Macroeconomic Impacts of the Clean Air Rule (Chapter 173-442) Costs on the Washington State Economy

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Overview

The state of Washington is seeking to cut greenhouse gas (GHG) emissions in order to protect human health and the environment. As part of this effort, the Washington State Department of Ecology (Ecology) is setting new standards to cap and reduce GHG emissions from significant in-state stationary sources, as well as petroleum product producers, importers, and distributors and natural gas distributors operating within the state, under the Clean Air Rule (Chapter 173-442 WAC).

This report describes a range of potential statewide macroeconomic impacts resulting from the costs of compliance of the Clean Air Rule, since it will restrict the total amount of emissions generated and consumed within the state of Washington. It builds on the analyses required for rulemaking under the Administrative Procedure Act (APA; Chapter 34.05 RCW) and Regulatory Fairness Act (RFA; Chapter 19.85 RCW), which are more limited in scope and intent.

This analysis evaluates the economic impacts of the costs in isolation. Although PI+ is capable of capturing other factors, this report does not simulate potential changes resulting from the regulation such as benefits related to health or migration from improved air quality or benefits related to preservation and retention of land and water supplies along with any demand for Washington based industries that provide equipment and services used to reduce emissions. For more information on the potential value of these benefits, see Ecology's Preliminary Cost-Benefit Analysis and upcoming Final Cost-Benefit Analysis for the Clean Air Rule.

Under the Clean Air Rule, there will be compliance costs borne by firms and industries across the state, as well as transfers.   Those value flows, which serve as direct inputs to the macroeconomic model, were estimated by the Department of Ecology, and are discussed in depth in Ecology's Preliminary Cost-Benefit Analysis (Ecology publication number 16-02-008) and rulemaking documents. Direct costs (negative impacts) arise from efforts to reduce emissions to achieve compliance with the CAR. Direct benefits (positive impacts) arise from elements such as reduced need for compliance effort (e.g., due to natural reductions over time in industry emissions related to changes in demand and technology). Transfers result from scenarios in which covered parties pay another in-state party for emissions reductions.

As described in the following methodology and accompanying results, a team at Regional Economic Models Inc. simulated the statewide economic impacts of those changes in costs using the proprietary software REMI PI+, a structural economic forecasting and policy analysis model. A longer description of PI+ can be found in the appendix.

Given the uncertainty around the way in which businesses will comply, the results and the methodology reflect a range of simulations to test the outcome given potential alternative behavior. As a simulation model PI+ is flexible enough to capture a range of impacts given alternative inputs assumptions. The outcomes of these alternatives can help inform not only the potential impacts of a policy choice, but provide guidance for how best to shape policy for achieving the best possible economic outcome.

Economic Impact Methodology

To further examine the economic impacts of the Clean Air Rule, we used the economic simulation model PI+. Unlike other possible methodologies, PI+ employs a broader economic framework than those required under the APA and RFA, allowing for changes in price and market equilibria, to develop a deeper understanding of the likely impacts of the Clean Air Rule (CAR). PI+ integrates input-output, computable general equilibrium, econometric and economic geography methodologies in a single model

structure. As a dynamic model, PI+ can be used to simulate different policy scenarios and forecast the comprehensive and dynamics impacts over time. A dynamic model evaluates the varying effects of a range of compliance options, beyond the information provided by the analyses required by law, including indirect impacts on energy consumers.

Direct Costs

To determine the economic impacts, REMI used the direct cost impacts provided by Ecology. The total cost stream comprises costs of immediate and reserved emissions reductions. Each year's costs for each likely covered facility were based on the expected emissions reduction from baseline emissions, and the use of one of five compliance methods:

On-site emissions reductions
1. Purchasing excess emissions reductions from other covered parties
2. Purchasing emissions reductions from in-state reduction projects
3. Purchasing allowances from approved out-of-state markets
4. Purchasing renewable energy credits

Ecology provided high cost and low costs for each of the compliance options. For purpose of simulation, each compliance option was modeled individually as if it were the only strategy used across all firms. In reality, compliance will be achieved using a combination of multiple compliance options, and true costs are likely to fall somewhere between these overall bounds.

It is important to note that compliance options #1 and #2 involve the same range of compliance costs resulting from on-site emissions reductions at covered parties, and differ only in whether those reductions are used by the covered party or sold to other covered parties. They are therefore modeled as a single option for this analysis.

Note also that Renewable Energy Credits are functionally a low-cost type of in-state project, but are singled out in this analysis as an existing illustration of what the project-based compliance option might look like in the case where there is an existing large market for that project type.

REMI Simulations

Through discussion with Ecology and the Washington Office of Financial Management, we determined it would be most appropriate to represent the impacts across three behavioral response scenarios, given the uncertainty of exactly how energy producers will respond to higher costs. Each scenario was run for each of the five high- and low-compliance strategies. REMI has policy variables related to general production cost changes, where costs are only indirectly passed along to customers, along with specific energy cost changes, where costs to energy producers are directly passed through to energy consumers. One scenario uses only the production cost variable for all sectors including energy producing sectors. The other two scenarios assume some or all of the direct cost to energy producers gets passed to energy consumers in the form of higher prices. The exact allocation of costs from energy producing sectors to consumers is shown in Appendix III. Here is an overview of each scenario.

Production Costs Only Scenario
This scenario ran all costs by sector using the production cost amount variable. This uses PI+ default indirect energy cost increases to downstream consumers. This scenario is likely not reflective of actual compliance behavior, as it is more likely that some, if not all, costs of

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compliance will be passed to energy consumers. This is because of the relatively inelastic nature of the energy market, and the consumers' limited ability to substitute away from electricity, natural gas, and petroleum fuels.[1] However, we include the results of modeling this scenario for reference in Appendix IV.

50% pass-through Scenario
Energy producers pass on 50% of direct costs to energy consumers
This scenario includes the same production cost variables as the "Production costs only" scenario for all non-utility sectors, but passes half of the costs on energy producing sectors directly to consumers. The share of energy costs passed to different types of energy consumer was based on the baseline data found within the Carbon Tax Assessment Model (CTAM) developed by the WA Department of Commerce.[2] This covered prices of electricity, natural gas, and petroleum to residential, commercial, industrial, and transportation consumers. The remaining 50% of costs to producers is modeled as a production cost.

100% pass-through Scenario
Energy producers pass on 100% of costs to energy consumers
This scenario is set up in a similar way to the 50% pass-through scenario. However, 100% of all costs to energy producing sectors was passed on to consumers of energy in the state of Washington in the form of higher prices.

Why choose the variables we did and what do they do within the model?

Through conversation with Ecology and the WA Office of Financial Management, it was determined that it would be best to run the model with several different arrangements of policy variables as described below.

Production Cost Variable

The production cost variable best represents an overall increase in costs to firms. It does not have a 1 to 1 or direct fixed relationship with sales, but rather affects the market shares equations of PI+. Effectively, higher costs make certain sectors less competitive than similar industries in other regions without this regulation, all else being equal. The change in competitiveness impacts market share, affects the ability to export, and through a loss in income, it also causes shifts in consumer demand.

Given much of the cost of complying with the Clean Air Rule is borne by producers of electricity, natural gas, and petroleum fuels, and given the unique industry they are part of, we also wanted to test the impacts should producers pass on all or half of the higher costs to consumers through higher energy prices. Those energy cost variables are split between industries and households, or separately thought of as residential, commercial and industrial consumers.

Energy Cost Variables to Industries

 Within PI+, there are energy cost variables for industries related to electricity, natural gas and residual fuel (primarily petroleum). Fuel is included as a factor of production in PI+ along with labor and capital.

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[1] For discussion of when costs are more likely to be passed through to consumers, see the theoretical discussion in Appendix A of Ecology's Preliminary Cost-Benefit Analysis (Ecology publication number 16-02-008).
[2] http://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/

As part of the production function, changes to energy costs factor into overall costs and impact market shares.

Energy Price Variables for Residential Consumers

For residential consumers, there are consumer price variables related to personal consumer expenditure categories of each fuel type. Any cost increase to these fuel cost variables includes a price elasticity of demand and impacts real disposable personal income. The loss of real disposable personal income impacts consumer demand, which impacts locally supplied products as well as imports.

Economic Impact Results

The following tables give a summary of select results generated from the PI+ model related to employment, GDP, Personal Income and Per capita personal income.

50% pass-through of costs from energy producers to consumers
Table 1-8
100% pass-through of costs from energy producers to consumers
Table 9-16

PI+ is a model that simulates how the Washington state economy can respond to costs resulting from a range of policy or market force changes. The internal structure responds through solving all internal equations in a single year, prior to moving on to solve of the next year. The policy variables related to costs and prices directly impact the relative competiveness of certain sectors and the cost of certain goods. As those shocks move throughout the economy, the model provides results as to the impact across the entire economic system. As REMI develops a baseline forecast for each region, the results should be interpreted as the difference in absolute value or as a percentage change in each year relative to the baseline forecast.

Employment

 Our employment concept is the same as used by the U.S. Bureau of Economic Analysis, so it captures full-time, part-time and sole proprietors as one. Because employment is a stock concept, the results cannot be aggregated over multiple years. They should be only interpreted as the impact in the single year relative to base year.

GDP

GDP is an accounting of all business transactions minus demand for intermediate goods and services. This ensures that dollars are not double counted in the production process and reflects net new economic activity. We included GDP as well as output because it better illustrates impacts to *growth* of the WA economy.

Personal Income

This concept is an aggregate of all sources of income to households across wages, supplemental income, rental income, and transfer payments.

Real Disposable Personal Income Per-capita

This concept captures the change in after tax real income on a per capita level and is reported directly from PI+. First, personal taxes are removed from total personal income. Then that value is multiplied by the PCE-Price Index (personal consumption expenditure). That figure is then divided by our annual total population projection for the state of Washington.

RESULTS: 50% pass-through of costs from energy producers to consumers

Table 1

Employment (Jobs)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	<10	-170	-640	-1020	-1320
Compliance 1 & 2 High	<10	-430	-1600	-2530	-3270
Compliance 3 Low	<10	-50	-170	-280	-360
Compliance 3 High	<10	-80	-310	-480	-630
Compliance 4 Low	<10	-100	-360	-570	-740
Compliance 4 High	<10	-100	-390	-610	-790
Compliance 5 Low	<10	-30	-100	-150	-200
Compliance 5 High	<10	-80	-320	-500	-650

Table 2

Gross Domestic Product (Millions of Inflation-Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.321	-19.542	-86.169	-157.793	-225.297
Compliance 1 & 2 High	0.802	-48.773	-214.679	-392.676	-560.017
Compliance 3 Low	0.087	-5.305	-23.414	-42.852	-61.226
Compliance 3 High	0.152	-9.282	-40.955	-74.996	-107.128
Compliance 4 Low	0.181	-11.037	-48.691	-89.169	-127.362
Compliance 4 High	0.193	-11.77	-51.922	-95.087	-135.81
Compliance 5 Low	0.043	-2.643	-11.666	-21.324	-30.475
Compliance 5 High	0.159	-9.682	-42.718	-78.228	-111.741

Table 3

Personal Income (Millions of Inflation-Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.186	-11.547	-53.842	-101.643	-144.505
Compliance 1 & 2 High	0.464	-28.819	-134.164	-253.054	-359.433
Compliance 3 Low	0.05	-3.135	-14.629	-27.585	-39.229
Compliance 3 High	0.088	-5.485	-25.589	-48.294	-68.677
Compliance 4 Low	0.105	-6.521	-30.423	-57.425	-81.66

	2017	2020	2025	2030	2035
Compliance 4 High	0.112	-6.954	-32.441	-61.238	-87.08
Compliance 5 Low	0.031	-2.041	-10.543	-21.928	-34.474
Compliance 5 High	0.092	-5.721	-26.691	-50.376	-71.637

Table 4

Real Disposable Personal Income per capita (Inflation Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.021	-1.872	-4.715	-5.171	-4.289
Compliance 1 & 2 High	0.052	-4.673	-11.743	-12.868	-10.655
Compliance 3 Low	0.006	-0.508	-1.281	-1.4	-1.163
Compliance 3 High	0.01	-0.889	-2.241	-2.455	-2.038
Compliance 4 Low	0.012	-1.057	-2.664	-2.92	-2.423
Compliance 4 High	0.013	-1.128	-2.841	-3.114	-2.585
Compliance 5 Low	0.003	-0.253	-0.638	-0.694	-0.576
Compliance 5 High	0.01	-0.928	-2.338	-2.561	-2.126

Table 5

Employment (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.004%	-0.015%	-0.023%	-0.029%
Compliance 1 & 2 High	0.000%	-0.010%	-0.037%	-0.058%	-0.071%
Compliance 3 Low	0.000%	-0.001%	-0.004%	-0.006%	-0.008%
Compliance 3 High	0.000%	-0.002%	-0.007%	-0.011%	-0.014%
Compliance 4 Low	0.000%	-0.002%	-0.008%	-0.013%	-0.016%
Compliance 4 High	0.000%	-0.002%	-0.009%	-0.014%	-0.017%
Compliance 5 Low	0.000%	-0.001%	-0.002%	-0.003%	-0.004%
Compliance 5 High	0.000%	-0.002%	-0.007%	-0.011%	-0.014%

Table 6

Gross Domestic Product (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.004%	-0.016%	-0.026%	-0.034%
Compliance 1 & 2 High	0.000%	-0.010%	-0.040%	-0.066%	-0.084%
Compliance 3 Low	0.000%	-0.001%	-0.004%	-0.007%	-0.009%
Compliance 3 High	0.000%	-0.002%	-0.008%	-0.013%	-0.016%
Compliance 4 Low	0.000%	-0.002%	-0.009%	-0.015%	-0.019%
Compliance 4 High	0.000%	-0.002%	-0.010%	-0.016%	-0.020%
Compliance 5 Low	0.000%	-0.001%	-0.002%	-0.004%	-0.005%
Compliance 5 High	0.000%	-0.002%	-0.008%	-0.013%	-0.017%

Table 7

Personal Income (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.003%	-0.012%	-0.020%	-0.025%
Compliance 1 & 2 High	0.000%	-0.007%	-0.029%	-0.049%	-0.063%
Compliance 3 Low	0.000%	-0.001%	-0.003%	-0.005%	-0.007%
Compliance 3 High	0.000%	-0.001%	-0.006%	-0.009%	-0.012%
Compliance 4 Low	0.000%	-0.002%	-0.007%	-0.011%	-0.014%
Compliance 4 High	0.000%	-0.002%	-0.007%	-0.012%	-0.015%
Compliance 5 Low	0.000%	0.000%	-0.002%	-0.003%	-0.004%
Compliance 5 High	0.000%	-0.001%	-0.006%	-0.010%	-0.013%

Table 8

Real Disposable Personal Income per capita (% Change from Baseline)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.004%	-0.009%	-0.009%	-0.008%
Compliance 1 & 2 High	0.000%	-0.010%	-0.023%	-0.024%	-0.019%
Compliance 3 Low	0.000%	-0.001%	-0.003%	-0.003%	-0.002%
Compliance 3 High	0.000%	-0.002%	-0.004%	-0.005%	-0.004%
Compliance 4 Low	0.000%	-0.002%	-0.005%	-0.005%	-0.004%
Compliance 4 High	0.000%	-0.002%	-0.006%	-0.006%	-0.005%
Compliance 5 Low	0.000%	-0.001%	-0.001%	-0.001%	-0.001%
Compliance 5 High	0.000%	-0.002%	-0.005%	-0.005%	-0.004%

RESULTS: 100% pass-through of costs from energy producers to consumers

Table 9

Employment (Jobs)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	<10	-290	-980	-1480	-1860
Compliance 1 & 2 High	10	-730	-2440	-3670	-4580
Compliance 3 Low	<10	-80	-270	-400	-510
Compliance 3 High	<10	-140	-470	-710	-880
Compliance 4 Low	<10	-170	-560	-840	-1050
Compliance 4 High	<10	-180	-590	-900	-1120
Compliance 5 Low	<10	-40	-150	-220	-280
Compliance 5 High	<10	-150	-490	-740	-920

Table 10

Gross Domestic Product (Millions of Inflation-Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.5138	-32.0904	-127.2344	-224.7416	-314.4723
Compliance 1 & 2 High	1.286	-79.929	-315.573	-555.663	-775.672
Compliance 3 Low	0.139	-8.721	-34.649	-61.301	-85.879
Compliance 3 High	0.244	-15.253	-60.569	-107.11	-150.004
Compliance 4 Low	0.29	-18.134	-71.991	-127.283	-178.229
Compliance 4 High	0.309	-19.338	-76.759	-135.701	-190.005
Compliance 5 Low	0.076	-4.78	-18.999	-33.621	-47.111
Compliance 5 High	0.254	-15.91	-63.173	-111.71	-156.441

Table 11

Personal Income (Millions of Inflation-Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.3142	-19.4946	-81.3301	-146.7369	-202.2958
Compliance 1 & 2 High	0.787	-48.563	-201.806	-363.056	-499.468
Compliance 3 Low	0.085	-5.297	-22.143	-40.011	-55.217
Compliance 3 High	0.149	-9.266	-38.711	-69.916	-96.461
Compliance 4 Low	0.177	-11.016	-46.012	-83.088	-114.619
Compliance 4 High	0.189	-11.747	-49.059	-88.584	-122.195
Compliance 5 Low	0.047	-2.904	-12.141	-21.943	-30.289
Compliance 5 High	0.155	-9.665	-40.375	-72.92	-100.602

Table 12

Real Disposable Personal Income per capita (Inflation Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.0285	-3.1087	-6.9135	-7.1854	-5.6858
Compliance 1 & 2 High	0.071	-7.743	-17.138	-17.737	-13.975
Compliance 3 Low	0.008	-0.845	-1.883	-1.961	-1.555
Compliance 3 High	0.014	-1.478	-3.292	-3.426	-2.716
Compliance 4 Low	0.016	-1.757	-3.912	-4.071	-3.226
Compliance 4 High	0.017	-1.873	-4.171	-4.34	-3.439
Compliance 5 Low	0.004	-0.463	-1.033	-1.076	-0.854
Compliance 5 High	0.014	-1.541	-3.433	-3.573	-2.832

Table 13

Employment (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.007%	-0.023%	-0.034%	-0.041%
Compliance 1 & 2 High	0.000%	-0.017%	-0.056%	-0.083%	-0.100%
Compliance 3 Low	0.000%	-0.002%	-0.006%	-0.009%	-0.011%
Compliance 3 High	0.000%	-0.003%	-0.011%	-0.016%	-0.019%
Compliance 4 Low	0.000%	-0.004%	-0.013%	-0.019%	-0.023%
Compliance 4 High	0.000%	-0.004%	-0.014%	-0.020%	-0.024%
Compliance 5 Low	0.000%	-0.001%	-0.003%	-0.005%	-0.006%
Compliance 5 High	0.000%	-0.003%	-0.011%	-0.017%	-0.020%

Table 14

Gross Domestic Product (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.007%	-0.024%	-0.038%	-0.047%
Compliance 1 & 2 High	0.000%	-0.017%	-0.059%	-0.093%	-0.117%
Compliance 3 Low	0.000%	-0.002%	-0.006%	-0.010%	-0.013%
Compliance 3 High	0.000%	-0.003%	-0.011%	-0.018%	-0.023%
Compliance 4 Low	0.000%	-0.004%	-0.013%	-0.021%	-0.027%
Compliance 4 High	0.000%	-0.004%	-0.014%	-0.023%	-0.029%
Compliance 5 Low	0.000%	-0.001%	-0.004%	-0.006%	-0.007%
Compliance 5 High	0.000%	-0.003%	-0.012%	-0.019%	-0.024%

Table 15

Personal Income (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.005%	-0.018%	-0.028%	-0.036%
Compliance 1 & 2 High	0.000%	-0.012%	-0.044%	-0.070%	-0.088%
Compliance 3 Low	0.000%	-0.001%	-0.005%	-0.008%	-0.010%
Compliance 3 High	0.000%	-0.002%	-0.008%	-0.013%	-0.017%
Compliance 4 Low	0.000%	-0.003%	-0.010%	-0.016%	-0.020%
Compliance 4 High	0.000%	-0.003%	-0.011%	-0.017%	-0.022%
Compliance 5 Low	0.000%	-0.001%	-0.003%	-0.004%	-0.005%
Compliance 5 High	0.000%	-0.002%	-0.009%	-0.014%	-0.018%

Table 16

Real Disposable Personal Income per capita (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.007%	-0.014%	-0.013%	-0.010%
Compliance 1 & 2 High	0.000%	-0.017%	-0.034%	-0.033%	-0.025%
Compliance 3 Low	0.000%	-0.002%	-0.004%	-0.004%	-0.003%
Compliance 3 High	0.000%	-0.003%	-0.007%	-0.006%	-0.005%
Compliance 4 Low	0.000%	-0.004%	-0.008%	-0.007%	-0.006%
Compliance 4 High	0.000%	-0.004%	-0.008%	-0.008%	-0.006%
Compliance 5 Low	0.000%	-0.001%	-0.002%	-0.002%	-0.002%
Compliance 5 High	0.000%	-0.003%	-0.007%	-0.007%	-0.005%

Energy Price Impacts

Methodology

For the purpose of determining the potential range of impacts to energy prices, the REMI team used the Washington State calibrated CTAM model from the Washington Department of Commerce.[3] The following results are determined solely by CTAM and not by the REMI PI+ model. CTAM was developed for the purpose of determining the revenue and price impacts from a potential carbon tax. To remain consistent with previous work, we determined the best way to estimate price impacts would be to assume that the costs of compliance under the 50% and 100% pass-through scenarios for each compliance strategy would be equivalent to costs generated from a carbon price. The energy price impacts are shown across four energy types.

- Residential Electricity
- Residential Natural Gas
- Motor Gasoline
- Diesel

The results reflect a percentage change calculated in CTAM from a difference between baseline costs and adjusted costs given a carbon price that raised an equivalent amount of revenue as the cost provided by Ecology.

The cost allocation under the pass-through scenarios described in the economic impact methodology was selected given the relative distribution of costs across the below consumer types was most similar with the distribution within CTAM.

- Residential
- Commercial
- Industrial
- Transportation

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[3] http://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/

The below results contain high and low estimates of the potential price impacts. CTAM provides several year estimates and therefore we also include two years of results as snapshots of the potential impact. The high and low price impact is based on the high and low level of cost estimates for each compliance option provided by Ecology.

Energy Price Results

Table 17

Compliance 1 & 2	High		Low	
	2020	**2035**	**2020**	**2035**
Electricity (Residential and Industrial) (¢/kWh)	1.4%	9.2%	0.6%	3.7%
Natural Gas (Residential) ($/therm)	0.8%	5.6%	0.3%	2.2%
Natural Gas (Industrial) ($/mmBtu)	1.4%	10.2%	0.5%	3.9%
Motor Gasoline ($/gal)	0.5%	3.3%	0.2%	1.3%
Diesel Fuel ($/gal)	0.5%	3.3%	0.2%	1.3%

Table 18

Compliance 3	High		Low	
	2020	**2035**	**2020**	**2035**
Electricity (Residential and Industrial) (¢/kWh)	0.3%	1.8%	0.2%	1.0%
Natural Gas (Residential) ($/therm)	0.1%	1.0%	0.1%	0.6%
Natural Gas (Industrial) ($/mmBtu)	0.3%	1.9%	0.1%	1.1%
Motor Gasoline ($/gal)	0.1%	0.6%	0.1%	0.3%
Diesel Fuel ($/gal)	0.1%	0.6%	0.1%	0.3%

Table 19

Compliance 4	High		Low	
	2020	**2035**	**2020**	**2035**
Electricity (Residential and Industrial) (¢/kWh)	0.3%	2.3%	0.3%	2.1%
Natural Gas (Residential) ($/therm)	0.2%	1.3%	0.2%	1.2%
Natural Gas (Industrial) ($/mmBtu)	0.3%	2.4%	0.3%	2.2%
Motor Gasoline ($/gal)	0.1%	0.8%	0.1%	0.7%
Diesel Fuel ($/gal)	0.1%	0.8%	0.1%	0.7%

Table 20

Compliance 5	High		Low	
	2020	**2035**	**2020**	**2035**
Electricity (Residential and Industrial) (¢/kWh)	0.3%	1.9%	0.1%	0.5%
Natural Gas (Residential) ($/therm)	0.2%	1.1%	0.0%	0.3%
Natural Gas (Industrial) ($/mmBtu)	0.3%	2.0%	0.1%	0.5%
Motor Gasoline ($/gal)	0.1%	0.6%	0.0%	0.2%
Diesel Fuel ($/gal)	0.1%	0.6%	0.0%	0.2%

Energy Cost Impacts Per-Household

Given the above changes in relative energy costs, we can also determine a potential range of annual average cost increases to households. Baseline household energy consumption values[4] from 2014 were taken from electricity, natural gas, and petroleum and multiplied by the expected percentage changes in each energy type from the above tables. The total change in household expenditures by energy category was divided by the number of households in WA[5] to equal the expected change in expenditures by year. The annual increase in costs reflect the percent change in energy costs from future years under the 100% pass-through scenario given the number of households, energy costs, and average consumption in WA in 2014. These estimates should be seen as conservative as they do not account for an elasticity of demand given the price increase.

Table 21

Compliance 1 & 2	High		Low	
Change in Average Household Consumption (2014)	**2020 price impact**	**2035 price impact**	**2020 price impact**	**2035 price impact**
Electricity	$16.15	$106.15	$6.92	$42.69
Natural Gas	$2.55	$17.86	$0.96	$7.02

Table 22

Compliance 3	High		Low	
Change in Average Household Consumption (2014)	**2020 price impact**	**2035 price impact**	**2020 price impact**	**2035 price impact**
Electricity	$3.46	$20.77	$2.31	$11.54
Natural Gas	$0.32	$3.19	$0.32	$1.91

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[4] https://www.eia.gov/state/data.cfm?sid=WA
[5] http://www.census.gov/quickfacts/table/HSD410214/53

Table 23

Compliance 4	2014 High		2014 Low	
Change in Average Household Consumption (2014)	**2020 price impact**	**2035 price impact**	**2020 price impact**	**2035 price impact**
Electricity	$3.46	$26.54	$3.46	$24.23
Natural Gas	$0.64	$4.15	$0.64	$3.83

Table 24

Compliance 5	2014 High		2014 Low	
Change in Average Household Consumption (2014)	**2020 price impact**	**2035 price impact**	**2020 price impact**	**2035 price impact**
Electricity	$3.46	$21.92	$1.15	$5.77
Natural Gas	$0.64	$3.51	$0.00	$0.96

Cost of Gasoline

Using the average percentage changes to the cost of motor vehicle fuel, we are also able to estimate the potential change in the cost per gallon of gasoline. Given the annual average price per gallon of gas for the state of Washington in 2015[6], the below table represents the per dollar increase under each future price impact from the CTAM simulations explained earlier.

Table 25

Dollar Change in Per Gallon Cost of Motor Vehicle Fuel	High		Low	
2015 Average Per Gallon Price of $2.75	**2020 price impact**	**2035 price impact**	**2020 price impact**	**2035 price impact**
Compliance 1 & 2	$0.01	$0.09	$0.01	$0.04
Compliance 3	$0.00	$0.02	$0.00	$0.01
Compliance 4	$0.00	$0.02	$0.00	$0.02
Compliance 5	$0.00	$0.02	$0.00	$0.01

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[6] https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_swa_a.htm

About Us

REMI

REMI was founded on the belief that impartial economic analysis is critical to sound decision making. It has been evaluating the fiscal and economic consequences of public policy for more than 35 years, including energy and environmental regulations. REMI has extensive experience with understanding how government actions and policy changes affect the economy. Our models are based on peer-reviewed research and years of study and development, and we have collaborated with government agencies, universities, and consultants throughout North America, Asia and the Middle East. At REMI, we develop and license economic models, as simulation tools to understand the broad impact of policy. For this project, we developed and used a 160 sector PI+ model. PI+ is a structural economic and demographic forecasting and simulation model that represents how a regional economy works and more importantly, how it responds to outside or exogenous shocks, including policy related, international, or of natural causes.

Washington State Office of Financial Management

The Office of Financial Management provides vital information, fiscal services and policy support that the Governor, Legislature and state agencies need to serve the people of Washington State. The OFM plays a central role in budget planning, policy development, and fiscal administration for the executive branch. It prepares the executive budget proposal, monitors changes in the state economy and labor force, and conducts research on a variety of issues affecting the state budget and public policy.

Appendix I: PI+ Model Information

PI[+] is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to compensation, price, and other economic factors.

The model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the specific model being used. The overall structure of the model can be summarized in five major blocks: (1) Output and Demand, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Compensation, Prices, and Costs, and (5) Market Shares. The blocks and their key interactions are shown in Figures 1 and 2.

Figure 1: REMI Model Linkages

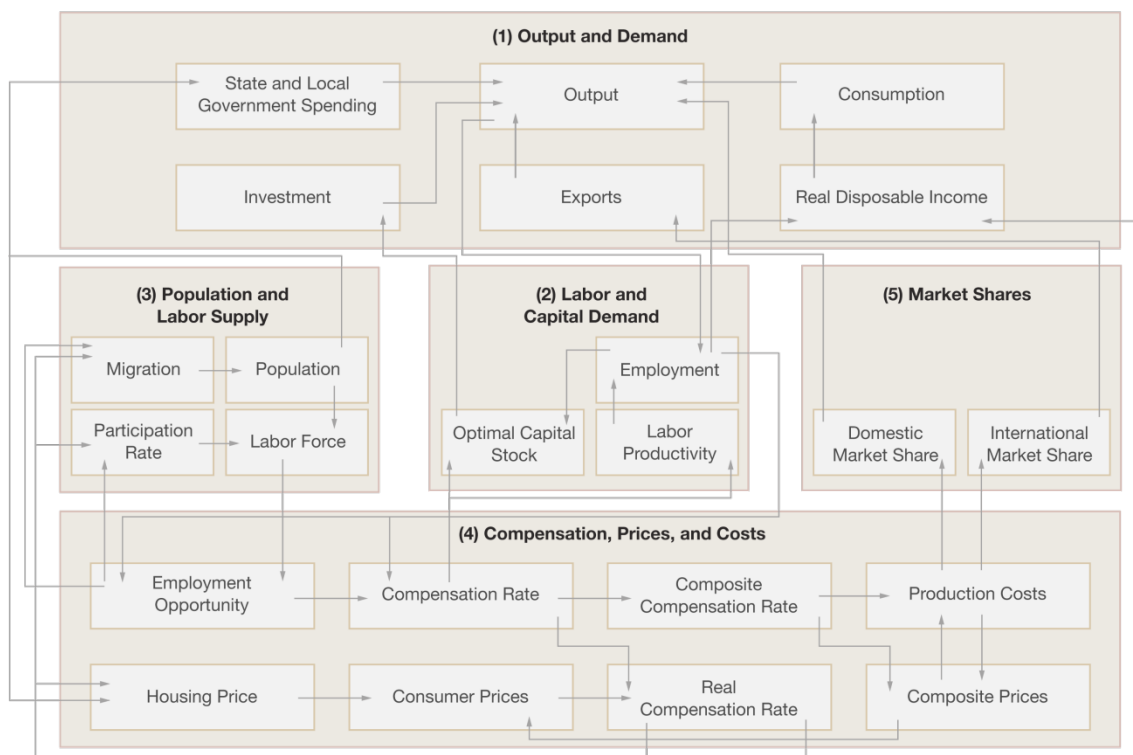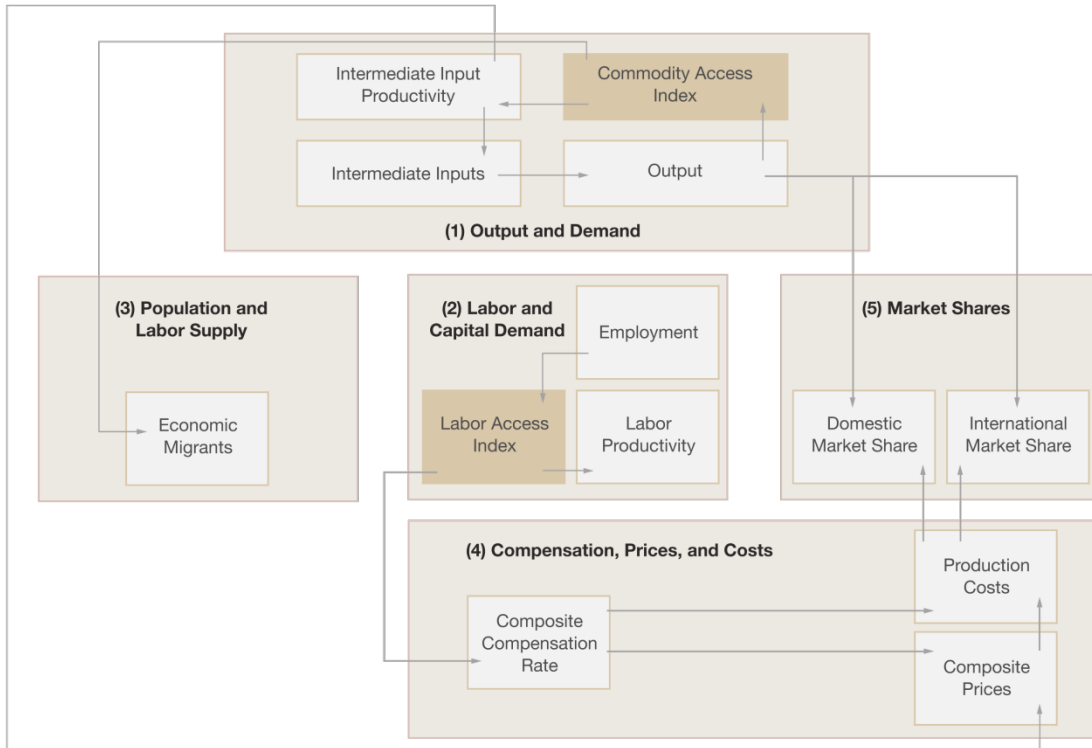REMI Model Linkages (Excluding Economic Geography Linkages)

Figure 2: Economic Geography Linkages

The Output and Demand block consists of output, demand, consumption, investment, government spending, exports, and imports, as well as feedback from output change due to the change in the productivity of intermediate inputs. The Labor and Capital Demand block includes labor intensity and productivity as well as demand for labor and capital. Labor force participation rate and migration equations are in the Population and Labor Supply block. The Compensation, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the compensation equations. The proportion of local, inter-regional, and export markets captured by each region is included in the Market Shares block.

Models can be built as single-region, multi-region, or multi-region national models. A region is defined broadly as a sub-national area, and could consist of a state, province, county, or city, or any combination of sub-national areas.

Single-region models consist of an individual region, called the home region. The rest of the nation is also represented in the model. However, since the home region is only a small part of the total nation, the changes in the region do not have an endogenous effect on the variables in the rest of the nation.

Multi-regional models have interactions among regions, such as trade and commuting flows. These interactions include trade flows from each region to each of the other regions. These flows are illustrated for a three-region model in Figure 3.

Figure 3: Trade and Commuter Flow Linkages

I. Trade and Commuter Flow Linkages
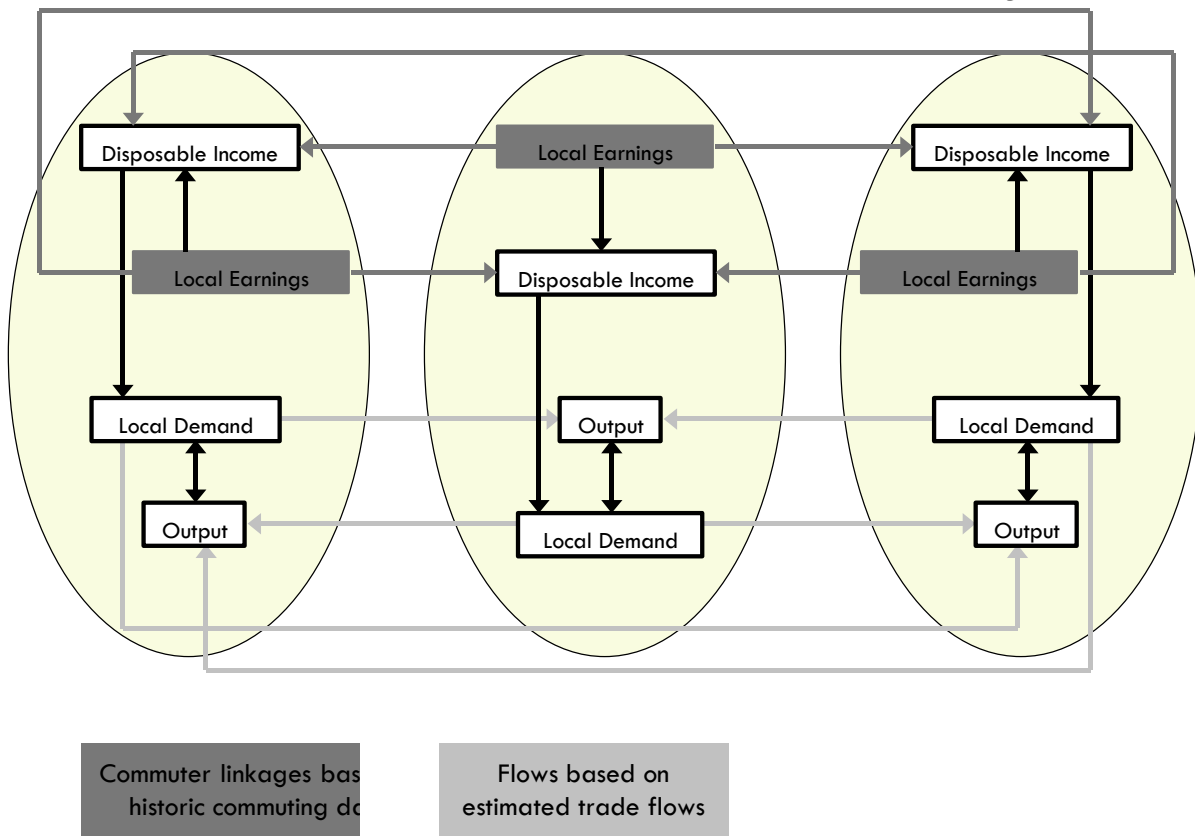
Multiregional national models also include a central bank monetary response that constrains labor markets. Models that only encompass a relatively small portion of a nation are not endogenously constrained by changes in exchange rates or monetary responses.

A. Block 1. Output and Demand

This block includes output, demand, consumption, investment, government spending, import, commodity access, and export concepts. Output for each industry in the home region is determined by industry demand in all regions in the nation, the home region's share of each market, and international exports from the region.

For each industry, demand is determined by the amount of output, consumption, investment, and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities, and population. Input productivity depends on access to inputs because a larger choice set of inputs means it is more likely that the input with the specific characteristics required for the job will be found. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

B. Block 2. Labor and Capital Demand

The Labor and Capital Demand block includes the determination of labor productivity, labor intensity, and the optimal capital stocks. Industry-specific labor productivity depends on the availability of

workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

C.   Block 3. Population and Labor Supply

The Population and Labor Supply block includes detailed demographic information about the region. Population data is given for age, gender, and race, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply. These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after-tax compensation rate. Migration includes retirement, military, international, and economic migration. Economic migration is determined by the relative real after-tax compensation rate, relative employment opportunity, and consumer access to variety.

D.   Block 4. Compensation, Prices and Costs

This block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the compensation equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods, and services.

These prices measure the price of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs of distance are significant.   Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of outputs in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by the cost of labor, capital, fuel, and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying compensation rates. Capital costs include costs of non-residential structures and equipment, while fuel costs incorporate electricity, natural gas, and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices. Housing prices change from their initial level depending on changes in income and population density.

Compensation changes are due to changes in labor demand and supply conditions and changes in the national compensation rate. Changes in employment opportunities relative to the labor force and occupational demand change determine compensation rates by industry.

E.   Block 5. Market Shares

The market shares equations measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and the effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

Appendix II: Simulation Inputs

Table 26: Compliance 1 & 2 High Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$5,837,696.51	$16,401,147.34	$38,639,991.20	$60,878,835.05
Production Cost (Electric power generation, transmission, and distribution)	-$492,441.17	$8,717,256.45	$24,066,752.49	$39,928,872.85	$55,763,620.06
Production Cost (Natural gas distribution)	$3,068,887.06	$33,143,980.22	$83,269,135.49	$133,394,290.75	$183,519,446.02
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$192,771.35
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	$299,681.64	$1,342,396.45	$2,357,047.106
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$545,529.63	$5,864,443.56	$11,183,357.49	$16,926,185.40
Production Cost (Petroleum and coal products manufacturing)	-$7,248,580.24	$86,678,040.86	$243,222,409.36	$399,766,777.86	$556,311,146.36
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$84,534.11	$908,741.73	$1,732,949.35	$2,557,156.96
Production Cost (Glass and glass product manufacturing)	$0.00	$58,021.40	$623,730.02	$1,189,438.64	$2,197,425.54
Production Cost (Cement and concrete product manufacturing)	$0.00	$240,616.96	$2,586,632.37	$4,932,647.77	$7,278,663.17
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$76,633.18	$823,806.71	$1,570,980.24	$2,318,153.76
Production Cost (Alumina and aluminum production and processing)	$0.00	$955,923.29	$10,276,175.39	$19,596,427.49	$28,916,679.59
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$78,633.20	$845,306.94	$1,611,980.67	$2,378,654.40
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$94,287.57	$1,013,591.34	$1,932,895.12	$2,852,198.89
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$194,042.19
Production Cost (Pipeline transportation)	$0.00	$54,654.59	$587,536.85	$1,613,981.86	$3,072,294.28
Production Cost (Monetary authorities, credit intermediation, and related activities)	$34,581.61	$843,791.20	$2,192,473.86	$3,541,156.52	$4,889,839.18
Production Cost (Waste management and remediation services)	$151,843.35	$3,704,977.83	$9,626,868.63	$15,548,759.43	$21,470,650.23
Production Cost (Educational services)	$0.00	$0.00	$0.00	$252,377.88	$725,586.40

Table 27: Compliance 1 & 2 Low Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$2,335,078.60	$6,560,458.94	$15,455,996.48	$24,351,534.02
Production Cost (Electric power generation, transmission, and distribution)	-$196,976.47	$3,486,902.58	$9,626,701.00	$15,971,549.14	$22,305,448.02
Production Cost (Natural gas distribution)	$1,227,554.82	$13,257,592.09	$33,307,654.19	$53,357,716.30	$73,407,778.41

Policy Variable Used					
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$77,108.54
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	$119,872.66	$536,958.58	$942,818.84
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$218,211.85	$2,345,777.42	$4,473,343.00	$6,770,474.16
Production Cost (Petroleum and coal products manufacturing)	-$2,899,432.10	$34,671,216.34	$97,288,963.74	$159,906,711.14	$222,524,458.55
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$33,813.65	$363,496.69	$693,179.74	$1,022,862.79
Production Cost (Glass and glass product manufacturing)	$0.00	$23,208.56	$249,492.01	$475,775.46	$878,970.22
Production Cost (Cement and concrete product manufacturing)	$0.00	$96,246.79	$1,034,652.95	$1,973,059.11	$2,911,465.27
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$30,653.27	$329,522.68	$628,392.09	$927,261.51
Production Cost (Alumina and aluminum production and processing)	$0.00	$382,369.32	$4,110,470.16	$7,838,571.00	$11,566,671.83
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$31,453.28	$338,122.77	$644,792.27	$951,461.76
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$37,715.03	$405,436.54	$773,158.05	$1,140,879.56
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$77,616.87
Production Cost (Pipeline transportation)	$0.00	$21,861.84	$235,014.74	$645,592.74	$1,228,917.71
Production Cost (Monetary authorities, credit intermediation, and related activities)	$13,832.64	$337,516.48	$876,989.54	$1,416,462.61	$1,955,935.67
Production Cost (Waste management and remediation services)	$60,737.34	$1,481,991.13	$3,850,747.45	$6,219,503.77	$8,588,260.09
Production Cost (Educational services)	$0.00	$0.00	$0.00	$100,951.15	$290,234.56

Table 28: Compliance 3 High Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$1,108,470.33	$3,114,273.78	$7,337,017.88	$11,559,761.99
Production Cost (Electric power generation, transmission, and distribution)	-$93,505.45	$1,655,245.37	$4,569,830.06	$7,581,752.61	$10,588,477.51
Production Cost (Natural gas distribution)	$582,724.75	$6,293,427.30	$15,811,264.89	$25,329,102.48	$34,846,940.07
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$36,603.70
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	$56,903.99	$254896.20	$447559.54
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$103,585.96	$1,113,549.10	$2,123,512.23	$3,213,968.77
Production Cost (Petroleum and coal products manufacturing)	-$1,376,370.99	$16,458,552.82	$46,183,425.83	$75,908,298.83	$105,633,171.84
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$16,051.46	$172,553.21	$329,054.95	$485,556.69
Production Cost (Glass and glass product manufacturing)	$0.00	$11,017.19	$118,434.77	$225,852.34	$417,250.37

Policy Variable Used					
Production Cost (Cement and concrete product manufacturing)	$0.00	$45,688.70	$491,153.53	$936,618.35	$1,382,083.18
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$14,551.22	$156,425.62	$298,300.02	$440,174.42
Production Cost (Alumina and aluminum production and processing)	$0.00	$181,512.11	$1,951,255.17	$3,720,998.23	$5,490,741.29
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$14,930.99	$160,508.11	$306,085.24	$451,662.37
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$17,903.46	$192,462.20	$367,020.94	$541,579.69
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$36,845.01
Production Cost (Pipeline transportation)	$0.00	$10,377.89	$111,562.35	$306,465.23	$583,371.72
Production Cost (Monetary authorities, credit intermediation, and related activities)	$6,566.41	$160,220.30	$416,310.13	$672,399.97	$928,489.80
Production Cost (Waste management and remediation services)	$28,832.24	$703,506.59	$1,827,963.86	$2,952,421.12	$4,076,878.38
Production Cost (Educational services)	$0.00	$0.00	$0.00	$47,921.88	$137,775.40

Table 29: Compliance 3 Low Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$633,411.62	$1,779,585.02	$4,192,581.65	$6,605,578.28
Production Cost (Electric power generation, transmission, and distribution)	-$53,431.68	$945,854.50	$2,611,331.47	$4,332,430.06	$6,050,558.58
Production Cost (Natural gas distribution)	$332,985.57	$3,596,244.17	$9,035,008.51	$14,473,772.85	$19,912,537.18
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$20,916.40
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	$32,516.56	$145654.97	$255748.31
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$59,191.98	$636,313.77	$1,213,435.56	$1,836,553.58
Production Cost (Petroleum and coal products manufacturing)	-$786,497.71	$9,404,887.32	$26,390,529.04	$43,376,170.76	$60,361,812.48
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$9,172.26	$98,601.83	$188,031.40	$277,460.97
Production Cost (Glass and glass product manufacturing)	$0.00	$6,295.54	$67,677.01	$129,058.48	$238,428.78
Production Cost (Cement and concrete product manufacturing)	$0.00	$26,107.83	$280,659.16	$535,210.49	$789,761.82
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$8,314.98	$89,386.07	$170,457.15	$251,528.24
Production Cost (Alumina and aluminum production and processing)	$0.00	$103,721.21	$1,115,002.95	$2,126,284.70	$3,137,566.45
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$8,531.99	$91,718.92	$174,905.85	$258,092.78
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$10,230.55	$109,978.40	$209,726.25	$309,474.11
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$21,054.29
Production Cost (Pipeline transportation)	$0.00	$5,930.22	$63,749.92	$175,122.99	$333,355.27

Policy Variable Used					
Production Cost (Monetary authorities, credit intermediation, and related activities)	$3,752.23	$91,554.46	$237,891.51	$384,228.55	$530,565.60
Production Cost (Waste management and remediation services)	$16,475.56	$402,003.77	$1,044,550.77	$1,687,097.78	$2,329,644.79
Production Cost (Educational services)	$0.00	$0.00	$0.00	$27,383.93	$78,728.80

Table 30: Compliance 4 High Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$1,405,714.84	$3,949,389.30	$9,304,493.44	$14,659,597.57
Production Cost (Electric power generation, transmission, and distribution)	-$118,579.62	$2,099,111.64	$5,795,263.76	$9,614,855.59	$13,427,855.98
Production Cost (Natural gas distribution)	$738,986.70	$7,981,056.33	$20,051,172.39	$32,121,288.45	$44,191,404.51
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$46,419.26
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	$71,163.21	323248.49	567575.94
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$131,363.30	$1,412,155.51	$2,692,947.72	$4,075,818.24
Production Cost (Petroleum and coal products manufacturing)	-$1,745,455.04	$20,872,035.35	$58,567,852.67	$96,263,669.99	$133,959,487.31
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$20,355.78	$218,824.62	$417,293.47	$615,762.31
Production Cost (Glass and glass product manufacturing)	$0.00	$13,971.53	$150,193.92	$286,416.32	$529,139.14
Production Cost (Cement and concrete product manufacturing)	$0.00	$57,940.46	$622,859.97	$1,187,779.48	$1,752,699.00
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$18,453.24	$198,372.31	$378,291.37	$558,210.44
Production Cost (Alumina and aluminum production and processing)	$0.00	$230,185.92	$2,474,498.66	$4,718,811.40	$6,963,124.14
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$18,934.84	$203,549.55	$388,164.26	$572,778.97
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$22,704.41	$244,072.36	$465,440.32	$686,808.28
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$46,725.28
Production Cost (Pipeline transportation)	$0.00	$13,160.80	$141,478.62	$388,646.14	$739,807.15
Production Cost (Monetary authorities, credit intermediation, and related activities)	$8,327.24	$203,184.56	$527,946.77	$852,708.98	$1,177,471.19
Production Cost (Waste management and remediation services)	$36,563.81	$892,157.09	$2,318,145.87	$3,744,134.65	$5,170,123.44
Production Cost (Educational services)	$0.00	$0.00	$0.00	$60,772.49	$174,720.90

Table 31: Compliance 4 Low Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$1,318,137.66	$3,703,339.13	$8,724,815.92	$13,746,292.71
Production Cost (Electric power generation, transmission, and distribution)	-$111,192.02	$1,968,335.28	$5,434,214.11	$9,015,842.26	$12,591,289.62

Production Cost (Natural gas distribution)	$692,947.22	$7,483,830.02	$18,801,968.02	$30,120,106.02	$41,438,244.01
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$43,527.30
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	67667.39	303109.85	532215.50
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$123,179.26	$1,324,177.08	$2,525,174.89	$3,821,891.45
Production Cost (Petroleum and coal products manufacturing)	-$1,636,711.77	$19,571,690.55	$54,919,027.75	$90,266,364.95	$125,613,702.15
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$19,087.60	$205,191.67	$391,295.74	$577,399.82
Production Cost (Glass and glass product manufacturing)	$0.00	$13,101.09	$140,836.72	$268,572.35	$496,173.34
Production Cost (Cement and concrete product manufacturing)	$0.00	$54,330.72	$584,055.29	$1,113,779.85	$1,643,504.42
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$17,303.59	$186,013.55	$354,723.51	$523,433.47
Production Cost (Alumina and aluminum production and processing)	$0.00	$215,845.15	$2,320,335.38	$4,424,825.61	$6,529,315.83
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$17,755.19	$190,868.25	$363,981.31	$537,094.37
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$21,289.90	$228,866.46	$436,443.01	$644,019.56
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$43,814.25
Production Cost (Pipeline transportation)	$0.00	$12,340.87	$132,664.39	$364,433.17	$693,716.57
Production Cost (Monetary authorities, credit intermediation, and related activities)	$7,808.44	$190,526.00	$495,055.26	$799,584.52	$1,104,113.78
Production Cost (Waste management and remediation services)	$34,285.86	$836,574.97	$2,173,723.49	$3,510,872.02	$4,848,020.54
Production Cost (Educational services)	$0.00	$0.00	$0.00	$56,986.31	$163,835.64

Table 32: Compliance 5 High Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$1,156,261.01	$3,248,542.82	$7,653,346.65	$12,058,150.48
Production Cost (Electric power generation, transmission, and distribution)	-$97,536.85	$1,726,609.75	$4,766,854.08	$7,908,632.89	$11,044,989.96
Production Cost (Natural gas distribution)	$607,848.39	$6,564,762.63	$16,492,953.02	$26,421,143.41	$36,349,333.80
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$38,181.84
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	59357.35	265885.81	466855.66
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$108,051.98	$1,161,558.74	$2,215,065.51	$3,352,536.07
Production Cost (Petroleum and coal products manufacturing)	-$1,435,711.96	$17,168,148.17	$48,174,581.70	$79,181,015.24	$110,187,448.77
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$16,743.50	$179,992.68	$343,241.85	$506,491.02

	2017	2020	2025	2030	2035
Production Cost (Glass and glass product manufacturing)	$0.00	$11,492.18	$123,540.97	$235,589.76	$435,239.73
Production Cost (Cement and concrete product manufacturing)	$0.00	$47,658.53	$512,329.16	$976,999.79	$1,441,670.42
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$15,178.58	$163,169.77	$311,160.95	$459,152.13
Production Cost (Alumina and aluminum production and processing)	$0.00	$189,337.84	$2,035,381.74	$3,881,425.64	$5,727,469.55
Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$15,574.72	$167,428.27	$319,281.82	$471,135.37
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$18,675.35	$200,760.03	$382,844.71	$564,929.39
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$38,433.55
Production Cost (Pipeline transportation)	$0.00	$10,825.33	$116,372.26	$319,678.20	$608,523.25
Production Cost (Monetary authorities, credit intermediation, and related activities)	$6,849.51	$167,128.06	$434,258.96	$701,389.87	$968,520.78
Production Cost (Waste management and remediation services)	$30,075.31	$733,837.63	$1,906,774.83	$3,079,712.04	$4,252,649.24
Production Cost (Educational services)	$0.00	$0.00	$0.00	$49,987.99	$143,715.46

Table 33: Compliance 5 Low Inputs

Policy Variable Used	2017	2020	2025	2030	2035
Production Cost (Wholesale trade)	$0.00	-$347,081.87	$975,134.77	$2,297,351.42	$3,619,568.06
Production Cost (Electric power generation, transmission, and distribution)	-$29,278.23	$518,286.91	$1,430,895.46	$2,373,982.23	$3,315,441.53
Production Cost (Natural gas distribution)	$182,461.53	$1,970,584.56	$4,950,789.59	$7,930,994.63	$10,911,199.67
Production Cost (Water, sewage, and other systems)	$0.00	$0.00	$0.00	$0.00	$11,461.27
Production Cost (Fruit and vegetable preserving and specialty food manufacturing)	$0.00	$0.00	17817.66	79812.55	140138.89
Production Cost (Pulp, paper, and paperboard mills)	$0.00	$32,434.62	$348,672.12	$664,909.63	$1,006,351.06
Production Cost (Petroleum and coal products manufacturing)	-$430,966.35	$5,153,467.01	$14,460,855.95	$23,768,244.89	$33,075,633.83
Production Cost (Pesticide, fertilizer, and other agricultural chemical manufacturing)	$0.00	$5,026.00	$54,029.49	$103,032.99	$152,036.48
Production Cost (Glass and glass product manufacturing)	$0.00	$3,449.68	$37,084.04	$70,718.40	$130,648.55
Production Cost (Cement and concrete product manufacturing)	$0.00	$14,305.95	$153,788.95	$293,271.94	$432,754.94
Production Cost (Iron and steel mills and ferroalloy manufacturing)	$0.00	$4,556.25	$48,979.66	$93,403.07	$137,826.48
Production Cost (Alumina and aluminum production and processing)	$0.00	$56,834.69	$610,972.86	$1,165,111.04	$1,719,249.22

Production Cost (Nonferrous metal (except aluminum) production and processing)	$0.00	$4,675.16	$50,257.96	$95,840.76	$141,423.56
Production Cost (Semiconductor and other electronic component manufacturing)	$0.00	$5,605.89	$60,263.35	$114,920.82	$169,578.28
Production Cost (Aerospace product and parts manufacturing)	$0.00	$0.00	$0.00	$0.00	$11,536.83
Production Cost (Pipeline transportation)	$0.00	$3,249.50	$34,932.17	$95,959.74	$182,664.11
Production Cost (Monetary authorities, credit intermediation, and related activities)	$2,056.06	$50,167.84	$130,354.14	$210,540.45	$290,726.75
Production Cost (Waste management and remediation services)	$9,027.89	$220,280.49	$572,368.15	$924,455.81	$1,276,543.48
Production Cost (Educational services)	$0.00	$0.00	$0.00	$15,005.20	$43,139.94

Appendix III: Allocation of Costs to Energy Producers Passed to Consumers

As described in the report, under the pass-through scenarios for each compliance strategy, costs to energy producing industries were assumed to be passed on to consumers directly. That allowed us to run the model with both production cost variables and energy cost and price variables. The below tables show the allocation of costs to consumers for each type of fuel production. The allocation for each fuel type is taken from the CTAM baseline for total annual consumption by consumer type.

Table 34: Allocation of Electricity
(Electric Power Generation,
Transmission and Distribution)

Policy Variable Used	Consumer Type	2017	2020	2025	2030	2035
Consumer Price - Electricity	Residential	40.1%	39.0%	37.6%	35.5%	34.1%
Electricity Fuel Cost (Commercial Sectors Except Transportation)	Commercial	39.9%	39.1%	38.1%	37.9%	38.6%
Electricity Fuel Cost (Industrial Sectors)	Industrial	19.9%	21.4%	23.2%	24.8%	25.1%
Electricity Fuel Cost (Transportation Sectors)	Transportation	0.2%	0.5%	1.1%	1.8%	2.2%

Table 35: Allocation of Natural Gas
(Natural Gas Distribution)

Policy Variable Used	Consumer Type	2017	2020	2025	2030	2035
Consumer Price - Electricity	Residential	36.3%	35.4%	34.8%	33.9%	32.8%
Electricity Fuel Cost (Commercial Sectors Except Transportation)	Commercial	24.4%	24.2%	24.0%	23.9%	24.0%
Electricity Fuel Cost (Industrial Sectors)	Industrial	39.3%	40.5%	41.1%	42.2%	43.2%
Electricity Fuel Cost (Transportation Sectors)	Transportation	0.0%	0.0%	0.0%	0.0%	0.0%

*Table 36: Allocation of Petroleum
(Petroleum and Coal Product
Manufacturing)*

Policy Variable Used	Consumer Type	2017	2020	2025	2030	2035
Consumer Price - Electricity	Residential	2.0%	1.8%	1.8%	1.8%	1.8%
Electricity Fuel Cost (Commercial Sectors Except Transportation)	Commercial	2.1%	2.0%	2.1%	2.2%	2.2%
Electricity Fuel Cost (Industrial Sectors)	Industrial	5.4%	5.6%	6.0%	6.2%	6.3%
Electricity Fuel Cost (Transportation Sectors)	Transportation	90.6%	90.5%	90.1%	89.8%	89.8%

Appendix IV: Analytic results with no direct pass-through to energy prices

To review, these tables represent the economic impacts generated from PI+, when we use the production cost variable for energy producers, rather than passing on any cost increases directly to consumers. The model does capture changes in energy costs to consumers but only indirectly.

Table 37

Employment (Jobs)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	<10	-50	-300	-550	-770
Compliance 1 & 2 High	<10	-110	-750	-1360	-1910
Compliance 3 Low	<10	-10	-80	-150	-210
Compliance 3 High	<10	-20	-140	-260	-370
Compliance 4 Low	<10	-30	-170	-310	-430
Compliance 4 High	<10	-30	-180	-330	-460
Compliance 5 Low	<10	<10	-40	-80	-110
Compliance 5 High	<10	-20	-150	-270	-380

Table 38

Gross Domestic Product (Millions of Inflation-Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.128	-6.952	-44.733	-90.003	-134.638
Compliance 1 & 2 High	0.32	-17.353	-111.519	-224.048	-334.743
Compliance 3 Low	0.035	-1.887	-12.151	-24.466	-36.622
Compliance 3 High	0.061	-3.302	-21.256	-42.79	-64.039
Compliance 4 Low	0.072	-3.926	-25.273	-50.87	-76.127
Compliance 4 High	0.077	-4.187	-26.95	-54.244	-81.173
Compliance 5 Low	0.019	-1.034	-6.66	-13.411	-20.077
Compliance 5 High	0.063	-3.444	-22.172	-44.632	-66.795

Table 39

Personal Income (Millions of Inflation-Adjusted 2015 Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.057	-3.574	-26.13	-56.058	-85.877
Compliance 1 & 2 High	0.143	-8.921	-65.151	-139.585	-213.589
Compliance 3 Low	0.016	-0.97	-7.097	-15.236	-23.355
Compliance 3 High	0.027	-1.698	-12.416	-26.649	-40.842
Compliance 4 Low	0.032	-2.019	-14.762	-31.682	-48.551
Compliance 4 High	0.034	-2.153	-15.742	-33.784	-51.77
Compliance 5 Low	0.009	-0.532	-3.89	-8.352	-12.803
Compliance 5 High	0.028	-1.771	-12.951	-27.796	-42.599

Table 40

Real Disposable Personal Income per capita (Inflation Adjusted (2015) Dollars)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.013	-0.632	-2.494	-3.13	-2.862
Compliance 1 & 2 High	0.033	-1.576	-6.213	-7.781	-7.099
Compliance 3 Low	0.004	-0.172	-0.678	-0.851	-0.78
Compliance 3 High	0.006	-0.3	-1.185	-1.489	-1.363
Compliance 4 Low	0.007	-0.357	-1.409	-1.77	-1.62
Compliance 4 High	0.008	-0.38	-1.503	-1.887	-1.727
Compliance 5 Low	0.002	-0.094	-0.371	-0.467	-0.427
Compliance 5 High	0.007	-0.313	-1.236	-1.553	-1.421

Table 41

Employment (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.001%	-0.007%	-0.012%	-0.017%
Compliance 1 & 2 High	0.000%	-0.003%	-0.017%	-0.031%	-0.042%
Compliance 3 Low	0.000%	0.000%	-0.002%	-0.003%	-0.005%
Compliance 3 High	0.000%	-0.001%	-0.003%	-0.006%	-0.008%
Compliance 4 Low	0.000%	-0.001%	-0.004%	-0.007%	-0.009%
Compliance 4 High	0.000%	-0.001%	-0.004%	-0.007%	-0.010%
Compliance 5 Low	0.000%	0.000%	-0.001%	-0.002%	-0.003%
Compliance 5 High	0.000%	-0.001%	-0.003%	-0.006%	-0.008%

Table 42

Gross Domestic Product (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.00%	0.00%	-0.01%	-0.02%	-0.02%
Compliance 1 & 2 High	0.00%	0.00%	-0.02%	-0.04%	-0.05%
Compliance 3 Low	0.00%	0.00%	0.00%	0.00%	-0.01%
Compliance 3 High	0.00%	0.00%	0.00%	-0.01%	-0.01%
Compliance 4 Low	0.00%	0.00%	-0.01%	-0.01%	-0.01%
Compliance 4 High	0.00%	0.00%	-0.01%	-0.01%	-0.01%
Compliance 5 Low	0.00%	0.00%	0.00%	0.00%	0.00%
Compliance 5 High	0.00%	0.00%	0.00%	-0.01%	-0.01%

Table 43

Personal Income (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.001%	-0.006%	-0.011%	-0.015%
Compliance 1 & 2 High	0.000%	-0.002%	-0.014%	-0.027%	-0.038%
Compliance 3 Low	0.000%	0.000%	-0.002%	-0.003%	-0.004%
Compliance 3 High	0.000%	0.000%	-0.003%	-0.005%	-0.007%
Compliance 4 Low	0.000%	-0.001%	-0.003%	-0.006%	-0.009%
Compliance 4 High	0.000%	-0.001%	-0.003%	-0.006%	-0.009%
Compliance 5 Low	0.000%	0.000%	-0.001%	-0.002%	-0.002%
Compliance 5 High	0.000%	0.000%	-0.003%	-0.005%	-0.007%

Table 44

Real Disposable Personal Income per capita (% Change from Baseline Forecast)	2017	2020	2025	2030	2035
Compliance 1 & 2 Low	0.000%	-0.001%	-0.005%	-0.006%	-0.005%
Compliance 1 & 2 High	0.000%	-0.003%	-0.012%	-0.014%	-0.012%
Compliance 3 Low	0.000%	0.000%	-0.001%	-0.002%	-0.001%
Compliance 3 High	0.000%	-0.001%	-0.002%	-0.003%	-0.002%
Compliance 4 Low	0.000%	-0.001%	-0.003%	-0.003%	-0.003%
Compliance 4 High	0.000%	-0.001%	-0.003%	-0.003%	-0.003%
Compliance 5 Low	0.000%	0.000%	-0.001%	-0.001%	-0.001%
Compliance 5 High	0.000%	-0.001%	-0.002%	-0.003%	-0.002%