade flows of commodities from region-to-region and the rest of the world in the model. For instance, wind turbines built for a new offshore wind product (anticipated as cost-effective and needed by ReEDS) in SA might come from a production facility in ENC, WNC, or Germany. Solar cells for a CSP project in MNT (Arizona or New Mexico) might come from PAC (California) or another country (such as China, Japan, Mexico, or Canada).

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95 Please see, <http://www.bea.gov/industry/io_annual.htm>
96 Please see, <http://www.bea.gov/industry/xls/IOMake_Before_Redefinitions_1997-2012_Summary.xlsx>
97 NAICS 221111 for hydroelectric power through NAICS 221118 for "other" power generation
98 NAICS 211, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=211&search=2012%20NAICS%20Search>
99 NAICS 2121, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=2121&search=2012%20NAICS%20Search>
100 NAICS 23, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=23&search=2012%20NAICS%20Search>
101 NAICS 336, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=3336&search=2012%20NAICS%20Search>
102 NAICS 3344, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=3344&search=2012%20NAICS%20Search>

NO_X and SO_X Emissions

This involved integrating data from ReEDS and taking a few additional steps beyond the price elasticity of demand of the general CAT with additional data from the AEO and exogenous parameters on average vehicle emissions per mile traveled for various types of pollutants. As illustrated in *Figure 5.3* and *Figure 5.4*, ReEDS includes results on NO_X and SO_X emissions in its simulations. Power-related emissions are oftentimes the deciding factor on the quality of the local atmosphere, although emissions from cars and trucks play a large part in urban centers in certain parts of the country. As described in the price elasticity of demand discussion before *Figure 5.6*, the AEO provides a forecast of the quantity of motor gasoline and diesel fuel purchased by region and by year in quadrillions of BTUs. CAT adjusts this to give a similar forecast only accounting for the price elasticity response from the carbon tax. The AEO also provides a forecast of total VMT for cars[103] and trucks[104] at the national level. This data is not available at the regional level, but the share of fuel demand in table A2 (motor gasoline for cars, diesel fuel for trucks) serves as an adequate proxy to share the national level VMT down to regional level VMT. This handles the baseline, and the alternative forecast for VMT by region simply has the same adjustment in percentage terms as the change in demand for gasoline and diesel MMBTUs from the price elasticity. That is, if CAT projected a 5% decrease in gasoline consumption in energy units in a region, then it also projected a 5% decline in car VMT relative to the baseline. This gives a forecast of baseline VMT by region and adjusted VMT by region for the two overarching modes with the assumption that most gasoline purchases are for cars and most diesel purchases are for medium or heavy trucks. EPA provides data on average emissions by mode for the average VMT.[105] For cars,[106] this is 0.693 grams per VMT of NO_X and 0.120 grams per VMT for SO_X and, for trucks,[107] 17.483 grams per VMT for NO_X and 0.120 grams per VMT for SO_X. Multiplying these parameters by the derived VMT forecasts gives quantities of pollutants, and subtracting the baseline from the alternative gives the results. This methodology may miss some small efficiency improvements in terms of vehicular-sourced NO_X and SO_X emissions against the Reference Case baseline and the EPA data. Conversely, the price elasticity of demand calculations do capture and reductions in fuel purchases for any reason—including driving less, switching modes (public transportation, cycling, walking for individuals or onto railroads or water for freight), or buying cars or trucks with greater fuel-efficiency in the first place. The forecast in grams undergoes the same monetization as the results from ReEDS. CAT adds the two of them together, reports a monetary figure of the benefit-cost value of saved pollution, and divides them by a parameter for the value of a life to give a simple estimation of the saved premature deaths from regional air pollution.

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[103] Please see, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=15-AEO2013&table=51-AEO2013&region=0-0&cases=ref2013-d102312a>
[104] Please see, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=15-AEO2013&table=58-AEO2013&region=0-0&cases=ref2013-d102312a>
[105] The main page with the studies and information for these parameters, which are also in REMI TranSight, is here, please see, <http://www.epa.gov/otaq/consumer.htm>
[106] Please see, "Average Annual Emission and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks," U.S. Environmental Protection Agency (USEPA), <http://www.epa.gov/otaq/consumer/420f08024.pdf>
[107] Please see, "Average In-Use Emissions from Heavy-Duty Trucks," U.S. Environmental Protection Agency (USEPA), <http://www.epa.gov/otaq/consumer/420f08027.pdf>

Fossil Fuel Exports

Energy trading oftentimes takes place in global markets, which means CAT needed concepts for international imports and exports of coal, natural gas, and petroleum to and from the United States. Petroleum has long had a "world market," and coal and natural gas are beginning to have similar dynamics in North America with Canada and the United States gearing up to begin the export of coal and gas via LNG.[108] Imports of fossil energy are implicitly part of the energy consumption forecast (table A2) from the Reference Case; many of those MMBTUs demanded at the regional level originally started in a foreign well or mine before they came to the United States for final consumption. PI$^+$ already takes account of the fact much of the energy used in the United States comes from Canada or overseas. For instance, demand for coal mining or oil and gas exaction can find its supply in another region or the rest of world through the model's trade tables. Rising demand for petroleum products in NE or MA can engender an increase in the output of related industries in ESC or WSC or increase imports from the rest of the world. Demand for industrial coal from processing facilities in ENC can come from mines in MNT or the SA region. While price elasticity eventually makes its way back to reduced imports through the trade tables in the structure of PI$^+$, there still needs to be a way in CAT to indicate the decrease in the competitiveness of America fossil fuel exports on the world market because they are now subject to a carbon price. AEO 2013 provides a forecast of energy exports by type (for coal, natural gas, and petroleum) in the Reference Case in quadrillions of BTUs.[109] This table is at the national level only, so data from PI$^+$ on each regional estimated share of international exports by the relevant industries (coal mining and oil and gas extraction) serves as a means to subdivide to the regional level. The data and intuition match in this case. WSC dominates the share of natural gas exports, and it has a large portion of the petroleum ones (though the PAC region also has a significant amount given the large refinery clusters near Los Angeles, San Francisco, and Seattle). Coal exports come from SA (which includes West Virginia) and ESC (eastern Kentucky and Tennessee) with a rising share for MNT (Wyoming). The calculation of alternative exports from the United States under carbon pricing is similar to the "domestic" CAT—the price of these fuels increases based on their underlying carbon content and the carbon tax rate, and the world market through price elasticity by purchasing less of them from suppliers in the nine regions of the United States. The elasticity comes from implicit price elasticity of demand from the world market for American exports in PI$^+$. This has an economic impact, too; regions like WSC lose a portion of their exports ("X"), which therefore lowers GRP. It may not have a significant impact on regional job creation given the high capital-intensity for these industries, but it does help to explain the negative impact to GRP in the WSC region and the neutral impact to GRP for ESC. **Unfortunately, ReEDS, CAT, and PI$^+$ collectively do not have detailed enough coverage of world energy markets to say how much foreign production of fossil fuels would make up for any decrease in the exports from the United States.** Hence, this section is mostly for adjusting GDP to match for a decline in exports and not for any climate implications.

[108] For example, please see Keith Johnson and Ben Lefebvre, "U.S. Approves Expanded Gas Exports," *Wall Street Journal*, May 18, 2013, <http://online.wsj.com/news/articles/SB10001424127887324767004578489130300876450>

[109] Please see, <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=0-AEO2013&table=1-AEO2013&region=0-0&cases=ref2013-d102312a>

The PI^{+} Model

This study used a nine region, 160 sector PI^{+} model of the United States and constituent regions to perform this analysis. PI^{+} is a computerized, multiregional, dynamic model of regions, states, counties, or other subnational disaggregates of the United States in a Microsoft Windows-based program. PI^{+} relies on four quantitative methodologies to guide its overall approach to regional modeling. The different methodologies highlight each other's strengths while compensating for any of their weaknesses when used individually.

1. **Input-output tabulation (IO)[110]** – At the core of PI^{+} is an input-output table (also known as a Social Accounting Matrix, or SAM).[111] An IO table captures the structure of the regional or national economy in terms of business-to-business transactions, wages, consumption, and can provide the "multiplier" from an additional dollar of spending or purchase. To provide a classic example, an automobile assembly plant in Michigan will have a lengthy supply chain across the rest of ENC and the rest of the United States. Vehicle assembly in Michigan requires parts from suppliers in Ohio and Wisconsin. Those suppliers need fabricated and primary metal products from steel mills in Indiana and Pennsylvania, drifting into the MA region. Railroads based in Omaha and Kansas City (WNC) move final and intermediate products around the Midwest, and Great Lakes boats based in Cleveland or Chicago bring in foreign supplies or iron ore from the Mesabi Range of northern Minnesota via Duluth. An IO model captures the effect of adding a dollar to car demand in Michigan and its echoing through the economy and into other industries. However, IO models have several weaknesses. They are very "rigid" in the computational sense, have no time horizon (only "before" and "after"), no concepts for the scarcity of labor and capital, and no internal concept for the competitiveness of different industries in dissimilar regions. They also sometimes lack trade flows between regions, they have no variables for energy prices or costs, and no adjustments to how the structure of supply chains and the overall economy responds to supply-side shocks. PI^{+} includes other modeling techniques to deepen the representation of the structure of the economy over time and include these various concepts.

2. **Computable general equilibrium (CGE)** – CGE models are a broad classification of models that rely on the principles of equilibrium economics. In essence, the addition of CGE principles to PI^{+} introduces market-based concepts and illustrations of the supply and demand for labor, housing, consumption, commuting, production, intermediate inputs, imports, exports, government spending, and other concepts. The CGE portion of the model demonstrates what happens after all markets have had a chance to "clear" in relation to each other back to a stable equilibrium. For example, the opening of a large manufacturer of wind turbines near a small city will cause more than just a multiplier at the local and regional level. The new plant will bring jobs with it, and, depending on the size and characteristics of the local labor pool, this will bid the price of labor up in the general economy of the area as more workers find a job at the plant. Certain technical

[110] Also called Leontief modeling after its developer, Wassily Leontief, who won a Nobel Prize for it in 1973, please see, <http://www.econlib.org/library/Enc/bios/Leontief.html>
[111] The raw data for the IO table comes from BLS, please see, "Inter-industry relationships (Input/output matrix)," <http://www.bls.gov/emp/ep_data_input_output_matrix.htm>

skills may be unavailable locally, so some households will move from other parts of the country in order to work there. This increases the city's population and puts upward pressure on local housing prices, which has the benefit of increasing local property tax revenues for the school board but also discourages others from buying homes. Some households may locate in another city far away. Others will make a calculation based on time, distance, price, and square footage and then locate themselves in a neighboring town with lower housing prices and commute the distance back to the city in order to work there or in the turbine manufacturer. Higher housing prices might also induce a developer to build a new housing subdivision in the area, as well. All of these effects, as well as any consequential loss of competitiveness and output from higher energy costs for commercial and industrial enterprises, are not present in pure IO models but an endogenous part of the CGE structure of PI$^+$.

3. **New Economic Geography** – Economic geography is the study of the idea that cities and interconnected industries are the engines of economic growth. PI$^+$ utilizes this theory to illustrate how specialized labor pools and industry clusters given a region a competitive advantage relative to its competitors. For instance, for labor inputs, the "selection" of trained surgeons in cities known for university-attached medical schools or healthcare clusters (such as Baltimore, Boston, and Minneapolis/Rochester, Minnesota) is much higher than cities known more for agricultural services or leisure (such as Helena, Montana). Under *ceteris paribus*, a hospital in a city like Cleveland or Houston is going to have an easier time finding a qualified, productive worker than a similar facility in Las Cruces, New Mexico or Chattanooga, Tennessee. This forms part of the competitiveness measure in PI$^+$, particularly for labor-intensive industries like healthcare, finance, insurance, entertainment, and professional and technical services. The same process is in effect for capital-intensive or intermediate input-reliant firms in terms of their relative access to a concentrated supply chain. These industries tend to cluster on top of each other in a certain niches across the country, such as with the textiles and furniture industries in SA, agribusiness in WNC, and shipbuilding on the Gulf Coast of ENC and WSC. The size and overall health of these clusters is important to the economic wellbeing of any region or city. Different parts of the United States tend to specialized in a handful of key industries—maintaining them is essential to maintaining local growth and the quality of the regional economy. PI$^+$ assesses these clusters in the baseline and in any alternative simulations like a FAD carbon tax.

4. **Econometrics** – REMI uses historical data to determine the parameters necessary to populate the mathematics of the model. This includes estimating elasticity (the implicit slope of supply and demand curves), terms, and "time lags" on how long it takes an individual market to adjust back to equilibrium. Some markets, such as that for labor, tend to work relatively quickly as people and firms look for jobs and employees while other, such as housing, tend to take more time as buyers, sellers, developers, banks, and regulators are always trying to catch-up to a new set of incentives in regional and national housing markets. Some equations in the model are entirely econometric in nature, and this allows the IO and CGE portions of the model to work with each other in a truly dynamic, multiyear structure with multiple regions.

The methodology and equations set in PI+ are peer-reviewed and available to the public.[112] The initial publications by REMI's founder, Dr. George I. Treyz, and his team have appeared in such publications as the *Journal of Regional Science*,[113] the *Review of Economics and Statistics*,[114] and the *American Economic Review*.[115] The data inside PI+ comes from public data agencies such as the BEA, BLS, EIA, U.S. Census, the U.S. Department of Defense, the U.S. Department of Education, and several other sources.[116] Trends in the macroeconomic portion of the model are from the BLS industry forecast and the Research Seminar in Quantitative Economics (RSQE) at the University of Michigan-Ann Arbor.[117] This all provides the background data and methodologies for running exogenous policy simulations.

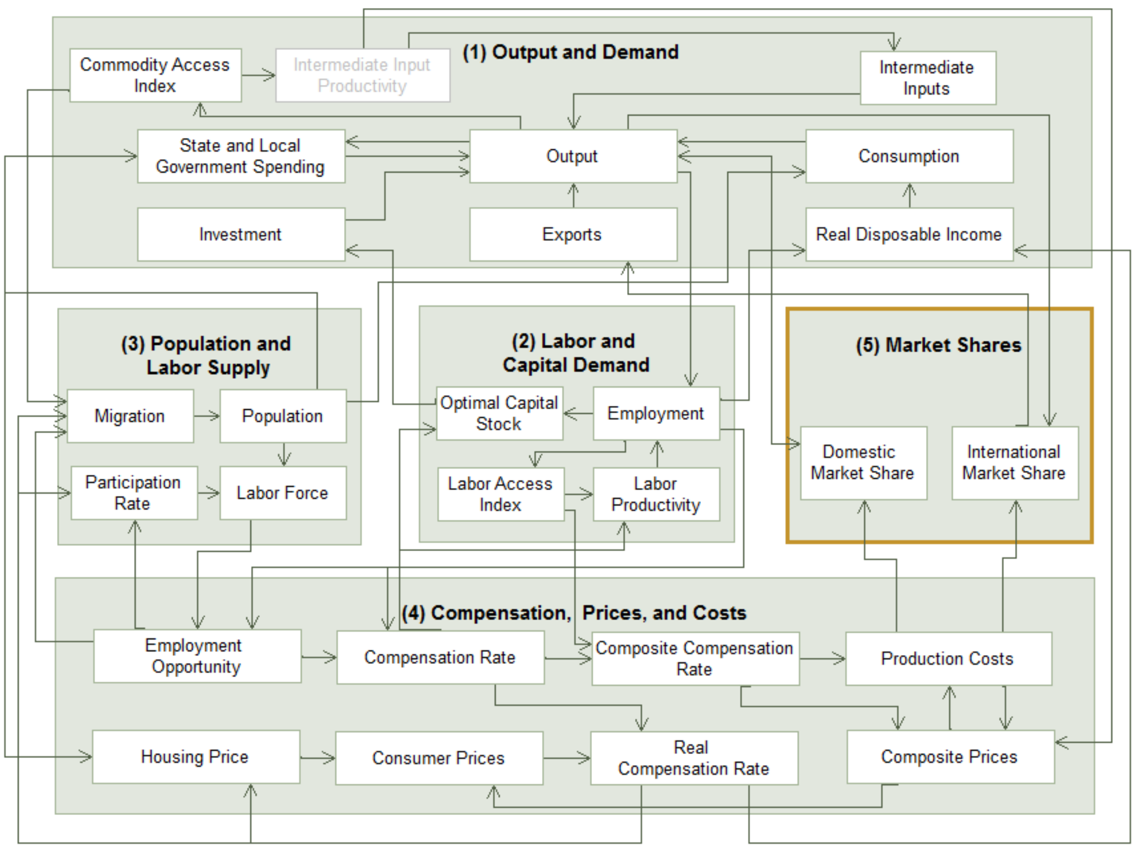

Figure 5.7 – This shows the explicit structure of PI+ with cause-and-effect linkages between different concepts and sectors of the economy and demographics.

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112 For the full PDF of model equations, please see, <http://tinyurl.com/l2nbgn2>
113 Dan S. Rickman, Gang Shao, and George I. Treyz, "Multiregional Stock Adjustment Equations of Residential and Nonresidential Investment in Structure," *Journal of Regional Science*, Vol. 33 (2), 1993, pp. 207-2019
114 George I. Treyz, Dan S. Rickman, and Michael J. Greenwood, "The Dynamics of U.S. Internal Migration," *Review of Economics and Statistics*, Vol. LXXV, No. 2, May 1993, pp. 209-214
115 Please see, <http://cas.umkc.edu/econ/economics/faculty/eaton/Eaton_main/Article%2018.pdf>
116 For a full accounting of the data sources and estimation procedures in the REMI model, please see, <http://www.remi.com/download/documentation/pi+/pi+_version_1.6/Data_Sources_and_Estimation_Procedures.pdf>
117 Their homepage on the Michigan and American economies is here, <http://rsqe.econ.lsa.umich.edu/>

Each block in the above structure of *Figure 5.7* describes a different portion of the economy. Block 1 is the macroeconomics of the model with final demand and GDP by component. The calculations in Block 2 make up the "business" perspective on the economy where firms will maximize profits by minimizing costs in hiring decisions (employment) and capital (their investments). Block 3 is a full demographic model with natural changes, labor mobility within the United States, and international migration and emigration. Block 3 also includes the interactions of households with the general economy through labor force participation, wages, and consumer spending. Block 4 introduces equilibrium concepts to the labor market concepts, the cost of living (including energy prices), and production costs (for labor, capital, fuel inputs, and intermediate goods). Block 5 illustrates the competitiveness of a region with explicit regional purchase coefficients (RPCs), which quantify how likely an area is to keep imports away while moving its own exports out to other regions and countries.

Other applications of the REMI model in the energy sphere include the aforementioned carbon tax studies at the state level in Massachusetts, Washington, and California in integration with CTAM. It is also possible to integrate REMI with other models besides CTAM, ReEDS, and CAT, including grid and dispatch models such as GPCM®[118] or IPM,[119] or travel-demand models (TDMs) such as TransCAD and Cube Voyager.[120] PI+ provides a flexible framework with a plethora of variables to make this level of integration typical.

Integrating ReEDS, CAT, and PI+

The ReEDS model and CAT in concert produced seven main types of exogenous inputs to PI+ in order to illustrate the direct costs and benefits of a FAD carbon tax. Each one of these inputs affected the economic model in different ways in the structure from *Figure 5.7*, and the results reported were for all inputs ran at the same time to give a net analysis. The seven categories included the following inputs, charted out in *Figure 5.8* below.

1. Monthly rebate checks that increase consumer spending
2. Higher end-use energy costs for residential, commercial, and industrial sectors
3. Changing investments in power generation capacity and O&M expenses
4. Quality of life and amenity benefits from improved air quality
5. Decreased competitiveness for foreign products on the American market through the border adjustment's assessment
6. Increased competitiveness for American products on foreign markets through the recycling of the border adjustment
7. Reduced fossil fuel exports by type and by region

[118] Scott Nystrom and Robert Brooks, "The Macroeconomic Impact of LNG Exports: Integrating the GPCM Natural Gas Model and the PI+ Regional Model," *United States Association for Energy Economics* (USAEE), presented at the annual conference 2012 in Austin, Texas, <http://www.usaee.org/usaee2012/submissions/Presentations/RBAC%20REMI%20LNG%20pdf.pdf>

[119] Please see, <http://www.rggi.org/docs/ProgramReview/February11/13_02_11_REMI.pdf>

[120] Described in the appendix of the TranSight documentation, please see, <http://www.remi.com/download/documentation/transight/transight_version_2.1/TranSight_User_Guide_and_Model_Doc_v2.1.pdf>

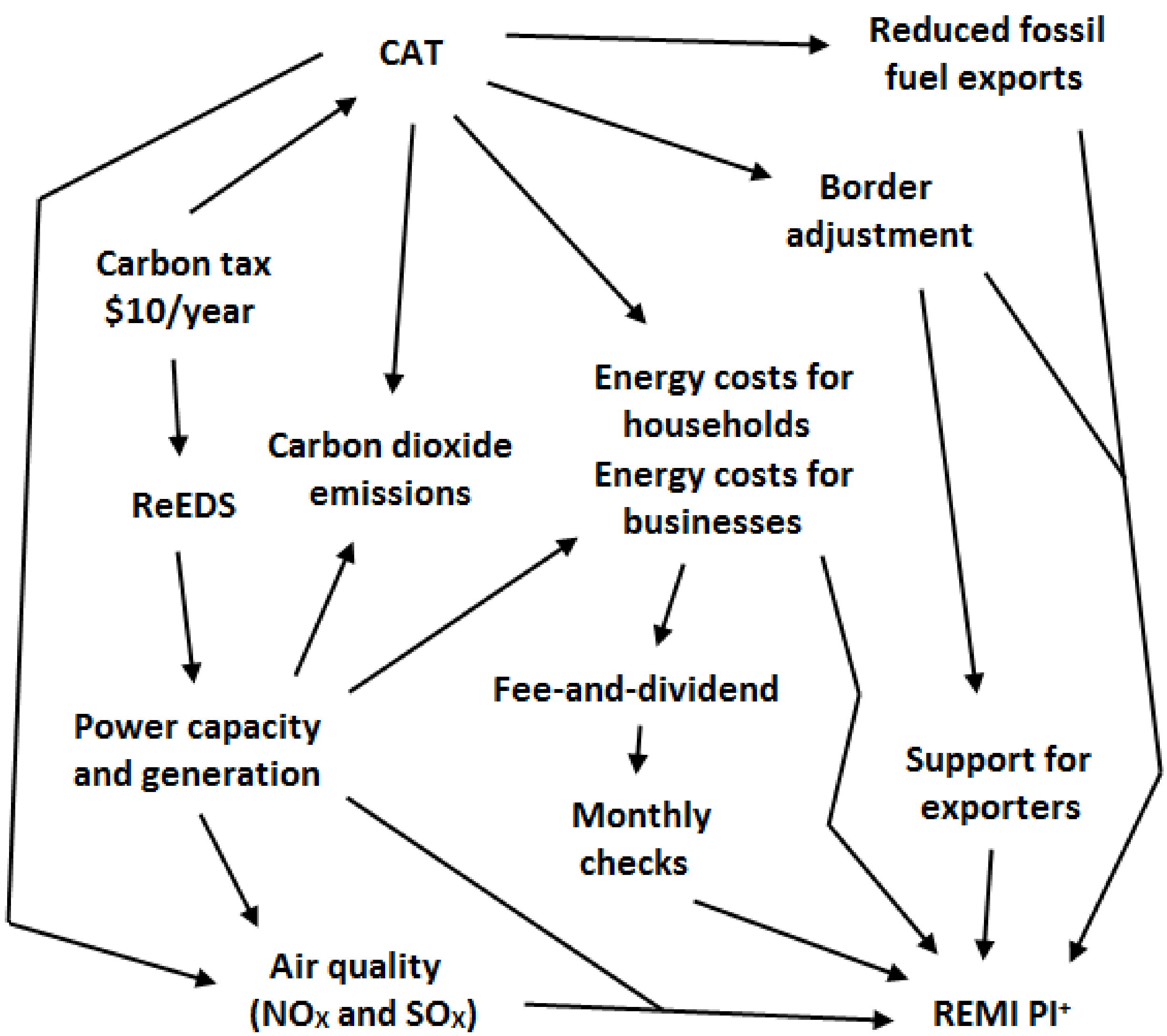


Figure 5.8 – This is the same chart as Figure 2.1 from earlier in the report. It shows the seven main types of inputs into PI⁺ to make the economic impact simulation reported here.

The next table, *Figure 5.9*, charts the source of the seven categories for PI⁺ from either ReEDS or CAT and any information from inside the baseline in PI⁺ necessary to share the information down to the regional level or 160 sectors. For example, the AEO only reports consumption of fuel types by broad sector (residential, consumer, and industrial) in table A2. PI⁺ needs inputs at its level of industrial detail. To rectify this, a multiplication of regional output by industry by the fuel share (by electricity, natural gas, and petroleum type) in the IO table gives an estimation of fuel demand by type for the various industries. This becomes a share by industry and region for breaking the high-level AEO data down to PI⁺ in a consistent manner.

	Data Source	Sharing Procedure	Policy Variable
1	CAT	Population by region from PI⁺	Consumption reallocation
2	CAT (underlying data from AEO 2013 and electricity results from ReEDS)	Industry output multiplied by fuel absorption coefficient in IO table between industries and regions	Consumer price (fuel oil and other fuels, natural gas, electricity, and motor vehicle fuels), electricity costs (by individual industry), natural gas costs (by individual industry), residual costs (by individual industry)
3	CAT (calculated off results from ReEDS)	N/A	Exogenous final demand (by industry)
4	CAT (transportation) and ReEDS (from power generation)	N/A	Non-pecuniary amenity (amount, by region)
5	CAT (with supplementary data from PI⁺)	Share of imports to different regions and industries	Production costs (by industry and region)
6	CAT (with supplementary data from PI⁺)	Share of exports from different regions and industries	Production costs (by industry and region)
7	CAT (calculated from AEO baseline)	Share of exports from fossil fuel-related industries by region	Industry sales/exogenous exports (by region and industry)

Figure 5.9 – This shows the exact data transfers from ReEDS and CAT into PI⁺ in order to perform these simulations from the modeling flowchart in Figure 5.8. The ReEDS runs and the AEO 2013 form the backbone of the study before building up changes and exogenous inputs into PI⁺ to represent the net economic, fiscal, and demographic impact of FAD carbon taxes.

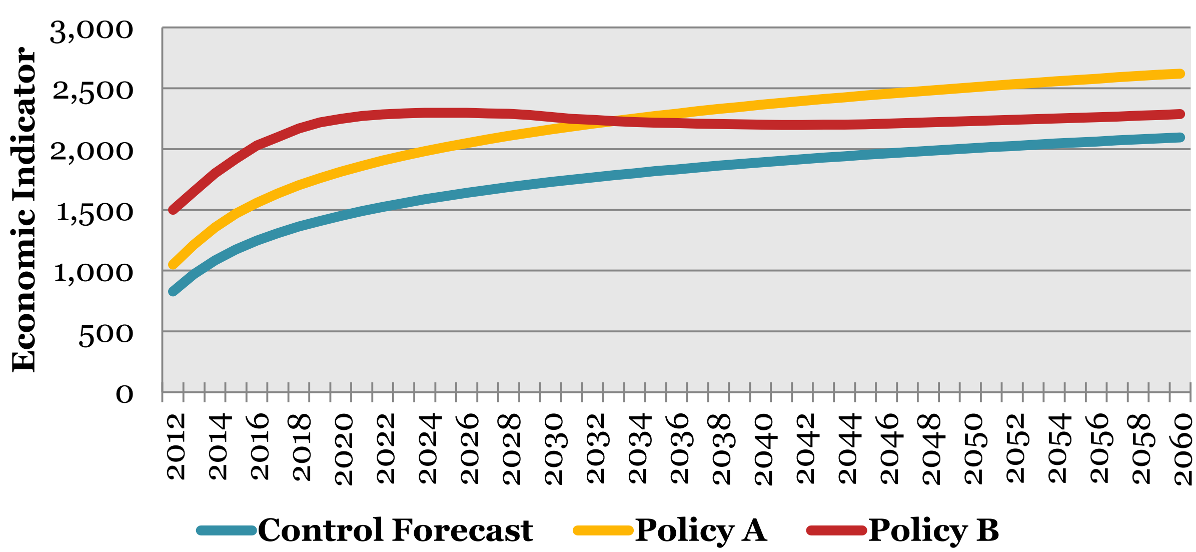
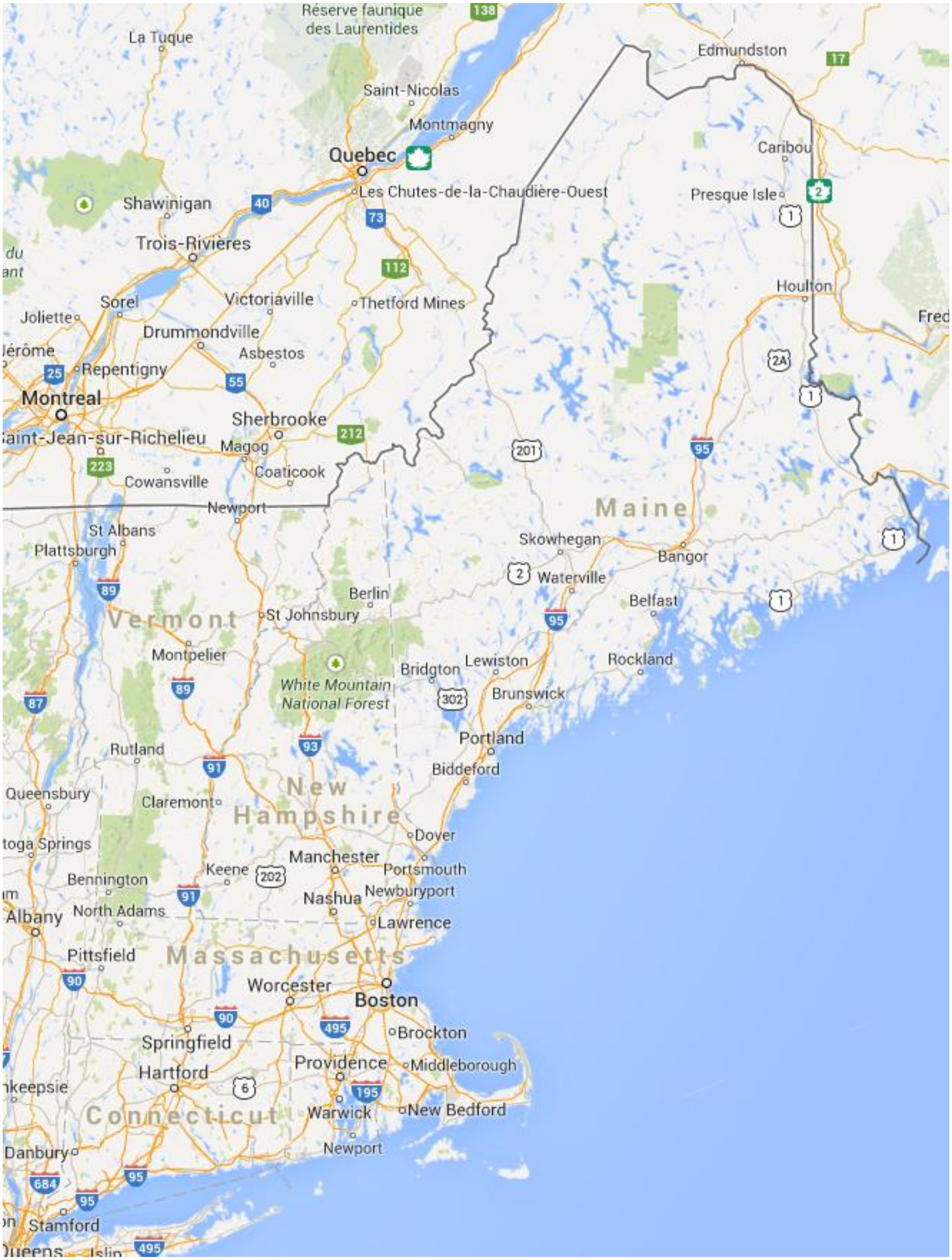


Figure 5.10 – This last illustration shows the fundamental idea of the PI⁺ model, where the changes in Figure 5.9 induce the economy to change over time from a baseline (Policy A or Policy B versus the Control Forecast) in order to compare the difference.

New England (NE)



Electrical Power Capacity (NE level)

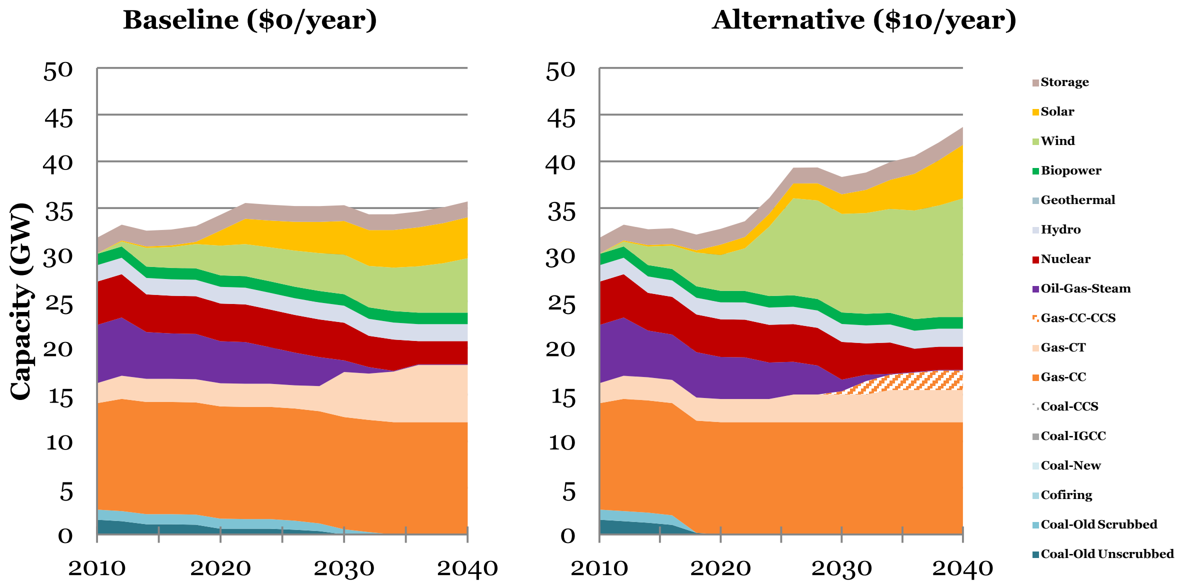


Figure 6.1 – The most notable change in power capacity in NE is a large addition of wind turbines at the expense of some natural gas capacity in the $10 per year scenario. The carbon tax also accelerates the retirement of the last few coal plants in the area by a decade or so.

Electrical Power Capacity (NE level)

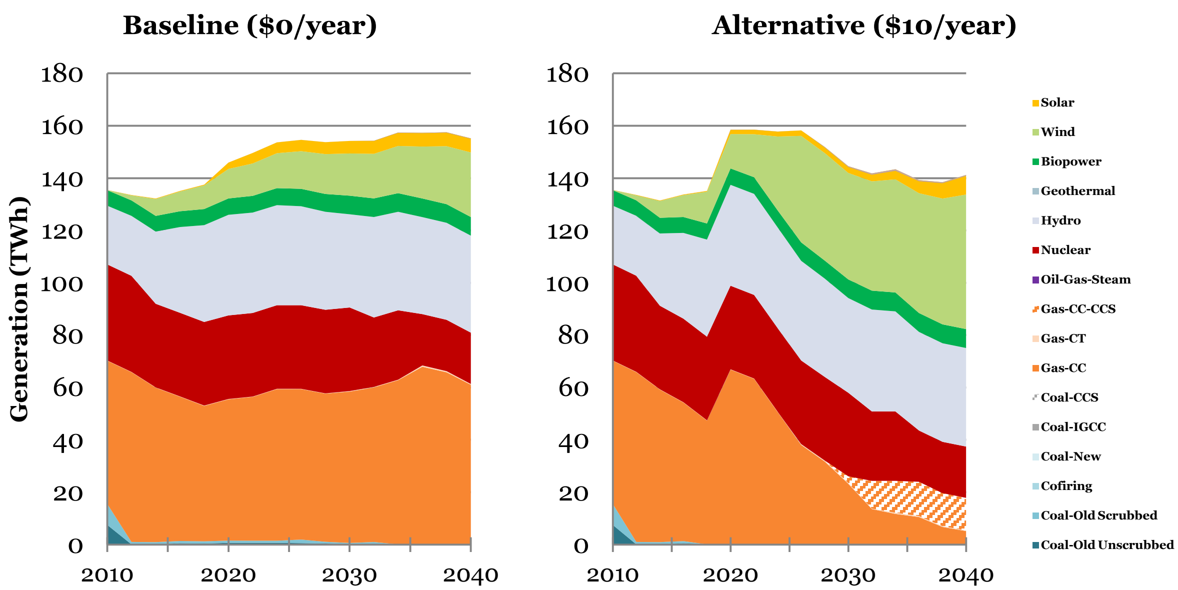


Figure 6.2 – NE already has a "favorable" generation mix in terms of emissions with mostly gas, nuclear, hydroelectric, biomass, wind, and some solar. The carbon tax reduces the share dedicated to gas (or makes carbon sequestration with that gas economical).

Figure 6.3 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$21	-$71	-$110	-$134
Agriculture and forestry support activities	-$1	-$3	-$4	-$4
Oil and gas extraction	-$3	-$8	-$15	-$17
Mining (except oil and gas)	$12	-$10	-$28	-$35
Support activities for mining	$0	$0	$0	$0
Utilities	-$208	-$387	-$416	-$387
Construction	$437	$545	$572	$722
Wood manufacturing	$9	$10	$8	$9
Nonmetallic mineral manufacturing	$16	$18	$16	$19
Primary metal manufacturing	-$6	-$29	-$41	-$37
Fabricated metal manufacturing	$58	$53	$11	-$2
Machinery manufacturing	$10	$43	$72	$67
Computer and electronic manufacturing	-$22	-$204	-$356	-$440
Electrical equipment and appliance manufacturing	-$11	-$77	-$137	-$181
Motor vehicles, bodies and trailers, and parts manufacturing	$8	$11	$13	$15
Other transportation equipment manufacturing	-$8	-$56	-$102	-$136
Furniture and related manufacturing	$14	$14	$9	$4
Miscellaneous manufacturing	$11	-$32	-$62	-$72
Food manufacturing	$35	$38	$32	$29
Beverage and tobacco manufacturing	$10	$9	$6	$5
Textile mills; Textile mills	$0	-$11	-$24	-$27
Apparel manufacturing; Leather and allied manufacturing	-$1	-$8	-$12	-$12
Paper manufacturing	$14	$0	-$16	-$26
Printing and related support activities	$17	$19	$17	$17
Petroleum and coals manufacturing	-$15	-$63	-$94	-$111
Chemical manufacturing	$78	-$47	-$183	-$268
Plastics and rubber manufacturing	$15	-$7	-$32	-$50
Wholesale trade	$310	$333	$319	$362
Retail trade	$531	$774	$950	$1,178
Air transportation	-$104	-$243	-$386	-$514
Rail transportation	-$6	-$16	-$26	-$31
Water transportation	-$2	-$6	-$10	-$14
Truck transportation	$16	$12	$3	-$2
Couriers and messengers	$11	$5	-$6	-$16
Transit and ground passenger transportation	$12	$8	-$1	-$7
Pipeline transportation	-$5	-$9	-$10	-$10
Scenic and sightseeing transportation; Support activities for transportation	-$22	-$58	-$98	-$139
Warehousing and storage	$8	$4	-$2	-$7
Publishing industries, except Internet	$146	$205	$243	$305
Motion picture and sound recording industries	$27	$43	$58	$76
Internet publishing and broadcasting; ISPs, search portals, and data processing	$47	$48	$40	$41
Broadcasting, except Internet	$23	$27	$26	$28
Telecommunications	$173	$230	$246	$271
Monetary authorities - central bank; Credit intermediation and related activities	$534	$726	$799	$873
Securities, commodity contracts, investments	$427	$552	$550	$560
Insurance carriers and related activities	$325	$419	$416	$403
Real estate	$869	$1,010	$988	$1,108
Rental and leasing services; Leasing of nonfinancial intangible assets	-$21	-$181	-$353	-$483
Professional, scientific, and technical services	$398	$286	$68	-$32
Management of companies and enterprises	$32	-$83	-$231	-$347
Administrative and support services	$186	$218	$199	$199
Waste management and remediation services	$23	$24	$21	$21
Educational services	$151	$187	$193	$206
Ambulatory health care services	$821	$1,239	$1,480	$1,682
Hospitals	$307	$380	$378	$397
Nursing and residential care facilities	$96	$115	$110	$112
Social assistance	$67	$92	$102	$113
Performing arts and spectator sports	$31	$37	$36	$39
Museums, historical sites, zoos, and parks	$8	$9	$10	$10
Amusement, gambling, and recreation	$52	$75	$86	$95
Accommodation	$93	$116	$113	$116
Food services and drinking places	$130	$117	$82	$74
Repair and maintenance	$74	$81	$72	$71
Personal and laundry services	$146	$217	$258	$289
Membership associations and organizations	$43	$47	$41	$40
Private households	$18	$28	$35	$40
State and local government	$360	$285	$156	$112
TOTAL OF ALL SECTORS =	$6,783	$7,100	$6,079	$6,167

Figure 6.4 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	-1	-1
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	0	0	0	0
Mining (except oil and gas)	0	0	0	0
Support activities for mining	0	0	0	0
Utilities	0	-1	0	0
Construction	8	11	12	14
Wood manufacturing	0	0	0	0
Nonmetallic mineral manufacturing	0	0	0	0
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	0	0	0	0
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	-1	-1	-1
Electrical equipment and appliance manufacturing	0	0	0	0
Motor vehicles, bodies and trailers, and parts manufacturing	0	0	0	0
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	0	0	0	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	0	0	0	0
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	0	0	0
Printing and related support activities	0	0	0	0
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	0	0	0	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	2	2	2	2
Retail trade	9	12	14	15
Air transportation	0	-1	-1	-1
Rail transportation	0	0	0	0
Water transportation	0	0	0	0
Truck transportation	0	1	1	2
Couriers and messengers	0	0	1	1
Transit and ground passenger transportation	0	1	1	1
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	0	-1	-1	-1
Warehousing and storage	0	0	0	0
Publishing industries, except Internet	1	1	1	1
Motion picture and sound recording industries	0	0	0	0
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	0	0	0
Telecommunications	0	1	1	1
Monetary authorities - central bank; Credit intermediation and related activities	2	2	2	2
Securities, commodity contracts, investments	3	4	4	4
Insurance carriers and related activities	2	2	2	2
Real estate	4	4	4	4
Rental and leasing services; Leasing of nonfinancial intangible assets	0	0	0	0
Professional, scientific, and technical services	4	4	3	2
Management of companies and enterprises	0	0	-1	-1
Administrative and support services	5	8	8	9
Waste management and remediation services	0	0	0	0
Educational services	4	6	6	7
Ambulatory health care services	10	16	19	22
Hospitals	4	5	6	6
Nursing and residential care facilities	2	3	3	4
Social assistance	2	3	4	4
Performing arts and spectator sports	1	1	1	1
Museums, historical sites, zoos, and parks	0	0	0	0
Amusement, gambling, and recreation	2	3	3	3
Accommodation	1	2	2	2
Food services and drinking places	4	5	5	5
Repair and maintenance	1	1	1	1
Personal and laundry services	3	5	5	6
Membership associations and organizations	1	2	1	2
Private households	2	3	4	4
State and local government	4	3	2	1
TOTAL OF ALL SECTORS =	81	107	113	123

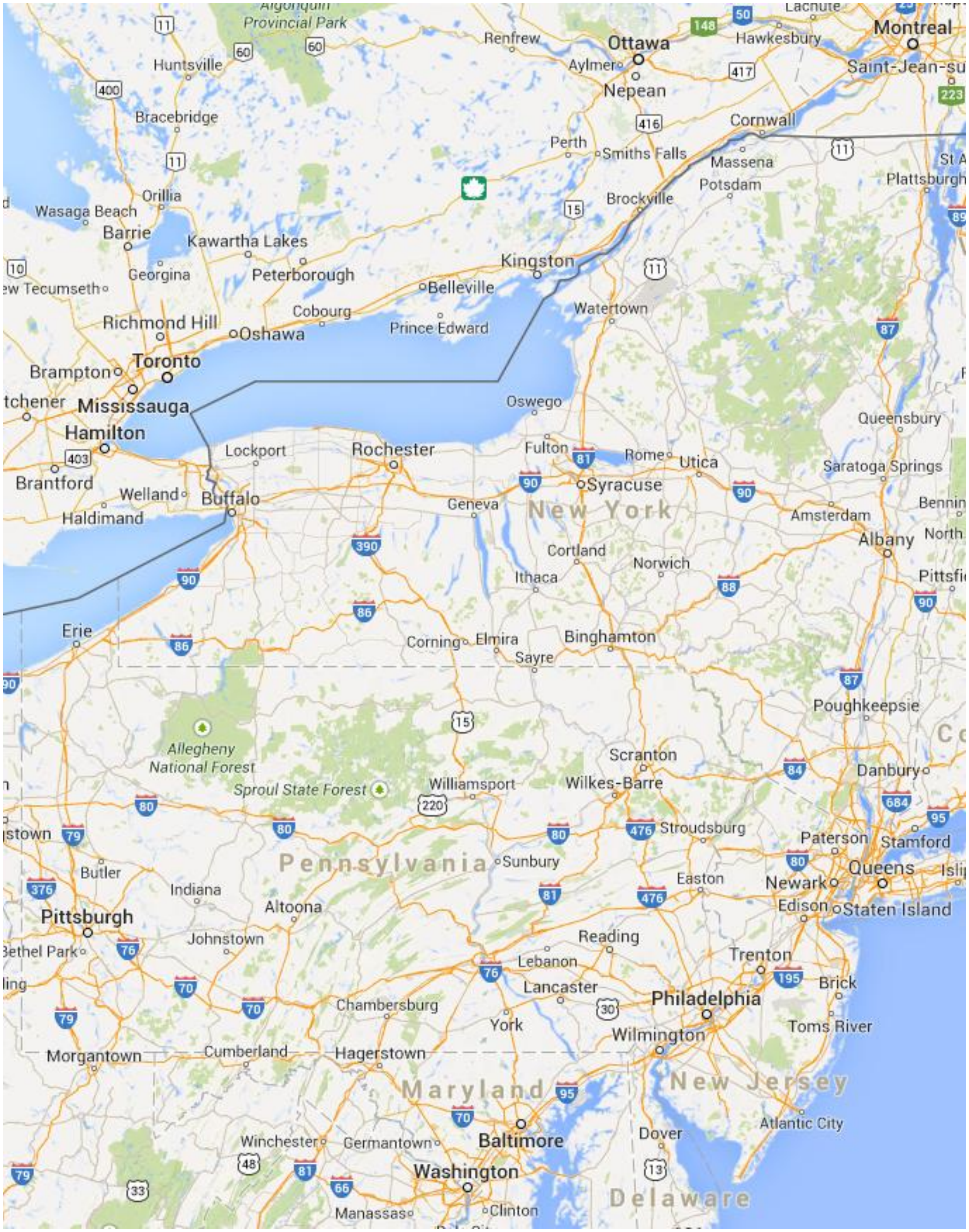
Figure 6.5 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	1	1	1	1
Advertising, marketing, promotions, public relations, and sales managers	0	0	0	0
Operations specialties managers	1	1	1	1
Other management occupations	1	2	2	2
Business operations specialists	2	2	2	2
Financial specialists	2	3	2	2
Computer occupations	2	2	1	1
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	0	0
Drafters, engineering technicians, and mapping technicians	0	0	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	0	0	0
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	1	1	1	1
Miscellaneous community and social service specialists	0	1	1	1
Religious workers	0	0	0	0
Lawyers, judges, and related workers	0	0	0	0
Legal support workers	0	0	0	0
Postsecondary teachers	1	2	2	2
Preschool, primary, secondary, and special education school teachers	1	2	1	1
Other teachers and instructors	1	1	1	1
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	1	1	1	1
Art and design workers	0	0	0	0
Entertainers and performers, sports and related workers	1	1	1	1
Media and communication workers	0	1	1	1
Media and communication equipment workers	0	0	0	0
Health diagnosing and treating practitioners	5	7	8	9
Health technologists and technicians	3	4	4	5
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	2	3	3	3
Occupational therapy and physical therapist assistants and aides	0	0	0	1
Other healthcare support occupations	2	3	4	4
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	0	0	0	0
Other protective service workers	1	1	1	1
Supervisors of food preparation and serving workers	0	0	0	1
Cooks and food preparation workers	1	2	2	2
Food and beverage serving workers	3	4	4	4
Other food preparation and serving related workers	1	1	1	1
Supervisors of building and grounds cleaning and maintenance workers	0	0	1	1
Building cleaning and pest control workers	3	4	4	4
Grounds maintenance workers	2	4	4	5
Supervisors of personal care and service workers	0	0	0	0
Animal care and service workers	0	0	0	0
Entertainment attendants and related workers	0	1	1	1
Funeral service workers	0	0	0	0
Personal appearance workers	2	3	3	3
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	3	4	4	5
Supervisors of sales workers	1	1	1	1
Retail sales workers	5	7	8	9
Sales representatives, services	2	2	2	2
Sales representatives, wholesale and manufacturing	1	1	1	1
Other sales and related workers	1	1	1	1
Supervisors of office and administrative support workers	1	1	1	1
Communications equipment operators	0	0	0	0
Financial clerks	2	3	3	3
Information and record clerks	4	5	5	5
Material recording, scheduling, dispatching, and distributing workers	1	2	2	2
Secretaries and administrative assistants	3	4	4	5
Other office and administrative support workers	3	3	3	4
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	1	1	1	1
Construction trades workers	4	6	7	8
Helpers, construction trades	0	1	1	1
Other construction and related workers	0	0	0	0
Extraction workers	0	0	0	0
Supervisors of installation, maintenance, and repair workers	0	0	0	0
Electrical and electronic equipment mechanics, installers, and repairers	0	0	0	0
Vehicle and mobile equipment mechanics, installers, and repairers	1	1	1	1
Other installation, maintenance, and repair occupations	2	2	2	3
Supervisors of production workers	0	0	0	0
Assemblers and fabricators	0	0	0	0
Food processing workers	0	0	0	0
Metal workers and plastic workers	0	0	0	0
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	0	0	0	0
Woodworkers	0	0	0	0
Plant and system operators	0	0	0	0
Other production occupations	1	1	1	0
Supervisors of transportation and material moving workers	0	0	0	0
Air transportation workers	0	0	0	-1
Motor vehicle operators	2	2	3	3
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	0	0	0	0
Material moving workers	2	2	2	2
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	80	108	111	120

Amherst, Massachusetts

Mid-Atlantic (MA)



Electrical Power Capacity (MA level)

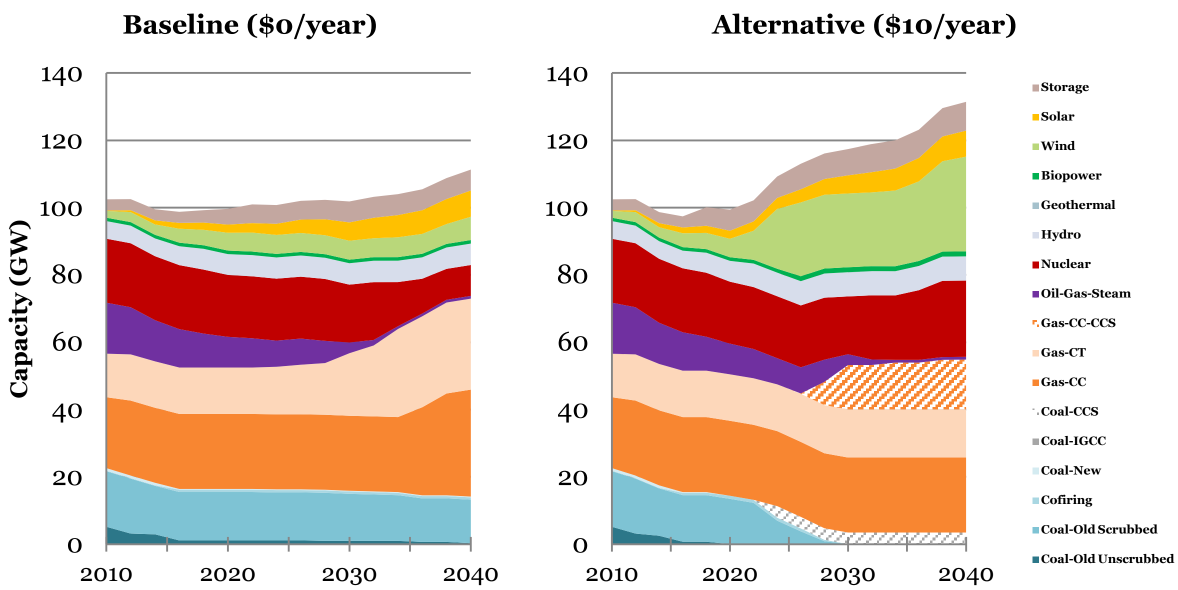


Figure 6.6 – The capacity patterns in MA mimic many of the national level trends with steady coal and expanding gas in the baseline. The carbon tax helps to retire the coal and introduce a decent amount of new wind to take its place with more overall capacity in the system.

Electrical Power Generation (MA level)

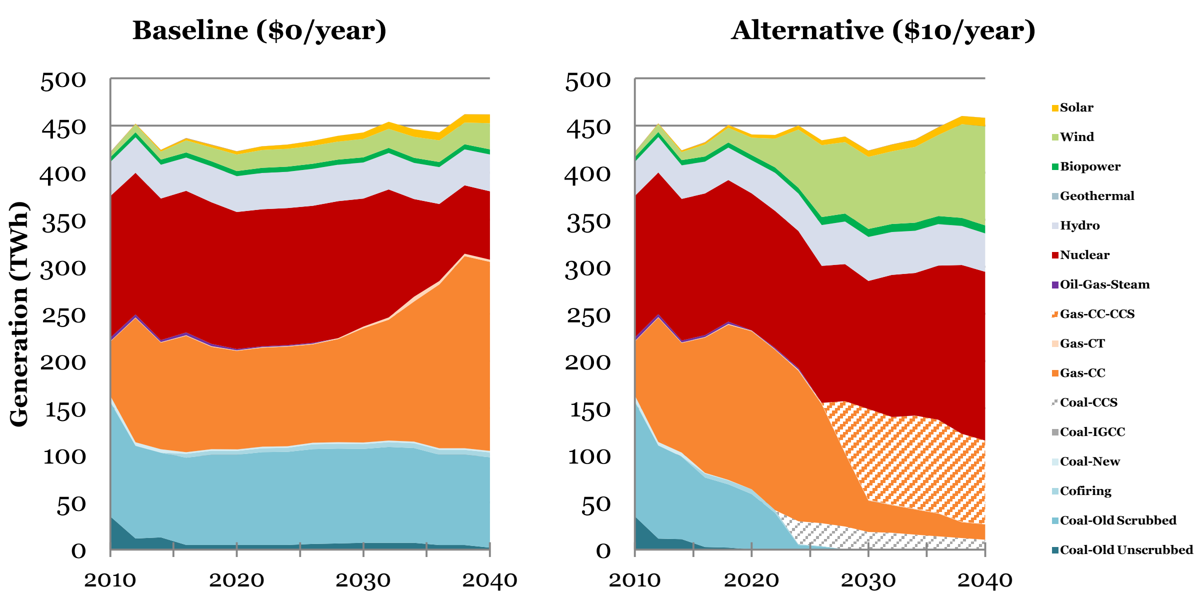


Figure 6.7 – The carbon price of $10 per year reduces the baseline's 100 TWh per year of power generation from coal to close to zero, although MA is one of the few regions where coal with carbon capture and sequestration proves economical to some degree.

Figure 6.8 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$3	-$9	-$14	-$17
Agriculture and forestry support activities	$0	-$1	-$2	-$2
Oil and gas extraction	-$86	-$224	-$341	-$409
Mining (except oil and gas)	-$305	-$965	-$1,554	-$1,653
Support activities for mining	-$14	-$14	$4	$23
Utilities	-$1,078	-$1,484	-$1,306	-$1,228
Construction	$662	$911	$1,166	$1,487
Wood manufacturing	$16	$20	$20	$21
Nonmetallic mineral manufacturing	$42	$44	$39	$41
Primary metal manufacturing	-$68	-$253	-$389	-$437
Fabricated metal manufacturing	$144	$103	$36	$120
Machinery manufacturing	$3	$34	$63	$39
Computer and electronic manufacturing	-$66	-$292	-$461	-$558
Electrical equipment and appliance manufacturing	-$30	-$130	-$220	-$285
Motor vehicles, bodies and trailers, and parts manufacturing	$35	$52	$62	$71
Other transportation equipment manufacturing	$0	-$26	-$53	-$71
Furniture and related manufacturing	$35	$32	$19	$4
Miscellaneous manufacturing	$16	-$58	-$108	-$124
Food manufacturing	$111	$113	$92	$78
Beverage and tobacco manufacturing	$30	$29	$22	$17
Textile mills; Textile mills	-$1	-$18	-$35	-$40
Apparel manufacturing; Leather and allied manufacturing	-$9	-$42	-$60	-$65
Paper manufacturing	$21	-$5	-$32	-$48
Printing and related support activities	$39	$43	$40	$39
Petroleum and coals manufacturing	-$355	-$932	-$1,364	-$1,714
Chemical manufacturing	$196	-$283	-$793	-$1,167
Plastics and rubber manufacturing	$15	-$45	-$109	-$157
Wholesale trade	$761	$835	$858	$993
Retail trade	$1,261	$1,947	$2,542	$3,189
Air transportation	-$539	-$1,304	-$2,105	-$2,834
Rail transportation	-$22	-$53	-$84	-$99
Water transportation	-$4	-$13	-$22	-$30
Truck transportation	$58	$50	$32	$34
Couriers and messengers	$35	$25	$1	-$17
Transit and ground passenger transportation	$50	$59	$59	$67
Pipeline transportation	-$26	-$42	-$48	-$48
Scenic and sightseeing transportation; Support activities for transportation	-$97	-$249	-$417	-$587
Warehousing and storage	$28	$20	$3	-$5
Publishing industries, except Internet	$264	$346	$386	$440
Motion picture and sound recording industries	$245	$396	$535	$693
Internet publishing and broadcasting; ISPs, search portals, and data processing	$113	$115	$107	$116
Broadcasting, except Internet	$86	$99	$96	$104
Telecommunications	$454	$602	$676	$772
Monetary authorities - central bank; Credit intermediation and related activities	$1,813	$2,572	$2,960	$3,302
Securities, commodity contracts, investments	$1,419	$1,863	$1,932	$2,015
Insurance carriers and related activities	$644	$835	$846	$829
Real estate	$1,988	$2,344	$2,605	$3,019
Rental and leasing services; Leasing of nonfinancial intangible assets	-$168	-$725	-$1,292	-$1,743
Professional, scientific, and technical services	$837	$522	$96	-$91
Management of companies and enterprises	$28	-$366	-$817	-$1,177
Administrative and support services	$372	$380	$325	$313
Waste management and remediation services	$40	$37	$31	$31
Educational services	$270	$345	$390	$437
Ambulatory health care services	$1,975	$3,039	$3,695	$4,212
Hospitals	$549	$682	$738	$828
Nursing and residential care facilities	$192	$238	$254	$279
Social assistance	$193	$270	$314	$358
Performing arts and spectator sports	$112	$144	$161	$184
Museums, historical sites, zoos, and parks	$17	$21	$24	$27
Amusement, gambling, and recreation	$110	$164	$197	$225
Accommodation	$147	$149	$139	$147
Food services and drinking places	$228	$201	$162	$163
Repair and maintenance	$146	$162	$159	$167
Personal and laundry services	$364	$558	$682	$766
Membership associations and organizations	$120	$138	$139	$149
Private households	$37	$61	$81	$92
State and local government	$856	$635	$386	$315
TOTAL OF ALL SECTORS =	$14,306	$13,702	$11,548	$11,600

Figure 6.9 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	0	0
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	-1	-2	-3	-3
Mining (except oil and gas)	-1	-4	-6	-5
Support activities for mining	0	0	0	0
Utilities	-2	-2	-1	-1
Construction	12	18	23	28
Wood manufacturing	0	0	0	1
Nonmetallic mineral manufacturing	0	1	1	1
Primary metal manufacturing	0	0	-1	0
Fabricated metal manufacturing	1	1	1	2
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	-1	-1	-1
Electrical equipment and appliance manufacturing	0	-1	-1	-1
Motor vehicles, bodies and trailers, and parts manufacturing	0	0	0	0
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	0	0	0	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	1	1	1	1
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	-1	-1	-1
Paper manufacturing	0	0	0	0
Printing and related support activities	0	1	1	0
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	1	0	0	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	5	6	7	7
Retail trade	22	32	38	42
Air transportation	-2	-4	-6	-7
Rail transportation	0	0	0	0
Water transportation	0	0	0	0
Truck transportation	1	3	4	6
Couriers and messengers	1	1	2	2
Transit and ground passenger transportation	2	3	4	5
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	-1	-2	-3	-4
Warehousing and storage	1	1	1	1
Publishing industries, except Internet	1	1	1	1
Motion picture and sound recording industries	1	2	2	2
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	1	1	1
Telecommunications	1	1	2	2
Monetary authorities - central bank; Credit intermediation and related activities	5	7	7	7
Securities, commodity contracts, investments	9	12	12	11
Insurance carriers and related activities	4	6	5	5
Real estate	8	10	11	12
Rental and leasing services; Leasing of nonfinancial intangible assets	1	1	1	0
Professional, scientific, and technical services	8	8	6	5
Management of companies and enterprises	0	-1	-2	-3
Administrative and support services	12	18	22	25
Waste management and remediation services	0	1	1	1
Educational services	8	13	16	19
Ambulatory health care services	26	41	51	58
Hospitals	8	11	13	15
Nursing and residential care facilities	5	7	9	10
Social assistance	7	11	13	15
Performing arts and spectator sports	3	3	4	4
Museums, historical sites, zoos, and parks	0	1	1	1
Amusement, gambling, and recreation	4	6	7	8
Accommodation	2	3	3	3
Food services and drinking places	9	12	13	15
Repair and maintenance	2	2	3	3
Personal and laundry services	8	13	15	16
Membership associations and organizations	4	5	5	6
Private households	4	7	8	9
State and local government	9	7	4	3
TOTAL OF ALL SECTORS =	189	260	294	327

Figure 6.10 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	3	3	4	4
Advertising, marketing, promotions, public relations, and sales managers	1	1	1	1
Operations specialties managers	2	2	2	2
Other management occupations	3	4	5	5
Business operations specialists	5	6	6	6
Financial specialists	6	7	7	7
Computer occupations	3	3	3	3
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	0	-1
Drafters, engineering technicians, and mapping technicians	0	0	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	0	0	0
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	2	3	3	4
Miscellaneous community and social service specialists	1	2	2	2
Religious workers	0	0	0	0
Lawyers, judges, and related workers	1	1	1	1
Legal support workers	0	1	0	0
Postsecondary teachers	3	4	5	5
Preschool, primary, secondary, and special education school teachers	3	4	4	4
Other teachers and instructors	1	2	2	2
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	2	2	2	2
Art and design workers	1	1	1	1
Entertainers and performers, sports and related workers	1	2	2	2
Media and communication workers	1	2	2	2
Media and communication equipment workers	0	1	1	1
Health diagnosing and treating practitioners	11	16	20	22
Health technologists and technicians	6	9	11	13
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	5	7	8	10
Occupational therapy and physical therapist assistants and aides	1	1	1	1
Other healthcare support occupations	5	8	10	11
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	1	0	0	0
Other protective service workers	2	2	3	3
Supervisors of food preparation and serving workers	1	1	1	2
Cooks and food preparation workers	3	4	5	5
Food and beverage serving workers	7	9	10	11
Other food preparation and serving related workers	1	2	2	2
Supervisors of building and grounds cleaning and maintenance workers	1	1	1	2
Building cleaning and pest control workers	6	8	10	11
Grounds maintenance workers	5	9	11	13
Supervisors of personal care and service workers	0	1	1	1
Animal care and service workers	1	1	1	1
Entertainment attendants and related workers	1	2	2	2
Funeral service workers	0	0	0	0
Personal appearance workers	5	7	9	10
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	7	10	12	14
Supervisors of sales workers	2	3	4	4
Retail sales workers	13	19	22	24
Sales representatives, services	4	5	5	5
Sales representatives, wholesale and manufacturing	2	2	2	2
Other sales and related workers	2	3	3	3
Supervisors of office and administrative support workers	2	3	4	4
Communications equipment operators	0	0	0	0
Financial clerks	6	8	8	9
Information and record clerks	9	12	13	14
Material recording, scheduling, dispatching, and distributing workers	3	4	4	5
Secretaries and administrative assistants	8	11	12	13
Other office and administrative support workers	7	8	9	10
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	1	1	1	1
Construction trades workers	6	10	12	14
Helpers, construction trades	1	1	1	1
Other construction and related workers	0	0	0	0
Extraction workers	-1	-1	-2	-2
Supervisors of installation, maintenance, and repair workers	0	1	1	1
Electrical and electronic equipment mechanics, installers, and repairers	1	1	1	1
Vehicle and mobile equipment mechanics, installers, and repairers	2	2	2	2
Other installation, maintenance, and repair occupations	3	4	5	6
Supervisors of production workers	0	0	0	0
Assemblers and fabricators	1	1	0	1
Food processing workers	1	1	1	1
Metal workers and plastic workers	1	0	0	0
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	1	0	0	0
Woodworkers	0	0	0	0
Plant and system operators	0	0	0	0
Other production occupations	2	2	1	1
Supervisors of transportation and material moving workers	0	0	1	1
Air transportation workers	-1	-2	-2	-3
Motor vehicle operators	5	7	9	11
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	1	1	1	1
Material moving workers	4	4	4	5
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	194	260	293	322

Poughkeepsie, New York

East North Central (ENC)

Electrical Power Capacity (ENC level)

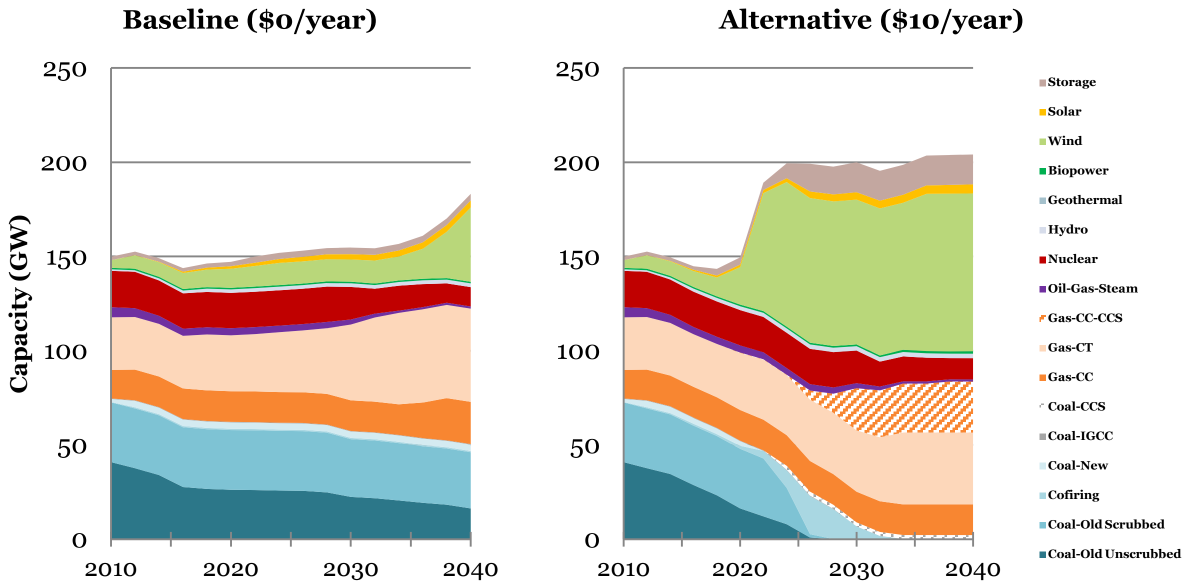


Figure 6.11 – The heavy concentration of coal plants in the area east of the Mississippi River, north of the Ohio River, and west of Pittsburgh give ENC more capacity in coal-based generation than NE has overall (and nearly more than MA overall). The carbon tax, however, incentivizes its retirement and replacement with large-scale wind farms in this region.

Electrical Power Generation (ENC level)

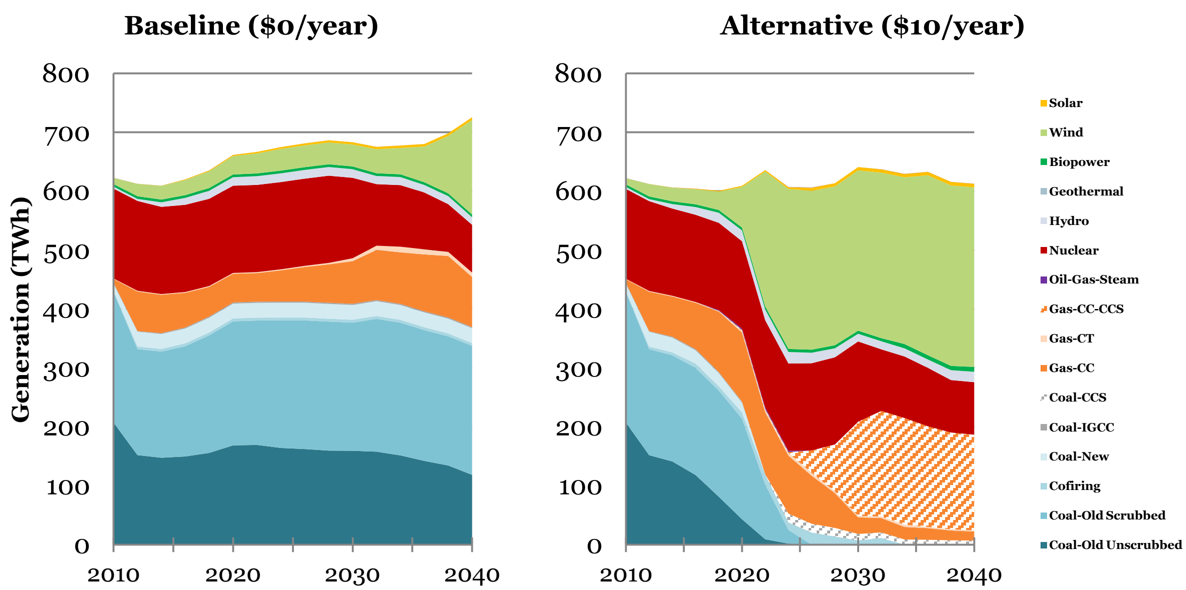


Figure 6.12 – The ENC remains a leading region for power generation in both cases—just through coal in the baseline and wind (with some gas and nuclear) and the alternative.

Figure 6.13 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$7	-$15	-$22	-$28
Agriculture and forestry support activities	$0	-$1	-$1	-$1
Oil and gas extraction	-$141	-$300	-$418	-$474
Mining (except oil and gas)	-$248	-$922	-$1,440	-$1,536
Support activities for mining	-$17	-$14	-$2	$6
Utilities	-$2,040	-$1,981	-$1,921	-$1,922
Construction	$385	$1,837	$2,618	$3,216
Wood manufacturing	$21	$45	$52	$56
Nonmetallic mineral manufacturing	$32	$61	$65	$72
Primary metal manufacturing	-$240	-$630	-$926	-$1,090
Fabricated metal manufacturing	$225	$146	$20	$114
Machinery manufacturing	-$32	$272	$287	$135
Computer and electronic manufacturing	-$69	-$220	-$289	-$284
Electrical equipment and appliance manufacturing	-$113	-$315	-$495	-$629
Motor vehicles, bodies and trailers, and parts manufacturing	$690	$1,285	$1,738	$2,195
Other transportation equipment manufacturing	$0	-$23	-$44	-$57
Furniture and related manufacturing	$69	$73	$46	$13
Miscellaneous manufacturing	-$13	-$129	-$206	-$228
Food manufacturing	$187	$241	$240	$228
Beverage and tobacco manufacturing	$43	$68	$77	$77
Textile mills; Textile mills	-$2	-$15	-$29	-$32
Apparel manufacturing; Leather and allied manufacturing	-$2	-$9	-$9	-$6
Paper manufacturing	$17	-$12	-$51	-$82
Printing and related support activities	$56	$82	$89	$95
Petroleum and coals manufacturing	-$1,112	-$2,102	-$2,694	-$3,349
Chemical manufacturing	-$200	-$805	-$1,351	-$1,800
Plastics and rubber manufacturing	-$24	-$166	-$326	-$457
Wholesale trade	$694	$1,259	$1,615	$2,064
Retail trade	$1,422	$3,127	$4,470	$5,896
Air transportation	-$434	-$1,091	-$1,845	-$2,570
Rail transportation	-$48	-$105	-$163	-$193
Water transportation	-$3	-$7	-$12	-$16
Truck transportation	$95	$134	$131	$160
Couriers and messengers	$31	$41	$37	$37
Transit and ground passenger transportation	$28	$53	$71	$86
Pipeline transportation	-$41	-$66	-$75	-$74
Scenic and sightseeing transportation; Support activities for transportation	-$95	-$232	-$390	-$560
Warehousing and storage	$31	$41	$39	$43
Publishing industries, except Internet	$143	$235	$302	$386
Motion picture and sound recording industries	$53	$90	$123	$162
Internet publishing and broadcasting; ISPs, search portals, and data processing	$56	$108	$144	$174
Broadcasting, except Internet	$29	$50	$61	$72
Telecommunications	$387	$716	$964	$1,190
Monetary authorities - central bank; Credit intermediation and related activities	$1,117	$1,819	$2,214	$2,580
Securities, commodity contracts, investments	$336	$469	$504	$540
Insurance carriers and related activities	$621	$910	$981	$997
Real estate	$1,661	$3,767	$4,907	$5,589
Rental and leasing services; Leasing of nonfinancial intangible assets	-$38	-$181	-$344	-$479
Professional, scientific, and technical services	$337	$557	$604	$701
Management of companies and enterprises	-$51	-$313	-$585	-$795
Administrative and support services	$344	$617	$777	$953
Waste management and remediation services	$37	$69	$86	$99
Educational services	$245	$490	$645	$742
Ambulatory health care services	$1,976	$3,302	$4,199	$5,176
Hospitals	$743	$1,445	$2,003	$2,473
Nursing and residential care facilities	$252	$508	$701	$858
Social assistance	$166	$304	$400	$475
Performing arts and spectator sports	$105	$198	$260	$317
Museums, historical sites, zoos, and parks	$18	$38	$53	$64
Amusement, gambling, and recreation	$121	$219	$284	$341
Accommodation	$98	$208	$294	$358
Food services and drinking places	$397	$937	$1,311	$1,572
Repair and maintenance	$187	$371	$490	$582
Personal and laundry services	$309	$530	$654	$772
Membership associations and organizations	$168	$326	$431	$501
Private households	$22	$47	$60	$76
State and local government	$758	$1,560	$1,948	$2,203
TOTAL OF ALL SECTORS =	$9,742	$19,001	$23,357	$27,784

Figure 6.14 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	0	0
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	-2	-4	-6	-7
Mining (except oil and gas)	-1	-3	-4	-4
Support activities for mining	0	0	0	0
Utilities	-3	-2	-1	-1
Construction	11	38	50	57
Wood manufacturing	0	1	1	1
Nonmetallic mineral manufacturing	0	1	1	2
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	2	2	2	3
Machinery manufacturing	0	1	1	1
Computer and electronic manufacturing	0	-1	-1	-1
Electrical equipment and appliance manufacturing	0	-1	-2	-2
Motor vehicles, bodies and trailers, and parts manufacturing	3	5	5	5
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	1	1	1	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	2	3	3	3
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	1	1	1
Printing and related support activities	1	1	1	1
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	0	0	0	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	5	10	12	15
Retail trade	26	52	66	77
Air transportation	-1	-3	-5	-6
Rail transportation	0	0	0	0
Water transportation	0	0	0	0
Truck transportation	2	5	8	12
Couriers and messengers	1	1	2	2
Transit and ground passenger transportation	1	2	3	3
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	-1	-2	-3	-4
Warehousing and storage	1	1	1	2
Publishing industries, except Internet	1	1	1	1
Motion picture and sound recording industries	0	1	1	1
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	1	0
Broadcasting, except Internet	0	0	0	1
Telecommunications	1	2	2	3
Monetary authorities - central bank; Credit intermediation and related activities	4	6	7	7
Securities, commodity contracts, investments	5	7	7	7
Insurance carriers and related activities	4	6	7	7
Real estate	8	18	23	25
Rental and leasing services; Leasing of nonfinancial intangible assets	1	2	2	2
Professional, scientific, and technical services	5	9	12	14
Management of companies and enterprises	0	-1	-1	-2
Administrative and support services	15	30	38	46
Waste management and remediation services	0	1	1	1
Educational services	8	17	22	26
Ambulatory health care services	26	45	58	72
Hospitals	12	23	31	38
Nursing and residential care facilities	7	14	20	25
Social assistance	7	13	18	21
Performing arts and spectator sports	2	4	5	6
Museums, historical sites, zoos, and parks	0	1	1	1
Amusement, gambling, and recreation	4	8	11	13
Accommodation	2	4	5	6
Food services and drinking places	17	36	48	54
Repair and maintenance	3	6	8	9
Personal and laundry services	8	13	15	17
Membership associations and organizations	6	12	16	19
Private households	3	5	6	7
State and local government	10	20	23	25
TOTAL OF ALL SECTORS =	207	412	524	612

Figure 6.15 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	3	5	7	8
Advertising, marketing, promotions, public relations, and sales managers	1	1	2	2
Operations specialties managers	2	3	3	4
Other management occupations	3	7	9	10
Business operations specialists	4	8	10	12
Financial specialists	4	7	8	9
Computer occupations	2	4	5	6
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	0	1
Drafters, engineering technicians, and mapping technicians	0	0	1	1
Life scientists	0	0	0	1
Physical scientists	0	0	0	0
Social scientists and related workers	0	1	1	1
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	2	4	6	7
Miscellaneous community and social service specialists	1	3	4	4
Religious workers	0	0	0	0
Lawyers, judges, and related workers	1	1	1	1
Legal support workers	0	1	1	1
Postsecondary teachers	3	5	7	8
Preschool, primary, secondary, and special education school teachers	4	7	9	10
Other teachers and instructors	1	2	3	4
Librarians, curators, and archivists	0	1	1	1
Other education, training, and library occupations	2	3	4	5
Art and design workers	1	1	1	2
Entertainers and performers, sports and related workers	1	2	3	3
Media and communication workers	1	2	3	3
Media and communication equipment workers	0	1	1	1
Health diagnosing and treating practitioners	13	23	30	37
Health technologists and technicians	7	13	18	22
Other healthcare practitioners and technical occupations	0	0	1	1
Nursing, psychiatric, and home health aides	6	12	16	20
Occupational therapy and physical therapist assistants and aides	1	1	1	2
Other healthcare support occupations	5	9	11	14
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	1	1	1	2
Other protective service workers	2	4	4	5
Supervisors of food preparation and serving workers	1	3	4	5
Cooks and food preparation workers	5	10	13	15
Food and beverage serving workers	11	24	31	35
Other food preparation and serving related workers	2	5	6	7
Supervisors of building and grounds cleaning and maintenance workers	1	2	2	3
Building cleaning and pest control workers	5	11	14	16
Grounds maintenance workers	6	13	18	21
Supervisors of personal care and service workers	0	1	1	1
Animal care and service workers	1	1	1	2
Entertainment attendants and related workers	1	2	3	3
Funeral service workers	0	0	0	0
Personal appearance workers	4	8	9	11
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	6	12	16	20
Supervisors of sales workers	3	5	6	7
Retail sales workers	15	30	39	45
Sales representatives, services	3	5	5	6
Sales representatives, wholesale and manufacturing	2	3	4	5
Other sales and related workers	2	4	6	6
Supervisors of office and administrative support workers	2	4	5	6
Communications equipment operators	0	0	0	0
Financial clerks	6	11	13	15
Information and record clerks	9	16	19	22
Material recording, scheduling, dispatching, and distributing workers	4	7	9	10
Secretaries and administrative assistants	8	14	18	21
Other office and administrative support workers	7	12	15	17
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	1	2	3	3
Construction trades workers	6	21	27	31
Helpers, construction trades	1	2	2	3
Other construction and related workers	0	1	1	1
Extraction workers	-1	-2	-2	-2
Supervisors of installation, maintenance, and repair workers	1	1	2	2
Electrical and electronic equipment mechanics, installers, and repairers	0	1	1	2
Vehicle and mobile equipment mechanics, installers, and repairers	2	4	6	7
Other installation, maintenance, and repair occupations	4	9	11	13
Supervisors of production workers	0	1	1	1
Assemblers and fabricators	2	3	3	4
Food processing workers	1	2	2	2
Metal workers and plastic workers	2	2	2	2
Printing workers	0	1	1	1
Textile, apparel, and furnishings workers	1	1	1	1
Woodworkers	0	1	1	1
Plant and system operators	0	0	0	0
Other production occupations	2	4	4	5
Supervisors of transportation and material moving workers	0	1	1	1
Air transportation workers	-1	-1	-2	-2
Motor vehicle operators	5	10	14	18
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	1	1	1	1
Material moving workers	5	8	10	13
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	207	408	519	615

Lafayette, Indiana

West North Central (WSC)

Electrical Power Capacity (WNC level)

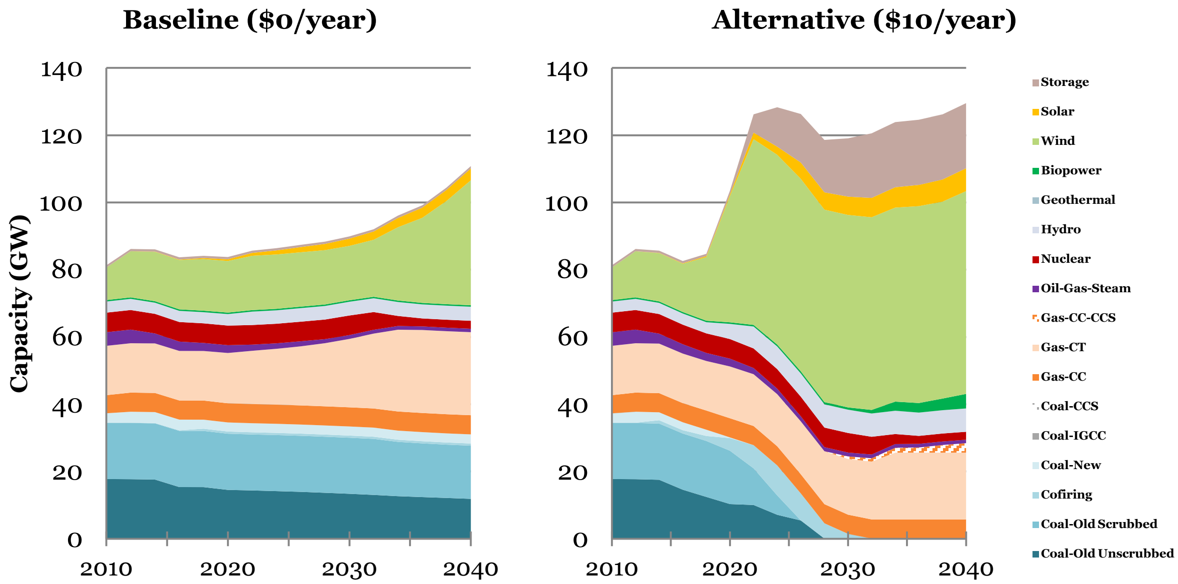


Figure 6.16 – The WNC region already has a significant portion of its power capacity in wind, although the $10 per year case triples current capacity to around 60 GW with significant storage to replace the retirement of most of the coal fleet by 2030 throughout the 2020s.

Electrical Power Generation (WNC level)

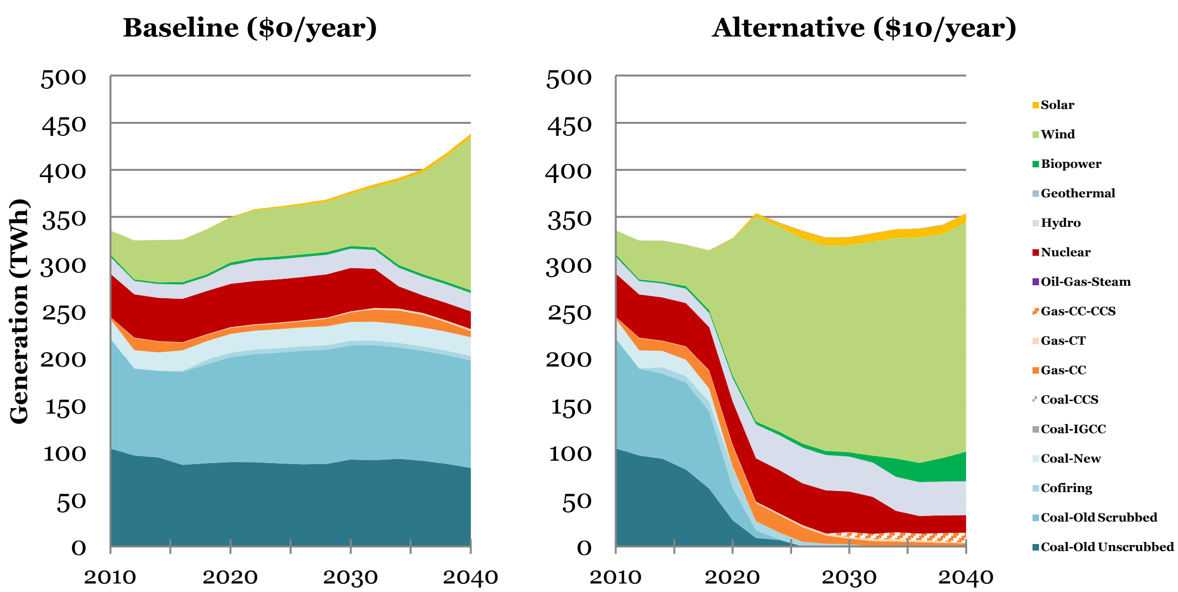


Figure 6.17 – Emissions from power generation in WNC decline to nearly zero in the alternative case with wind in its open farmlands, biomass, hydroelectricity, and small amounts of nuclear and sequestered gas serving as the base-load.

Figure 6.18 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$7	-$13	-$18	-$23
Agriculture and forestry support activities	-$1	-$2	-$3	-$3
Oil and gas extraction	-$132	-$263	-$360	-$395
Mining (except oil and gas)	-$5	-$208	-$331	-$372
Support activities for mining	-$75	-$52	-$24	-$10
Utilities	-$1,165	-$1,105	-$1,131	-$1,232
Construction	-$41	$938	$1,281	$1,510
Wood manufacturing	$8	$22	$21	$20
Nonmetallic mineral manufacturing	-$2	$13	$7	$5
Primary metal manufacturing	-$42	-$100	-$149	-$174
Fabricated metal manufacturing	$53	$20	-$33	-$16
Machinery manufacturing	-$18	$34	-$18	-$83
Computer and electronic manufacturing	-$67	-$192	-$282	-$312
Electrical equipment and appliance manufacturing	-$39	-$101	-$160	-$203
Motor vehicles, bodies and trailers, and parts manufacturing	$78	$148	$198	$253
Other transportation equipment manufacturing	-$31	-$84	-$131	-$167
Furniture and related manufacturing	$21	$21	$7	-$8
Miscellaneous manufacturing	$3	-$35	-$66	-$77
Food manufacturing	$107	$133	$112	$86
Beverage and tobacco manufacturing	$17	$29	$32	$31
Textile mills; Textile mills	-$1	-$7	-$14	-$16
Apparel manufacturing; Leather and allied manufacturing	-$2	-$7	-$8	-$7
Paper manufacturing	$3	-$4	-$16	-$26
Printing and related support activities	$24	$37	$37	$37
Petroleum and coals manufacturing	-$723	-$1,404	-$2,053	-$2,723
Chemical manufacturing	-$152	-$392	-$667	-$912
Plastics and rubber manufacturing	-$23	-$77	-$148	-$208
Wholesale trade	$219	$534	$679	$851
Retail trade	$503	$1,346	$1,956	$2,600
Air transportation	-$135	-$375	-$648	-$907
Rail transportation	-$60	-$127	-$201	-$245
Water transportation	-$1	-$2	-$4	-$5
Truck transportation	$27	$20	-$20	-$42
Couriers and messengers	$8	$5	-$6	-$17
Transit and ground passenger transportation	$7	$12	$13	$13
Pipeline transportation	-$27	-$44	-$52	-$52
Scenic and sightseeing transportation; Support activities for transportation	-$40	-$97	-$164	-$238
Warehousing and storage	$6	$7	$2	-$1
Publishing industries, except Internet	$68	$119	$141	$165
Motion picture and sound recording industries	$16	$27	$37	$48
Internet publishing and broadcasting; ISPs, search portals, and data processing	$36	$85	$111	$129
Broadcasting, except Internet	$14	$29	$35	$40
Telecommunications	$202	$419	$568	$696
Monetary authorities - central bank; Credit intermediation and related activities	$578	$996	$1,201	$1,389
Securities, commodity contracts, investments	$127	$193	$209	$222
Insurance carriers and related activities	$352	$531	$567	$571
Real estate	$547	$1,914	$2,454	$2,624
Rental and leasing services; Leasing of nonfinancial intangible assets	-$151	-$362	-$597	-$789
Professional, scientific, and technical services	$28	$208	$229	$239
Management of companies and enterprises	-$56	-$173	-$311	-$419
Administrative and support services	$95	$256	$325	$381
Waste management and remediation services	$10	$30	$38	$42
Educational services	$99	$225	$299	$342
Ambulatory health care services	$786	$1,331	$1,705	$2,139
Hospitals	$291	$676	$973	$1,207
Nursing and residential care facilities	$127	$294	$416	$510
Social assistance	$89	$169	$222	$262
Performing arts and spectator sports	$45	$97	$128	$154
Museums, historical sites, zoos, and parks	$6	$16	$23	$28
Amusement, gambling, and recreation	$56	$109	$142	$169
Accommodation	$44	$145	$209	$249
Food services and drinking places	$163	$492	$710	$848
Repair and maintenance	$77	$197	$267	$315
Personal and laundry services	$123	$220	$270	$319
Membership associations and organizations	$71	$160	$217	$252
Private households	$10	$20	$26	$33
State and local government	$225	$729	$923	$1,017
TOTAL OF ALL SECTORS =	$2,373	$7,780	$9,175	$10,114

Figure 6.19 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	0	0
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	-2	-3	-5	-6
Mining (except oil and gas)	0	-1	-2	-2
Support activities for mining	0	0	0	0
Utilities	-2	-1	-1	-1
Construction	3	21	26	30
Wood manufacturing	0	1	1	1
Nonmetallic mineral manufacturing	0	1	1	1
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	1	1	1	1
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	-1	-1	-1
Electrical equipment and appliance manufacturing	0	0	-1	-1
Motor vehicles, bodies and trailers, and parts manufacturing	1	1	1	1
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	0	0	0	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	1	2	2	3
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	0	0	0
Printing and related support activities	0	1	1	1
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	0	0	0	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	2	4	5	7
Retail trade	10	23	30	35
Air transportation	0	-1	-2	-2
Rail transportation	0	0	0	0
Water transportation	0	0	0	0
Truck transportation	1	3	6	8
Couriers and messengers	0	1	1	1
Transit and ground passenger transportation	0	1	1	1
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	0	-1	-1	-2
Warehousing and storage	0	0	0	0
Publishing industries, except Internet	0	1	1	1
Motion picture and sound recording industries	0	0	0	0
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	0	0	0
Telecommunications	1	1	1	1
Monetary authorities - central bank; Credit intermediation and related activities	2	3	4	4
Securities, commodity contracts, investments	2	3	3	4
Insurance carriers and related activities	3	4	4	4
Real estate	3	9	11	12
Rental and leasing services; Leasing of nonfinancial intangible assets	0	1	1	1
Professional, scientific, and technical services	1	4	5	6
Management of companies and enterprises	0	-1	-1	-1
Administrative and support services	5	12	15	18
Waste management and remediation services	0	0	1	1
Educational services	4	8	10	12
Ambulatory health care services	10	18	23	29
Hospitals	5	10	14	18
Nursing and residential care facilities	4	8	12	15
Social assistance	4	8	10	12
Performing arts and spectator sports	1	2	3	3
Museums, historical sites, zoos, and parks	0	0	0	0
Amusement, gambling, and recreation	2	4	5	6
Accommodation	1	3	4	4
Food services and drinking places	7	18	24	27
Repair and maintenance	1	3	4	5
Personal and laundry services	3	5	6	7
Membership associations and organizations	3	6	9	10
Private households	1	2	3	3
State and local government	3	10	13	13
TOTAL OF ALL SECTORS =	81	194	248	290

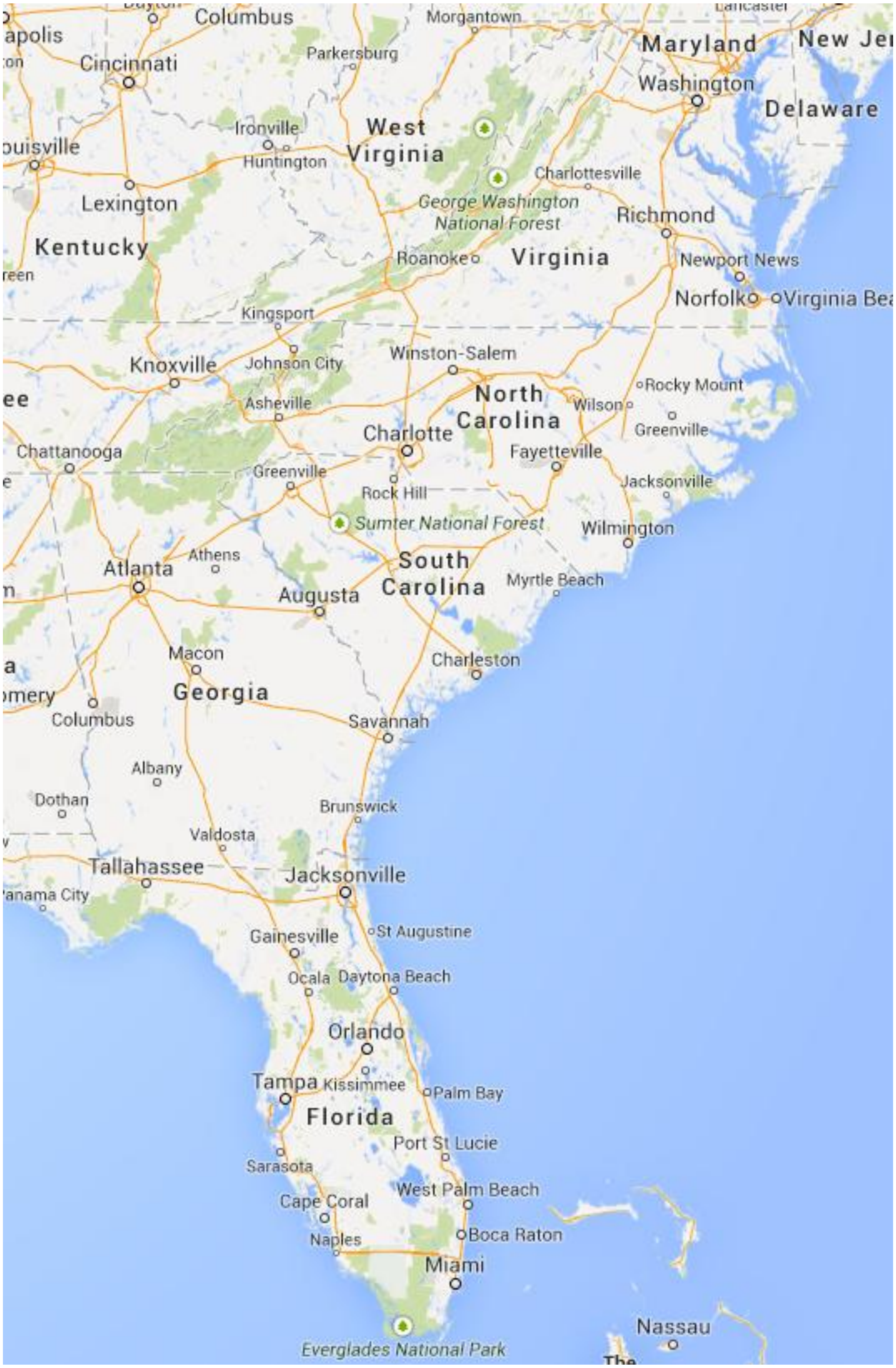
Figure 6.20 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	1	3	3	4
Advertising, marketing, promotions, public relations, and sales managers	0	1	1	1
Operations specialties managers	1	1	2	2
Other management occupations	1	3	4	5
Business operations specialists	2	4	5	6
Financial specialists	2	3	4	4
Computer occupations	1	2	2	2
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	0	0
Drafters, engineering technicians, and mapping technicians	0	0	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	0	0	0
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	1	2	3	4
Miscellaneous community and social service specialists	1	2	2	2
Religious workers	0	0	0	0
Lawyers, judges, and related workers	0	0	1	1
Legal support workers	0	0	0	0
Postsecondary teachers	1	3	3	4
Preschool, primary, secondary, and special education school teachers	1	4	5	5
Other teachers and instructors	1	1	2	2
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	1	2	2	2
Art and design workers	0	1	1	1
Entertainers and performers, sports and related workers	1	1	1	2
Media and communication workers	1	1	1	2
Media and communication equipment workers	0	0	0	0
Health diagnosing and treating practitioners	5	10	13	17
Health technologists and technicians	3	6	8	10
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	3	6	9	11
Occupational therapy and physical therapist assistants and aides	0	0	1	1
Other healthcare support occupations	2	4	5	6
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	0	1	1	1
Other protective service workers	1	2	2	3
Supervisors of food preparation and serving workers	1	2	2	2
Cooks and food preparation workers	2	5	7	8
Food and beverage serving workers	5	12	16	18
Other food preparation and serving related workers	1	2	3	3
Supervisors of building and grounds cleaning and maintenance workers	0	1	1	1
Building cleaning and pest control workers	2	5	7	8
Grounds maintenance workers	2	6	8	9
Supervisors of personal care and service workers	0	0	0	1
Animal care and service workers	0	1	1	1
Entertainment attendants and related workers	1	1	1	2
Funeral service workers	0	0	0	0
Personal appearance workers	2	3	3	4
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	3	6	8	10
Supervisors of sales workers	1	2	3	3
Retail sales workers	6	14	18	21
Sales representatives, services	1	2	3	3
Sales representatives, wholesale and manufacturing	1	1	2	2
Other sales and related workers	1	2	3	3
Supervisors of office and administrative support workers	1	2	3	3
Communications equipment operators	0	0	0	0
Financial clerks	2	5	6	7
Information and record clerks	4	7	9	10
Material recording, scheduling, dispatching, and distributing workers	1	3	4	5
Secretaries and administrative assistants	3	6	8	9
Other office and administrative support workers	3	6	7	8
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	0	1	2	2
Construction trades workers	2	11	14	16
Helpers, construction trades	0	1	1	1
Other construction and related workers	0	0	1	1
Extraction workers	-1	-1	-1	-1
Supervisors of installation, maintenance, and repair workers	0	1	1	1
Electrical and electronic equipment mechanics, installers, and repairers	0	1	1	1
Vehicle and mobile equipment mechanics, installers, and repairers	1	2	3	4
Other installation, maintenance, and repair occupations	1	4	6	6
Supervisors of production workers	0	0	0	0
Assemblers and fabricators	0	1	1	1
Food processing workers	1	1	1	1
Metal workers and plastic workers	0	1	1	1
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	0	0	0	1
Woodworkers	0	0	0	0
Plant and system operators	0	0	0	0
Other production occupations	1	2	2	2
Supervisors of transportation and material moving workers	0	0	1	1
Air transportation workers	0	0	-1	-1
Motor vehicle operators	2	5	8	10
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	0	0	1	1
Material moving workers	2	4	5	6
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	82	191	251	293

Ames, Iowa

South Atlantic (SA)



Electrical Power Capacity (SA level)

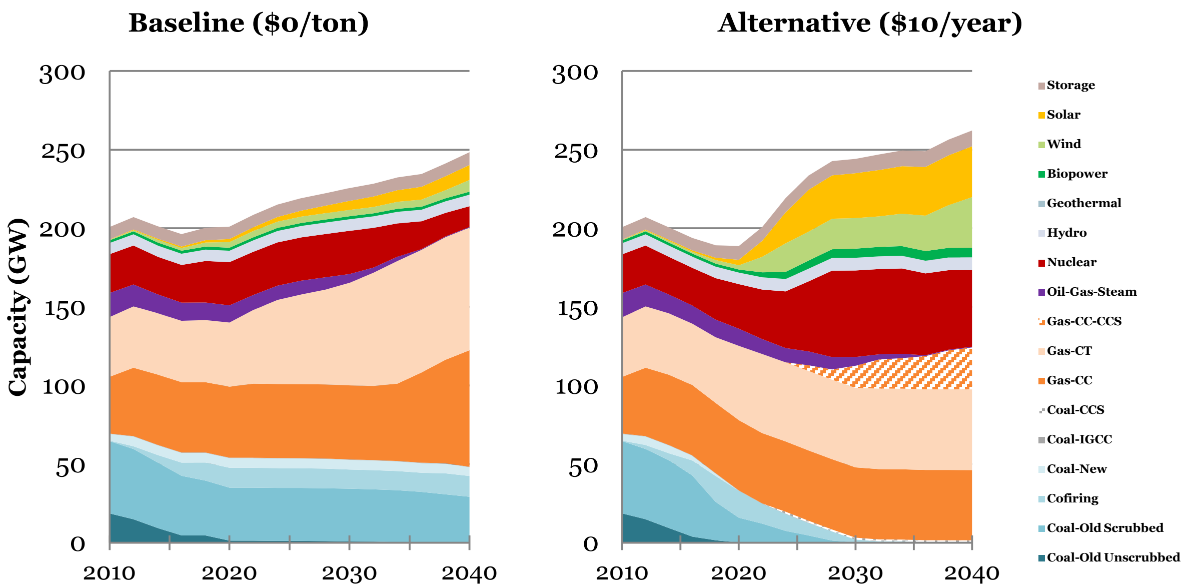


Figure 6.21 – SA lacks the geography, topography, and meteorology of the ENC and WNC to encourage much wind development, and therefore the region concentrates on replacing its reduction in coal output with renewals and expansions in its nuclear fleet.

Electrical Power Generation (SA level)

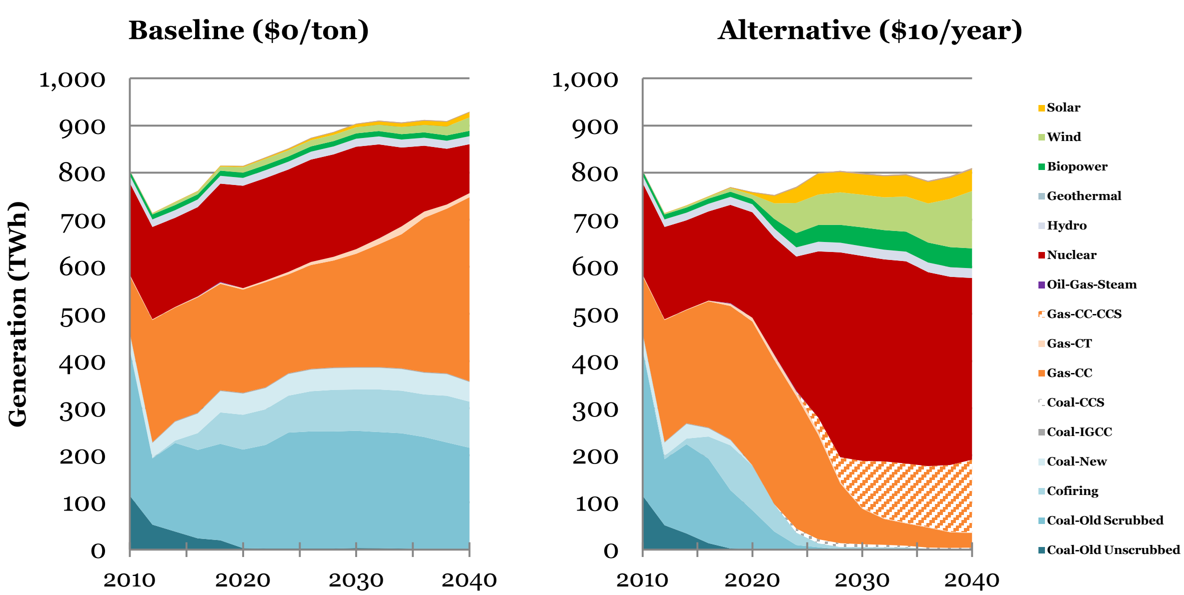


Figure 6.22 – Nuclear overwhelms the alternative case and replaces the coal and gas in the baseline. Additionally, SA has a greater quantity of solar generation than is typical in the other regions owing to the bright sunlight in Florida and some of the other states.

Figure 6.23 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$38	-$102	-$139	-$160
Agriculture and forestry support activities	-$4	-$12	-$15	-$17
Oil and gas extraction	-$132	-$295	-$432	-$484
Mining (except oil and gas)	-$1,157	-$3,308	-$5,290	-$5,555
Support activities for mining	-$23	-$28	-$8	$13
Utilities	-$1,903	-$2,251	-$1,695	-$1,591
Construction	$631	$1,443	$2,589	$3,287
Wood manufacturing	$27	$32	$33	$32
Nonmetallic mineral manufacturing	$34	$42	$51	$62
Primary metal manufacturing	-$59	-$182	-$261	-$288
Fabricated metal manufacturing	$94	$66	$167	$447
Machinery manufacturing	-$3	$64	$107	$60
Computer and electronic manufacturing	-$104	-$382	-$531	-$582
Electrical equipment and appliance manufacturing	-$66	-$214	-$337	-$424
Motor vehicles, bodies and trailers, and parts manufacturing	$116	$205	$279	$352
Other transportation equipment manufacturing	-$5	-$60	-$110	-$146
Furniture and related manufacturing	$63	$57	$31	$0
Miscellaneous manufacturing	$5	-$61	-$103	-$115
Food manufacturing	$129	$136	$120	$111
Beverage and tobacco manufacturing	$203	$222	$194	$157
Textile mills; Textile mills	-$13	-$110	-$206	-$237
Apparel manufacturing; Leather and allied manufacturing	-$6	-$26	-$33	-$33
Paper manufacturing	$12	-$37	-$81	-$111
Printing and related support activities	$32	$38	$41	$45
Petroleum and coals manufacturing	-$415	-$955	-$1,305	-$1,639
Chemical manufacturing	-$155	-$837	-$1,411	-$1,876
Plastics and rubber manufacturing	-$6	-$121	-$233	-$322
Wholesale trade	$751	$964	$1,270	$1,675
Retail trade	$1,663	$2,967	$4,330	$5,661
Air transportation	-$590	-$1,777	-$3,188	-$4,577
Rail transportation	-$49	-$113	-$175	-$205
Water transportation	-$12	-$33	-$58	-$79
Truck transportation	$67	$60	$39	$45
Couriers and messengers	$39	$29	$1	-$22
Transit and ground passenger transportation	$22	$29	$33	$38
Pipeline transportation	-$29	-$47	-$54	-$54
Scenic and sightseeing transportation; Support activities for transportation	-$160	-$427	-$728	-$1,043
Warehousing and storage	$27	$19	$4	-$1
Publishing industries, except Internet	$169	$229	$306	$412
Motion picture and sound recording industries	$76	$127	$176	$232
Internet publishing and broadcasting; ISPs, search portals, and data processing	$85	$98	$127	$167
Broadcasting, except Internet	$69	$89	$108	$135
Telecommunications	$729	$1,094	$1,428	$1,778
Monetary authorities - central bank; Credit intermediation and related activities	$1,772	$2,593	$3,146	$3,656
Securities, commodity contracts, investments	$441	$568	$616	$674
Insurance carriers and related activities	$604	$815	$861	$872
Real estate	$2,641	$4,004	$6,141	$8,049
Rental and leasing services; Leasing of nonfinancial intangible assets	-$117	-$583	-$1,025	-$1,350
Professional, scientific, and technical services	$633	$290	$189	$368
Management of companies and enterprises	-$37	-$423	-$807	-$1,083
Administrative and support services	$569	$732	$956	$1,218
Waste management and remediation services	$49	$58	$76	$97
Educational services	$246	$366	$474	$557
Ambulatory health care services	$2,962	$4,778	$6,057	$7,065
Hospitals	$615	$894	$1,162	$1,413
Nursing and residential care facilities	$212	$306	$398	$480
Social assistance	$160	$244	$306	$361
Performing arts and spectator sports	$127	$186	$235	$287
Museums, historical sites, zoos, and parks	$15	$23	$31	$39
Amusement, gambling, and recreation	$223	$363	$470	$560
Accommodation	$281	$422	$638	$853
Food services and drinking places	$406	$547	$797	$1,018
Repair and maintenance	$221	$296	$384	$464
Personal and laundry services	$509	$831	$1,075	$1,236
Membership associations and organizations	$207	$288	$360	$424
Private households	$106	$193	$264	$308
State and local government	$740	$699	$831	$1,021
TOTAL OF ALL SECTORS =	$13,699	$15,122	$18,676	$23,735

Figure 6.24 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	-1	-1	-1
Agriculture and forestry support activities	0	0	-1	-1
Oil and gas extraction	-1	-3	-5	-6
Mining (except oil and gas)	-3	-8	-12	-11
Support activities for mining	0	0	0	0
Utilities	-3	-3	-1	-1
Construction	18	41	61	69
Wood manufacturing	1	1	1	1
Nonmetallic mineral manufacturing	1	1	1	2
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	1	1	2	4
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	-1	-1	-1
Electrical equipment and appliance manufacturing	0	-1	-1	-1
Motor vehicles, bodies and trailers, and parts manufacturing	1	1	1	1
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	1	1	1	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	1	2	2	2
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	-1	-2	-2
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	0	0	0
Printing and related support activities	0	1	1	1
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	0	0	-1	-1
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	6	8	9	10
Retail trade	29	49	62	71
Air transportation	-2	-5	-9	-11
Rail transportation	0	0	0	0
Water transportation	0	0	0	1
Truck transportation	2	4	7	10
Couriers and messengers	1	2	2	3
Transit and ground passenger transportation	1	1	2	2
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	-2	-4	-6	-7
Warehousing and storage	1	1	1	1
Publishing industries, except Internet	1	1	1	1
Motion picture and sound recording industries	1	1	1	1
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	1	1	1
Telecommunications	2	3	3	4
Monetary authorities - central bank; Credit intermediation and related activities	6	9	9	10
Securities, commodity contracts, investments	7	9	9	9
Insurance carriers and related activities	5	6	7	6
Real estate	12	18	25	28
Rental and leasing services; Leasing of nonfinancial intangible assets	1	1	1	1
Professional, scientific, and technical services	8	8	9	11
Management of companies and enterprises	0	-2	-3	-3
Administrative and support services	23	37	48	55
Waste management and remediation services	1	1	1	1
Educational services	8	13	17	19
Ambulatory health care services	38	61	78	91
Hospitals	9	14	18	22
Nursing and residential care facilities	6	9	12	14
Social assistance	6	10	13	15
Performing arts and spectator sports	3	4	5	5
Museums, historical sites, zoos, and parks	0	0	1	1
Amusement, gambling, and recreation	7	12	15	17
Accommodation	4	7	9	11
Food services and drinking places	16	25	32	36
Repair and maintenance	3	5	6	7
Personal and laundry services	11	18	22	23
Membership associations and organizations	7	10	12	14
Private households	13	21	27	29
State and local government	10	9	10	12
TOTAL OF ALL SECTORS =	261	398	502	576

Figure 6.25 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	4	5	6	7
Advertising, marketing, promotions, public relations, and sales managers	1	1	2	2
Operations specialties managers	2	2	3	3
Other management occupations	4	6	8	9
Business operations specialists	5	8	9	10
Financial specialists	6	7	8	9
Computer occupations	3	3	3	4
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	0	0
Drafters, engineering technicians, and mapping technicians	0	0	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	1	1	1
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	2	3	4	5
Miscellaneous community and social service specialists	1	2	3	3
Religious workers	0	0	0	0
Lawyers, judges, and related workers	1	1	1	1
Legal support workers	1	1	1	1
Postsecondary teachers	3	4	5	6
Preschool, primary, secondary, and special education school teachers	4	5	6	7
Other teachers and instructors	1	2	2	2
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	2	2	3	3
Art and design workers	1	1	1	1
Entertainers and performers, sports and related workers	1	2	3	3
Media and communication workers	1	2	2	3
Media and communication equipment workers	0	1	1	1
Health diagnosing and treating practitioners	15	23	30	35
Health technologists and technicians	8	14	17	20
Other healthcare practitioners and technical occupations	0	0	0	1
Nursing, psychiatric, and home health aides	5	8	11	13
Occupational therapy and physical therapist assistants and aides	1	1	2	2
Other healthcare support occupations	7	12	15	17
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	1	1	1	1
Other protective service workers	3	4	5	6
Supervisors of food preparation and serving workers	2	2	3	3
Cooks and food preparation workers	5	8	10	11
Food and beverage serving workers	11	18	23	26
Other food preparation and serving related workers	2	3	4	5
Supervisors of building and grounds cleaning and maintenance workers	1	2	3	4
Building cleaning and pest control workers	12	19	24	27
Grounds maintenance workers	10	19	25	29
Supervisors of personal care and service workers	1	1	1	1
Animal care and service workers	1	2	2	2
Entertainment attendants and related workers	2	3	4	4
Funeral service workers	0	0	0	0
Personal appearance workers	6	10	12	13
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	11	18	23	26
Supervisors of sales workers	3	5	6	7
Retail sales workers	18	29	37	42
Sales representatives, services	4	5	6	6
Sales representatives, wholesale and manufacturing	2	3	3	4
Other sales and related workers	3	4	6	6
Supervisors of office and administrative support workers	3	5	6	6
Communications equipment operators	0	0	0	0
Financial clerks	8	11	14	16
Information and record clerks	12	17	21	23
Material recording, scheduling, dispatching, and distributing workers	4	6	7	8
Secretaries and administrative assistants	10	15	19	21
Other office and administrative support workers	8	12	15	17
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	1	2	3	4
Construction trades workers	10	21	32	36
Helpers, construction trades	1	2	3	3
Other construction and related workers	0	1	1	1
Extraction workers	-1	-3	-4	-4
Supervisors of installation, maintenance, and repair workers	1	1	1	2
Electrical and electronic equipment mechanics, installers, and repairers	1	1	2	2
Vehicle and mobile equipment mechanics, installers, and repairers	2	3	4	4
Other installation, maintenance, and repair occupations	5	8	11	13
Supervisors of production workers	0	0	0	0
Assemblers and fabricators	1	1	1	2
Food processing workers	1	1	2	2
Metal workers and plastic workers	1	1	1	2
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	1	1	1	0
Woodworkers	0	1	1	1
Plant and system operators	0	0	0	0
Other production occupations	2	2	2	3
Supervisors of transportation and material moving workers	0	1	1	1
Air transportation workers	-1	-2	-3	-4
Motor vehicle operators	5	8	11	15
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	1	1	1	1
Material moving workers	5	6	7	9
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	258	396	505	576

Orlando, Florida

East South Central (ESC)

Electrical Power Capacity (ESC level)

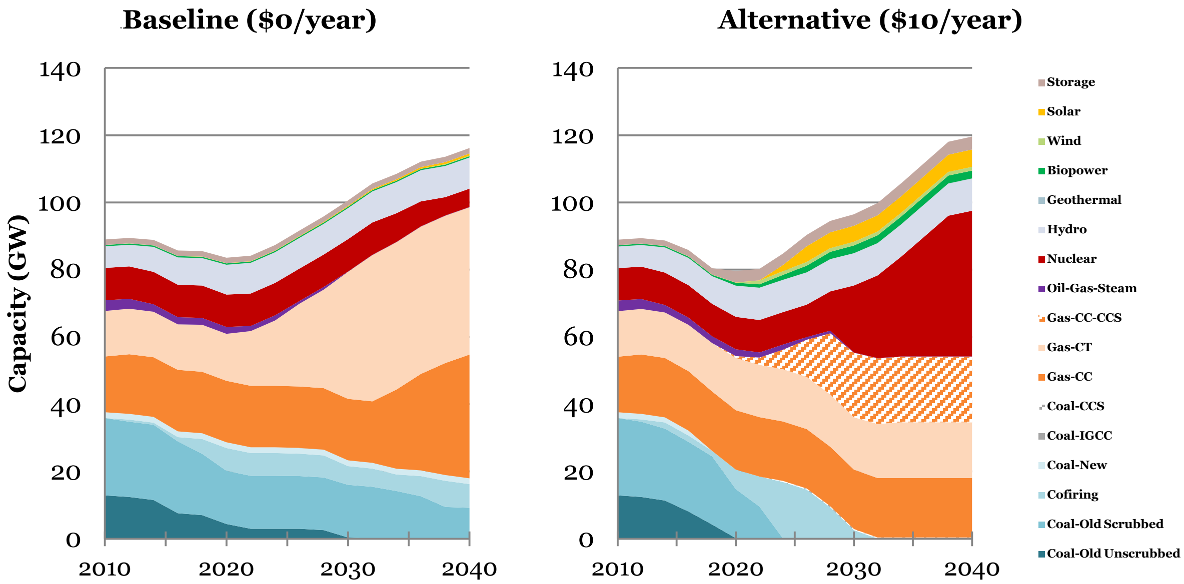


Figure 6.26 – ESC, like SA, lacks the conditions to add mass quantities of wind power in the $10 per year case (like the regions in the Midwest). It makes up the difference mostly with nuclear power and some natural gas with carbon sequestration technology included.

Electrical Power Generation (ESC level)

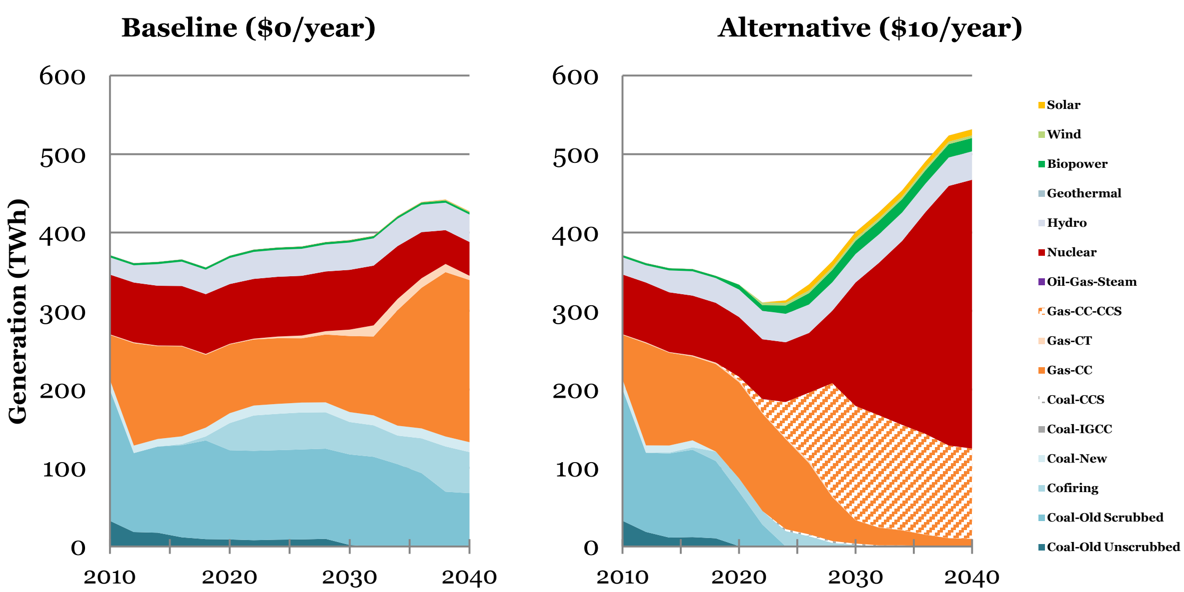


Figure 6.27 – ESC retires nearly all its coal plants in the alternative case by 2030 and receives the majority of its power from nuclear generation. Wind plays almost no role in this region, although there is still some renewable production from hydroelectricity, solar, and biomass.

Figure 6.28 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$21	-$51	-$69	-$77
Agriculture and forestry support activities	-$1	-$4	-$5	-$5
Oil and gas extraction	-$92	-$195	-$269	-$302
Mining (except oil and gas)	-$943	-$2,608	-$3,973	-$4,151
Support activities for mining	-$28	-$38	-$26	-$8
Utilities	-$713	-$872	-$842	-$845
Construction	-$37	$186	$388	$664
Wood manufacturing	$7	$7	$2	$3
Nonmetallic mineral manufacturing	$4	$2	-$2	$3
Primary metal manufacturing	-$95	-$256	-$366	-$403
Fabricated metal manufacturing	$36	$2	-$31	$155
Machinery manufacturing	-$9	$7	-$4	-$27
Computer and electronic manufacturing	-$20	-$71	-$87	-$77
Electrical equipment and appliance manufacturing	-$52	-$148	-$234	-$294
Motor vehicles, bodies and trailers, and parts manufacturing	$206	$382	$520	$673
Other transportation equipment manufacturing	$7	-$4	-$16	-$22
Furniture and related manufacturing	$30	$26	$9	-$8
Miscellaneous manufacturing	-$3	-$32	-$53	-$60
Food manufacturing	$53	$57	$50	$47
Beverage and tobacco manufacturing	$45	$56	$52	$46
Textile mills; Textile mills	-$3	-$20	-$37	-$42
Apparel manufacturing; Leather and allied manufacturing	-$3	-$13	-$17	-$17
Paper manufacturing	-$4	-$42	-$76	-$96
Printing and related support activities	$10	$12	$12	$13
Petroleum and coals manufacturing	-$686	-$1,438	-$1,922	-$2,284
Chemical manufacturing	-$315	-$800	-$1,180	-$1,455
Plastics and rubber manufacturing	-$18	-$83	-$146	-$190
Wholesale trade	$109	$97	$79	$162
Retail trade	$442	$866	$1,260	$1,755
Air transportation	-$168	-$401	-$618	-$797
Rail transportation	-$23	-$51	-$79	-$94
Water transportation	-$5	-$13	-$23	-$31
Truck transportation	$23	$6	-$23	-$32
Couriers and messengers	$19	$8	-$19	-$44
Transit and ground passenger transportation	$3	$4	$4	$4
Pipeline transportation	-$28	-$47	-$54	-$54
Scenic and sightseeing transportation; Support activities for transportation	-$40	-$103	-$173	-$246
Warehousing and storage	$8	$4	-$3	-$5
Publishing industries, except Internet	$26	$35	$40	$49
Motion picture and sound recording industries	$29	$49	$68	$89
Internet publishing and broadcasting; ISPs, search portals, and data processing	$8	$10	$12	$17
Broadcasting, except Internet	$11	$14	$16	$21
Telecommunications	$123	$198	$256	$322
Monetary authorities - central bank; Credit intermediation and related activities	$389	$573	$673	$790
Securities, commodity contracts, investments	$66	$82	$83	$94
Insurance carriers and related activities	$172	$238	$251	$254
Real estate	$280	$563	$796	$1,123
Rental and leasing services; Leasing of nonfinancial intangible assets	-$18	-$92	-$172	-$218
Professional, scientific, and technical services	$3	-$111	-$209	-$199
Management of companies and enterprises	-$26	-$117	-$209	-$275
Administrative and support services	$96	$122	$138	$198
Waste management and remediation services	$8	$7	$5	$9
Educational services	$50	$87	$110	$128
Ambulatory health care services	$868	$1,386	$1,749	$2,118
Hospitals	$175	$286	$374	$462
Nursing and residential care facilities	$60	$100	$129	$157
Social assistance	$42	$69	$87	$103
Performing arts and spectator sports	$28	$44	$55	$68
Museums, historical sites, zoos, and parks	$3	$6	$8	$10
Amusement, gambling, and recreation	$31	$52	$67	$82
Accommodation	$50	$82	$120	$173
Food services and drinking places	$89	$166	$235	$302
Repair and maintenance	$49	$69	$84	$109
Personal and laundry services	$113	$182	$232	$278
Membership associations and organizations	$50	$82	$103	$122
Private households	$25	$46	$62	$75
State and local government	$54	-$4	-$45	$33
TOTAL OF ALL SECTORS =	$549	-$1,344	-$2,853	-$1,647

Figure 6.29 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	0	0
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	-1	-2	-3	-3
Mining (except oil and gas)	-3	-7	-9	-8
Support activities for mining	0	0	0	0
Utilities	-1	-1	-1	-1
Construction	3	11	17	21
Wood manufacturing	0	1	1	1
Nonmetallic mineral manufacturing	0	0	1	1
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	0	0	0	2
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	0	0	0
Electrical equipment and appliance manufacturing	0	-1	-1	-1
Motor vehicles, bodies and trailers, and parts manufacturing	1	2	2	2
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	0	0	0	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	1	1	1	1
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	0	0	0
Printing and related support activities	0	0	0	0
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	0	-1	-1	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	1	2	2	2
Retail trade	8	15	19	23
Air transportation	-1	-1	-2	-2
Rail transportation	0	0	0	0
Water transportation	0	0	0	0
Truck transportation	1	2	3	5
Couriers and messengers	0	1	1	2
Transit and ground passenger transportation	0	0	0	0
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	0	-1	-1	-2
Warehousing and storage	0	0	0	0
Publishing industries, except Internet	0	0	0	0
Motion picture and sound recording industries	0	0	0	0
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	0	0	0
Telecommunications	0	1	1	1
Monetary authorities - central bank; Credit intermediation and related activities	2	2	2	2
Securities, commodity contracts, investments	1	1	1	1
Insurance carriers and related activities	1	2	2	2
Real estate	2	4	5	6
Rental and leasing services; Leasing of nonfinancial intangible assets	0	0	0	1
Professional, scientific, and technical services	1	0	0	1
Management of companies and enterprises	0	0	-1	-1
Administrative and support services	5	9	11	13
Waste management and remediation services	0	0	0	0
Educational services	2	3	4	5
Ambulatory health care services	11	18	23	28
Hospitals	3	5	6	7
Nursing and residential care facilities	2	3	4	5
Social assistance	2	3	4	5
Performing arts and spectator sports	1	1	1	1
Museums, historical sites, zoos, and parks	0	0	0	0
Amusement, gambling, and recreation	1	2	3	3
Accommodation	1	2	2	3
Food services and drinking places	4	8	11	12
Repair and maintenance	1	1	2	2
Personal and laundry services	3	4	5	6
Membership associations and organizations	2	4	4	5
Private households	3	5	6	7
State and local government	1	0	-1	0
TOTAL OF ALL SECTORS =	58	99	124	158

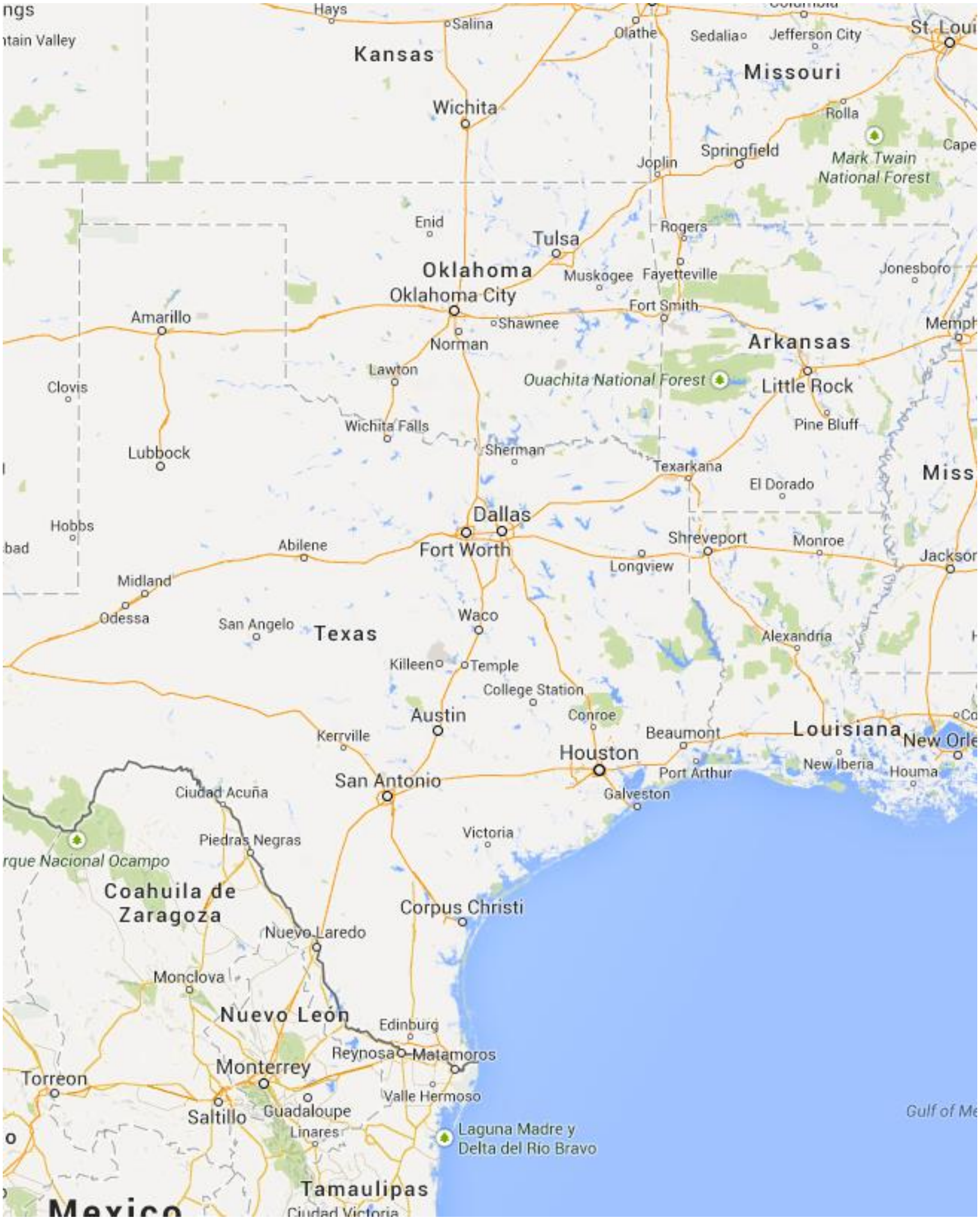
Figure 6.30 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	1	1	2	2
Advertising, marketing, promotions, public relations, and sales managers	0	0	0	0
Operations specialties managers	0	1	1	1
Other management occupations	1	2	2	3
Business operations specialists	1	2	2	3
Financial specialists	1	1	2	2
Computer occupations	0	0	0	1
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	-1	-1
Drafters, engineering technicians, and mapping technicians	0	0	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	0	0	0
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	1	1	1	2
Miscellaneous community and social service specialists	0	1	1	1
Religious workers	0	0	0	0
Lawyers, judges, and related workers	0	0	0	0
Legal support workers	0	0	0	0
Postsecondary teachers	1	1	1	1
Preschool, primary, secondary, and special education school teachers	1	1	1	1
Other teachers and instructors	0	0	1	1
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	0	1	1	1
Art and design workers	0	0	0	0
Entertainers and performers, sports and related workers	0	1	1	1
Media and communication workers	0	1	1	1
Media and communication equipment workers	0	0	0	0
Health diagnosing and treating practitioners	4	7	9	11
Health technologists and technicians	2	4	5	6
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	1	2	3	4
Occupational therapy and physical therapist assistants and aides	0	0	1	1
Other healthcare support occupations	2	3	4	5
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	0	0	0	0
Other protective service workers	1	1	1	1
Supervisors of food preparation and serving workers	0	1	1	1
Cooks and food preparation workers	1	2	3	3
Food and beverage serving workers	3	5	7	8
Other food preparation and serving related workers	1	1	1	2
Supervisors of building and grounds cleaning and maintenance workers	0	1	1	1
Building cleaning and pest control workers	3	5	6	7
Grounds maintenance workers	2	5	6	7
Supervisors of personal care and service workers	0	0	0	0
Animal care and service workers	0	0	0	1
Entertainment attendants and related workers	0	1	1	1
Funeral service workers	0	0	0	0
Personal appearance workers	1	2	3	3
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	3	5	6	7
Supervisors of sales workers	1	1	2	2
Retail sales workers	5	9	11	13
Sales representatives, services	1	1	1	2
Sales representatives, wholesale and manufacturing	0	1	1	1
Other sales and related workers	1	1	1	2
Supervisors of office and administrative support workers	1	1	2	2
Communications equipment operators	0	0	0	0
Financial clerks	2	3	4	4
Information and record clerks	3	4	5	6
Material recording, scheduling, dispatching, and distributing workers	1	2	2	3
Secretaries and administrative assistants	2	4	5	6
Other office and administrative support workers	2	3	4	4
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	0	0	1	1
Construction trades workers	1	5	8	10
Helpers, construction trades	0	1	1	1
Other construction and related workers	0	0	0	0
Extraction workers	-1	-3	-3	-3
Supervisors of installation, maintenance, and repair workers	0	0	0	0
Electrical and electronic equipment mechanics, installers, and repairers	0	0	0	0
Vehicle and mobile equipment mechanics, installers, and repairers	0	1	1	1
Other installation, maintenance, and repair occupations	1	1	2	3
Supervisors of production workers	0	0	0	0
Assemblers and fabricators	1	1	1	1
Food processing workers	0	1	1	1
Metal workers and plastic workers	0	0	0	1
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	0	0	0	0
Woodworkers	0	0	0	0
Plant and system operators	0	0	0	0
Other production occupations	1	1	1	1
Supervisors of transportation and material moving workers	0	0	0	0
Air transportation workers	0	-1	-1	-1
Motor vehicle operators	1	3	4	6
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	0	0	0	0
Material moving workers	1	1	1	2
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	55	100	129	158

Clarksville, Tennessee

West South Central (WSC)



Electrical Power Capacity (WSC level)

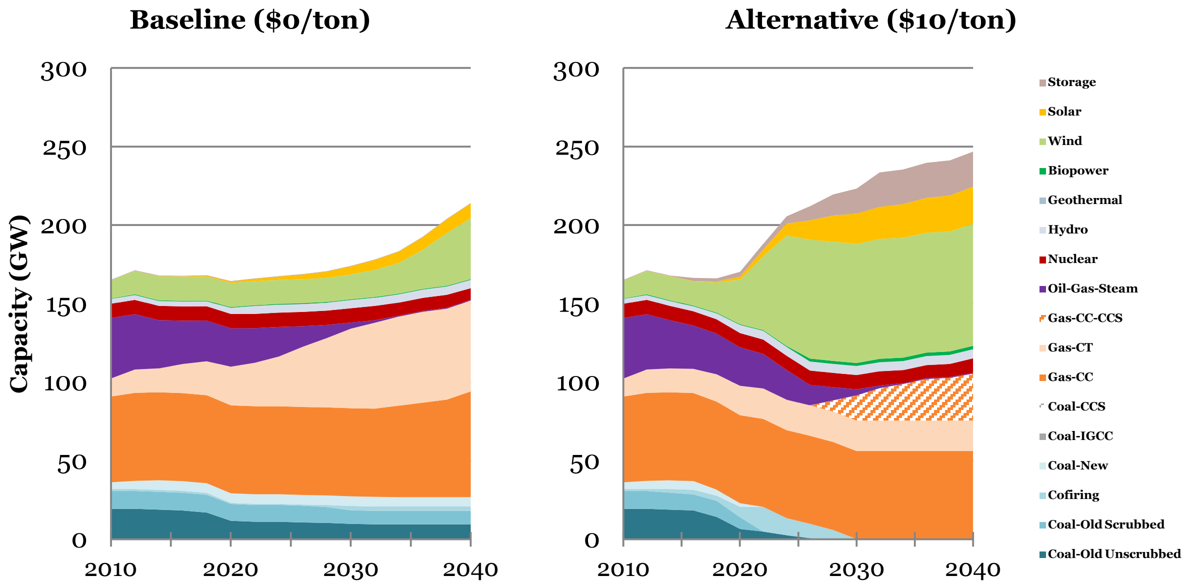


Figure 6.31 – WSC relies on natural gas more in the baseline than other regions, and it still remains an important part of the base-load in the alternative forecast. The flat terrain of western Texas and western Oklahoma has strong potential for the wind capacity above.

Electrical Power Generation (WSC level)

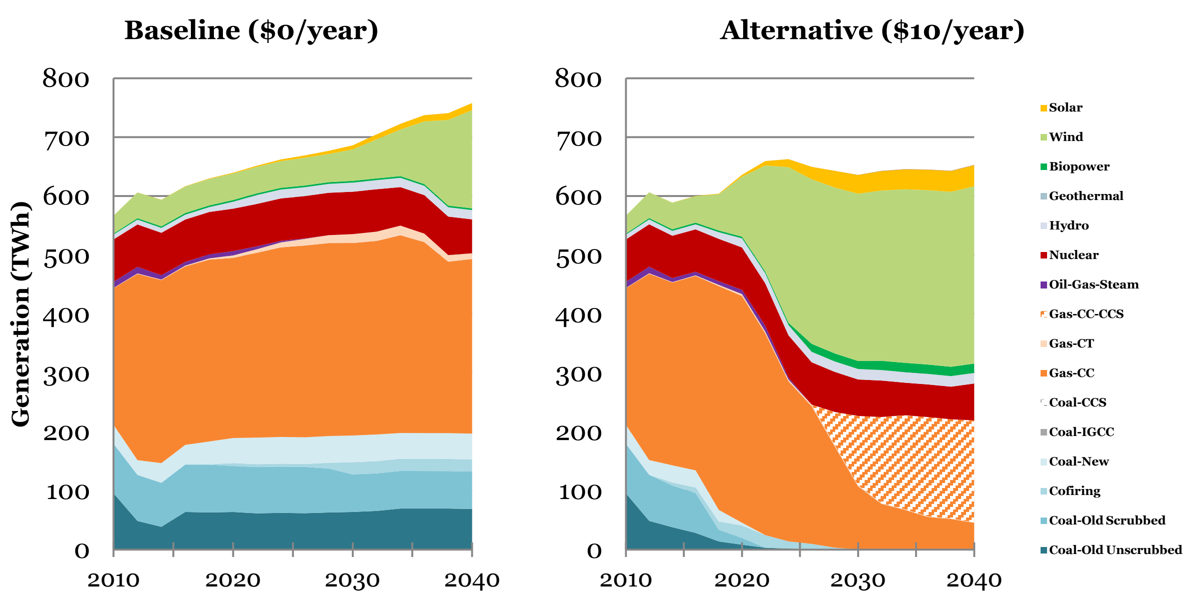


Figure 3.32 – Natural gas replaces coal as the base-load source in the alternative, and wind and solar take the place as the variable generation resource. WSC behaves much like the national level results although with a larger proportion for natural gas than other regions.

Figure 6.33 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$23	-$63	-$94	-$111
Agriculture and forestry support activities	-$2	-$6	-$9	-$10
Oil and gas extraction	-$4,710	-$10,677	-$14,796	-$15,780
Mining (except oil and gas)	$4	-$213	-$358	-$406
Support activities for mining	-$770	-$1,226	-$1,315	-$1,170
Utilities	-$1,544	-$2,173	-$2,285	-$2,241
Construction	-$1,042	-$2,525	-$3,525	-$3,275
Wood manufacturing	-$4	-$25	-$49	-$57
Nonmetallic mineral manufacturing	-$25	-$76	-$126	-$134
Primary metal manufacturing	-$77	-$240	-$385	-$459
Fabricated metal manufacturing	$4	-$232	-$437	-$412
Machinery manufacturing	-$50	-$46	-$166	-$298
Computer and electronic manufacturing	-$160	-$551	-$905	-$1,117
Electrical equipment and appliance manufacturing	-$43	-$126	-$201	-$247
Motor vehicles, bodies and trailers, and parts manufacturing	$50	$73	$69	$76
Other transportation equipment manufacturing	-$30	-$107	-$183	-$239
Furniture and related manufacturing	$17	$6	-$15	-$32
Miscellaneous manufacturing	-$23	-$86	-$139	-$168
Food manufacturing	$83	$78	$45	$23
Beverage and tobacco manufacturing	$27	$21	$7	-$1
Textile mills; Textile mills	-$1	-$10	-$19	-$22
Apparel manufacturing; Leather and allied manufacturing	-$4	-$15	-$22	-$23
Paper manufacturing	-$7	-$55	-$104	-$133
Printing and related support activities	$7	-$4	-$16	-$21
Petroleum and coals manufacturing	-$3,559	-$8,941	-$13,939	-$17,985
Chemical manufacturing	-$827	-$2,580	-$4,402	-$5,830
Plastics and rubber manufacturing	-$38	-$158	-$288	-$377
Wholesale trade	-$183	-$966	-$1,914	-$2,595
Retail trade	$243	$96	-$116	$24
Air transportation	-$656	-$1,831	-$3,132	-$4,348
Rail transportation	-$42	-$95	-$150	-$181
Water transportation	-$10	-$29	-$52	-$71
Truck transportation	$20	-$40	-$138	-$196
Couriers and messengers	$10	-$4	-$31	-$54
Transit and ground passenger transportation	$8	$6	$2	-$1
Pipeline transportation	-$277	-$465	-$546	-$553
Scenic and sightseeing transportation; Support activities for transportation	-$150	-$400	-$694	-$1,011
Warehousing and storage	$15	$13	$6	$3
Publishing industries, except Internet	$23	-$44	-$142	-$212
Motion picture and sound recording industries	$49	$82	$112	$149
Internet publishing and broadcasting; ISPs, search portals, and data processing	$11	-$45	-$112	-$151
Broadcasting, except Internet	$16	$10	-$2	-$4
Telecommunications	$336	$432	$440	$515
Monetary authorities - central bank; Credit intermediation and related activities	$781	$992	$983	$1,100
Securities, commodity contracts, investments	$189	$224	$216	$241
Insurance carriers and related activities	$323	$414	$396	$385
Real estate	$1,081	$833	$616	$1,219
Rental and leasing services; Leasing of nonfinancial intangible assets	-$478	-$1,367	-$2,317	-$3,025
Professional, scientific, and technical services	-$354	-$1,389	-$2,518	-$3,220
Management of companies and enterprises	-$105	-$381	-$691	-$942
Administrative and support services	$77	-$154	-$459	-$627
Waste management and remediation services	$3	-$33	-$74	-$96
Educational services	$93	$101	$85	$85
Ambulatory health care services	$1,234	$1,917	$2,351	$2,796
Hospitals	$323	$376	$342	$351
Nursing and residential care facilities	$97	$103	$78	$67
Social assistance	$91	$132	$148	$166
Performing arts and spectator sports	$38	$33	$12	$6
Museums, historical sites, zoos, and parks	$7	$6	$4	$3
Amusement, gambling, and recreation	$67	$102	$122	$145
Accommodation	$102	$111	$115	$159
Food services and drinking places	$192	$72	-$105	-$185
Repair and maintenance	$76	$7	-$87	-$118
Personal and laundry services	$181	$281	$351	$423
Membership associations and organizations	$87	$98	$84	$85
Private households	$34	$65	$89	$111
State and local government	-$434	-$1,603	-$2,548	-$2,835
TOTAL OF ALL SECTORS =	-$9,629	-$32,297	-$52,933	-$62,841

Figure 6.34 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	-1	-1	-1
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	-15	-33	-48	-54
Mining (except oil and gas)	0	-2	-2	-2
Support activities for mining	-3	-3	-3	-1
Utilities	-2	-3	-2	-2
Construction	-11	-24	-30	-23
Wood manufacturing	0	0	0	0
Nonmetallic mineral manufacturing	0	0	0	1
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	0	-1	-2	-1
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	-1	-1	-1	-1
Electrical equipment and appliance manufacturing	0	-1	-1	-1
Motor vehicles, bodies and trailers, and parts manufacturing	0	0	0	0
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	0	0	0	0
Miscellaneous manufacturing	0	0	-1	0
Food manufacturing	1	2	2	2
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	0	0	0
Printing and related support activities	0	0	0	0
Petroleum and coals manufacturing	-1	-2	-2	-2
Chemical manufacturing	-1	-2	-3	-3
Plastics and rubber manufacturing	0	-1	-1	-1
Wholesale trade	0	-3	-6	-7
Retail trade	6	7	6	8
Air transportation	-2	-6	-8	-11
Rail transportation	0	0	0	0
Water transportation	0	0	0	1
Truck transportation	1	3	4	6
Couriers and messengers	0	1	1	1
Transit and ground passenger transportation	0	0	0	1
Pipeline transportation	-1	-1	-1	0
Scenic and sightseeing transportation; Support activities for transportation	-1	-3	-5	-6
Warehousing and storage	0	0	0	1
Publishing industries, except Internet	0	0	0	0
Motion picture and sound recording industries	0	1	1	1
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	0	0	0
Telecommunications	1	1	1	1
Monetary authorities - central bank; Credit intermediation and related activities	3	4	3	4
Securities, commodity contracts, investments	4	4	4	5
Insurance carriers and related activities	3	4	4	3
Real estate	5	6	6	7
Rental and leasing services; Leasing of nonfinancial intangible assets	0	0	-1	-2
Professional, scientific, and technical services	-2	-9	-17	-21
Management of companies and enterprises	0	-2	-2	-3
Administrative and support services	6	7	6	5
Waste management and remediation services	0	0	0	0
Educational services	3	5	5	5
Ambulatory health care services	18	28	35	41
Hospitals	5	7	7	7
Nursing and residential care facilities	3	4	3	3
Social assistance	4	6	7	8
Performing arts and spectator sports	1	1	1	1
Museums, historical sites, zoos, and parks	0	0	0	0
Amusement, gambling, and recreation	2	4	5	5
Accommodation	2	2	3	3
Food services and drinking places	8	9	7	6
Repair and maintenance	1	1	1	1
Personal and laundry services	4	6	7	8
Membership associations and organizations	4	5	4	5
Private households	4	7	9	11
State and local government	-6	-22	-33	-36
TOTAL OF ALL SECTORS =	43	5	-38	-27

Figure 6.35 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	0	-1	-2	-2
Advertising, marketing, promotions, public relations, and sales managers	0	0	0	0
Operations specialties managers	0	-1	-2	-2
Other management occupations	1	0	-1	-1
Business operations specialists	0	-2	-4	-5
Financial specialists	1	0	-1	-1
Computer occupations	0	-3	-6	-7
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	-1	-1
Engineers	-3	-8	-11	-12
Drafters, engineering technicians, and mapping technicians	-1	-2	-2	-3
Life scientists	0	0	0	0
Physical scientists	-1	-2	-3	-3
Social scientists and related workers	0	0	0	0
Life, physical, and social science technicians	-1	-1	-2	-2
Counselors and Social workers	1	1	1	1
Miscellaneous community and social service specialists	1	1	1	1
Religious workers	0	0	0	0
Lawyers, judges, and related workers	0	0	-1	-1
Legal support workers	0	0	-1	-1
Postsecondary teachers	0	0	-1	-1
Preschool, primary, secondary, and special education school teachers	0	-3	-5	-5
Other teachers and instructors	0	0	0	0
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	0	-1	-1	-1
Art and design workers	0	0	0	0
Entertainers and performers, sports and related workers	0	0	0	0
Media and communication workers	0	0	0	0
Media and communication equipment workers	0	0	0	0
Health diagnosing and treating practitioners	6	9	10	12
Health technologists and technicians	3	5	5	6
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	3	4	5	5
Occupational therapy and physical therapist assistants and aides	0	1	1	1
Other healthcare support occupations	3	5	5	6
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	-1	-1
Law enforcement workers	0	-1	-2	-2
Other protective service workers	1	0	0	0
Supervisors of food preparation and serving workers	1	1	1	1
Cooks and food preparation workers	2	2	2	2
Food and beverage serving workers	5	6	5	4
Other food preparation and serving related workers	1	1	1	1
Supervisors of building and grounds cleaning and maintenance workers	0	1	1	1
Building cleaning and pest control workers	4	5	6	7
Grounds maintenance workers	3	5	6	7
Supervisors of personal care and service workers	0	0	0	0
Animal care and service workers	0	0	1	1
Entertainment attendants and related workers	1	1	1	1
Funeral service workers	0	0	0	0
Personal appearance workers	2	3	4	4
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	5	7	9	10
Supervisors of sales workers	1	1	0	1
Retail sales workers	4	5	4	5
Sales representatives, services	2	2	1	1
Sales representatives, wholesale and manufacturing	0	-1	-2	-3
Other sales and related workers	1	1	1	1
Supervisors of office and administrative support workers	1	1	0	0
Communications equipment operators	0	0	0	0
Financial clerks	2	1	0	0
Information and record clerks	4	3	2	2
Material recording, scheduling, dispatching, and distributing workers	0	-1	-2	-2
Secretaries and administrative assistants	2	1	0	1
Other office and administrative support workers	2	0	-1	-1
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	-1	-3	-4	-3
Construction trades workers	-6	-13	-17	-14
Helpers, construction trades	0	-1	-1	-1
Other construction and related workers	0	-1	-1	-1
Extraction workers	-4	-8	-10	-10
Supervisors of installation, maintenance, and repair workers	0	-1	-1	-1
Electrical and electronic equipment mechanics, installers, and repairers	0	0	-1	-1
Vehicle and mobile equipment mechanics, installers, and repairers	0	0	-1	-1
Other installation, maintenance, and repair occupations	-1	-3	-5	-4
Supervisors of production workers	0	-1	-1	-1
Assemblers and fabricators	0	-1	-1	-1
Food processing workers	0	1	1	1
Metal workers and plastic workers	0	-1	-2	-2
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	0	0	0	0
Woodworkers	0	0	0	0
Plant and system operators	-2	-3	-4	-4
Other production occupations	0	-1	-2	-2
Supervisors of transportation and material moving workers	0	0	0	0
Air transportation workers	-1	-2	-3	-4
Motor vehicle operators	1	1	1	2
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	0	0	0	0
Material moving workers	-1	-3	-6	-6
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	42	6	-37	-28

Dallas, Texas

Mountain (MNT)

Electrical Power Capacity (MNT level)

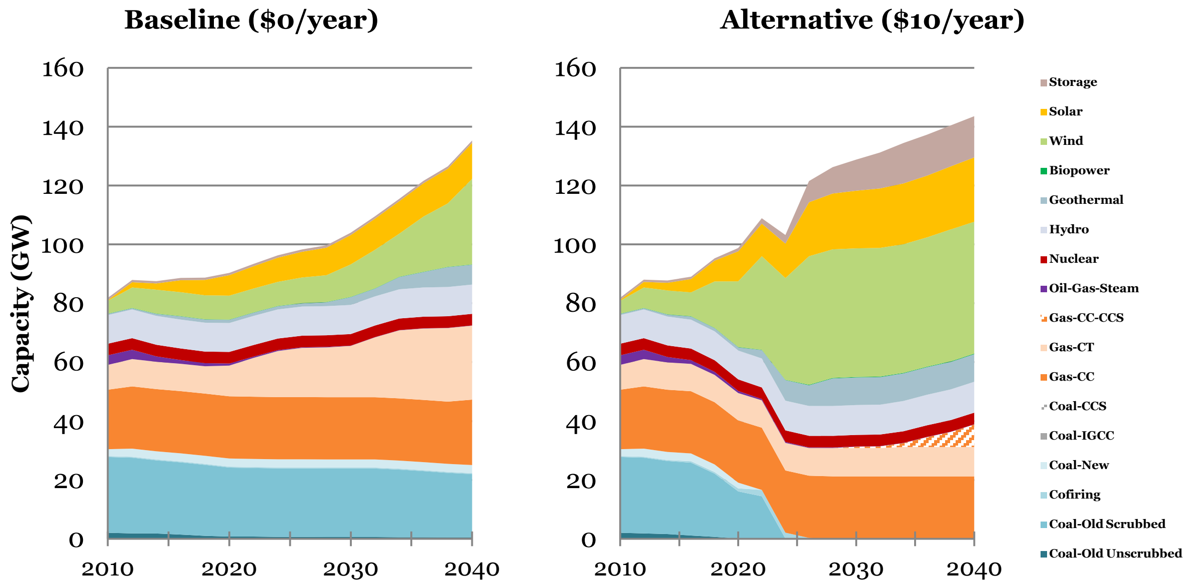


Figure 6.36 – Coal is steady in the MNT baseline, although the carbon price quickly makes it uneconomical in the 2020s. It sees replacement by larger capacities of wind and solar. The solar capacity of this region is higher than in any of the other under consideration.

Electrical Power Generation (MNT level)

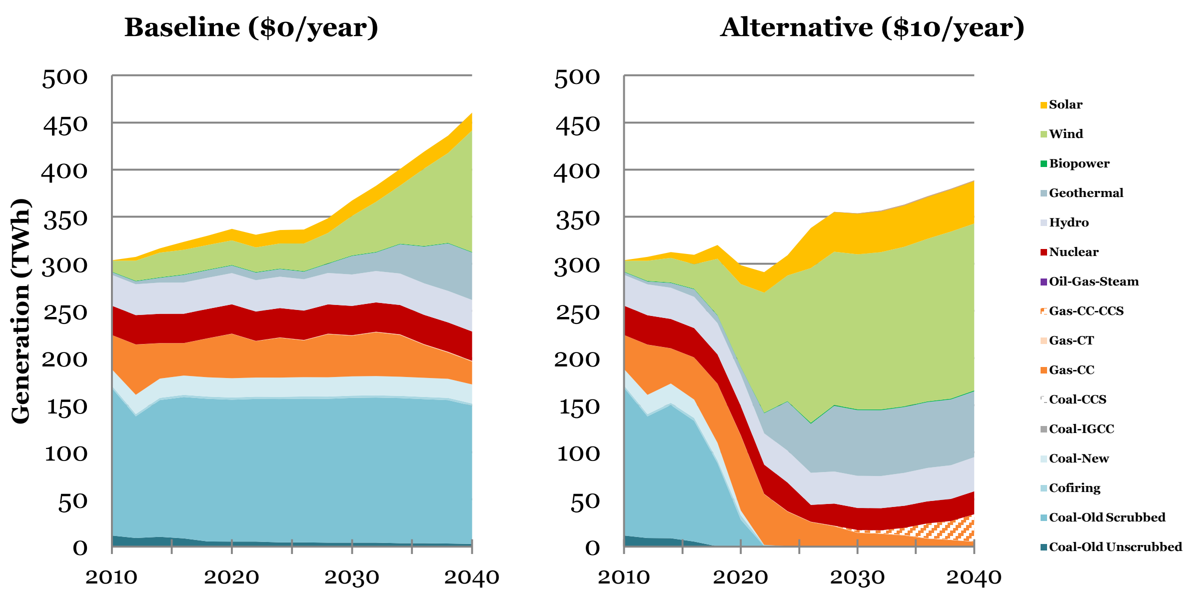


Figure 6.37 – The removal of the coal generation in the area improves the quality of life and means more solar, wind, and geothermal resources take its place. The MNT region even has very little natural gas or nuclear power in its generation profile from the above results.

Figure 6.38 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$7	-$11	-$18	-$24
Agriculture and forestry support activities	-$1	-$1	-$2	-$3
Oil and gas extraction	-$542	-$1,148	-$1,521	-$1,589
Mining (except oil and gas)	-$899	-$2,048	-$2,719	-$2,834
Support activities for mining	-$181	-$107	-$69	-$58
Utilities	-$712	-$598	-$736	-$845
Construction	$206	$1,324	$1,262	$1,341
Wood manufacturing	$7	$20	$16	$14
Nonmetallic mineral manufacturing	$6	$32	$23	$18
Primary metal manufacturing	-$29	-$60	-$86	-$95
Fabricated metal manufacturing	$50	$57	$13	$3
Machinery manufacturing	-$16	$11	$3	-$19
Computer and electronic manufacturing	-$34	-$109	-$291	-$408
Electrical equipment and appliance manufacturing	-$2	-$15	-$33	-$48
Motor vehicles, bodies and trailers, and parts manufacturing	$16	$31	$37	$43
Other transportation equipment manufacturing	-$34	-$84	-$132	-$170
Furniture and related manufacturing	$18	$24	$15	$5
Miscellaneous manufacturing	-$4	-$49	-$92	-$111
Food manufacturing	$43	$61	$57	$50
Beverage and tobacco manufacturing	$17	$28	$29	$27
Textile mills; Textile mills	$0	-$4	-$8	-$9
Apparel manufacturing; Leather and allied manufacturing	$0	-$1	-$1	$0
Paper manufacturing	$3	$3	-$1	-$5
Printing and related support activities	$13	$23	$23	$23
Petroleum and coals manufacturing	-$730	-$1,152	-$1,626	-$2,197
Chemical manufacturing	-$30	-$53	-$131	-$216
Plastics and rubber manufacturing	-$2	-$10	-$31	-$50
Wholesale trade	$433	$936	$1,087	$1,277
Retail trade	$1,063	$2,314	$2,939	$3,630
Air transportation	-$250	-$707	-$1,212	-$1,652
Rail transportation	-$25	-$53	-$87	-$106
Water transportation	$0	$0	-$1	-$1
Truck transportation	$38	$56	$34	$24
Couriers and messengers	$14	$14	$0	-$12
Transit and ground passenger transportation	$13	$18	$14	$9
Pipeline transportation	-$31	-$51	-$60	-$61
Scenic and sightseeing transportation; Support activities for transportation	-$57	-$138	-$232	-$332
Warehousing and storage	$8	$8	$1	-$4
Publishing industries, except Internet	$77	$138	$145	$162
Motion picture and sound recording industries	$33	$57	$77	$99
Internet publishing and broadcasting; ISPs, search portals, and data processing	$32	$66	$69	$72
Broadcasting, except Internet	$22	$41	$44	$47
Telecommunications	$281	$534	$643	$738
Monetary authorities - central bank; Credit intermediation and related activities	$788	$1,356	$1,524	$1,668
Securities, commodity contracts, investments	$155	$244	$245	$247
Insurance carriers and related activities	$206	$312	$319	$312
Real estate	$913	$2,562	$2,901	$2,975
Rental and leasing services; Leasing of nonfinancial intangible assets	-$101	-$268	-$518	-$713
Professional, scientific, and technical services	$104	$314	$96	-$74
Management of companies and enterprises	-$20	-$88	-$213	-$318
Administrative and support services	$226	$453	$449	$446
Waste management and remediation services	$19	$43	$46	$47
Educational services	$95	$189	$228	$249
Ambulatory health care services	$1,184	$2,071	$2,503	$2,957
Hospitals	$246	$492	$624	$728
Nursing and residential care facilities	$80	$163	$207	$241
Social assistance	$75	$134	$164	$188
Performing arts and spectator sports	$48	$94	$111	$128
Museums, historical sites, zoos, and parks	$7	$16	$20	$23
Amusement, gambling, and recreation	$95	$176	$210	$239
Accommodation	$266	$625	$722	$742
Food services and drinking places	$215	$499	$612	$681
Repair and maintenance	$108	$229	$268	$298
Personal and laundry services	$179	$326	$376	$423
Membership associations and organizations	$66	$130	$156	$172
Private households	$31	$60	$70	$79
State and local government	$299	$725	$690	$679
TOTAL OF ALL SECTORS =	$4,091	$10,254	$9,252	$9,150

Figure 6.39 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	0	0
Agriculture and forestry support activities	0	0	0	0
Oil and gas extraction	-2	-5	-7	-8
Mining (except oil and gas)	-4	-8	-9	-8
Support activities for mining	-1	0	0	0
Utilities	-1	-1	-1	-1
Construction	8	27	26	27
Wood manufacturing	0	0	0	0
Nonmetallic mineral manufacturing	0	1	1	1
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	0	1	0	1
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	0	-1	-1
Electrical equipment and appliance manufacturing	0	0	0	0
Motor vehicles, bodies and trailers, and parts manufacturing	0	0	0	0
Other transportation equipment manufacturing	0	0	0	0
Furniture and related manufacturing	0	0	0	0
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	1	1	1	1
Beverage and tobacco manufacturing	0	0	0	0
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	0	0	0
Paper manufacturing	0	0	0	0
Printing and related support activities	0	0	0	0
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	0	0	0	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	3	6	6	7
Retail trade	18	34	39	43
Air transportation	-1	-2	-3	-4
Rail transportation	0	0	0	0
Water transportation	0	0	0	0
Truck transportation	1	2	4	5
Couriers and messengers	0	1	1	1
Transit and ground passenger transportation	0	1	1	1
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	-1	-1	-2	-2
Warehousing and storage	0	0	0	0
Publishing industries, except Internet	0	1	1	1
Motion picture and sound recording industries	0	1	1	1
Internet publishing and broadcasting; ISPs, search portals, and data processing	0	0	0	0
Broadcasting, except Internet	0	0	0	0
Telecommunications	1	1	1	1
Monetary authorities - central bank; Credit intermediation and related activities	3	5	5	5
Securities, commodity contracts, investments	4	5	5	5
Insurance carriers and related activities	2	3	3	2
Real estate	6	13	14	15
Rental and leasing services; Leasing of nonfinancial intangible assets	1	1	1	1
Professional, scientific, and technical services	2	5	4	3
Management of companies and enterprises	0	0	-1	-1
Administrative and support services	8	16	18	20
Waste management and remediation services	0	0	1	1
Educational services	3	6	8	9
Ambulatory health care services	15	27	33	40
Hospitals	4	7	9	10
Nursing and residential care facilities	2	4	5	6
Social assistance	3	5	7	8
Performing arts and spectator sports	1	2	3	3
Museums, historical sites, zoos, and parks	0	0	0	0
Amusement, gambling, and recreation	3	6	7	8
Accommodation	4	8	9	9
Food services and drinking places	8	16	19	21
Repair and maintenance	2	3	4	4
Personal and laundry services	4	7	8	8
Membership associations and organizations	2	4	5	6
Private households	4	7	7	7
State and local government	4	10	9	8
TOTAL OF ALL SECTORS =	107	220	242	264

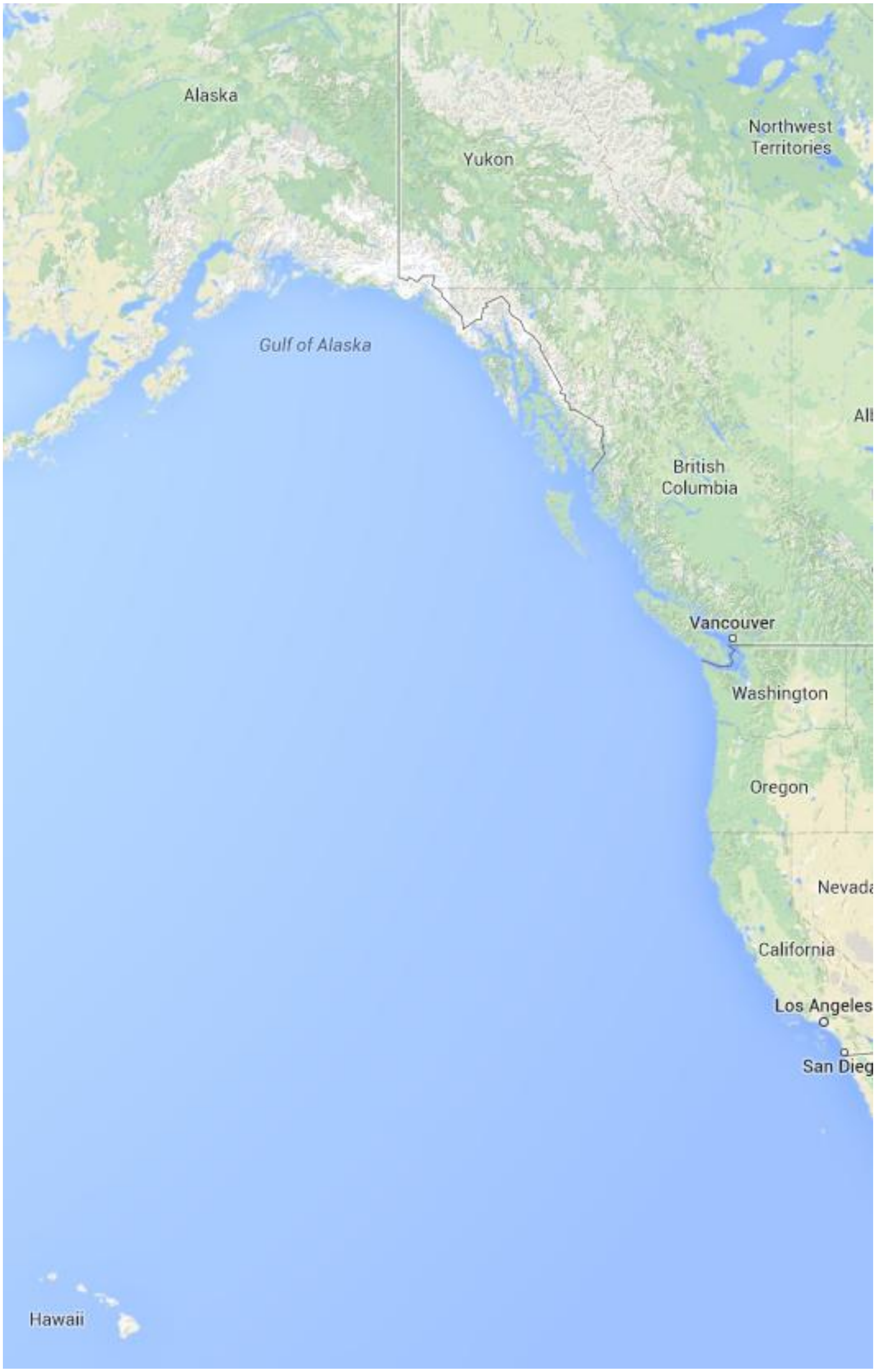
Figure 6.40 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	1	3	3	3
Advertising, marketing, promotions, public relations, and sales managers	0	1	1	1
Operations specialties managers	1	1	1	1
Other management occupations	2	4	4	4
Business operations specialists	2	4	4	5
Financial specialists	2	4	4	4
Computer occupations	1	2	1	1
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	0	0	-1	-1
Drafters, engineering technicians, and mapping technicians	0	0	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	0	0	0
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	1	2	2	3
Miscellaneous community and social service specialists	1	1	1	2
Religious workers	0	0	0	0
Lawyers, judges, and related workers	0	1	0	0
Legal support workers	0	0	0	0
Postsecondary teachers	1	2	3	3
Preschool, primary, secondary, and special education school teachers	1	3	3	3
Other teachers and instructors	0	1	1	1
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	1	1	1	2
Art and design workers	0	1	1	1
Entertainers and performers, sports and related workers	1	1	1	2
Media and communication workers	1	1	1	1
Media and communication equipment workers	0	0	0	0
Health diagnosing and treating practitioners	6	11	13	16
Health technologists and technicians	4	7	8	10
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	2	4	5	6
Occupational therapy and physical therapist assistants and aides	0	1	1	1
Other healthcare support occupations	3	5	6	7
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	0	1	1	1
Other protective service workers	1	2	3	3
Supervisors of food preparation and serving workers	1	2	2	2
Cooks and food preparation workers	2	5	6	6
Food and beverage serving workers	6	12	14	15
Other food preparation and serving related workers	1	2	3	3
Supervisors of building and grounds cleaning and maintenance workers	1	1	1	1
Building cleaning and pest control workers	5	9	10	11
Grounds maintenance workers	4	7	9	10
Supervisors of personal care and service workers	0	0	1	1
Animal care and service workers	0	1	1	1
Entertainment attendants and related workers	1	2	2	2
Funeral service workers	0	0	0	0
Personal appearance workers	2	4	4	5
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	4	7	9	10
Supervisors of sales workers	2	3	4	4
Retail sales workers	10	20	23	25
Sales representatives, services	2	3	3	3
Sales representatives, wholesale and manufacturing	1	2	2	2
Other sales and related workers	1	3	3	3
Supervisors of office and administrative support workers	1	3	3	3
Communications equipment operators	0	0	0	0
Financial clerks	3	6	7	7
Information and record clerks	6	10	11	12
Material recording, scheduling, dispatching, and distributing workers	2	4	4	5
Secretaries and administrative assistants	4	8	9	9
Other office and administrative support workers	3	7	7	8
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	0	1	1	1
Construction trades workers	4	13	13	13
Helpers, construction trades	0	1	1	1
Other construction and related workers	0	1	0	0
Extraction workers	-2	-3	-4	-4
Supervisors of installation, maintenance, and repair workers	0	1	1	1
Electrical and electronic equipment mechanics, installers, and repairers	0	1	1	1
Vehicle and mobile equipment mechanics, installers, and repairers	1	2	2	3
Other installation, maintenance, and repair occupations	2	5	6	6
Supervisors of production workers	0	0	0	0
Assemblers and fabricators	0	1	1	1
Food processing workers	0	1	1	1
Metal workers and plastic workers	0	0	0	0
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	0	1	1	1
Woodworkers	0	0	0	0
Plant and system operators	0	0	0	0
Other production occupations	1	1	1	1
Supervisors of transportation and material moving workers	0	0	0	1
Air transportation workers	0	-1	-1	-2
Motor vehicle operators	2	5	6	8
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	0	1	1	1
Material moving workers	2	3	4	4
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	104	219	241	266

Albuquerque, New Mexico

Pacific (PAC)


Alaska
Yukon
Northwest
Territories
Gulf of Alaska
British
Columbia
Vancouver
Washington
Oregon
California
Los Angeles
Hawaii

Electrical Power Capacity (PAC level)

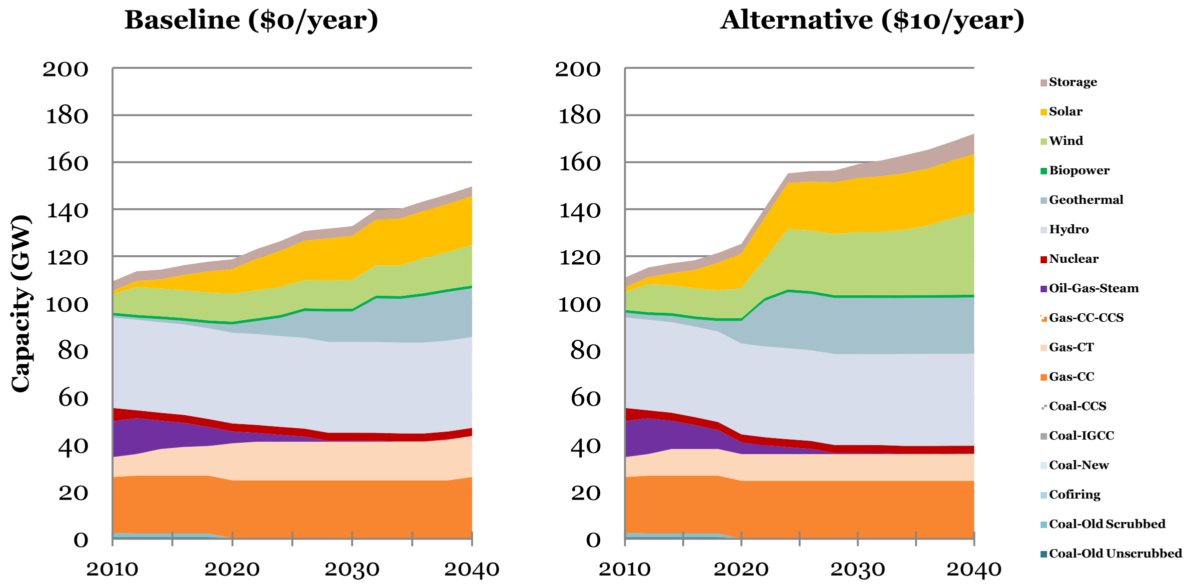


Figure 6.41 – PAC is unique among the nine regions for its large share of hydroelectric capacity and lack of coal in the baseline. The important difference in the alternative includes adding more wind, solar, and geothermal power sooner than in the baseline.

Electrical Power Generation (PAC level)

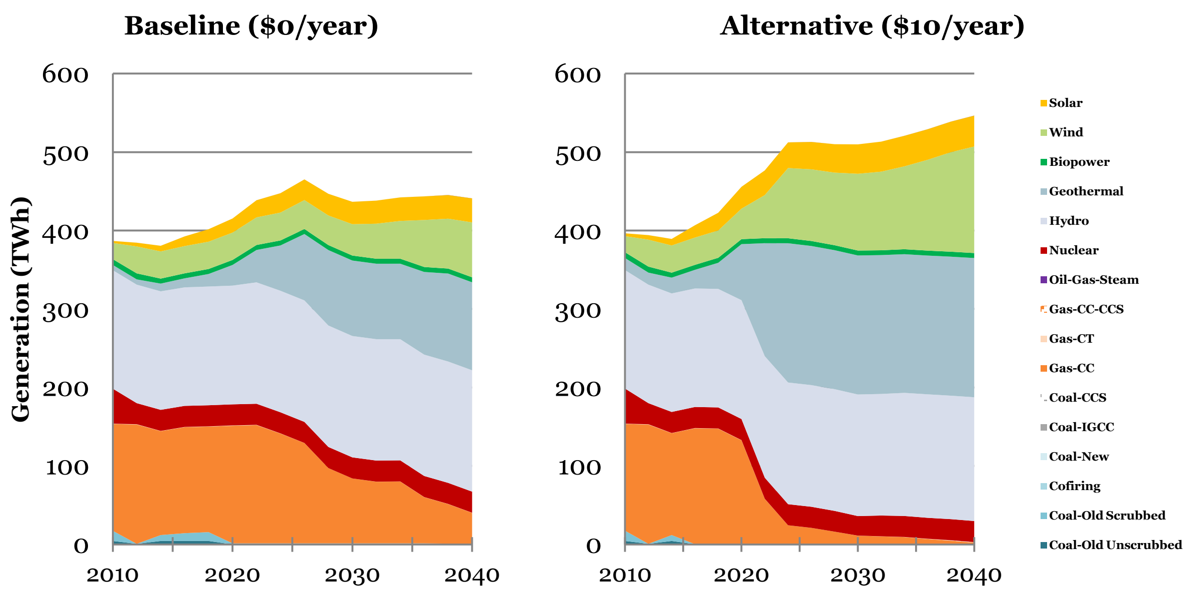


Figure 6.42 – Geothermal has the largest increase in generation during the alternative simulation, and PAC has a special case of its base-load coming from hydroelectric dams and geothermal plants instead of nuclear facilities or gas with carbon sequestration.

Figure 6.43 – GRP by Industry (millions of 2012 dollars)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	-$31	-$94	-$163	-$221
Agriculture and forestry support activities	-$2	-$13	-$23	-$29
Oil and gas extraction	-$507	-$812	-$1,055	-$1,155
Mining (except oil and gas)	$161	-$114	-$277	-$330
Support activities for mining	$8	$56	$73	$83
Utilities	-$570	-$612	-$744	-$768
Construction	$614	$1,632	$1,457	$1,438
Wood manufacturing	$47	$80	$68	$59
Nonmetallic mineral manufacturing	$58	$100	$93	$92
Primary metal manufacturing	$3	-$40	-$76	-$82
Fabricated metal manufacturing	$256	$118	$29	-$15
Machinery manufacturing	-$31	$20	$13	-$22
Computer and electronic manufacturing	$39	-$516	-$1,111	-$1,191
Electrical equipment and appliance manufacturing	$21	-$37	-$107	-$161
Motor vehicles, bodies and trailers, and parts manufacturing	$67	$127	$164	$198
Other transportation equipment manufacturing	-$77	-$250	-$419	-$549
Furniture and related manufacturing	$72	$95	$81	$60
Miscellaneous manufacturing	$66	$14	-$47	-$66
Food manufacturing	$196	$256	$234	$205
Beverage and tobacco manufacturing	$91	$121	$113	$98
Textile mills; Textile mills	$2	-$12	-$30	-$35
Apparel manufacturing; Leather and allied manufacturing	-$8	-$49	-$69	-$73
Paper manufacturing	$33	$32	$13	-$4
Printing and related support activities	$50	$69	$68	$68
Petroleum and coals manufacturing	-$603	-$1,222	-$2,030	-$3,030
Chemical manufacturing	$389	$456	$295	$149
Plastics and rubber manufacturing	$41	$26	-$25	-$69
Wholesale trade	$1,540	$2,335	$2,525	$2,793
Retail trade	$2,766	$4,700	$5,603	$6,546
Air transportation	-$1,061	-$2,665	-$4,274	-$5,716
Rail transportation	-$14	-$35	-$63	-$79
Water transportation	-$7	-$21	-$37	-$52
Truck transportation	$146	$220	$219	$227
Couriers and messengers	$57	$70	$46	$24
Transit and ground passenger transportation	$33	$48	$51	$52
Pipeline transportation	-$42	-$68	-$80	-$81
Scenic and sightseeing transportation; Support activities for transportation	-$208	-$527	-$891	-$1,281
Warehousing and storage	$38	$46	$33	$25
Publishing industries, except Internet	$474	$754	$850	$1,031
Motion picture and sound recording industries	$775	$1,288	$1,689	$2,168
Internet publishing and broadcasting; ISPs, search portals, and data processing	$227	$319	$312	$314
Broadcasting, except Internet	$117	$176	$185	$200
Telecommunications	$752	$1,184	$1,342	$1,485
Monetary authorities - central bank; Credit intermediation and related activities	$1,864	$2,863	$3,190	$3,449
Securities, commodity contracts, investments	$686	$994	$1,027	$1,048
Insurance carriers and related activities	$566	$795	$788	$751
Real estate	$3,835	$5,975	$6,300	$6,469
Rental and leasing services; Leasing of nonfinancial intangible assets	-$73	-$485	-$1,039	-$1,499
Professional, scientific, and technical services	$1,467	$1,937	$1,565	$1,329
Management of companies and enterprises	$129	-$9	-$269	-$481
Administrative and support services	$769	$1,130	$1,155	$1,207
Waste management and remediation services	$88	$127	$125	$124
Educational services	$268	$397	$425	$431
Ambulatory health care services	$2,921	$4,652	$5,476	$6,213
Hospitals	$623	$964	$1,078	$1,142
Nursing and residential care facilities	$205	$315	$350	$370
Social assistance	$189	$291	$330	$357
Performing arts and spectator sports	$154	$235	$262	$297
Museums, historical sites, zoos, and parks	$24	$39	$45	$49
Amusement, gambling, and recreation	$217	$348	$400	$442
Accommodation	$462	$729	$839	$935
Food services and drinking places	$606	$912	$943	$931
Repair and maintenance	$301	$452	$476	$493
Personal and laundry services	$570	$907	$1,036	$1,143
Membership associations and organizations	$175	$257	$271	$276
Private households	$128	$216	$250	$279
State and local government	$1,564	$1,994	$1,651	$1,422
TOTAL OF ALL SECTORS =	$23,716	$33,290	$30,709	$29,483

Figure 6.44 – Employment by Industry (thousands over baseline)

70 sector NAICS	2020	2025	2030	2035
Forestry and logging; Fishing, hunting, and trapping	0	0	-1	-1
Agriculture and forestry support activities	0	0	-1	-1
Oil and gas extraction	-2	-3	-4	-4
Mining (except oil and gas)	0	-2	-3	-3
Support activities for mining	0	0	0	0
Utilities	-1	-1	-1	-1
Construction	11	26	23	23
Wood manufacturing	1	1	1	1
Nonmetallic mineral manufacturing	0	1	1	1
Primary metal manufacturing	0	0	0	0
Fabricated metal manufacturing	2	1	1	0
Machinery manufacturing	0	0	0	0
Computer and electronic manufacturing	0	-1	-2	-2
Electrical equipment and appliance manufacturing	0	0	0	0
Motor vehicles, bodies and trailers, and parts manufacturing	0	1	1	1
Other transportation equipment manufacturing	0	-1	-1	-1
Furniture and related manufacturing	1	1	1	1
Miscellaneous manufacturing	0	0	0	0
Food manufacturing	2	2	2	2
Beverage and tobacco manufacturing	0	1	1	1
Textile mills; Textile mills	0	0	0	0
Apparel manufacturing; Leather and allied manufacturing	0	-1	-1	-1
Paper manufacturing	0	0	0	0
Printing and related support activities	1	1	1	1
Petroleum and coals manufacturing	0	0	0	0
Chemical manufacturing	1	1	1	0
Plastics and rubber manufacturing	0	0	0	0
Wholesale trade	10	13	13	13
Retail trade	43	65	69	72
Air transportation	-4	-9	-12	-14
Rail transportation	0	0	0	0
Water transportation	0	0	0	1
Truck transportation	3	6	8	10
Couriers and messengers	1	2	2	3
Transit and ground passenger transportation	1	2	2	2
Pipeline transportation	0	0	0	0
Scenic and sightseeing transportation; Support activities for transportation	-2	-4	-7	-9
Warehousing and storage	1	1	1	1
Publishing industries, except Internet	1	2	2	2
Motion picture and sound recording industries	3	4	4	5
Internet publishing and broadcasting; ISPs, search portals, and data processing	1	1	1	0
Broadcasting, except Internet	1	1	1	1
Telecommunications	2	3	3	2
Monetary authorities - central bank; Credit intermediation and related activities	7	9	9	9
Securities, commodity contracts, investments	9	12	11	11
Insurance carriers and related activities	4	5	5	5
Real estate	15	22	22	21
Rental and leasing services; Leasing of nonfinancial intangible assets	1	2	1	1
Professional, scientific, and technical services	15	20	17	16
Management of companies and enterprises	1	0	-1	-1
Administrative and support services	21	31	33	35
Waste management and remediation services	1	1	1	1
Educational services	7	11	12	13
Ambulatory health care services	36	58	68	77
Hospitals	8	12	13	14
Nursing and residential care facilities	5	8	9	9
Social assistance	7	11	13	14
Performing arts and spectator sports	4	5	6	6
Museums, historical sites, zoos, and parks	0	1	1	1
Amusement, gambling, and recreation	6	10	12	13
Accommodation	6	8	9	10
Food services and drinking places	18	26	26	26
Repair and maintenance	4	6	6	6
Personal and laundry services	11	17	18	19
Membership associations and organizations	5	8	8	8
Private households	15	24	25	26
State and local government	17	21	17	14
TOTAL OF ALL SECTORS =	300	442	447	460

Figure 6.45 – Employment by Occupation (thousands over baseline)

95 occupation SOC	2020	2025	2030	2035
Top executives	4	6	5	5
Advertising, marketing, promotions, public relations, and sales managers	1	2	2	2
Operations specialties managers	3	3	3	3
Other management occupations	4	6	6	6
Business operations specialists	7	9	9	9
Financial specialists	7	10	9	9
Computer occupations	5	6	5	5
Mathematical science occupations	0	0	0	0
Architects, surveyors, and cartographers	0	0	0	0
Engineers	1	1	0	0
Drafters, engineering technicians, and mapping technicians	0	1	0	0
Life scientists	0	0	0	0
Physical scientists	0	0	0	0
Social scientists and related workers	0	1	1	1
Life, physical, and social science technicians	0	0	0	0
Counselors and Social workers	2	4	4	4
Miscellaneous community and social service specialists	1	2	2	2
Religious workers	0	0	0	0
Lawyers, judges, and related workers	1	1	1	1
Legal support workers	1	1	1	1
Postsecondary teachers	3	4	4	4
Preschool, primary, secondary, and special education school teachers	5	7	6	6
Other teachers and instructors	1	2	2	2
Librarians, curators, and archivists	0	0	0	0
Other education, training, and library occupations	2	3	3	3
Art and design workers	1	2	2	2
Entertainers and performers, sports and related workers	2	3	3	3
Media and communication workers	2	3	3	3
Media and communication equipment workers	1	1	1	1
Health diagnosing and treating practitioners	14	22	25	28
Health technologists and technicians	9	14	16	17
Other healthcare practitioners and technical occupations	0	0	0	0
Nursing, psychiatric, and home health aides	5	7	8	9
Occupational therapy and physical therapist assistants and aides	1	1	2	2
Other healthcare support occupations	7	12	14	15
Supervisors of protective service workers	0	0	0	0
Fire fighting and prevention workers	0	0	0	0
Law enforcement workers	1	1	1	1
Other protective service workers	3	4	4	5
Supervisors of food preparation and serving workers	2	3	3	3
Cooks and food preparation workers	6	8	8	8
Food and beverage serving workers	13	19	20	19
Other food preparation and serving related workers	3	4	4	4
Supervisors of building and grounds cleaning and maintenance workers	1	2	2	2
Building cleaning and pest control workers	13	20	21	22
Grounds maintenance workers	8	13	14	15
Supervisors of personal care and service workers	1	1	1	1
Animal care and service workers	1	2	2	2
Entertainment attendants and related workers	2	3	3	4
Funeral service workers	0	0	0	0
Personal appearance workers	6	9	10	10
Baggage porters, bellhops, and concierges; Tour and travel guides	0	0	0	0
Other personal care and service workers	12	19	21	22
Supervisors of sales workers	4	6	6	7
Retail sales workers	25	37	40	41
Sales representatives, services	5	6	6	6
Sales representatives, wholesale and manufacturing	3	4	4	4
Other sales and related workers	3	5	5	5
Supervisors of office and administrative support workers	4	5	5	5
Communications equipment operators	0	0	0	0
Financial clerks	9	13	13	13
Information and record clerks	13	19	19	19
Material recording, scheduling, dispatching, and distributing workers	6	8	7	7
Secretaries and administrative assistants	11	16	17	17
Other office and administrative support workers	9	13	13	14
Supervisors of farming, fishing, and forestry workers	0	0	0	0
Agricultural workers	0	0	0	0
Fishing and hunting workers	0	0	0	0
Forest, conservation, and logging workers	0	0	0	0

Supervisors of construction and extraction workers	1	2	1	1
Construction trades workers	7	15	13	13
Helpers, construction trades	1	1	1	1
Other construction and related workers	0	1	1	1
Extraction workers	0	-1	-1	-1
Supervisors of installation, maintenance, and repair workers	1	1	1	1
Electrical and electronic equipment mechanics, installers, and repairers	1	1	1	1
Vehicle and mobile equipment mechanics, installers, and repairers	3	4	4	4
Other installation, maintenance, and repair occupations	6	9	9	9
Supervisors of production workers	1	1	0	0
Assemblers and fabricators	1	1	1	1
Food processing workers	1	2	2	2
Metal workers and plastic workers	1	1	0	0
Printing workers	0	0	0	0
Textile, apparel, and furnishings workers	1	1	1	1
Woodworkers	1	1	1	1
Plant and system operators	0	0	0	0
Other production occupations	3	4	3	3
Supervisors of transportation and material moving workers	1	1	1	1
Air transportation workers	-2	-3	-5	-6
Motor vehicle operators	7	10	12	14
Rail transportation workers	0	0	0	0
Water transportation workers	0	0	0	0
Other transportation workers	1	1	1	1
Material moving workers	7	9	9	9
Military	0	0	0	0
TOTAL OF ALL OCCUPATIONS =	297	436	442	456

San Francisco, California

Regional Economic Models, Inc. (REMI)

REMI is an economic and policy analysis firm specializing in services related to modeling. REMI's headquarters is in Amherst, Massachusetts, although its research and consulting practice reside in Washington, DC. It initially began as a research project at the University of Massachusetts-Amherst by a professor named Dr. George I. Treyz. During the late 1970s, Dr. Treyz developed an economic model to study the potential 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 to head out to Syracuse, Rochester, and eventually Buffalo). He later generalized the methodology to all counties in the United States and incorporated the firm in 1980. The current entity provides data, software, technical support, and issue-oriented expertise and consulting across the United States and the globe. There are users of the REMI model, its data, or studies in every state (and the District of Columbia) and foreign nations in North America, Europe, Asia, and the Middle East.[121] Typical REMI clients include state or local governments, federal agencies, consulting firms, academic institutions, research groups, non-profits, labor unions, and trade associations.

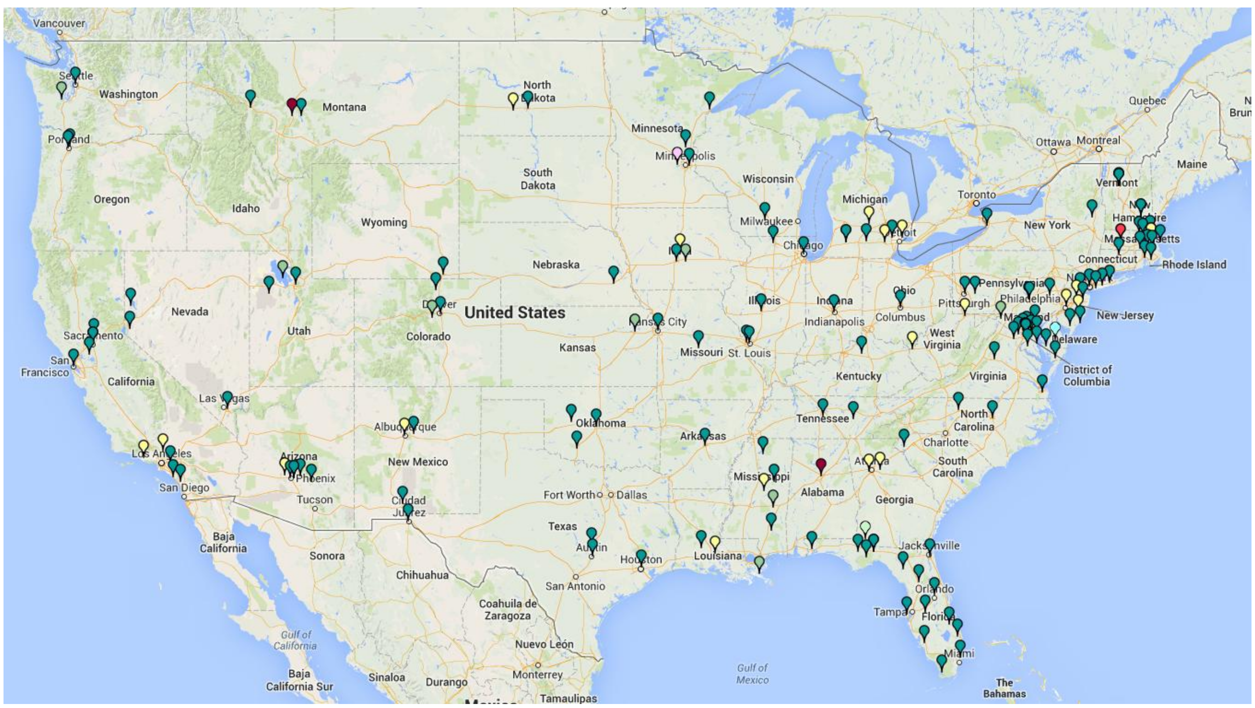


Figure 7.1 – This map shows the REMI client base in the United States. Each point represents a current model subscriber in either the private sector or a level of government. The different colors are for different model types—teal is for the "standard" PI⁺ model, green is Tax-PI (an expansion for state level budget analysis), gold is for TranSight (and transportation), purple is Metro-PI (on subcounty planning), and red is the eREMI online forecasting tool.

Some of the notable REMI clients in the United States include the American Gas Association (AGA), the National Education Association (NEA), the National Federation of Independent

[121] For the full list of clients, please see, <http://www.remi.com/clients>

Business (NFIB), the University of Michigan-Ann Arbor, Sandia National Laboratory (SNL), the Texas Comptroller of Public Accounts (CPA), and the California Department of Finance (CalFinance). Others include the Southern California Association of Governments (SCAG), the Atlanta Regional Commission (ARC), the city and county of San Francisco, California, the New York City Independent Budget Office (IBO), and the consulting firms Cambridge Systematics, CDM Smith, Booz Allen Hamilton, EY, and PWC. Clients outside of the United States include the provincial government of Alberta and the Korea Energy Economics Institute (KEEI). Prominent consulting studies by REMI in the past year include the state-by-state impact of immigration reform options, and the *Wall Street Journal* featured the results.[122] Another topic included the Medicaid expansion option for state governors and legislatures.[123] This study is part of REMI's record on analyzing the state level and federal level implications of changes in energy policies such as carbon taxes or renewable generation standards.

Synapse Energy Economics

Synapse Energy Economics, Inc. is a research and consulting firm specializing in energy, economic, and environmental topics. Since inception in 1996, Synapse has become a leader in providing rigorous analysis of the electrical power sector for public interest and governmental clients. Synapse's staff of thirty includes experts in energy and environmental economics, resource planning, electricity dispatch and economic modeling, energy efficiency, renewable energy, transmission and distribution, rate design, cost allocation, risk management, and benefit-cost analysis. Other areas include rate design and cost allocation, climate science, and both regulated and competitive electricity and natural gas markets. Several senior staff members have more than thirty years of experience in the economics and regulation of the electricity and natural gas sectors. Many of them have held positions as regulators, economists, and as utility commissioners or ISO staff.

Synapse's services include economic and technical analyses, regulatory support, research and report writing, policy analysis and development, representation in stakeholder committees, facilitation, development of analytical tools, and expert witnessing. Synapse commits to the idea that robust, transparent analyses can help to inform better policy and planning decisions. Many of Synapse's clients seek expertise to help them participate effectively in planning, regulation, and litigation cases, as well as other forums requiring public involvement. Synapse's clients include public utility commissions in American states and in Canada, offices of consumer advocates, attorney generals, environmental organizations, foundations, regional associations, public interest groups, and federal agencies such as the U.S. Environmental Protection Agency and the U.S. Department of Justice. International clients include projects for the United Nations Framework Convention on Climate Change (UNFCCC), the Global Environmental Facility, the International Joint Commission, and several others.[124]

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[122] Please see Sara Murray, "Immigration Overhaul Would Benefit Big States the Most: California, Texas, Florida Would Get Large Economic Boost, Study Says," *Wall Street Journal* (WSJ), July 16, 2013, <http://online.wsj.com/news/articles/SB10001424127887323664204578610161344880542>

[123] Please see, <http://www.remi.com/medicaid-expansion-studies-cite-remi-analysis>

[124] For the full list of clients, please see, <http://www.synapse-energy.com/clients/>

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Scott Nystrom[125] received B.A. in history, B.S. in economics, and M.A. in economic history from Iowa State University (ISU) in Ames, Iowa. He has worked at REMI since 2011, and he is the main point of contact in the Washington, DC office for training, technical support, and economic consulting. Mr. Nystrom works on a daily basis with clients across the United States and the rest of the world in state governments, federal agencies, provincial authorities, regional councils, consulting firms, academic institutions, and non-profit research groups. His major projects have included economic impact analyses of the federal "fiscal cliff" and sequestration, the TransCanada Keystone XL pipeline, the $500 billion long-range transportation plan of the Southern California Association of Governments (SCAG), the potential Medicaid expansion in North Carolina, and carbon tax studies in Massachusetts, Washington, and California. His other research and responsibilities include integrating regional models with PI$^+$, modeling the impact of changing commuting patterns and intermodal transportation, and business development and travel throughout North America and Europe.

Patrick Luckow[126] performs modeling analyses of power systems using industry-standard models to evaluate long-term energy plans and the environmental and economic impacts of policy initiatives. His recent work at Synapse includes modeling the market price impacts of adding high-level wind resources in PJM, modeling the New England electric system to calculate avoided costs associated with energy efficiency, modeling the cost and emissions impacts of transmission and renewable energy additions. His previous analyses with the ReEDS model include evaluating several clean energy futures for the Energy Foundation. Prior to joining Synapse, he worked as a scientist at the Joint Global Change Research Institute (JGCRI) in College Park, Maryland and evaluated the long-term implications of potential climate policies at the national and international level using a variety of energy and electricity models. He holds a B.S. in mechanical engineering from Northwestern University in Evanston, Illinois and a M.S. in mechanical engineering from the University of Maryland-College Park.

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Notes