Nevada Policy Research Institute

analysis

Evaluating the Costs and Benefits of Renewable Energy Portfolio Standards

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Executive Summary

In Nevada, as well as 29 states and the District of Columbia, laws require that ever-growing percentages of the electricity you use must come from wind, solar and other forms of renewable energy.vament.

Because those forms of energy are more costly and less efficient, state governments eager to be seen as "green" have had to make their use by utility companies mandatory.

Thus giving the utility companies — and you — no choice.

"Renewable Portfolio Standards" are the name of these mandates.

To estimate the costs and benefits of renewable standards, this study develops models of electricity supply and demand for each state, using forecasts for coal and natural gas prices out to 2040 from the U.S. Energy Information Administration.

The results show that mandated renewable use in states' energy portfolios have had, and will continue to have, a significant cost on the economy.

Because dependable and affordable energy is such a pivotal element in a state's economy, standards that increase the cost of energy production have a widespread impact.

Not only do renewable standards directly impact utility bills. Everything from job growth to business investment is also negatively affected by government's diktat that everyone must turn to less dependable and more expensive energy production.

While there are some marginal economic benefits to greater reliance on renewable energy, these benefits are overshadowed by the substantially more expensive cost of production.

Looking at Nevada specifically, the net cost of renewable standards are striking:

- Energy prices are expected to climb by nearly 15 percent in 2016.
- Employment growth will be reduced by more than 11,000 jobs in 2016 due to higher energy costs.
- Economic growth will be reduced by more than $1.7 billion in 2016.

The impact of such renewable standards is clearly dramatic — draining vitality out of Nevadans' efforts to fully recover from years of sluggish economic growth.

Eventually, the renewable energy market almost certainly will become more cost competitive. Until it does, however, steering energy production toward renewable sources prematurely substantially bleeds ratepayers, businesses and the state.

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Preface

Renewable Portfolio Standards (RPS), now existing in 29 states and the District of Columbia, require utilities to provide a certain percentage of electricity consumption from wind, solar, and other forms of renewable energy. Federal policies, such as the wind production tax credit and the solar investment tax credit, also promote the production of wind and solar power. Given the widespread use of rate of return regulation based upon average cost pricing, the costs of these policies are less than transparent. Moreover, to the extent that these policies drive up electricity prices, output and employment could be adversely affected. The objective of this study is to understand and estimate these costs and economic impacts.

Central to this effort is the estimation of the opportunity costs of higher cost, intermittent renewable power in terms of the foregone electricity from lower cost, deployable fossil fuel fired electricity. These opportunity costs vary considerably by state based upon the cost of existing capacity and availability of wind and solar resources. Accordingly, this study estimates these costs for the twelve states identified in Figure ES1. The timing and stringency of the RPS goals varies considerably by state. Moreover, there is wide variation in the size and composition of electricity generation for this sample of states.[1]

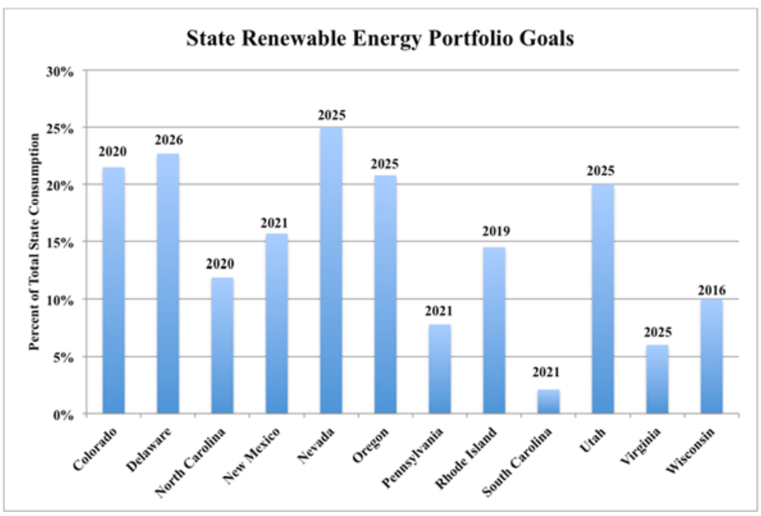

Figure ES1: RPS Goals by State

To estimate the costs and benefits of RPS, this study develops models of electricity supply and demand for each state. These models are projected using forecasts for coal and natural gas prices out to 2040 from the U.S. Energy Information Administration. The baseline forecast assumes existing electricity production capacity remains in place with new generation requirements met by natural gas integrated combined cycle (NGCC) plants. The RPS scenario imposes the goals identified in Figure

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[1] The selection of these states is determined by the states expressing an interest in this study to the Interstate Policy Alliance, who sponsored this study.

ES1. Average electricity generation costs, power consumption, and retail rates under the baseline and RPS scenarios are then compared.

The costs of RPS policies depend upon the opportunity costs of electricity generation from wind and solar. For states with a fleet of low cost electricity generation capacity, imposition of RPS could raise electricity costs significantly because higher cost wind and solar generation displace low cost sources of power. While this displacement reduces expenditures on fossil fuels, coal and natural gas plants are cycled to accommodate the intermittent generation of renewable generators, which reduces their thermal efficiency and raises generation costs. On the other hand, building more renewable energy plants to meet RPS goals reduces the need to build new NGCC plants. Finally, investments in RPS capacity earn federal tax subsidies. Wind power receives a production tax credit of $23 per megawatt hour (Mwh) while solar plants receive a 30% investment tax credit. Hence, RPS policies contribute to lower federal tax revenues.

These costs are summarized in Table ES1 for the entire twelve states. For example, in 2016, the RPS goals involve $5.4 billion in additional expenditures to build and operate the required RPS facilities, $271 million in cycling costs, and $1.8 billion of tax subsidies. These costs are partially offset by $1.478 billion in fossil fuel cost savings and $261 million in avoided new NGCC generation costs. Hence, the total net cost of RPS policies is $5.762 billion in 2016. The total net costs of RPS policies reach $8.7 billion in 2025 and then decline to $8.1 billion in 2040 after RPS goals are met and the unit costs of solar and wind decline due to technological improvements.

Table ES1: Costs of RPS for Entire 12 State Sample

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Renewable Energy Costs	5,400.0	7,815.2	8,881.6	8,935.2	8,995.5	9,070.6
Cycling Costs	271.1	316.0	339.6	371.9	409.2	452.6
Tax Subsidies	1,830.1	2,672.2	3,098.0	3,156.2	3,217.9	3,287.8
Fossil Fuel Costs	-1,478.3	-2,319.5	-2,966.3	-3,299.9	-3,661.3	-4,042.2
New Fossil Fuel Costs	-260.7	-462.0	-597.5	-614.5	-628.8	-630.7
Total Net Costs	5,762.2	8,022.0	8,755.4	8,549.0	8,332.5	8,138.1

These higher costs are passed on to customers in the form of higher retail electricity prices, summarized in Table ES2. States with modest RPS goals, such as South Carolina, experience moderate rate increases. Similarly, states meeting their RPS goals with wind power, such as Colorado, face rate increases of roughly 5%. On the other hand, states meeting rather ambitious RPS goals with relatively higher cost solar power, such as North Carolina, Nevada, Utah, and Virginia incur much steeper electricity rate increases.

Electricity rate increases peak as RPS goals are reached in the early 2020s for most states. Thereafter, electricity rate increases begin to taper off as the costs of wind and solar decline due to technological improvements. Despite these expected reductions in the cost of wind and solar technology, RPS polices increase prices for electricity.

Table ES2: Impact of RPS Policies on Retail Electricity Prices

	Electricity Price Changes in Percent					
	2016	2020	2025	2030	2035	2040
Colorado	6.12	8.23	7.69	7.32	6.69	5.93
Delaware	11.02	14.50	14.99	12.50	10.14	8.20
North Carolina	10.04	16.06	14.12	12.55	11.03	9.79
New Mexico	6.18	6.77	5.95	5.30	4.54	3.92
Nevada	14.77	15.60	15.14	13.28	11.21	9.12
Oregon	9.41	10.00	11.09	10.55	9.83	9.11
Pennsylvania	2.14	2.56	2.54	2.40	2.25	2.08
Rhode Island	13.61	18.16	16.62	15.55	14.46	13.17
South Carolina	0.39	1.52	2.08	1.97	1.85	1.75
Utah	5.13	9.07	12.78	11.78	10.67	9.47
Virginia	5.45	7.75	9.85	8.76	7.74	6.93
Wisconsin	4.34	4.29	4.01	3.70	3.39	3.08

Many economic studies in the peer-reviewed literature demonstrate that higher energy prices reduce economic growth and employment. Energy is an essential factor of production and consumption activities. Given limited substitution possibilities, higher electricity prices raise business costs and consumer energy bills, which reduces spending on other goods and services. Investments in renewable energy, however, constitute an economic stimulus.

A comparison of these economic impacts is summarized in Table ES3 for the entire twelve states. For example, in 2025 higher electricity prices associated with RPS policies reduce value added by $23.1 billion. Investments required for new renewable energy plants increase value added by $668 million. With a small offset from reductions in required NGCC plants to meet load growth, the net reduction in value added is nearly $22.5 billion in 2025. Similarly, gross employment losses are over 160 thousand in 2025 but over 9 thousand jobs are created building and operating new solar and wind capacity to meet RPS goals. But again the net change involves over 150 thousand jobs lost in 2025. Overall, this study finds that the stimulus from building and operating renewable energy facilities are offset by the negative impacts that higher electricity rates have on employment and value added.

The estimated losses in value added for each of the twelve states are summarized in Table ES4. The largest losses occur in North Carolina with value added reductions between $3.3 billion in 2016 to nearly $6 billion in 2025. Losses in annual value added exceed $1 billion in seven other states.

Table ES3: RPS Impacts on Value Added and Employment for All States

	Millions of 2013 Dollars					
Value Added	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
Electric prices	-16,779	-22,799	-23,140	-20,992	-18,751	-16,682
RPS Invest.	2,069	1,290	668	244	243	254
NGCC Invest.	-146	-34	-22	0	4	4
Net Change	-14,856	-21,543	-22,495	-20,749	-18,504	-16,424
Employment	**Number of Jobs**					
Electric prices	-118,606	-159,094	-161,595	-146,787	-131,324	-117,072
RPS Invest.	29,826	18,332	9,073	3,339	3,321	3,464
NGCC Invest.	-1,246	-305	-206	-2	31	34
Net Change	-90,026	-141,066	-152,727	-143,450	-127,972	-113,574

Table ES4: RPS Impacts on Value Added by State

	Change in Value Added in Millions of 2013 Dollars					
	2016	2020	2025	2030	2035	2040
Colorado	-1,442	-1,996	-1,992	-1,895	-1,730	-1,530
Delaware	-603	-812	-839	-715	-578	-466
North Carolina	-3,899	-7,145	-6,664	-5,918	-5,196	-4,606
New Mexico	-239	-444	-390	-348	-298	-251
Nevada	-1,711	-1,792	-1,715	-1,534	-1,287	-1,038
Oregon	-1,451	-1,571	-1,636	-1,646	-1,532	-1,418
Pennsylvania	-1,226	-1,503	-1,640	-1,545	-1,449	-1,337
Rhode Island	-629	-890	-813	-760	-707	-643
South Carolina	-63	-198	-349	-318	-298	-283
Utah	-662	-1,420	-2,025	-1,964	-1,777	-1,575
Virginia	-1,865	-2,655	-3,390	-3,149	-2,778	-2,486
Wisconsin	-1,065	-1,116	-1,041	-958	-874	-791
Total	-14,856	-21,543	-22,495	-20,749	-18,504	-16,424

The employment impacts of RPS policies are summarized in Table ES5. The jobs lost by state mirror the losses in value added. Again, the magnitudes differ by state depending upon the stringency of the RPS goals, the size of the state, and the technologies available for each state to meet the RPS goals. Solar energy is the only feasible means to attain RPS goals for eastern states due to limited wind resources.

The economic impacts are summarized in Figure ES2 using the present discounted value of lost value added and average annual job losses from 2016 to 2040. The largest losses occur in North Carolina with a cumulative loss in value added of over $106 billion and annual average job losses of more than 37 thousand. The next largest losses occur in Virginia with over $50 billion in lost value added and more than 20 thousand lost jobs per year. Five other states – Colorado, Nevada, Oregon, Pennsylvania, and Utah – incur losses exceeding $25 billion in value added and 9 thousand jobs per year from 2016 to 2040 associated with the economic burdens associated with RPS policies.

Table ES5: Impact of RPS Policies on Employment by State

	Change in Number of Jobs					
State	2016	2020	2025	2030	2035	2040
Colorado	-8,060	-11,619	-12,445	-11,823	-10,779	-9,516
Delaware	-2,705	-3,845	-3,970	-3,536	-2,846	-2,272
North Carolina	-17,821	-43,277	-44,093	-39,107	-34,289	-30,345
New Mexico	-743	-3,483	-3,060	-2,724	-2,333	-1,921
Nevada	-11,827	-12,540	-11,868	-10,813	-9,037	-7,237
Oregon	-12,309	-13,459	-13,547	-14,048	-13,077	-12,095
Pennsylvania	-7,781	-9,712	-11,396	-10,726	-10,046	-9,255
Rhode Island	-4,003	-6,023	-5,496	-5,137	-4,771	-4,339
South Carolina	-561	-1,331	-3,084	-2,794	-2,617	-2,480
Utah	-1,912	-7,137	-10,517	-11,153	-10,077	-8,916
Virginia	-13,182	-18,779	-24,060	-23,144	-20,399	-18,241
Wisconsin	-9,121	-9,862	-9,193	-8,447	-7,701	-6,957
Total	-90,026	-141,066	-152,727	-143,450	-127,972	-113,574

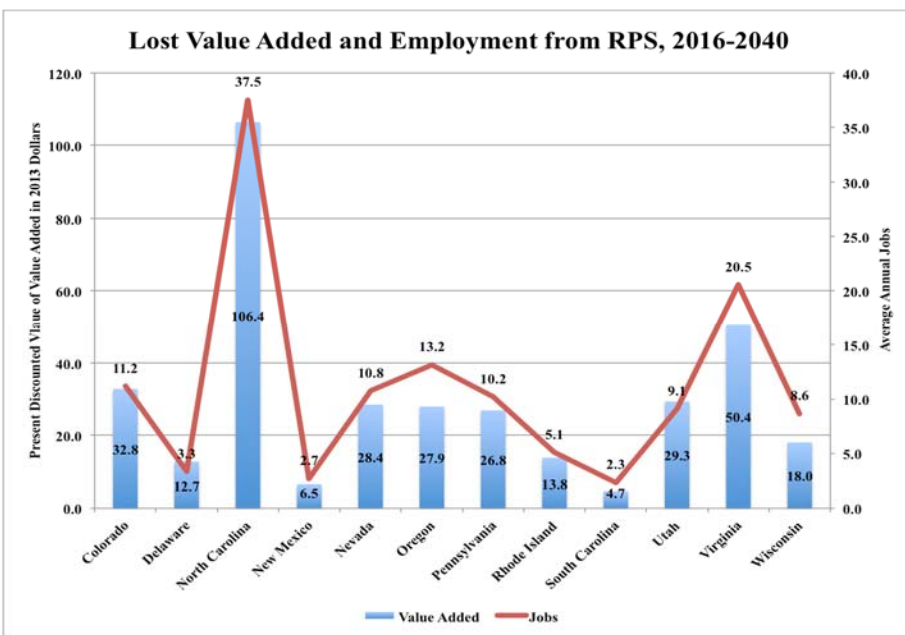

Figure ES2: Cumulative Economic Impacts of RPS

While incurring economic costs in terms of lost value added and employment, RPS policies generate benefits by reducing carbon dioxide emissions. These emission savings, however, come at a relatively high price with the avoided cost of carbon of between $227 and $36 per ton in 2016 and between $130 and $27 per ton in 2040. An emissions weighted average of CO2 abatement costs across all 12 states examined in this study is $78 in 2016 and $62 dollars per ton in 2040.

Table ES6: Costs of CO2 Reductions using RPS

	2013 Dollars per ton					
State	2016	2020	2025	2030	2035	2040
Colorado	36.28	40.39	38.71	38.30	36.91	34.99
Delaware	101.41	86.55	75.10	65.55	57.24	50.17
North Carolina	192.66	178.61	157.24	142.64	128.95	117.14
New Mexico	45.54	37.19	34.48	32.38	29.59	27.31
Nevada	75.75	55.75	49.77	45.26	40.90	36.66
Oregon	44.43	47.57	44.09	42.60	40.94	39.27
Pennsylvania	43.08	43.13	41.24	40.30	39.25	38.04
Rhode Island	201.24	169.75	154.02	146.07	138.39	129.94
South Carolina	97.98	151.95	137.99	122.98	116.35	110.97
Utah	95.67	84.16	80.33	74.46	68.78	63.12
Virginia	227.62	199.70	177.31	157.25	142.64	131.20
Wisconsin	50.86	47.75	46.05	44.30	42.43	40.58

The social cost of carbon estimated by the US Environmental Protection Agency is well below these average avoided emissions costs, suggesting that Renewable Portfolio Standards are a relatively expensive strategy to cut greenhouse gas emissions (see Figure ES3). In summary, this study finds that the economic impacts of Renewable Portfolio Standards vary significantly across states depending upon the RPS goals and the availability of solar and wind resources. Across all states, however, RPS policies increase electricity prices.

RPS investments are in fact associated with some increase in economic activity. The negative economic impacts associated with higher electricity prices, however, offset the economic stimulus from these RPS investments. In many cases, especially for states that must utilize solar energy technology to meet RPS goals, the costs per ton of carbon is much higher than the social cost of carbon estimated by the US federal government. Avoided carbon costs are lower for wind power but still involve net losses in value added and employment. These findings suggest that for the twelve states examined in this study Renewable Portfolio Standards are a costly and inefficient means to reduce greenhouse gas emissions and reduce economic growth and employment.

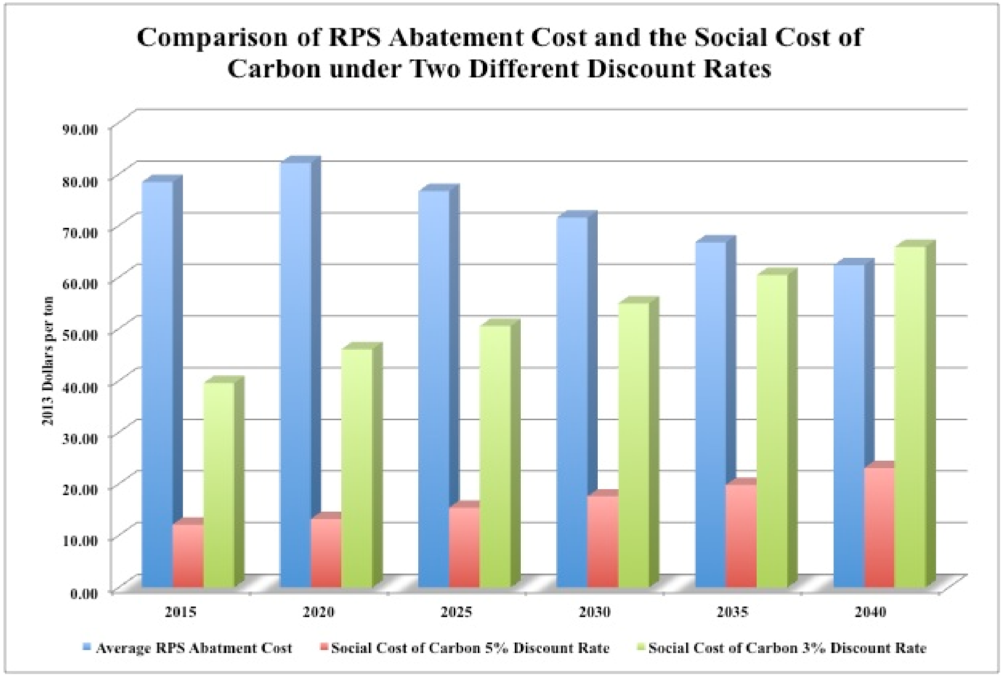

Figure ES3: RPS Abatement Costs and the Social Cost of Carbon

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1. Introduction

Thirty states including the District of Columbia have adopted Renewable Portfolio Standards (RPS) specifying shares of electricity consumption provided by renewable energy. RPS proponents argue that these policies are needed to reduce greenhouse gas emissions. They also argue that the construction of renewable energy facilities increase employment opportunities. Opponents assert that Renewable Portfolio Standards increase electricity generation costs and rates paid by customers, which reduces regional economic activity. The objective of this study is to provide a balanced look at this issue, weighing the costs and benefits of Renewable Energy Portfolio Standards.

Our focus is on 12 states in four regions of the United States: the Northeast and Mid-Atlantic states of Rhode Island, Pennsylvania, and Delaware; the South Atlantic states of Virginia and North and South Carolina; the Midwestern state of Wisconsin, and five western states, including Colorado, New Mexico, Utah, Nevada, and Oregon. These states are quite diverse both respect to their sources of electric power generation and their economies. Moreover, their RPS policies also differ both in terms of timelines, goals, and an array of special provisions. This sample of states, therefore, provides a rather robust sample from which to determine the net social costs and benefits of Renewable Energy Portfolio Standards.

There are several components of these benefits and costs. On the benefit side, there are avoided greenhouse gas emissions and additional economic activity generated by the construction of renewable energy plants. The costs include three components. The first cost category is the foregone state and federal tax revenues from renewable energy tax credits. The second impact is the lost consumer surplus from higher electricity rates induced by the RPS. Finally, these higher electricity rates affect regional economic activity, reducing output, income, employment, and state and local tax revenues. The following section provides an overview of the methods used to estimate these costs and benefits. Subsequent sections discuss the findings for each of the twelve states, presenting the impacts on electricity markets and the environmental and economic impacts.

2. Methodology

Renewable Portfolio Standards are generally met with wind and solar electric generating technologies. Relatively small amounts of biomass and other renewable sources of generation are also used to meet these standards. Given this fact and the limited information available on the renewable alternatives to wind and solar this study assumes that RPS goals are met by building wind and solar generation capacity.

Adding these facilities to a generation fleet incurs opportunity costs, which vary depending upon the cost, efficiency, and composition of the existing fleet of generation capacity. Likewise, the benefits in terms of avoided emissions will also vary with the characteristics of the generation fleet. Hence, the opportunity costs of RPS policies could vary considerably by state. For example, if a state has a high cost of electric power generation, adding wind and solar would involve relatively lower costs than those incurred for a system with very low costs. These costs are also affected by coal, oil, and natural gas prices among other factors. If natural gas prices rise, for instance, the increase in average generation costs from adopting RPS policies would be relatively lower than under low natural gas prices.

Another important adjustment affecting the opportunity costs of RPS policies is how the demand for electricity adjusts to higher electricity rates that would be required to recover the additional costs of building and operating renewable energy plants. This price induced energy conservation would reduce the costs of RPS policies.

To estimate these electricity supply and demand adjustments in response to RPS policies, this study develops a simplified version of the models developed by Considine and Manderson (2014, 2015) in which electricity demand models are integrated with engineering-economic models of electric power generation. Electricity demand is projected based upon assumptions for the growth of gross state product and upon retail electricity prices that are determined based upon average generation costs come from engineering-economic models of electricity generation.

Generation costs are calculated based upon observed levels of installed generation capacity, utilization rates, and unit costs of generation that include operating costs and capital recovery charges. Available generation from existing natural gas, coal, nuclear, hydro, and renewable capacity are estimated by multiplying the respective capacities by their utilization rates. The displacement of fossil fuel generation and associated efficiency losses due to sub-optimal cycling of these plants to balance system load from rising levels of intermittent renewable energy generation are estimated using the Avoided Emissions and Generation Tool (AVERT) developed by the U.S. Environmental Protection Agency (2015). For this study, these models are run and estimated for the respective electric reliability regions associated with each of the twelve states.

These electricity supply and demand models for each state are simulated from 2016 to 2040 under two scenarios. The first scenario is the base case defined as the existing generation fleet without RPS policies in place. For existing wind and solar capacity, which are assumed to reflect current RPS, costs and benefits are computed separately and are designated as RPS legacy costs. Electricity supply and demand are balanced by new investment and generation from natural gas integrated combined cycle (NGCC) plants. The second scenario assumes the RPS goals are phased in over the forecast horizon, specifying an amount of wind and solar generation equal to the RPS share multiplied by projected electricity consumption. In this case, the required amount of new NGCC capacity would be reduced due to the rising share of renewable energy in the generation portfolio. The impacts of RPS policies on retail electricity prices are determined by comparing retail electricity prices in these two scenarios.

These retail electricity price changes and the net changes in new power plant investments will affect local economic activity. Value added and employment multipliers reported by recent economic studies will be used to estimate the state level economic impacts of RPS policies. The Jobs and Economic Development Impact (JEDI) modeling tool developed by the National Renewable Energy Laboratory (2015) is used to estimate the impacts of power plant investments on value added and employment. The net effects on employment and value added are then estimated.

Benefits are the avoided air emissions, which are estimated by taking the difference between emissions in the base case and the RPS scenario including the emissions saved from existing wind and solar capacity. The total cost of RPS policies defined above divided by these emission savings provide an estimate of the unit or average abatement cost of greenhouse gas reductions from RPS policies.

The following five sub-sections describe the results obtained from the econometric estimation of the electricity demand models, the specification of the electricity generation cost models, average cost calculations under RPS policies, the decomposition of RPS opportunity costs, and the parameters used for the economic impact analysis.

2.1 Electricity Demand

The demand model for electricity is a simple partial adjustment model in log-linear form, in which total consumption of electricity in state I in year t, Q_{it}, is a function of the real price for electricity, P_{it}, gross state product or total value added, Y_{it}, and lagged consumption, Q_{it-1}:

$$\ln Q_{it} = \alpha_i + \beta_i \ln P_{it} + \gamma_i \ln Y_{it} + \lambda_i \ln Q_{it-1}. \quad (1)$$

where $\alpha_i, \beta_i, \gamma_i, \lambda_i$ are parameters estimated with ordinary least squares. This equation is estimated for each of the twelve states. The results for alternative specifications including a first differenced version, a specification with natural gas prices, and fixed and random effects models appear in Appendix A and are not substantially different from those reported in Tables 1-3.

The econometric estimates for equation (1) are reported below in Table 1. As expected, the coefficients on price for all twelve states are negative indicating an inverse relationship between electricity consumption and retail prices. Eight out of the twelve price coefficients are statistically different from zero at either the one or five percent level of significance. Similarly, the coefficients on gross state product are positive, which reflects the well-known positive relationship between economic growth and electricity use. Eleven of the 12 estimated income coefficients are statistically significant. The summary fit statistics reported in Table 2 reflect a very good fit of the models to the observed data and the absence of autocorrelation. Eight of the twelve models have very low probabilities of unit roots in the residuals. The own price and output elasticities appear in Table 3. The short-run and long run own price elasticities are on average -0.07 and -0.20 respectively, which are quite similar to those found in the economic literature. Output elasticities average 0.2 and 0.5 in the short and long-run respectively across the twelve states that again are very close to estimates found in many other studies. With projections of future gross state product and retail prices, equation (1) can be used to project future electricity consumption.

Table 1: Electricity Demand Model Parameter Estimates by State

State	Estimate	Constant	Log of Real Price	Log of Real GSP	Lagged Quantity
Colorado	Estimate	-0.4902	-0.0379	0.1447	0.7701
	t-Statistic	-1.9138	-2.4042	3.2219	12.8862
	P-Value	[.063]	[.021]	[.003]	[.000]
Delaware	Estimate	-0.6542	-0.1395	0.2465	0.5723
	t-Statistic	-2.9194	-4.7098	4.8575	7.0174
	P-Value	[.006]	[.000]	[.000]	[.000]
North Carolina	Estimate	-0.2608	-0.0278	0.1706	0.6959
	t-Statistic	-1.0556	-1.1898	2.3595	6.1758
	P-Value	[.298]	[.241]	[.023]	[.000]
New Mexico	Estimate	0.0475	-0.0280	0.0392	0.9099
	t-Statistic	0.1156	-0.5632	0.7022	13.3443
	P-Value	[.909]	[.577]	[.487]	[.000]
Nevada	Estimate	-1.0216	-0.1686	0.2877	0.6216
	t-Statistic	-4.8414	-6.2297	6.2116	10.2848
	P-Value	[.000]	[.000]	[.000]	[.000]
Oregon	Estimate	0.5212	-0.0491	0.0849	0.7277
	t-Statistic	2.7591	-1.5102	2.2751	7.4734
	P-Value	[.009]	[.139]	[.028]	[.000]
Pennsylvania	Estimate	0.1410	-0.0814	0.2132	0.5643
	t-Statistic	1.1377	-3.9395	3.7515	5.2630
	P-Value	[.262]	[.000]	[.001]	[.000]
Rhode Island	Estimate	-0.4151	-0.1020	0.1981	0.5877
	t-Statistic	-3.1521	-6.3470	6.2642	9.4167
	P-Value	[.003]	[.000]	[.000]	[.000]
South Carolina	Estimate	-1.4600	-0.0864	0.4437	0.3557
	t-Statistic	-3.5542	-3.5018	4.5002	2.6698
	P-Value	[.001]	[.001]	[.000]	[.011]
Utah	Estimate	-0.9474	-0.0228	0.2057	0.6969
	t-Statistic	-1.8262	-1.3388	2.4048	6.2836
	P-Value	[.075]	[.188]	[.021]	[.000]
Virginia	Estimate	-0.4332	-0.0385	0.1711	0.7208
	t-Statistic	-1.4929	-1.9802	2.6287	7.8650
	P-Value	[.144]	[.055]	[.012]	[.000]
Wisconsin	Estimate	-1.1833	-0.0816	0.3342	0.5010
	t-Statistic	-3.0000	-3.1200	3.8977	4.2555
	P-Value	[.005]	[.003]	[.000]	[.000]

Table 2: Electricity Demand Model Summary Fit Statistics by State

State	Adj. R-Squared	Durbin H Probability Value	Weighted Symmetric Unit Root Prob.
Colorado	0.998	0.029	0.010
Delaware	0.990	0.481	0.000
North Carolina	0.993	0.576	0.274
New Mexico	0.990	0.494	0.000
Nevada	0.998	0.288	0.001
Oregon	0.943	0.780	0.739
Pennsylvania	0.987	0.975	0.031
Rhode Island	0.992	0.259	0.416
South Carolina	0.995	0.931	0.021
Utah	0.997	0.738	0.008
Virginia	0.996	0.224	0.143
Wisconsin	0.994	0.308	0.004

Table 3: Short and Long Run Price and Income Elasticities of Electricity Demand

	Own Price Elasticity		Gross State Product Elasticity	
State	Short-Run	Long-Run	Short-Run	Long-Run
Colorado	-0.038	-0.165	0.145	0.629
Delaware	-0.139	-0.326	0.246	0.576
North Carolina	-0.028	-0.092	0.039	0.129
New Mexico	-0.028	-0.311	0.039	0.435
Nevada	-0.169	-0.445	0.288	0.760
Oregon	-0.049	-0.180	0.085	0.312
Pennsylvania	-0.081	-0.187	0.213	0.489
Rhode Island	-0.102	-0.247	0.198	0.480
South Carolina	-0.086	-0.134	0.444	0.689
Utah	-0.023	-0.075	0.206	0.679
Virginia	-0.023	-0.082	0.206	0.737
Wisconsin	-0.082	-0.163	0.334	0.670
Average	-0.071	-0.201	0.204	0.549

2.2 Generation Costs

The supply of electricity is determined by simple engineering-economic relationships and generation cost calculations. Generation is determined by multiplying installed capacity by utilization rates. Costs of electricity generation are determined on the basis of the levelized costs of generation, which include operating costs and capital cost recovery charges. Retail electricity prices equal average generation cost plus a fixed markup for transmission and distribution charges.

Installed capacity for each state is adjusted for planned generation and capacity additions and retirements reported by the US Energy Information Administration (2016) from 2014 to 2025. Total generation from various types of capacity is defined as:

$$G_{it} = \sum_{j=cl}^{wo} G_{ijt} \tag{2}$$

where the index j includes 13 different type of electricity generation capacity, including coal (cl), geothermal (gt), hydro (hy), natural gas (ng), nuclear (nu), other (ot), other biomass (ob), other gas (og), petroleum (pe), pumped storage (ps), solar (sl), wind (wn), and wood (wo). The base year of generation is 2013.

Under the base case scenario, new generation requirements are met with new natural gas combined cycle generation (nc), G_{inct}, which is determined as follows:

$$G_{inct} = Q_{it} - B_{it} - G_{it} \tag{3}$$

where B_{it} is a balance term that includes net electricity imports and other miscellaneous adjustments, which is held fixed at base year values of 2013 over the forecast horizon.

The average cost of generation is defined as follows:

$$AC_{it} = \frac{\left[\sum_{j=cl}^{wo} c_{ijt} G_{ijt} + c_{inct} G_{inct}\right]}{G_{it} + G_{inct}}, \tag{4}$$

where c_{ijt} is the levelized cost of existing generation in state i for capacity type j in year t and c_{inct} is the levelized cost of new natural gas combined cycle generation, defined as operating costs plus capital and maintenance costs:

$$c_{inct} = HR_{nc} \times P_{ingt} + \frac{p_{nc} K_{nc} \left[\frac{r(1+r)^t}{(1+r)^t - 1} + OM_{nc}\right]}{\left[K_{nc} U_{nc} \times 365 \times 24\right]} \tag{5}$$

where HR_{nc} is the heat rate for new NGCC capacity in million BTU per Mwh assumed to be 6.43, P_{ngt} is the price of natural gas paid by electric utilities in 2013 dollars per million BTU, p_{nc} is the so-called overnight capital costs of NGCC capacity equal to $1,023 per kilowatt (KW) capacity, K_{nc} is installed capacity of 400 KW, r is the discount rate assumed to be 7.1 percent per annum, t is the capital cost recovery period of 20 years, OM_{nc} is operating and maintenance expenditures per KW of capacity, and U_{nc} is the capacity utilization rate for NGCC units, which is assumed to be 85 percent. The last two terms in the denominator of the second term in equation (5) computes the number of hours in a calendar year so that levelized costs are in terms of dollars per megawatt hours of electricity generation. The values of these cost parameters are based upon data provided by EIA (2013). The first term in the brackets in the numerator of (5) is the capital cost recovery factor.

The average retail price for electricity is defined as a fixed markup over average costs of generation:

$$P_{it} = AC_{it} + M_{i2013} \qquad (6)$$

where M_{i2013} is the margin for transmission and distribution costs to customers in 2013. The base case model consists of equations (1)-(6).

For existing fossil fuel generation plants, actual observed heat rates and observed prices paid by electricity companies are used to calculate operating costs by state. Operating costs are simply the product of heat rates and the cost of fuels. Heat rates and operating costs in 2013 are reported in Tables 4 and 5 respectively.

Table 4: Heat Rates for Fossil Fuel Generation

	Heat Rates in Million BTU / MWh		
States	Coal	Natural Gas	Oil
Colorado	10.58	8.77	10.39
Delaware	11.81	7.37	8.89
North Carolina	10.03	7.25	10.39
New Mexico	10.57	8.57	11.04
Nevada	10.89	7.57	10.45
Oregon	9.80	7.28	9.58
Pennsylvania	10.23	7.56	8.50
Rhode Island	NA	7.79	6.93
South Carolina	10.00	8.09	10.18
Utah	9.92	7.75	10.11
Virginia	10.63	7.83	9.89
Wisconsin	10.41	7.69	4.29

Capital and maintenance costs for existing coal, natural gas, and nuclear power plants are reported in Table 6 based upon Stacy and Taylor (2015) who collected actual observed costs for existing power plants based upon data reported by the Federal Energy Regulatory Commission (2016). Levelized costs from 2016 to 2040 are projected on the basis of forecasts from the Energy Information Administration (2015).

Table 5: Fuel Operating Costs for Fossil Fuel Generation, 2013

	Fuel Operating Costs 2013 $ / MWh		
States	Coal	Natural Gas	Oil
Colorado	20.21	41.04	245.29
Delaware	37.81	29.76	192.04
North Carolina	38.12	36.16	234.41
New Mexico	24.41	36.27	269.67
Nevada	29.84	32.34	254.10
Oregon	19.21	27.72	211.35
Pennsylvania	25.27	30.26	200.84
Rhode Island	NA	44.03	152.35
South Carolina	37.48	37.05	235.13
Utah	20.24	30.76	226.91
Virginia	35.28	32.50	184.18
Wisconsin	24.14	33.76	35.64

Table 6: Capital and Maintenance Costs Fossil Fuel and Nuclear Plants, 2013

	2013 Dollars per MWh					
	Coal		Natural Gas		Nuclear	
States	CapEx	O&M	CapEx	O&M	CapEx	O&M
Colorado	4.60	6.62	9.61	7.09		
Delaware	6.08	6.55	5.47	5.03		
North Carolina	7.91	5.33	5.47	5.03	5.54	14.19
New Mexico	3.10	5.91	5.47	5.03		
Nevada	15.92	13.96	5.83	4.60		
Oregon	6.27	6.47	4.81	4.35		
Pennsylvania	4.59	4.45	5.47	5.03	3.84	18.15
Rhode Island	6.08	6.55	5.47	5.03		
South Carolina	9.40	4.83	3.50	2.79	2.24	15.42
Utah	6.08	6.55	5.47	5.03		
Virginia	5.88	6.54	5.47	5.03	4.76	11.51
Wisconsin	5.41	8.04	5.47	5.03	7.81	23.81

The EIA high oil and gas scenario, which results in relatively low natural gas prices, is used as the base case in this study because the EIA's reference case scenario consistently over-estimates natural gas prices in recent years, as Figure 1 illustrates. Nevertheless, the models are computed using the EIA reference case with higher fossil fuel prices and the results are compared in Appendix B.

Figure 2 presents the twelve state average projected levelized generation costs for existing coal and natural gas plants and for new NGCC plants. Notice that all three series are relatively close with NGCC costs the lowest due to greater thermal efficiency than existing fossil fuel plants. Levelized costs for new NGCC capacity are lowest given its high efficiency. Coal fired generation costs are highest given relatively low natural gas prices in the base case scenario.

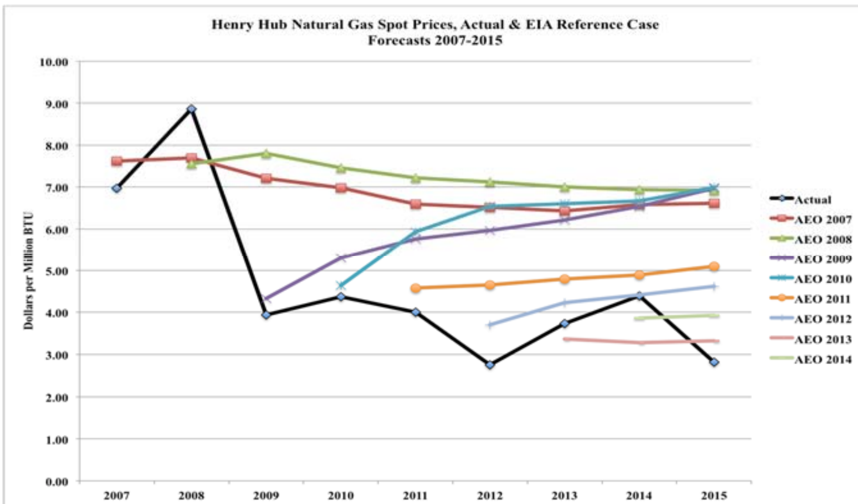

Figure 1: EIA Forecast Accuracy of Henry Hub Prices

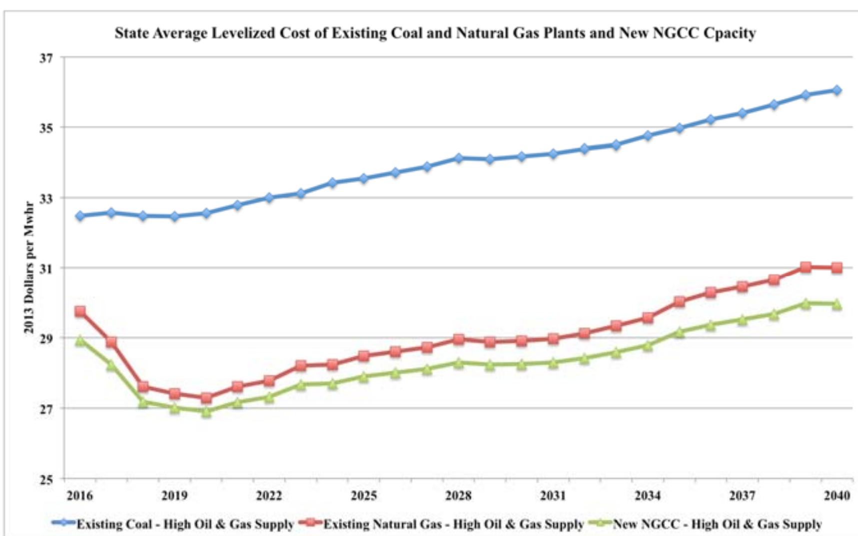

Figure 2: Projected Levelized Costs for Fossil Fuel Generation, 2016-2040

The cost for hydroelectric generation is \$14.70 per Mwh, based upon observed data reported by Stacy and Taylor (2015). Generation from petroleum-fired capacity is computed on the basis of observed heat rates and oil prices and maintenance and capital recovery costs of \$10.50 per MWh reported by Stacy and Taylor (2015).

The levelized costs for wind generation, c_{iwnt}, are defined as follows:

$$c_{iwnt} = \frac{p_{wnt} K_{wn} \left[\frac{r(1+r)^t}{(1+r)^t - 1} + OM_{wn} \right]}{\left[K_{wn} U_{iwn} \times 365 \times 24 \right]} - \tau_{wn} \qquad (7)$$

where p_{wnt} is equal to \$2,213 per KW for capital construction costs in 2013, OM_{wn} is \$39.55 per KW for operation and maintenance costs, K_{wn} is 100 megawatts, and the capacity factors, U_{iwn}, are reported below in Table 7 based upon data from EIA (2016). Note that levelized costs for wind are reduced by the production tax credit for wind power, τ_{wn}, which is equal to \$23 / MWh.

There is a wide dispersion in capacity factors for wind across states. Windier western states have generally higher capacity factors compared to the eastern regions of the US. The highest wind capacity factor is in Colorado followed by Pennsylvania, New Mexico, Wisconsin, and Oregon. Also, reported in Table 7 are the shares of new capacity supplied by wind for each state. These shares are determined based upon recent and the planned mix of renewable capacity. Wind power is likely to play a major role in meeting RPS goals in Colorado, New Mexico, Oregon, Pennsylvania, Rhode Island, and Wisconsin.

Table 7: Capacity Utilization and Shares of New RPS Capacity

	Capacity Utilization		Shares of RPS Capacity	
State	Wind	Solar	Wind	Solar
Colorado	0.353	0.233	0.448	0.552
Delaware	0.255	0.180	0.909	0.091
North Carolina	0.151	0.117	0.885	0.115
New Mexico	0.322	0.233	0.110	0.890
Nevada	0.191	0.230	0.873	0.127
Oregon	0.269	0.219	0.036	0.963
Pennsylvania	0.285	0.153	0.018	0.982
Rhode Island	0.151	0.132	0.437	0.563
South Carolina	0.351	0.132	0.500	0.500
Utah	0.217	0.184	0.735	0.265
Virginia	0.151	0.117	0.680	0.320
Wisconsin	0.280	0.132	0.020	0.980

The levelized costs for wind power appears in Table 8. Wind power technology is reaching maturity as noted by EIA (2013), so future overnight capital costs are assumed to decline 0.3 percent annually from 2016 to 2040. This reduces wind power costs by slightly more than 7.7 percent over the forecast horizon.

Table 8: Projected Levelized Costs for Wind Power by State, 2016-2040

	Levelized Costs after Wind Tax Credit 2013 Dollars per MWh					
State	2016	2020	2025	2030	2035	2040
Colorado	44.47	43.61	42.55	41.51	40.48	39.47
Delaware	70.52	69.33	67.86	66.42	65.00	63.60
North Carolina	134.84	132.83	130.35	127.91	125.51	123.15
New Mexico	50.92	49.98	48.82	47.68	46.55	45.45
Nevada	101.81	100.22	98.26	96.34	94.44	92.57
Oregon	65.42	64.29	62.90	61.54	60.19	58.87
Pennsylvania	60.60	59.54	58.23	56.93	55.66	54.41
Rhode Island	134.84	132.83	130.35	127.91	125.51	123.15
South Carolina	180.55	177.96	174.76	171.62	168.52	165.48
Utah	86.58	85.19	83.47	81.78	80.11	78.47
Virginia	134.84	132.83	130.35	127.91	125.51	123.15
Wisconsin	61.92	60.83	59.50	58.19	56.90	55.63

The levelized costs for solar photovoltaic generation, c_{islt} is defined as follows:

$$c_{islt} = \frac{p_{slt}\left(1-\tau_{sl}\right)K_{sl}\left[\frac{r\left(1+r\right)^{t}}{\left(1+r\right)^{t}-1}+OM_{sl}\right]}{\left[K_{sl}U_{isl}\times 365\times 24\right]} \tag{8}$$

where p_{isl} is equal to $2,479 per KW for capital construction costs, OM_{sl} is $39.90 per KW for operation and maintenance costs, K_{sl} is 150 megawatts, τ_{sl} is the investment tax credit of 30 percent, and the capacity factors, U_{isl} , are reported in Table 7 based upon data from EIA (2016). Given the lack of wind resources, most new renewable capacity is supplied by solar in some eastern states, such as Delaware, the Carolinas, and Virginia.

Projected costs for solar power assume a 1.5 percent annual decline, which reduces solar costs by 30 percent from 2016 to 2040. Also note that the projected costs for solar assume the investment tax credit remains in place. Despite this favorable treatment, solar costs for several states, such as North Carolina, Rhode Island, and South Carolina are substantially higher than other states due to relatively low solar capacity factors.

Table 9: Projected Levelized Costs for Solar Power by State, 2016-2040

	Levelized Costs after Solar Investment Tax Credit 2013 Dollars per MWh					
State	2016	2020	2025	2030	2035	2040
Colorado	77.32	72.79	67.49	62.58	58.02	53.80
Delaware	99.83	93.97	87.13	80.79	74.91	69.46
North Carolina	153.92	144.89	134.35	124.57	115.50	107.10
New Mexico	77.46	72.91	67.61	62.69	58.12	53.89
Nevada	78.30	73.71	68.34	63.37	58.76	54.48
Oregon	82.38	77.55	71.91	66.67	61.82	57.32
Pennsylvania	118.01	111.09	103.01	95.51	88.56	82.11
Rhode Island	136.22	128.23	118.90	110.25	102.22	94.78
South Carolina	136.22	128.23	118.90	110.25	102.22	94.78
Utah	97.66	91.93	85.24	79.04	73.29	67.95
Virginia	153.92	144.89	134.35	124.57	115.50	107.10
Wisconsin	136.22	128.23	118.90	110.25	102.22	94.78

2.3 Grid Disruption Costs

Additional renewable electricity generation displaces coal and natural gas generation and reduces the operational efficiency of existing fossil fuel facilities. To estimate these impacts, this study uses an open-access tool available from EPA (2014). This modeling tool is based upon statistical analysis of the behavioral characteristics of individual electric generation units (EGUs) from hourly historical generation and emissions data Fisher, et al. (2015). This tool tracks the generation and heat rates for each fossil EGU within ten separate electricity generation systems within the US.

AVERT is used to simulate how existing coal and natural gas generation is displaced by renewable electricity generation. Given grid flexibility and excess capacity this study assumes that new investment in backup natural gas capacity to accommodate renewables is unnecessary. The percentage changes in heat rates for coal and gas generation are also estimated for RPS goals. The AVERT tool is simulated for each region and state combination under four different RPS shares from one to twenty percent. Quadratic functions are then fitted to these model outcomes to estimate how fossil fuel displacement shares and the percentage changes in coal and natural gas heat rates adjust as the share of renewable energy approach the RPS goals presented in Table 10.

The average fossil fuel generation displacement shares and percentages changes in heat rates from the RPS goals are summarized in Table 11. For example, on average a megawatt of renewable electricity generation displaces 0.7337 megawatts of coal-fired electricity generation and 0.2663 megawatts of natural gas generation in Pennsylvania. Likewise, the RPS goals for coal heat rates in Pennsylvania are 1.11 percent higher than the base case without RPS while the corresponding heat rates for natural gas are 1.64 percent higher.

Table 10: RPS Goals by State

	RPS Goal	Year
Colorado	21.5%	2020
Delaware	22.7%	2026
North Carolina	11.9%	2020
New Mexico	15.7%	2021
Nevada	25.0%	2025
Oregon	20.8%	2025
Pennsylvania	7.8%	2021
Rhode Island	14.5%	2019
South Carolina	2.1%	2021
Utah	20.0%	2025
Virginia	6.0%	2025
Wisconsin	10.0%	2016

The shares of coal and natural gas generation displaced by renewables vary by state based upon the mix of capacity within each region. Likewise, heat rates also vary depending upon the existing level of renewable generation. States with higher levels of existing or legacy RPS generation, such as Colorado and Wisconsin, face higher increases in heat rates with additional levels of RPS generation. These displacement rates and percentage changes in heat rates are used to compute average system wide costs under RPS, which are now discussed.

Table 11: Average Fossil Fuel Displacement and Changes in Heat Rates from RPS

	RPS Displacement Shares		% Change in Heat Rates	
States	Coal	Natural Gas	Coal	Natural Gas
Colorado	0.5546	0.4454	6.78%	14.05%
Delaware	0.6960	0.3040	0.09%	0.14%
North Carolina	0.4932	0.5068	0.44%	0.58%
New Mexico	0.2412	0.7588	0.66%	2.81%
Nevada	0.4627	0.5373	1.22%	2.62%
Oregon	0.4908	0.5092	1.92%	4.11%
Pennsylvania	0.7337	0.2663	1.11%	1.64%
Rhode Island	0.1343	0.8657	0.55%	0.42%
South Carolina	0.4931	0.5069	0.12%	0.18%
Utah	0.4973	0.5027	1.18%	2.51%
Virginia	0.4531	0.5469	0.50%	0.83%
Wisconsin	0.8183	0.1817	2.15%	10.26%

2.4 Average Costs under RPS

Under renewable energy portfolio standards, new renewable electricity generation is given by:

$$R_{it} = \rho_{it} Q_{it} - \left(G_{islt} + G_{iwnt} \right) \geq 0 \tag{9}$$

The inequality on the right indicates that new renewable generation is either positive or zero. Under the RPS, new generation from natural gas combined cycle capacity is given by:

$$G_{inct} = Q_{it} - B_{it} - G_{it} - R_{it} \ . \tag{10}$$

Hence, the RPS standard reduces the need for additional new natural gas combined cycle capacity and generation. So while additional renewable generation would raise costs, some of these additional expenditures would be offset by lower outlays for new natural gas combined cycle generation to meet future electricity demand growth.

An additional benefit from an RPS would occur from reduced generation from coal and natural gas powered generation units, D_{iclt} and D_{ingt}, respectively, which are calculated as follows:

$$\begin{aligned} D_{iclt} &= \delta_{iclt} R_{it} \\ D_{ingt} &= \delta_{ingt} R_{it} \end{aligned} \tag{11}$$

where δ_{iclt} and δ_{ingt} are the shares of renewable generation displacing existing coal and natural gas generation summarized in Table 11. Total generation from existing capacity, therefore, becomes:

$$G_{it}^{rps} = \sum_{j \neq cl,ng} G_{ijt} - D_{iclt} - D_{ingt} \tag{12}$$

Additional electricity generation from renewable sources, however, would impose cycling costs on existing generation capacity to accommodate the intermittency of renewable generation. These costs raise the heat rates for existing coal and natural gas capacity. In this case, the levelized costs for existing coal and natural gas generation are defined as:

$$\begin{aligned} c_{iclt}^{rps} &= \left(1 + \theta_{iclt} \right) H_{iclt} w_{iclt} + x_{iclt} + o_{iclt} \\ c_{ingt}^{rps} &= \left(1 + \theta_{ingt} \right) H_{ingt} w_{ingt} + x_{ingt} + o_{ingt} \end{aligned} \tag{13}$$

where θ_{iclt} and θ_{ingt} are the percentage increases in heat rates, defined as million British Thermal Units (BTUs) per megawatt hour (MWh) summarized in Table 11, and

$x_{iclt}, x_{ingt}, o_{iclt}, o_{ingt}$ are capital expenses and operating and maintenance costs per MWh for existing coal and natural gas generation respectively.

Average generation costs under the RPS scenario, therefore, is as follows:

$$AC_{it}^{rps} = \frac{\left[\sum_{j \neq cl,ng} c_{ijt} G_{ijt} + c_{inct} G_{ingt} + c_{iclt}^{rps}\left(G_{iclt} - D_{iclt}\right) + c_{ingt}^{rps}\left(G_{ingt} - D_{ingt}\right) + c_{irt} R_{it}\right]}{G_{it}^{rps} + G_{inct}^{rps} + R_{it}} \quad (14)$$

where c_{irt} is a weighted average of the levelized costs generation from of solar and wind capacity. These weights vary by state and are based upon observations on capacity and generation in 2013.

Finally, retail electricity prices under the RPS are given by:

$$P_{it} = AC_{it}^{rps} + M_{i2013} \quad (15)$$

In summary the RPS model is given by the demand equation (1) and the electricity supply model given by (9)-(15).

2.5 Net Costs of RPS

The costs of the RPS goals are estimated by calculating the difference in retail electricity expenditures between the base case and the RPS scenarios for each state. To understand the sources of changes in costs arising from the RPS goals a cost decomposition is calculated for each state.

The first component of this decomposition is the cost associated with existing renewable energy capacity, which is assumed to be the result of RPS goals implemented prior to 2016. These costs are called net RPS legacy costs and include the direct costs of operating legacy RPS capacity including cycling costs less fuel cost savings arising from the displacement of coal and natural gas generation by renewable electricity generation.

The second component of the costs of RPS policies is incurred in the future as higher RPS goals are met. These are costs are defined the same as RPS legacy costs except avoided NGCC costs are added.

The third cost component is the cost of federal renewable energy subsidies. For wind power the subsidy is the $23 per megawatt hour production tax credit. Similarly, solar electricity generation units receive a 30 percent investment tax credit.

The total costs of RPS goals equal RPS legacy costs plus new RPS costs and subsidies. Reductions in carbon dioxide emissions are also calculated based upon the two scenarios and the direct (both legacy and new RPS) costs and subsidies per ton of avoided emissions are calculated.

2.6 Economic Impacts

The changes in electricity prices and investments in both renewable energy and NGCC capacity will affect regional value added and employment. Changes in value added and employment for a 10 percent increase in electricity prices are presented in Tables 12 and 13 based upon the econometric analysis conducted by Patrick et al. (2015). These estimates vary by state and industry so that the economic impacts of electricity price changes vary by state based in part upon the mix of industries. States with electricity intensive industries would be most affected by changes in electricity prices.

Table 12: Changes in Value Added for 10% Increase in Electricity Prices

	Millions of Real 2013 Dollars									
State	*Total*	*Metals*	*Paper*	*Wood*	*Man*	*Textiles*	*Minerals*	*Const.*	*Trans.*	*Other*	*Utilities*
CO	-2623	-32	-11	-12	-130	-6	-24	-390	-157	-2159	298
DE	-579	-6	-19	-1	-71	-2	-2	-54	-17	-458	50
NC	-4760	-105	-140	-71	-1321	-88	-53	-539	-203	-2682	443
NM	-656	-2	-6	-2	-10	-1	-4	-117	-47	-552	86
NV	-1185	-9	-6	-3	-13	-2	-8	-187	-109	-977	129
OR	-1571	-110	-80	-111	-30	-2	-19	-222	-101	-1128	232
PA	-6553	-642	-306	-72	-629	-18	-64	-740	-371	-4438	725
RI	-492	-38	-8	-2	-24	-5	-2	-74	-16	-365	42
SC	-1638	-93	-190	-36	-186	-57	-24	-252	-82	-1043	327
UT	-1681	-368	-45	-4	-115	-2	-21	-223	-93	-901	92
VA	-3628	-39	-76	-57	-195	-36	-26	-534	-219	-2834	386
WI	-2643	-140	-326	-66	-193	-9	-42	-305	-157	-1714	312

Table 13: Changes in Employment for 10% Increase in Electricity Prices

	Millions of Real 2013 Dollars										
State	*Total*	*Metals*	*Paper*	*Wood*	*Man*	*Textiles*	*Minerals*	*Const.*	*Trans.*	*Other*	*Utilities*
CO	-16,577	-86	-80	-162	-1,396	-107	-73	-2,759	-1,751	-10,705	542
DE	-2,923	-22	-44	-17	-261	-6	-6	-442	-288	-1,952	114
NC	-31,868	-265	-859	-889	-3,903	-2,396	-143	-4,090	-3,012	-17,060	750
NM	-5,140	-14	-29	-49	-310	-11	-18	-980	-527	-3,440	238
NV	-8,544	-49	-42	-53	-400	-35	-26	-1,236	-1,363	-5,596	257
OR	-13,463	-288	-261	-1,126	-1,629	-80	-45	-1,644	-1,374	-7,367	352
PA	-46,032	-1,385	-1,288	-1,044	-5,229	-530	-215	-5,379	-6,053	-26,308	1,398
RI	-3,342	-52	-63	-31	-407	-38	-6	-382	-268	-2,188	94
SC	-14,605	-204	-687	-413	-1,894	-1,289	-72	-1,848	-1,376	-7,618	796
UT	-9,669	-154	-149	-102	-1,169	-84	-51	-1,649	-1,274	-5,312	276
VA	-26,843	-147	-419	-721	-2,210	-520	-86	-4,211	-2,892	-16,302	666
WI	-23,543	-620	-1,668	-920	-4,567	-211	-89	-2,229	-2,516	-11,305	583

Investment multipliers are reported in Table 14 based upon the estimates from the Jobs and Economic Development Impact Models (JEDI) developed by National Energy Renewable Energy Laboratory (2016). Considine and Manderson (2014, 2015) also use these models to estimate the employment impacts from RPS policies in Arizona and California.

The JEDI models are based upon estimates for investment expenditures and operation costs for various types of electricity generation technology. Given these expenditures, which vary by state, economic input-output models are used to estimate impacts on value added and employment.

The JEDI value added multipliers appear in Table 14, which are defined in terms of dollars of value added per dollar of investment. Similarly, the employment multipliers are expressed in number of full-time equivalent jobs per dollar of investment. Notice, that the value added and employment multipliers for NGCC capacity are somewhat higher than the corresponding multipliers for investments in wind power and solar capacity. This finding suggest a NGCC technology has more extensive local supply chain linkages than wind and solar technologies that are supported by imported supplies from outside each states' boundaries. Also, there is some variation in these multipliers across states reflecting the presence or absence of industries and services supporting the supply chains for each technology.

Table 14: Investment Multipliers for Solar, Wind, and NGCC

	Solar		*Wind*		*Natural Gas*	
State	*VA / $*	*Jobs / $*	*VA / $*	*Jobs / $*	*VA / $*	*Jobs / $*
Colorado	0.2258	2.9565	0.2078	2.4459	0.2923	2.5876
Delaware	0.1921	2.7415	0.1761	2.1248	0.2569	2.0132
North Carolina	0.2071	3.3325	0.1892	2.4138	0.2777	2.4237
New Mexico	0.1817	3.4155	0.1607	2.1836	0.2416	2.1972
Nevada	0.2131	2.9768	0.1969	2.1299	0.2713	2.1653
Oregon	0.2055	3.3672	0.1857	2.3990	0.2720	2.4211
Pennsylvania	0.2194	3.2295	0.2091	2.4543	0.2977	2.5412
Rhode Island	0.2097	3.0812	0.1884	2.1906	0.2774	2.1944
South Carolina	0.1853	3.4696	0.1630	2.3973	0.2553	2.4998
Utah	0.2101	3.3548	0.2059	2.5244	0.2848	2.6915
Virginia	0.2081	2.7776	0.1919	2.2536	0.2751	2.2895
Wisconsin	0.2012	3.2736	0.1938	2.5226	0.2839	2.6010

VA = Value Added per dollar of invested capital

3. Colorado

As the above analysis suggests the costs of RPS policies are affected by a number of factors including the mix of electricity generation and capacity. Almost 84 percent of electricity generated in Colorado is from coal and natural gas. Hydroelectric generation provides about 2.7 percent while wind power provides 13.6 percent of total generation in 2013 (see Table 15). Solar power accounts for 0.5 percent of total generation.

The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market in Colorado and on state value added and employment.

Table 15: Capacity, Generation, and Utilization Rates for Colorado 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	6,229	33,703,437	0.6177
Geothermal	0	0	0.0000
Hydroelectric	657	1,212,872	0.2107
Natural gas	6,885	10,708,805	0.1775
Nuclear	0	0	0.0000
Other	11	46,180	0.4973
Other biomass	21	81,121	0.4327
Other gas	0	0	0.0000
Petroleum	205	10,192	0.0057
Pumped storage	509	-280,433	-0.0630
Solar	122	248,452	0.2329
Wind	2,331	7,203,720	0.3528
Wood	11	3,089	0.0312
Total	16,980	52,937,436	0.3559

3.1 Impacts on Electricity Sector

The impacts on electricity markets from existing Colorado RPS goals and the extension of those goals to increase the share of renewable energy to 22 percent by 2020 are presented in Table 16. The RPS goals reduce the need for additional new NGCC. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 96.2 megawatts (MW) and under RPS policies incremental NGCC capacity declines to 46.6 MW in 2016.

As Table 7 indicates slightly over 55 percent of new RPS capacity for Colorado is assumed to come from wind power with the remainder supplied by new solar generating plants. New RPS wind and solar capacity to meet the RPS goals are 194.7 and 239.2 million MW respectively in 2016. New wind and solar capacity requirements rise to 186 and 228.6 MW respectively in 2020. The electricity generation from these new facilities rises from 1.6 million MWh in 2016 to 9.1 million MWh in 2040 (see Table 16).

The increase in average electricity costs from the additional RPS goals from 14 to 22 percent of total electricity consumption are 5 percent in 2016, rising to 11.2 percent in 2020, over 10 percent out to 2030, and slightly under 8 percent in 2040. The associated increases in retail electricity rates are between 1.73 and 3.62 percent. When existing or legacy RPS costs are included, average electricity rates are between 6 and 8 percent higher than they would be in the absence of renewable portfolio standards. These rate increases are somewhat moderated by the relatively high capacity utilization rates for wind and solar in Colorado.

Table 16: Impacts of RPS on Colorado Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	96.2	99.9	102.9	109.4	114.5	119.9
With RPS	46.6	93.5	100.9	108.6	114.7	120.5
New RPS Capacity						
Wind	194.7	186.0	28.8	31.0	32.8	34.4
Solar	239.2	228.6	35.4	38.1	40.3	42.3
	Million Megawatt hours					
New NGCC Generation						
Without RPS	1.9	5.8	9.5	13.5	17.7	22.1
With RPS	1.4	4.5	8.1	12.0	16.2	20.6
Legacy RPS Generation	7.4	7.4	7.4	7.4	7.4	7.4
New RPS Generation	1.6	5.6	6.4	7.3	8.2	9.1
	Percentage Changes from Base Case					
Average Costs	5.07	11.20	10.67	10.31	9.32	7.94
Electricity Consumption	-0.10	-0.36	-0.53	-0.56	-0.54	-0.49
Average Rates	1.73	3.77	3.62	3.50	3.19	2.78
Average Rates + Legacy Costs	6.12	8.23	7.69	7.32	6.69	5.93

To gain additional insights into the costs of RPS policies on the Colorado electricity sector, Table 17 provides a decomposition of the costs. The direct RPS legacy costs, equal to the product of generation from existing renewable capacity and Colorado's levelized cost of wind and solar generation, are around $300 million per year (see Table 17). Cycling costs add another $35 to $88 million per annum. These costs, however, are partially offset by avoided fossil fuel costs that vary between $126 and $156 million per year. Net RPS legacy costs, therefore, are around $230 million per year (see Table 17).

The net costs associated with new RPS capacity are $86.8 million in 2016, rise to $188.8 million in 2020 and track down to $162.9 million in 2040. RPS tax subsidies for Colorado renewable electricity generators are significant, rising from $203 million in 2016 to over $354 million in 2040. Total RPS costs, which include legacy and new RPS costs and tax subsidies, are over $523 million in 2016 and rise to over $743 million in 2040.

Table 17: Costs of Colorado RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	336.1	328.8	319.9	311.3	302.9	294.6
Cycling Costs	30.2	45.1	53.6	65.2	76.1	88.0
less Fuel Costs	132.9	126.6	133.1	136.7	144.6	156.2
Net RPS Legacy Costs	233.3	247.3	240.4	239.8	234.3	226.4
New RPS Costs						
Direct	99.6	316.0	342.0	367.5	392.4	416.1
Cycling Costs	37.0	56.1	66.5	81.1	95.3	110.5
less Fuel Costs	35.1	149.2	188.5	225.6	269.6	319.8
less NGCC Costs	14.7	34.1	38.1	39.6	42.1	43.8
Net New RPS Costs	86.8	188.8	181.9	183.4	176.1	162.9
RPS Tax Subsidies	203.0	292.9	307.9	323.2	338.7	354.2
Total RPS Cost	523.1	729.0	730.2	746.4	749.1	743.6
	Million Tons					
CO2 Reductions	13.80	17.40	18.16	18.76	19.43	20.22
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	23.20	25.06	23.26	22.56	21.13	19.26
Subsidy Costs	14.71	16.83	16.96	17.23	17.43	17.52
Total Costs	37.92	41.89	40.22	39.79	38.56	36.78

The emission reductions associated with both legacy and new RPS capacity are also reported in Table 17. Carbon dioxide emission reductions are 13.8 million tons in 2016 and exceed 20 million tons per year by 2040. The direct costs per ton of avoided emissions are $23.20 per ton in 2016 and decline to $19.26 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are $14.71 per ton in 2016 and rise to $17.52 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $37.92 per ton in 2016 and $36.78 per ton in 2040.

Using a 5 percent discount rate, which is somewhat less than the 7.1 percent discount rate used in our levelized cost calculations, EPA (2015) estimates a social cost of carbon of $12 per ton in 2020 and $21 per ton in 2040. Hence, reducing carbon dioxide emissions with renewable portfolio standards in Colorado is not cost effective. Above and beyond this inefficiency, Colorado households and businesses also incur lost value added and employment from RPS policies, which are estimated in the next section.
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3.2 Economic Impacts

By raising retail prices for electricity, legacy and new RPS goals raise consumer electricity bills and the costs of providing goods and services in the Colorado economy. Theses impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 18. Annual losses in Colorado value added range from $2.158 billion in 2020 to $1.55 billion in 2040. Annual employment levels are 10 thousand lower in 2016 over 13 thousand lower in 2020 and remain over 9.8 thousand lower in 2040 (see Table 19). By sector, most of these losses in economic output and employment occur in Colorado's service sector.

Table 18: Impacts of RPS on Colorado Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-19.58	-26.33	-24.60	-23.42	-21.41	-18.98
Paper	-6.73	-9.05	-8.46	-8.05	-7.36	-6.53
Wood	-7.34	-9.88	-9.22	-8.78	-8.03	-7.12
Other Man	-79.56	-106.98	-99.92	-95.13	-87.00	-77.12
Textiles	-3.67	-4.94	-4.61	-4.39	-4.02	-3.56
Minerals	-14.69	-19.75	-18.45	-17.56	-16.06	-14.24
Const.	-238.69	-320.95	-299.77	-285.40	-260.99	-231.35
Trans.	-96.09	-129.20	-120.68	-114.89	-105.06	-93.13
Services	-1,321.35	-1,776.73	-1,659.52	-1,579.97	-1,444.80	-1,280.71
Utilities	182.38	245.24	229.06	218.08	199.42	176.77
Total	-1,605.32	-2,158.57	-2,016.17	-1,919.53	-1,755.30	-1,555.95

Table 19: Impacts of RPS on Colorado Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-53	-71	-66	-63	-58	-51
Paper	-49	-66	-61	-59	-54	-47
Wood	-99	-133	-125	-119	-108	-96
Other Man	-854	-1,149	-1,073	-1,022	-934	-828
Textiles	-65	-88	-82	-78	-72	-63
Minerals	-45	-60	-56	-53	-49	-43
Const.	-1,689	-2,270	-2,121	-2,019	-1,846	-1,637
Trans.	-1,072	-1,441	-1,346	-1,281	-1,172	-1,039
Services	-6,552	-8,810	-8,228	-7,834	-7,164	-6,350
Utilities	332	446	417	397	363	322
Total	-10,145	-13,642	-12,742	-12,131	-11,093	-9,833

These losses from higher electricity prices, however, are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. On the other hand, RPS investment also precludes new NGCC investment.

These different impacts of RPS investments on Colorado value added and employment are summarized in Table 20. For example, RPS investments contributed $164 million in value added and over 2 thousand jobs in 2020. Avoided NGCC investments reduce value added $0.59 million in 2020. The gains from RPS investments, however, are only significant during the building of RPS capacity. For example, the stimulus to value added drops to $24 million in 2025 and only 302 jobs are created from RPS investment in 2025.

This stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance net annual loss in value added from Colorado's RPS is almost $2 billion in 2025 and $1.5 billion in 2040. Employment levels are 12,445 lower in 2025 and 9,516 lower in 2040. Overall, under Colorado's renewable energy portfolio standards households and businesses face lower employment and value added.

Table 20: Net Impacts of RPS on Colorado Valued Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	823.38	759.36	112.71	116.24	117.71	118.70
Value Added						
Electric prices	-1,605.32	-2,158.57	-2,016.17	-1,919.53	-1,755.30	-1,555.95
RPS Invest.	178.24	164.22	24.34	25.08	25.36	25.54
NGCC Invest.	-14.83	-1.90	-0.59	-0.24	0.06	0.19
Net Change	-1,441.92	-1,996.26	-1,992.42	-1,894.69	-1,729.88	-1,530.21
Employment	**Number of Jobs**					
Electric prices	-10,145	-13,642	-12,742	-12,131	-11,093	-9,833
RPS Invest.	2,216	2,040	302	310	314	315
NGCC Invest.	-131	-17	-5	-2	1	2
Net Change	-8,060	-11,619	-12,445	-11,823	-10,779	-9,516

Whether these negative economic impacts are balanced by the benefits from avoided carbon dioxide emissions is unknown. Since the environmental benefits of greenhouse gas emissions in Colorado are likely to be very small in relation to global carbon dioxide emissions and are only partially realized by Colorado residents, the losses in value added and employment suggest that RPS policies would likely involve a decrease in net economic welfare for Colorado.

4. Delaware

As a considerably smaller state than Colorado both in terms of land mass and population, Delaware generates 7.7 million Mwh, which is about 15 percent of Colorado's electricity generation. More than 96 percent of electricity generated in Delaware is from coal and natural gas. Generation from other gas and petroleum accounts for 2.3 percent while wind power provides 0.1 percent of total generation in 2013 (see Table 21). Solar power accounts for 0.6 percent of total generation.

The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market in Colorado and on state value added and employment.

Table 21: Capacity, Generation, and Utilization Rates for Delaware 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	1,052	1,544,721	0.1676
Geothermal	0	0	0.0000
Hydroelectric	0	0	0.0000
Natural gas	2,331	5,931,288	0.2904
Nuclear	0	0	0.0000
Other	0	0	0.0000
Other biomass	8	57,347	0.8183
Other gas	324	155,409	0.0548
Petroleum	122	22,912	0.0215
Pumped storage	0	0	0.0000
Solar	28	44,727	0.1804
Wind	2	4,458	0.2545
Wood	0	0	0.0000
Total	3,867	7,760,861	0.2291

4.1 Impacts on Electricity Sector

The impacts on electricity markets from existing Delaware RPS goals and the extension of those goals to increase the share of renewable energy to 23 percent by 2026 are presented in Table 22. The RPS goals reduce the need for additional new NGCC up until 2025. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 46.3 megawatts (MW) and with RPS incremental NGCC capacity declines to 30.1 MW in 2016.

As Table 7 indicates slightly over 90 percent of new RPS capacity for Delaware is assumed to come from solar power with the remainder supplied by new wind generating plants. New RPS solar and wind capacity to meet the RPS goals are 7.9 and 112.5 MW respectively in 2016 and 96.8 and 6.8 MW respectively in 2025. The electricity generation from these new facilities rises from 1.6 million MWh in 2016 to 3.9 million MWh in 2040 (see Table 22).

The increase in average electricity costs from RPS policies are 30.6 percent in 2016, rising to 44.47 percent in 2025, over 36 percent in 2030, and more than 23 percent in 2040 (see Table 22). The associated increases in retail electricity rates are from 8 to 15 percent. These rate increases are significant due to the reliance on relatively high cost solar power to meet RPS goals and the relatively low capacity utilization rates for solar in Delaware. These sharp increases in retail electricity rates reduce electricity consumption from 2 to 4 percent per annum compared to the base case without renewable portfolio standards.

Table 22: Impacts of RPS on Delaware Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	46.3	31.6	26.5	28.7	29.1	34.1
With RPS	30.1	25.5	24.5	30.0	31.3	35.7
New RPS Capacity						
Wind	7.9	6.2	6.8	2.1	2.2	2.5
Solar	112.5	88.1	96.8	29.2	30.5	34.8
	Million Megawatt hours					
New NGCC Generation						
Without RPS	1.0	2.1	3.1	4.2	5.3	6.4
With RPS	0.7	1.6	2.5	3.5	4.7	6.0
Legacy RPS Generation	0.0	0.0	0.0	0.0	0.0	0.0
New RPS Generation	1.6	2.4	3.2	3.4	3.7	3.9
	Percentage Changes from Base Case					
Average Costs	30.64	44.01	44.47	36.72	29.38	23.82
Electricity Consumption	-2.05	-3.89	-4.34	-3.88	-3.25	-2.64
Average Rates	10.73	14.24	14.78	12.33	10.00	8.08
Average Rates + Legacy Costs	11.02	14.50	14.99	12.50	10.14	8.20

Given limited capacity of existing wind and solar to meet RPS goals, legacy RPS costs are quite small, between 3.7 to 2.2 million per year (see Table 23). The net costs associated with new RPS capacity are $109.6 million in 2016, rise to $143.8 in 2025, and then track down to $94.8 million in 2040. RPS tax subsidies for Delaware's renewable electricity generators are significant, rising from $67.1 million in 2016 to over $116.6 million in 2040. Total RPS costs, which include legacy and new RPS costs and tax subsidies, are over $180 million in 2016 and rise to over $262.6 million in 2025.

The RPS policies reduce carbon dioxide emissions by 1.71 million tons in 2016 to over 4 million tons per year by 2040 (see Table 23). The direct costs per ton of avoided emissions are $66.40 per ton in 2016 and decline to $24.21 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are slightly over $39 per ton in

2016 and remain over $29 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $105.74 per ton in 2016 and $53.31 per ton in 2040.

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Table 23: Costs of Delaware RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	4.8	4.5	4.2	3.9	3.6	3.4
Cycling Costs	0.3	0.2	0.2	0.2	0.2	0.2
less Fuel Costs	1.3	1.2	1.3	1.3	1.4	1.4
Net RPS Legacy Costs	3.7	3.5	3.1	2.8	2.4	2.2
New RPS Costs						
Direct	154.3	216.2	269.8	270.2	271.2	272.2
Cycling Costs	0.3	0.2	0.2	0.2	0.2	0.2
less Fuel Costs	36.4	68.2	106.4	125.3	144.6	162.3
less NGCC Costs	8.7	15.8	19.8	19.3	17.7	15.3
Net New RPS Costs	109.6	132.4	143.8	125.8	109.2	94.8
RPS Tax Subsidies	67.1	93.1	115.7	115.8	116.2	116.6
Total RPS Cost	180.4	229.0	262.6	244.4	227.8	213.6
	Million Tons					
CO2 Reductions	1.71	2.58	3.38	3.58	3.79	4.01
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	66.40	52.71	43.47	35.90	29.48	24.21
Subsidy Costs	39.34	36.12	34.23	32.32	30.68	29.10
Total Costs	105.74	88.83	77.70	68.22	60.16	53.31

Using a 5 percent discount rate, EPA (2015) estimates a social cost of carbon of $12 and $21 per ton in 2020 and 2040 respectively. With a three percent discount, EPA's social cost of carbon is $42 per ton in 2020 and $60 per ton in 2040. Hence, reducing carbon dioxide emissions with renewable portfolio standards in Delaware is not cost effective at discount rates of three percent and only cost effective beyond 2035 at five percent discount rates. Above and beyond this comparison of the RPS abatements costs and the social cost of carbon, households and businesses in Delaware face higher electricity costs that reduce value added and employment.

4.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Delaware economy. Theses impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 24. Annual losses in Delaware value added range from $637.8 million in 2016 to almost $724 million in 2030, and over $474 million in 2040. Employment levels are 3,200 lower in 2016, 4,3781 lower in 2025 and almost 2,400 lower in 2040 (see Table 25).

Table 24: Impacts of RPS on Delaware Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-6.61	-8.70	-8.99	-7.50	-6.08	-4.92
Paper	-20.93	-27.55	-28.48	-23.76	-19.26	-15.57
Wood	-1.10	-1.45	-1.50	-1.25	-1.01	-0.82
Other Man	-78.21	-102.94	-106.41	-88.78	-71.99	-58.19
Textiles	-2.20	-2.90	-3.00	-2.50	-2.03	-1.64
Minerals	-2.20	-2.90	-3.00	-2.50	-2.03	-1.64
Const.	-59.48	-78.29	-80.93	-67.52	-54.75	-44.26
Trans.	-18.73	-24.65	-25.48	-21.26	-17.24	-13.93
Services	-504.50	-664.04	-686.40	-572.68	-464.38	-375.37
Utilities	55.08	72.49	74.93	62.52	50.70	40.98
Total	-637.78	-839.47	-867.75	-723.98	-587.07	-474.54

Table 25: Impacts of RPS on Delaware Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-24	-32	-33	-28	-22	-18
Paper	-48	-64	-66	-55	-45	-36
Wood	-19	-25	-25	-21	-17	-14
Other Man	-287	-378	-391	-326	-265	-214
Textiles	-7	-9	-9	-8	-6	-5
Minerals	-7	-9	-9	-8	-6	-5
Const.	-487	-641	-662	-553	-448	-362
Trans.	-317	-418	-432	-360	-292	-236
Services	-2,150	-2,830	-2,925	-2,441	-1,979	-1,600
Utilities	126	165	171	143	116	93
Total	-3,220	-4,238	-4,381	-3,655	-2,964	-2,396

These losses from higher electricity prices, however, are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. On the other hand, RPS investment also precludes new NGCC investment. These different impacts of RPS on Delaware value added and employment are summarized in Table 26. For example, in 2020 RPS investments contributed $29.49 million in value added and 415 jobs. Avoided NGCC investments reduce value added $0.52 million in 2020.

This stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Delaware's RPS goals are $603 million in 2016, $838 million in 2025, and over $465 million in 2040. Employment levels are 2,705 lower in 2016, 3.970 in 2025, and 2,272 lower in 2040 (see Table 26).

Table 26: Net Impacts of RPS on Delaware Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	203.95	151.04	154.74	43.51	42.35	45.13
Value Added						
Electric prices	-637.78	-839.47	-867.75	-723.98	-587.07	-474.54
RPS Invest.	38.90	28.80	29.49	8.29	8.06	8.59
NGCC Invest.	-4.25	-1.60	-0.52	0.35	0.57	0.43
Net Change	-603.13	-812.27	-838.77	-715.34	-578.43	-465.53
Employment	**Number of Jobs**					
Electric prices	-3,220	-4,238	-4,381	-3,655	-2,964	-2,396
RPS Invest.	548	406	415	117	113	121
NGCC Invest.	-33	-13	-4	3	5	3
Net Change	-2,705	-3,845	-3,970	-3,536	-2,846	-2,272

These regional economic impacts combined with the comparison of RPS abatement costs in Delaware to the social cost of carbon suggest that RPS policies are inefficient from two perspectives. First, from a global cost-benefit standpoint, RPS abatement costs are substantially higher than the social costs of carbon, indicating that RPS policies in Delaware are inefficient. Secondly, RPS policies in Delaware reduce employment and value added in the state's economy.

These negative economic impacts are not balanced by the benefits from avoided carbon dioxide emissions. Since the environmental benefits of greenhouse gas emissions are likely to be very small in relation to global carbon dioxide emissions and are only partially realized by Delaware residents, these results suggest that RPS policies for Delaware may involve a decrease in net economic welfare.

5. North Carolina

North Carolina has a sizeable electricity sector, generating more than 125 million MWh with 37 percent coming from coal, 32 percent from nuclear, and 22 percent from natural gas (see Table 27). Five percent of total generation comes from hydroelectric facilities and 1.7 percent from wood fired power plants. Solar power accounts for 0.3 percent of total generation in 2013 (see Table 27). The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in North Carolina.

Table 27: Capacity, Generation, and Utilization Rates for North Carolina 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	13,021	47,072,210	0.4127
Geothermal	0	0	0.0000
Hydroelectric	1,890	6,900,533	0.4167
Natural gas	12,713	27,982,509	0.2513
Nuclear	5,395	40,241,737	0.8515
Other	50	566,884	1.2840
Other biomass	64	410,294	0.7284
Other gas	0	0	0.0000
Petroleum	504	217,571	0.0493
Pumped storage	95	0	0.0000
Solar	336	344,663	0.1170
Wind	0	0	0.0000
Wood	571	2,199,893	0.4398
Total	34,641	125,936,293	0.4150

5.1 Impacts on Electricity Sector

The RPS goal for North Carolina is 11.9 percent of total consumption by 2020. The impacts on electricity markets from these goals are presented in Table 28. The RPS goals significantly reduce the need for additional new NGCC as these goals are met from 2016 to 2020. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 364.7 megawatts (MW) in the base case and with RPS incremental NGCC capacity declines to 202 MW in 2016. After 2030, NGCC capacity additions are slightly higher than the base case NGCC capacity additions.

Slightly over 88 percent of new RPS capacity for North Carolina is supplied by solar power with the remainder met by new wind generating plants. New RPS wind and solar capacity to meet the RPS goals are 243.3 and 2,407 MW respectively in 2016. New wind and solar capacity requirements are 17.2 and 170.9 MW respectively in 2025. The electricity generation from these new facilities rises from 10.1 million MWh in 2016 to 22 million MWh in 2040 (see Table 28).

The increase in average electricity costs from RPS policies are 25 percent in 2016, rising to 42 percent in 2020, over 36 percent in 2025, and almost 24 percent in 2040 (see Table 28). The associated increases in retail electricity rates are from 9 to 15 percent. These rate increases are significant due to the reliance on relatively high cost solar power to meet RPS goals, which reflects relatively low capacity utilization rates for solar in North Carolina. These sharp increases in retail electricity rates reduce electricity consumption compared to the base case without renewable portfolio standards.

Table 28: Impacts of RPS on North Carolina Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	364.7	258.5	226.2	231.9	239.8	256.2
With RPS	202.0	229.5	224.1	233.9	243.3	258.9
New RPS Capacity						
Wind	242.3	140.1	17.2	17.9	18.7	19.9
Solar	2407.7	1391.9	170.9	178.4	185.6	197.5
	Million Megawatt hours					
New NGCC Generation						
Without RPS	9.1	17.5	26.2	34.6	43.5	52.8
With RPS	7.0	14.0	22.3	30.8	39.8	49.2
Legacy RPS Generation	0.3	0.3	0.3	0.3	0.3	0.3
New RPS Generation	10.1	17.8	18.8	19.8	20.9	22.0
	Percentage Changes from Base Case					
Average Costs	25.01	42.15	36.26	31.85	27.55	24.30
Electricity Consumption	-0.39	-1.03	-1.18	-1.10	-0.99	-0.88
Average Rates	9.64	15.67	13.79	12.26	10.78	9.57
Average Rates + Legacy Costs	10.04	16.06	14.12	12.55	11.03	9.79

The decomposition of RPS costs on the North Carolina electricity sector appear in Table 29. Net annual RPS legacy costs are $51.6 million in 2016 and remain over $38 million in 2040. Cycling costs due to the inefficient operation of the electricity grid to accommodate intermittent renewable energy sources are roughly equal to the fossil fuel cost savings.

The costs arising from new renewable capacity associated to meet North Carolina's RPS goals are also summarized in Table 29. The net costs associated with new RPS capacity are $1.17 billion in 2016, $1.9 billion in 2025, $1.8 billion in 2025 and remain $1.4 billion out to 2040. RPS tax subsidies associated with North Carolina's renewable electricity generators are significant, increasing from $546 million in 2016 to over $937 million in 2020. Total RPS costs, which include legacy and new RPS costs and tax subsidies, are over $1.7 billion in 2016 and rise to over $2.9 billion in 2020.

Table 29: Costs of North Carolina RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	53.1	49.9	46.3	42.9	39.8	36.9
Cycling Costs	8.4	9.8	10.3	10.6	11.0	11.3
less Fuel Costs	9.9	8.8	9.4	9.6	10.0	10.2
Net RPS Legacy Costs	51.6	50.9	47.3	43.9	40.8	38.0
New RPS Costs						
Direct	1,532.9	2,557.6	2,518.7	2,477.5	2,437.1	2,397.5
Cycling Costs	8.9	10.2	10.9	11.1	11.6	11.8
less Fuel Costs	286.7	534.5	632.4	697.1	768.8	829.9
less NGCC Costs	78.7	117.2	135.1	136.7	136.3	131.2
Net New RPS Costs	1,176.5	1,916.2	1,762.0	1,654.8	1,543.5	1,448.3
RPS Tax Subsidies	546.7	937.9	925.6	912.0	898.3	884.7
Total RPS Cost	1,774.7	2,904.9	2,734.9	2,610.7	2,482.7	2,371.0
	Million Tons					
CO2 Reductions	8.92	15.85	16.87	17.68	18.50	19.35
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	137.72	124.10	107.25	96.08	85.65	76.83
Subsidy Costs	61.31	59.17	54.87	51.58	48.56	45.73
Total Costs	199.03	183.27	162.12	147.65	134.22	122.56

The RPS policies reduce carbon dioxide emissions by 8.92 million tons in 2016 to over 19 million tons per year by 2040 (see Table 29). The direct costs per ton of avoided emissions are $137.72 per ton in 2016 and decline to $76.83 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are over $61 per ton in 2016 and remain over $45 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $199 per ton in 2016 and $122 per ton in 2040.

These RPS carbon abatement costs are well beyond the EPA social cost of carbon, indicating that RPS policies in North Carolina are a very inefficient greenhouse gas emission strategy. So even from a global cost-benefit perspective, adopting RPS policies in North Carolina would involve a net loss in producer and consumer surplus or net social welfare. From a North Carolina perspective, the wide gap between the estimated RPS carbon abatement costs and the social benefit from reducing greenhouse gas emissions estimated by the avoided social costs of carbon is compounded by the significant losses in economic output and employment associated with the significant increase in electricity rates caused by renewable energy portfolio standards. These impacts are now presented and discussed.

5.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the North Carolina economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 30. Annual losses in North Carolina value added range from $4.78 billion in 2016 to $7.6 billion in 2020, and over $4.6 billion in 2040. Employment levels are 30,000 to 50,000 below employment in the base case without renewable energy portfolio standards (see Table 31). Other manufacturing and services are particularly hard hit.

Table 30: Impacts of RPS on North Carolina Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-105.45	-168.62	-148.27	-131.80	-115.85	-102.83
Paper	-140.61	-224.83	-197.69	-175.73	-154.46	-137.10
Wood	-71.31	-114.02	-100.26	-89.12	-78.33	-69.53
Other Man	-1,326.72	-2,121.43	-1,865.37	-1,658.14	-1,457.47	-1,293.64
Textiles	-88.38	-141.32	-124.26	-110.46	-97.09	-86.18
Minerals	-53.23	-85.11	-74.84	-66.53	-58.48	-51.90
Const.	-541.34	-865.60	-761.11	-676.56	-594.68	-527.84
Trans.	-203.88	-326.00	-286.65	-254.81	-223.97	-198.80
Services	-2,693.62	-4,307.10	-3,787.21	-3,366.48	-2,959.07	-2,626.46
Utilities	444.92	711.43	625.55	556.06	488.76	433.83
Total	-4,780.62	-7,644.22	-6,721.53	-5,974.81	-5,251.73	-4,661.42

Table 31: Impacts of RPS on North Carolina Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-266	-426	-374	-333	-292	-260
Paper	-863	-1,379	-1,213	-1,078	-948	-841
Wood	-893	-1,428	-1,255	-1,116	-981	-871
Other Man	-3,920	-6,268	-5,511	-4,899	-4,306	-3,822
Textiles	-2,406	-3,848	-3,383	-3,007	-2,644	-2,346
Minerals	-144	-230	-202	-179	-158	-140
Const.	-4,108	-6,568	-5,775	-5,134	-4,513	-4,005
Trans.	-3,025	-4,837	-4,253	-3,781	-3,323	-2,950
Services	-17,134	-27,397	-24,090	-21,414	-18,822	-16,707
Utilities	753	1,204	1,059	941	827	734
Total	-32,006	-51,178	-45,000	-40,001	-35,160	-31,208

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. On the other hand, RPS investment also precludes new NGCC investment. These different impacts of RPS on North Carolina value added and employment are summarized in Table 32. For example, in 2016 RPS investments contributed $927 million in value added and 14,588 jobs. Avoided NGCC investments reduce value added $46.21 million in 2020.

The stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from North Carolina's RPS goals are $3.9 billion in 2016, $7.145 billion in 2020 and remain well above $4 billion out to the end of the forecast horizon in 2040. Employment levels are 17,821 lower in 2016, 43,277 lower in 2020, and 44,093 lower in 2025.

Table 32: Net Impacts of RPS on North Carolina Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	4,523.89	2,476.02	284.05	277.03	269.46	268.17
Value Added						
Electric prices	-4,780.62	-7,644.22	-6,721.53	-5,974.81	-5,251.73	-4,661.42
RPS Invest.	927.39	507.36	58.17	56.70	55.12	54.82
NGCC Invest.	-46.21	-8.24	-0.59	0.58	1.01	0.76
Net Change	-3,899.44	-7,145.10	-6,663.95	-5,917.54	-5,195.61	-4,605.84
Employment	**Number of Jobs**					
Electric prices	-32,006	-51,178	-45,000	-40,001	-35,160	-31,208
RPS Invest.	14,588	7,973	913	889	863	857
NGCC Invest.	-403	-72	-5	5	9	7
Net Change	-17,821	-43,277	-44,093	-39,107	-34,289	-30,345

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in North Carolina are substantially higher than EPA estimates of the social cost of carbon. From a global perspective, therefore, renewable energy portfolio standards in North Carolina are an inefficient means to address global climate change. Other strategies employing alternative resources and technologies to reduce greenhouse gas emissions could prove far more cost effective.

Moreover, the RPS goals impose additional costs on households and businesses in North Carolina in the form of billions of dollars in lost value added and tens of thousands of jobs lost. Hence, RPS policies for North Carolina involve a double penalty with marginal abatement costs far above the expected benefits from reducing greenhouse gas emission and burdens on the local economy that reduce growth and employment.

6. New Mexico

New Mexico has an electricity sector somewhat smaller than Colorado, generating more than 35.8 million MWh with 67 percent coming from coal and 25 percent from natural gas (see Table 33). More than 6 percent of generation comes from wind power. Solar power accounts for 1.1 percent of total generation in 2013 (see Table 33). The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in New Mexico.

Table 33: Capacity, Generation, and Utilization Rates for New Mexico 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	4,375	24,145,271	0.6300
Geothermal	4	69	0.0020
Hydroelectric	82	91,838	0.1283
Natural gas	3,876	8,975,243	0.2644
Nuclear	0	0	0.0000
Other	3	716	0.0314
Other biomass	7	18,518	0.3203
Other gas	0	0	0.0000
Petroleum	31	57,848	0.2103
Pumped storage	0	0	0.0000
Solar	191	388,041	0.2325
Wind	778	2,193,421	0.3220
Wood	0	0	0.0000
Total	9,345	35,870,965	0.4382

6.1 Impacts on Electricity Sector

The RPS goal for New Mexico is 15.7 percent of total consumption by 2021 so New Mexico is already almost half way in achieving their standard. The impacts on electricity markets from these goals are presented in Table 34. The RPS eliminates the need for new NGCC capacity in 2016. Afterward, however, the RPS goals marginally reduce the need for additional new NGCC. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 47.7 megawatts (MW) in the base case and with RPS incremental NGCC capacity declines to 46.1 MW in 2020.

Slightly over 89 percent of new RPS capacity for New Mexico is supplied by wind power with the remainder met by new solar generating plants. Planned RPS wind and solar capacity to meet the RPS goals are 440.9 and 75.3 MW respectively in 2016. The electricity generation from these new facilities rises from 1.4 million MWh in 2016 to 2.7 million MWh in 2040 (see Table 34).

The increases in average electricity costs from new RPS capacity additions are 3.87 percent in 2016, rising to 6.31 percent in 2020, 5.58 percent in 2025, and 3.81 percent in 2040 (see Table 34). With legacy costs average electricity rates in New Mexico increase 6.18 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 6.77 percent in 2020, slightly less than 6 percent in 2025, and 4-5 percent from 2030 to 2040.

Table 34: Impacts of RPS on New Mexico Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	47.2	47.7	47.8	49.0	50.2	51.4
With RPS	0.0	46.1	46.8	48.5	50.0	51.3
New RPS Capacity						
Wind	440.9	0.0	0.0	0.0	0.0	19.0
Solar	75.3	0.0	0.0	0.0	0.0	3.2
	Million Megawatt hours					
New NGCC Generation						
Without RPS	0.8	7.0	8.8	10.6	12.4	14.3
With RPS	0.0	4.5	6.3	8.0	9.9	11.8
Legacy RPS Generation	2.6	2.6	2.6	2.6	2.6	2.6
New RPS Generation	1.4	2.4	2.4	2.4	2.4	2.7
	Percentage Changes from Base Case					
Average Costs	3.87	6.31	5.58	5.01	4.25	3.81
Electricity Consumption	-0.06	-0.26	-0.40	-0.46	-0.48	-0.47
Average Rates	1.40	2.23	1.99	1.79	1.54	1.42
Average Rates + Legacy Costs	6.18	6.77	5.95	5.30	4.54	3.92

The decomposition of RPS costs for the New Mexico electricity sector appear in Table 35. Direct legacy costs are more than $140 million in 2016 and remain over $120 million through the end of the projection period. After including cycling costs and deducting avoided fossil fuel costs, net RPS legacy costs are $100 million in 2016 and remain over $72 million in 2040.

The costs arising from new renewable capacity associated to meet New Mexico's RPS goals are also summarized in Table 35. The direct costs to go from the current 7.2 percent of generation from solar and wind to the 15.7 percent goal of total electricity consumption are $76 million in 2016 and rise to over $123 million in 2020 and remain at roughly that level through 2040. After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $28 million in 2016, $43 million in 2020, and between $27 and $30 million thereafter. With subsidies, the total costs of New Mexico's RPS are $192 million in 2016, $205.8 million in 2020, $192.8 million in 2025 and are more than $160 million in 2040 (see Table 35).

Table 35: Costs of New Mexico RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	141.7	137.9	133.3	128.9	124.7	120.6
Cycling Costs	6.2	5.6	5.9	6.0	6.4	6.9
less Fuel Costs	47.2	43.5	45.5	46.6	50.2	54.7
Net RPS Legacy Costs	100.7	100.0	93.7	88.3	80.9	72.8
New RPS Costs						
Direct	76.3	123.9	120.3	116.9	113.5	123.9
Cycling Costs	7.2	6.6	6.9	7.1	7.5	8.2
less Fuel Costs	33.3	25.9	26.1	25.6	23.9	32.5
less NGCC Costs	22.0	61.3	63.7	64.9	68.6	72.3
Net New RPS Costs	28.2	43.2	37.5	33.4	28.5	27.3
RPS Tax Subsidies	63.3	62.6	61.7	60.9	60.1	66.2
Total RPS Cost	192.2	205.8	192.8	182.6	169.5	166.2
	Million Tons					
CO2 Reductions	4.19	5.17	5.20	5.21	5.22	5.43
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	30.79	27.70	25.22	23.34	20.95	18.41
Subsidy Costs	15.13	12.10	11.87	11.68	11.51	12.17
Total Costs	45.92	39.80	37.09	35.02	32.46	30.59

The RPS policies in New Mexico reduce carbon dioxide emissions by 4.19 million tons in 2016 to over 5.4 million tons per year by 2040 (see Table 35). The direct costs per ton of avoided emissions are $30.77 per ton in 2016 and decline to $18.41 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are over $15 per ton in 2016 and remain over $11 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $45.92 per ton in 2016 and $30.59 per ton in 2040.

Assuming a 5 percent discount rate these RPS carbon abatement costs are above the EPA social cost of carbon suggesting that RPS policies in New Mexico are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, however, the total costs per ton of using RPS to reduce carbon emissions is below the social cost of carbon beyond 2020. So from a global cost-benefit perspective, adopting RPS policies in New Mexico could be acceptable. From a New Mexico perspective, however, there are economic impacts resulting from higher electricity rates in the form of losses in economic output and employment. These impacts are now presented and discussed.

6.2 Economic Impacts

By raising retail prices for electricity, RPS goals raise consumer electricity bills and the costs of providing goods and services in the New Mexico economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 36. Annual losses in New Mexico value added range from $405 million in 2016 to $444 billion in 2020, and over $250 million in 2040. Employment levels are 2,000 to 3,000 below employment in the base case without renewable energy portfolio standards (see Table 37).

Table 36: Impacts of RPS on New Mexico Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-1.24	-1.35	-1.19	-1.06	-0.91	-0.78
Paper	-3.71	-4.06	-3.57	-3.18	-2.72	-2.35
Wood	-1.24	-1.35	-1.19	-1.06	-0.91	-0.78
Other Man	-6.18	-6.77	-5.95	-5.30	-4.54	-3.92
Textiles	-0.62	-0.68	-0.59	-0.53	-0.45	-0.39
Minerals	-2.47	-2.71	-2.38	-2.12	-1.82	-1.57
Const.	-72.26	-79.19	-69.60	-61.97	-53.10	-45.92
Trans.	-29.03	-31.81	-27.96	-24.89	-21.33	-18.45
Services	-340.90	-373.63	-328.39	-292.36	-250.52	-216.65
Utilities	53.11	58.21	51.16	45.55	39.03	33.75
Total	-405.12	-444.02	-390.26	-347.44	-297.72	-257.47

Table 37: Impacts of RPS on New Mexico Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-9	-9	-8	-7	-6	-5
Paper	-18	-20	-17	-15	-13	-11
Wood	-30	-33	-29	-26	-22	-19
Other Man	-191	-210	-184	-164	-141	-122
Textiles	-7	-7	-7	-6	-5	-4
Minerals	-11	-12	-11	-10	-8	-7
Const.	-605	-663	-583	-519	-445	-385
Trans.	-325	-357	-314	-279	-239	-207
Services	-2,124	-2,328	-2,046	-1,822	-1,561	-1,350
Utilities	147	161	142	126	108	93
Total	-3,174	-3,479	-3,058	-2,722	-2,333	-2,017

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on New Mexico value added and employment are summarized in Table 38. For example, in 2016 RPS investments contributed $178 million in value added and 2,537 jobs. Avoided NGCC investments reduce value added $11.66 million and reduce employment by 106 in 2016.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from New Mexico's RPS goals are $238 million in 2016, $444 million in 2020, $390 million in 2025, and remain over $250 million through the end of the forecast horizon. Employment levels are 743 lower in 2016, 3,483 lower in 2020, and 3,060 lower in 2025.

Table 38: Net Impacts of RPS on New Mexico Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	1,091.35	0.00	0.00	0.00	0.00	42.25
Value Added						
Electric prices	-405.12	-444.02	-390.26	-347.44	-297.72	-257.47
RPS Invest.	178.00	0.00	0.00	0.00	0.00	6.87
NGCC Invest.	-11.66	-0.39	-0.24	-0.14	-0.06	-0.02
Net Change	-238.78	-444.41	-390.50	-347.58	-297.78	-250.63
Employment	**Number of Jobs**					
Electric prices	-3,174	-3,479	-3,058	-2,722	-2,333	-2,017
RPS Invest.	2,537	0	0	0	0	97
NGCC Invest.	-106	-4	-2	-1	-1	0
Net Change	-743	-3,483	-3,060	-2,724	-2,333	-1,921

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in New Mexico are higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate but are below the social cost of capital assuming a 3 percent discount rate after 2020. From a global perspective, therefore, renewable energy portfolio standards in New Mexico may be an efficient means to address global climate change under a relatively low discount rate for future damages associated with global climate change. From the viewpoint of the New Mexico economy, however, renewable portfolio standards raise electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus that building and operating renewable energy facilities provide.

7. Nevada

Nevada has an electricity sector about the size of New Mexico's, generating more than 36.4 million MWh with 68 percent coming from natural gas, 14 percent from coal, slightly over 7.3 percent from geothermal, and 7.4 percent from hydroelectricity (see Table 39). Solar power accounts for 2 percent of total generation in 2013 (see Table 33) while wind contributes 0.7 percent. The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in Nevada.

Table 39: Capacity, Generation, and Utilization Rates for Nevada 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	4,375	5,254,553	0.1946
Geothermal	4	2,669,953	0.5027
Hydroelectric	82	2,681,943	0.2910
Natural gas	3,876	24,766,633	0.3231
Nuclear	0	0	0.0000
Other	3	25,389	0.0000
Other biomass	7	24,277	0.8660
Other gas	0	6,304	0.0000
Petroleum	31	18,890	0.3594
Pumped storage	0	0	0.0000
Solar	191	745,382	0.2300
Wind	778	250,549	0.1907
Wood	0	0	0.0000
Total	9,345	36,443,874	0.2967

7.1 Impacts on Electricity Sector

The RPS goal for Nevada is 25 percent of total consumption by 2025. The impacts on electricity markets from these goals are presented in Table 40. The RPS goals marginally reduce the need for additional new NGCC as these goals are met from 2016 to 2025. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 134.8 MW in the base case and under the RPS incremental NGCC capacity declines to 114.4 MW in 2020.

Slightly over 87 percent of new RPS capacity for Nevada is supplied by solar power with the remainder met by new wind generating plants. RPS wind and solar capacity to meet the RPS goals are 36.2 and 206.9 MW respectively in 2016. The electricity generation from these new facilities rises from 6.9 million MWh in 2016 to 14.6 million MWh in 2040 (see Table 40).

The increases in average electricity costs from new RPS capacity additions are 32.85 percent in 2016, rising to 37.58 percent in 2020, 37.33 percent in 2025, and 21.32

percent in 2040 (see Table 40). With legacy costs average electricity rates in Nevada increase 14.77 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 15.6 percent in 2020, more than 15 percent in 2025, and 9-13 percent from 2030 to 2040.

Table 40: Impacts of RPS on Nevada Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	179.1	134.8	124.6	138.6	141.5	152.6
With RPS	0.0	114.4	117.1	138.8	146.3	159.5
New RPS Capacity						
Wind	36.2	26.7	37.2	19.6	20.6	22.5
Solar	206.9	152.8	212.9	112.0	118.0	128.7
	Million Megawatt hours					
New NGCC Generation						
Without RPS	2.7	7.8	13.5	18.4	23.6	29.1
With RPS	0.0	2.4	7.7	12.6	17.9	23.6
Legacy RPS Generation	1.0	1.0	1.0	1.0	1.0	1.0
New RPS Generation	6.9	8.3	10.6	11.8	13.1	14.6
	Percentage Changes from Base Case					
Average Costs	32.85	37.58	37.33	32.83	27.03	21.32
Electricity Consumption	-2.97	-5.07	-5.42	-5.01	-4.37	-3.64
Average Rates	12.19	13.40	13.39	11.80	9.96	8.09
Average Rates + Legacy Costs	14.77	15.60	15.14	13.28	11.21	9.12

The decomposition of RPS costs for the Nevada electricity sector appear in Table 41. Direct legacy costs are more than $83 million in 2016 and remain over $60 million through the end of the forecast period. After including cycling costs and deducting avoided fossil fuel costs, net RPS legacy costs are $79.2 million in 2016 and remain over $50 million in 2040.

The costs arising from new renewable capacity associated to meet Nevada's RPS goals are also summarized in Table 41. The direct costs to go from the current 2.7 percent of generation from solar and wind to the 25 percent goal of total electricity consumption are $553.2 million in 2016 and rise to over $762 million in 2025 and escalate to over $860 million per year by 2040. After adding cycling costs and deducting for fossil fuel and NGCC capacity cost savings, the net costs to bring meet the RPS goal are $271.4 million in 2016, $254.8 million in 2020, and between $208 and $250 million thereafter. With subsidies, the total costs of Nevada's RPS are $520.6 million in 2016, $514.3 million in 2020, $573.2 million in 2025 and more than $500 million per year from 2030 to 2040 (see Table 41).

Table 41: Costs of Nevada RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	83.9	80.1	75.6	71.4	67.5	63.8
Cycling Costs	14.9	12.0	9.2	9.4	10.2	11.2
less Fuel Costs	19.5	18.9	19.8	20.4	21.4	23.1
Net RPS Legacy Costs	79.2	73.2	64.9	60.4	56.3	52.0
New RPS Costs						
Direct	553.2	635.1	762.8	796.1	829.6	862.3
Cycling Costs	16.8	13.6	10.4	10.7	11.6	12.8
less Fuel Costs	226.4	259.6	358.3	404.4	453.4	510.2
less NGCC Costs	72.2	134.3	147.6	150.1	154.6	156.1
Net New RPS Costs	271.4	254.8	267.4	252.2	233.3	208.8
RPS Tax Subsidies	170.0	186.3	240.9	257.7	274.3	290.4
Total RPS Cost	520.6	514.3	573.2	570.3	563.9	551.1
	Million Tons					
CO2 Reductions	6.78	9.05	11.20	12.22	13.23	14.25
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	51.73	36.24	29.67	25.59	21.89	18.29
Subsidy Costs	25.09	20.59	21.51	21.10	20.74	20.37
Total Costs	76.82	56.83	51.17	46.68	42.64	38.66

The RPS policies in Nevada reduce carbon dioxide emissions by 6.78 million tons in 2016 to over 14.25 million tons per year by 2040 (see Table 35). The direct costs per ton of avoided emissions are $51.73 per ton in 2016 and decline to $18.29 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are over $25 per ton in 2016 and remain over $20 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $76.82 per ton in 2016 and gradually decline to $38.66 per ton in 2040.

Assuming a 5 percent discount rate these RPS carbon abatement costs are well above the EPA social cost of carbon of $12 to $24 per ton, suggesting that RPS policies in Nevada are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Nevada is questionable. From a Nevada perspective, however, there are economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

7.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Nevada economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 42. Annual losses in Nevada value added range from $1.75 billion in 2016 to $1.8 billion in 2020, and remain over $1 billion per year out to 2040. Employment levels are 7,800 to 12,000 below employment in the base case without renewable energy portfolio standards (see Table 43).

Table 42: Impacts of RPS on Nevada Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-13.29	-14.04	-13.63	-11.95	-10.09	-8.21
Paper	-8.86	-9.36	-9.09	-7.97	-6.72	-5.47
Wood	-4.43	-4.68	-4.54	-3.98	-3.36	-2.74
Other Man	-19.20	-20.28	-19.68	-17.27	-14.57	-11.85
Textiles	-2.95	-3.12	-3.03	-2.66	-2.24	-1.82
Minerals	-11.82	-12.48	-12.11	-10.63	-8.97	-7.29
Const.	-276.23	-291.70	-283.16	-248.37	-209.57	-170.52
Trans.	-161.01	-170.03	-165.05	-144.77	-122.16	-99.39
Services	-1,443.17	-1,524.03	-1,479.40	-1,297.62	-1,094.94	-890.90
Utilities	190.55	201.23	195.34	171.33	144.57	117.63
Total	-1,750.42	-1,848.49	-1,794.36	-1,573.88	-1,328.04	-1,080.56

Table 43: Impacts of RPS on Nevada Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-72	-76	-74	-65	-55	-45
Paper	-62	-66	-64	-56	-47	-38
Wood	-78	-83	-80	-70	-59	-48
Other Man	-591	-624	-606	-531	-448	-365
Textiles	-52	-55	-53	-46	-39	-32
Minerals	-38	-41	-39	-35	-29	-24
Const.	-1,826	-1,928	-1,872	-1,642	-1,385	-1,127
Trans.	-2,013	-2,126	-2,064	-1,810	-1,528	-1,243
Services	-8,266	-8,729	-8,474	-7,432	-6,272	-5,103
Utilities	380	401	389	341	288	234
Total	-12,621	-13,328	-12,938	-11,348	-9,575	-7,791

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Nevada value added and employment are summarized in Table 44. For example, in 2016 RPS investments contributed $88 million in value added and 1,190 jobs. Avoided NGCC investments reduce value added $49.69 million and reduce employment by 397 in 2016.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Nevada's RPS goals are $1.7 billion in 2016, $1.8 billion in 2020, $1.7 billion in 2025, and remain over $1 billion through the end of the forecast horizon. Employment levels are over 11 thousand lower in 2016, 12 thousand lower in 2020, and 11.9 thousand lower in 2025.

Table 44: Net Impacts of RPS on Nevada Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	422.32	296.25	387.35	191.30	189.45	194.15
Value Added						
Electric prices	-1,750.42	-1,848.49	-1,794.36	-1,573.88	-1,328.04	-1,080.56
RPS Invest.	88.71	62.20	81.26	40.10	39.68	40.63
NGCC Invest.	-49.69	-5.64	-2.08	0.04	1.33	1.90
Net Change	-1,711.40	-1,791.93	-1,715.18	-1,533.73	-1,287.03	-1,038.03
Employment	**Number of Jobs**					
Electric prices	-12,621	-13,328	-12,938	-11,348	-9,575	-7,791
RPS Invest.	1,190	833	1,086	535	528	539
NGCC Invest.	-397	-45	-17	0	11	15
Net Change	-11,827	-12,540	-11,868	-10,813	-9,037	-7,237

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Nevada are higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate but are slightly below the social cost of capital assuming a 3 percent discount rate after 2030. From a global perspective, therefore, renewable energy portfolio standards in Nevada are most likely an inefficient means to address global climate change if one using a relatively low discount rate for future damages associated with global climate change. From the viewpoint of the Nevada economy, however, renewable portfolio standards raise electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus that building and operating renewable energy facilities provide.

8. Oregon

Oregon generates almost 60 million MWh of electricity, with 55 percent from hydroelectric facilities, 24 percent from natural gas, and 6.3 percent from coal (see Table 45). Wind power accounts for 12.4 percent of total generation in 2013 (see Table 45) while solar power generation is negligible. The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in Oregon.

Table 45: Capacity, Generation, and Utilization Rates for Oregon 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	601	3,758,996	0.7140
Geothermal	33	164,649	0.5696
Hydroelectric	8,312	33,097,667	0.4546
Natural gas	3,605	14,363,040	0.4548
Nuclear	0	0	0.0000
Other	0	34,746	0.0000
Other biomass	49	293,888	0.6917
Other gas	0	0	0.0000
Petroleum	0	6,151	0.0000
Pumped storage	0	0	0.0000
Solar	11	20,493	0.2186
Wind	3,161	7,455,702	0.2692
Wood	360	700,182	0.2221
Total	16,131	59,895,515	0.4239

8.1 Impacts on Electricity Sector

The RPS goal for Oregon is 20.8 percent of total consumption by 2025. The impacts on electricity markets from the enactment of these goals are presented in Table 46. The RPS goals reduce the need for additional new NGCC as these goals are met in 2025. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 51.8 MW in the base case and under the RPS incremental NGCC capacity declines to 47 MW in 2020.

Slightly over 96 percent of new RPS capacity for Oregon is supplied by wind power with the remainder met by new solar generating plants. RPS wind and solar capacity to meet the RPS goals are 261.3 and 11.9 MW respectively in 2025. The electricity generation from these new facilities rises from 0.2 million MWh in 2016 to 5.6 million MWh in 2040 (see Table 46). This generation is in addition to the 7.5 million MWh from existing or legacy RPS capacity.

The increases in average electricity costs from new RPS capacity additions are small in 2016, increase to 4.6 percent in 2020, and rise to over 10 percent after 2025 (see

Table 46). With legacy costs average electricity rates in Oregon increase 9.41 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 10 percent in 2020, more than 11 percent in 2025, and 9-11 percent from 2030 to 2040 compared to the base case without RPS standards.

Table 46: Impacts of RPS on Oregon Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	0.0	0.0	51.8	50.7	50.0	50.9
With RPS	0.0	0.0	47.0	49.4	49.7	51.0
New RPS Capacity						
Wind	64.6	0.0	261.3	31.3	31.5	32.3
Solar	2.9	0.0	11.9	1.4	1.4	1.5
	Million Megawatt hours					
New NGCC Generation						
Without RPS	0.6	0.0	2.4	4.2	6.1	8.0
With RPS	0.4	0.0	0.5	2.3	4.2	6.0
Legacy RPS Generation	7.5	7.5	7.5	7.5	7.5	7.5
New RPS Generation	0.2	1.6	4.4	4.8	5.2	5.6
	Percentage Changes from Base Case					
Average Costs	1.12	4.64	10.97	11.01	10.59	10.02
Electricity Consumption	-0.03	-0.15	-0.41	-0.54	-0.56	-0.54
Average Rates	0.34	1.37	3.23	3.23	3.14	3.01
Average Rates + Legacy Costs	9.41	10.00	11.09	10.55	9.83	9.11

The decomposition of RPS costs for the Oregon electricity sector appear in Table 47. Direct legacy costs are more than $489 million in 2016 and remain over $440 million through the end of the forecast period. After including cycling costs and deducting avoided fossil fuel costs, net RPS legacy costs are $386.1 million in 2016 and remain over $300 million in 2040.

The costs for additional renewable capacity to meet Oregon's RPS goals are also summarized in Table 47. The direct costs to go from the current generation from solar and wind to the 20.8 percent goal of total electricity consumption are $104.7 million in 2020 and rise to over $300 million per year after 2025 After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $53 million in 2020 and over $120 million per year thereafter. With subsidies, the total costs of Nevada's RPS are $571 million in 2016, $605.8 million in 2020, $724.2 million in 2025 and are more than $695 million per year from 2030 to 2040 (see Table 47).

Table 47: Costs of Oregon RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	489.4	480.9	470.5	460.2	450.0	440.1
Cycling Costs	6.3	5.7	4.3	4.3	4.7	5.2
less Fuel Costs	109.6	106.4	115.5	119.2	127.7	136.6
Net RPS Legacy Costs	386.1	380.2	359.3	345.2	327.0	308.7
New RPS Costs						
Direct	10.6	104.7	278.0	294.5	310.7	326.3
Cycling Costs	10.3	9.7	8.1	8.2	8.9	9.7
less Fuel Costs	3.4	61.0	112.4	128.7	144.0	159.2
less NGCC Costs	4.4	0.0	45.7	47.8	50.3	52.7
Net New RPS Costs	13.2	53.4	128.1	126.1	125.3	124.1
RPS Tax Subsidies	172.2	172.2	236.8	245.2	253.9	262.6
Total RPS Cost	571.5	605.8	724.2	716.6	706.2	695.4
	Million Tons					
CO2 Reductions	12.45	12.35	15.77	16.13	16.46	16.78
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	32.06	35.12	30.91	29.23	27.48	25.79
Subsidy Costs	13.83	13.94	15.02	15.21	15.42	15.65
Total Costs	45.89	49.06	45.93	44.44	42.91	41.44

The RPS policies in Oregon reduce carbon dioxide emissions by 12.45 million tons in 2016 to over 16.78 million tons per year by 2040 (see Table 47). The direct costs per ton of avoided emissions are $32.06 per ton in 2016 and decline to $25.79 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are over $13.83 per ton in 2016 and remain over $15 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $45.89 per ton in 2016 and gradually decline to $41.44 per ton in 2040 (see Table 47).

Assuming a 5 percent discount rate these RPS carbon abatement costs are well above the EPA social cost of carbon of $12 to $24 per ton, suggesting that RPS policies in Oregon are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Oregon may be cost effective after 2025 if a 3 percent discount rate is used. From perspective of households and businesses in Oregon, however, there are economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

8.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Oregon economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 48. Annual losses in Oregon value added range from $1.48 billion in 2016 to $1.74 billion in 2025, and remain over $1.4 billion per year out to 2040. Employment levels are 12 to 14 thousand below employment in the base case without renewable energy portfolio standards (see Table 49).

Table 48: Impacts of RPS on Oregon Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-103.48	-109.97	-121.97	-116.09	-108.16	-100.16
Paper	-75.26	-79.98	-88.71	-84.43	-78.66	-72.84
Wood	-104.43	-110.97	-123.08	-117.15	-109.15	-101.07
Other Man	-28.22	-29.99	-33.27	-31.66	-29.50	-27.32
Textiles	-1.88	-2.00	-2.22	-2.11	-1.97	-1.82
Minerals	-17.87	-18.99	-21.07	-20.05	-18.68	-17.30
Const.	-208.85	-221.93	-246.16	-234.30	-218.29	-202.13
Trans.	-95.02	-100.97	-111.99	-106.59	-99.31	-91.96
Services	-1,061.19	-1,127.67	-1,250.77	-1,190.47	-1,109.15	-1,027.04
Utilities	218.26	231.93	257.25	244.85	228.12	211.24
Total	-1,477.95	-1,570.53	-1,741.99	-1,658.01	-1,544.75	-1,430.40

Table 49: Impacts of RPS on Oregon Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-271	-288	-319	-304	-283	-262
Paper	-246	-261	-289	-275	-257	-238
Wood	-1,059	-1,126	-1,249	-1,188	-1,107	-1,025
Other Man	-1,533	-1,629	-1,806	-1,719	-1,602	-1,483
Textiles	-75	-80	-89	-84	-79	-73
Minerals	-42	-45	-50	-47	-44	-41
Const.	-1,547	-1,644	-1,823	-1,735	-1,617	-1,497
Trans.	-1,293	-1,374	-1,524	-1,450	-1,351	-1,251
Services	-6,931	-7,365	-8,169	-7,775	-7,244	-6,708
Utilities	331	352	390	371	346	320
Total	-12,666	-13,459	-14,928	-14,209	-13,238	-12,258

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Oregon value added and employment are summarized in Table 50. For example, in 2025 RPS investments contributed $106.88 million in value added and 1,393 jobs. Avoided NGCC investments reduce value added $1.34 million and reduce employment by 12 in 2016.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Oregon's RPS goals are $1.45 billion in 2016, $1.57 billion in 2020, $1.64 billion in 2025, and remain over $1.4 billion through the end of the forecast horizon. Employment levels are over 12 to 14 thousand lower during the forecast period compared to the base case.

Table 50: Net Impacts of RPS on Oregon Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	146.50	0.00	573.71	67.57	66.78	67.22
Value Added						
Electric prices	-1,477.95	-1,570.53	-1,741.99	-1,658.01	-1,544.75	-1,430.40
RPS Invest.	27.30	0.00	106.88	12.59	12.44	12.52
NGCC Invest.	0.00	0.00	-1.34	-0.36	-0.07	0.01
Net Change	-1,450.64	-1,570.53	-1,636.45	-1,645.78	-1,532.39	-1,417.87
Employment	**Number of Jobs**					
Electric prices	-12,666	-13,459	-14,928	-14,209	-13,238	-12,258
RPS Invest.	356	0	1,393	164	162	163
NGCC Invest.	0	0	-12	-3	-1	0
Net Change	-12,309	-13,459	-13,547	-14,048	-13,077	-12,095

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Oregon are higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate but are below the social cost of capital assuming a 3 percent discount rate after 2025. From a global perspective, therefore, whether renewable energy portfolio standards in Oregon are an efficient means to address global climate change is not clear because the choice of a discount rate is subjective. What is clear, however, is that Oregonian households and businesses pay a price for renewable portfolio standards. RPS policies raise electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus that building and operating renewable energy facilities provide.

9. Pennsylvania

As the largest state in our sample, Pennsylvania generates more than 226 million MWh of electricity (see Table 51). Coal is the single largest source of power in 2013 providing 39 percent of total generation, followed closely by nuclear power at 34 percent, and then by natural gas at 22 percent of total generation. Wind power accounts for 1.5 percent of total generation in 2013 while solar power generation is negligible (see Table 45). The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and economy of Pennsylvania.

Table 51: Capacity, Generation, and Utilization Rates for Pennsylvania 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	20,160	88,443,209	0.5008
Geothermal	0	0	0.0000
Hydroelectric	920	2,524,673	0.3132
Natural gas	13,324	49,937,702	0.4278
Nuclear	0	78,714,031	0.0000
Other	20	840,579	4.7978
Other biomass	514	1,846,840	0.4104
Other gas	116	650,147	0.6398
Petroleum	2,938	460,072	0.0179
Pumped storage	1,541	-538,770	-0.0399
Solar	47	63,106	0.1526
Wind	1,344	3,352,043	0.2847
Wood	144	491,998	0.3898
Total	41,069	226,785,630	0.6304

9.1 Impacts on Electricity Sector

The RPS goal for Pennsylvania is 7.8 percent of total consumption by 2021. The impacts on electricity markets from the enactment of these goals are presented in Table 52. The RPS goals slightly reduce the need for additional new NGCC as these goals are met in 2025. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 253.1 MW in the base case and under the RPS incremental NGCC capacity declines to 252.3 MW in 2025.

Slightly over 98 percent of new RPS capacity for Pennsylvania is supplied by wind power with the remainder met by new solar generating plants. RPS wind and solar capacity to meet the RPS goals are 368 and 12.9 MW respectively in 2016 and 378.7 and 13.3 MW respectively in 2020. The electricity generation from these new facilities rises from 5.3 million MWh in 2016 to 12.9 million MWh in 2040 (see Table 52). This generation is in addition to the 3.4 million MWh from existing or legacy RPS capacity.

The increases in average electricity costs from new RPS capacity additions are 3.5 percent in 2016, 5.25 percent in 2020, and between 4.5 and 5.5 percent after 2025 (see Table 52). With legacy costs average electricity rates in Pennsylvania increase 2.41 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 2-2.5 percent thereafter compared to the base case without RPS standards.

Table 52: Impacts of RPS on Pennsylvania Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	0.0	0.0	253.1	268.1	281.4	293.5
With RPS	0.0	0.0	252.3	267.8	281.4	293.6
New RPS Capacity						
Wind	368.0	378.7	57.4	60.9	64.0	66.8
Solar	12.9	13.3	2.0	2.1	2.2	2.3
	Million Megawatt hours					
New NGCC Generation						
Without RPS	2.7	0.0	7.2	17.0	27.3	38.0
With RPS	2.5	0.0	6.7	16.5	26.8	37.5
Legacy RPS Generation	3.4	3.4	3.4	3.4	3.4	3.4
New RPS Generation	5.3	9.0	10.5	11.3	12.1	12.9
	Percentage Changes from Base Case					
Average Costs	3.53	5.25	5.43	5.21	4.95	4.54
Electricity Consumption	-0.11	-0.24	-0.28	-0.28	-0.26	-0.25
Average Rates	0.96	1.45	1.53	1.47	1.41	1.32
Average Rates + Legacy Costs	2.14	2.56	2.54	2.40	2.25	2.08

The decomposition of RPS costs for the Pennsylvania electricity sector appear in Table 53. Direct legacy costs are more than $210 million in 2016 and remain over $187 million through the end of the forecast period. After including cycling costs and deducting avoided fossil fuel costs, net RPS legacy costs are $173.5 million in 2016 and remain over $150 million in 2040.

The costs for additional renewable capacity to meet Pennsylvania's RPS goals are also summarized in Table 53. The direct costs to achieve 7.8 percent of consumption supplied by renewable energy are $324 million in 2016 and rise to over $650 million per year after 2025. After adding cycling costs and deducting for fossil fuel and NGCC capacity cost savings, the net costs to meet the RPS goal are $125 million in 2016 and over $200 million per year thereafter. With subsidies, the total costs of Pennsylvania's RPS are $503 million in 2016, $655 million in 2020, $701 million in 2025 and are more than $740 million per year from 2030 to 2040 (see Table 53).

Table 53: Costs of Pennsylvania RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	210.6	206.6	201.7	196.9	192.2	187.6
Cycling Costs	20.8	28.0	31.2	32.0	33.0	35.1
less Fuel Costs	57.9	60.6	64.1	66.1	68.4	71.9
Net RPS Legacy Costs	173.5	174.0	168.8	162.8	156.8	150.8
New RPS Costs						
Direct	324.0	544.9	622.4	651.4	680.9	710.3
Cycling Costs	21.8	29.3	32.7	33.5	34.6	36.8
less Fuel Costs	216.4	384.7	437.1	463.0	490.8	523.4
less NGCC Costs	3.9	0.0	12.0	12.4	12.7	13.2
Net New RPS Costs	125.4	189.4	206.0	209.5	212.0	210.5
RPS Tax Subsidies	203.8	291.4	326.4	343.3	361.1	379.7
Total RPS Cost	502.7	654.8	701.3	715.6	729.9	741.0
	Million Tons					
CO2 Reductions	11.41	14.81	16.55	17.27	18.02	18.80
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	26.19	24.54	22.65	21.55	20.46	19.22
Subsidy Costs	17.86	19.67	19.72	19.88	20.04	20.20
Total Costs	44.05	44.21	42.37	41.43	40.50	39.41

The RPS policies in Pennsylvania reduce carbon dioxide emissions by 11.41 million tons in 2016 to over 18.8 million tons per year by 2040 (see Table 53). The direct costs per ton of avoided emissions are $26.19 per ton in 2016 and decline to $19.22 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are over $17.86 per ton in 2016 and remain over $20 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $44.05 per ton in 2016 and gradually decline to $39.41 per ton in 2040 (see Table 53).

These RPS carbon abatement costs are well above the EPA social cost of carbon of $12 to $24 per ton, assuming a 5 percent discount rate, suggesting that RPS policies in Pennsylvania are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Pennsylvania may be cost effective after 2025 if a 3 percent discount rate on future greenhouse gas damages is appropriate. From the perspective of households and businesses in Pennsylvania, however, there are economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

9.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Pennsylvania economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 54. Annual losses in Pennsylvania value added range from $1.4 billion in 2016 to $1.7 billion in 2025, and remain over $1.4 billion per year out to 2040. Employment levels are 9.5 to 11.7 thousand below employment in the base case without renewable energy portfolio standards (see Table 55).

Table 54: Impacts of RPS on Pennsylvania Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-137.09	-164.44	-163.22	-154.08	-144.75	-133.85
Paper	-65.34	-78.38	-77.80	-73.44	-68.99	-63.80
Wood	-15.38	-18.44	-18.31	-17.28	-16.23	-15.01
Other Man	-134.32	-161.11	-159.92	-150.96	-141.82	-131.14
Textiles	-3.84	-4.61	-4.58	-4.32	-4.06	-3.75
Minerals	-13.67	-16.39	-16.27	-15.36	-14.43	-13.34
Const.	-158.02	-189.54	-188.14	-177.60	-166.85	-154.28
Trans.	-79.22	-95.03	-94.32	-89.04	-83.65	-77.35
Services	-947.70	-1,136.75	-1,128.31	-1,065.12	-1,000.63	-925.28
Utilities	154.82	185.70	184.32	174.00	163.46	151.16
Total	-1,399.34	-1,678.49	-1,666.03	-1,572.73	-1,477.49	-1,366.24

Table 55: Impacts of RPS on Pennsylvania Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-296	-355	-352	-332	-312	-289
Paper	-275	-330	-327	-309	-290	-269
Wood	-223	-267	-265	-251	-235	-218
Other Man	-1,117	-1,339	-1,329	-1,255	-1,179	-1,090
Textiles	-113	-136	-135	-127	-119	-110
Minerals	-46	-55	-55	-52	-48	-45
Const.	-1,149	-1,378	-1,368	-1,291	-1,213	-1,121
Trans.	-1,293	-1,550	-1,539	-1,453	-1,365	-1,262
Services	-5,618	-6,739	-6,689	-6,314	-5,932	-5,485
Utilities	299	358	355	336	315	291
Total	-9,830	-11,791	-11,703	-11,048	-10,379	-9,597

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Pennsylvania value added and employment are summarized in Table 56. For example, in 2020 RPS investments contributed $175.9 million in value added and 2,078 jobs.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Pennsylvania's RPS goals are $1.2 billion in 2016, $1.5 billion in 2020, $1.6 billion in 2025, and remain over $1.3 billion through the end of the forecast horizon. Employment levels are over 7-11 thousand lower during the forecast period compared to the base case.

Table 56: Net Impacts of RPS on Pennsylvania Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	827.97	840.20	125.08	130.51	134.76	138.22
Value Added						
Electric prices	-1,399.34	-1,678.49	-1,666.03	-1,572.73	-1,477.49	-1,366.24
RPS Invest.	173.35	175.90	26.18	27.32	28.21	28.93
NGCC Invest.	0.00	0.00	-0.26	-0.07	-0.01	0.05
Net Change	-1,225.99	-1,502.59	-1,640.10	-1,545.47	-1,449.30	-1,337.26
Employment	**Number of Jobs**					
Electric prices	-9,830	-11,791	-11,703	-11,048	-10,379	-9,597
RPS Invest.	2,049	2,078	309	323	333	341
NGCC Invest.	0	0	-2	-1	0	0
Net Change	-7,781	-9,712	-11,396	-10,726	-10,046	-9,255

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Pennsylvania are higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate but are below the social cost of capital assuming a 3 percent discount rate after 2025. From a global perspective, therefore, whether renewable energy portfolio standards in Pennsylvania are an efficient means to address global climate change is not clear because the choice of a discount rate is subjective.

What is clear, however, is that households and businesses in Pennsylvania pay a price for renewable portfolio standards. RPS policies raise electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus from building and operating renewable energy facilities.

10. Rhode Island

Rhode Island generates 6.2 million MWh (see Table 57) of electricity. Natural gas provides more than 98 percent of this electricity generation. Wind and solar capacity in Rhode Island is currently is very limited (see Table 57). The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in Rhode Island.

Table 57: Capacity, Generation, and Utilization Rates for Rhode Island 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	0	0	0.0000
Geothermal	0	0	0.0000
Hydroelectric	3	4,447	0.1813
Natural gas	1,971	6,139,090	0.3555
Nuclear	0	0	0.0000
Other	0	0	0.0000
Other biomass	40	48,132	0.1360
Other gas	0	0	0.0000
Petroleum	18	50,540	0.3260
Pumped storage	0	0	0.0000
Solar	7	2,007	0.0332
Wind	3	2,590	0.0986
Wood	0	0	0.0000
Total	2,042	6,246,807	0.3492

10.1 Impacts on Electricity Sector

The RPS goal for Rhode Island is 14.5 percent of total consumption by 2019. The impacts on electricity markets from the enactment of these goals are presented in Table 58. The RPS goals reduce the need for additional new NGCC as these goals are met in 2019. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 36.1 MW in the base case and under the RPS incremental NGCC capacity declines to 17.6 MW in 2025.

Slightly over 56 percent of new RPS capacity for Rhode Island is supplied by solar power with the remainder met by new wind generating plants. RPS wind and solar capacity to meet the RPS goals are 63 and 55.7 MW respectively in 2016 and 5.9 and 5.2 MW respectively in 2020. The electricity generation from these new facilities rises from 0.9 million MWh in 2016 to 1.7 million MWh in 2040 (see Table 58).

The increases in average electricity costs from new RPS capacity additions are 57 percent in 2016, 73 percent in 2020, and between 48 and 64 percent after 2025 (see Table 58). These steep increases in costs are due to the low capacity factors for wind and solar in Rhode Island. With legacy costs average electricity rates in Rhode Island increase 13.6

percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 13-18 percent thereafter compared to the base case without RPS standards. These substantial rate increases reflect the low capacity utilization rates for wind and solar in Rhode Island and the rather ambitious 14.5 percent RPS goal.

Table 58: Impacts of RPS on Rhode Island Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	36.1	16.3	14.8	16.0	16.7	17.1
With RPS	17.6	12.8	14.8	16.1	16.9	17.4
New RPS Capacity						
Wind	63.0	5.9	6.8	7.4	7.8	8.0
Solar	55.7	5.2	6.0	6.6	6.9	7.1
	Million Megawatt hours					
New NGCC Generation						
Without RPS	0.7	1.3	1.9	2.5	3.1	3.7
With RPS	0.5	0.9	1.5	2.0	2.7	3.3
Legacy RPS Generation	0.0	0.0	0.0	0.0	0.0	0.0
New RPS Generation	0.9	1.3	1.4	1.5	1.6	1.7
	Percentage Changes from Base Case					
Average Costs	57.54	73.17	64.68	60.52	55.60	48.71
Electricity Consumption	-1.90	-3.72	-3.78	-3.57	-3.35	-3.08
Average Rates	13.55	18.11	16.57	15.51	14.42	13.13
Average Rates + Legacy Costs	13.61	18.16	16.62	15.55	14.46	13.17

The decomposition of RPS costs for the Rhode Island electricity sector appear in Table 59. RPS legacy costs are negligible given the very small amount of existing wind and solar capacity. The costs for additional renewable capacity to meet Rhode Island's RPS goals are also summarized in Table 59.

The direct costs to achieve 7.8 percent of consumption supplied by renewable energy are $118.2 million in 2016 and rise to over $174 million in 2020, $177 million in 2025 and remain around $180 million after 2030. After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $109 million in 2016 and over $125 million per year thereafter. With subsidies, the total costs of Rhode Island's RPS are $140.9 million in 2016, $190 million in 2020, $183 million in 2025 and are more than $179 million per year from 2030 to 2040 (see Table 59).

Table 59: Costs of Rhode Island RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	0.6	0.6	0.6	0.6	0.5	0.5
Cycling Costs	0.0	0.0	0.0	0.0	0.0	0.0
less Fuel Costs	0.1	0.1	0.1	0.1	0.1	0.1
Net RPS Legacy Costs	0.6	0.5	0.5	0.5	0.5	0.4
New RPS Costs						
Direct	118.2	174.1	176.6	179.8	183.0	186.1
Cycling Costs	0.3	0.4	0.4	0.4	0.5	0.5
less Fuel Costs	3.9	21.3	29.8	34.3	39.1	45.4
less NGCC Costs	5.6	10.8	12.0	12.0	12.0	12.3
Net New RPS Costs	108.9	142.4	135.2	134.0	132.3	128.9
RPS Tax Subsidies	31.4	47.1	47.6	48.3	49.0	49.7
Total RPS Cost	140.9	190.1	183.3	182.7	181.8	179.1
	Million Tons					
CO2 Reductions	0.69	1.10	1.17	1.23	1.28	1.34
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	159.59	129.65	116.05	109.64	103.40	96.62
Subsidy Costs	45.84	42.74	40.68	39.36	38.15	37.11
Total Costs	205.42	172.39	156.73	148.99	141.55	133.72

The RPS policies in Rhode Island reduce carbon dioxide emissions by 0.69 million tons in 2016 to over 1.3 million tons per year by 2040 (see Table 59). The direct costs per ton of avoided emissions are $159.59 per ton in 2016 and decline to $96.62 per ton in 2040 as wind and solar costs decline over time. Tax subsidies, however, are over $45.84 per ton in 2016 and remain over $37 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $205.42 per ton in 2016 and gradually decline to $133.72 per ton in 2040 (see Table 59). These large unit costs of carbon emission reductions reflect the low capacity utilization rates for wind and solar in Rhode Island. Another factor is the predominance of natural gas in total generation so that any generation displaced by renewables has relatively low emissions.

These RPS carbon abatement costs are far above the EPA social cost of carbon of $12 to $24 per ton, assuming a 5 percent discount rate, suggesting that RPS policies in Rhode Island are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Rhode Island is not cost effective. There are also economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

10.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Rhode Island economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 60. Annual losses in Rhode Island value added range from $669 million in 2016 to $893 million in 2025, and remain over $640 million per year out to 2040. Employment levels are 4-5 thousand below employment in the base case without renewable energy portfolio standards (see Table 61).

Table 60: Impacts of RPS on Rhode Island Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-51.72	-69.00	-63.16	-59.11	-54.95	-50.04
Paper	-10.89	-14.53	-13.30	-12.44	-11.57	-10.53
Wood	-2.72	-3.63	-3.32	-3.11	-2.89	-2.63
Other Man	-32.66	-43.58	-39.89	-37.33	-34.70	-31.60
Textiles	-6.80	-9.08	-8.31	-7.78	-7.23	-6.58
Minerals	-2.72	-3.63	-3.32	-3.11	-2.89	-2.63
Const.	-100.71	-134.37	-122.99	-115.10	-107.00	-97.44
Trans.	-21.78	-29.05	-26.59	-24.89	-23.13	-21.07
Services	-496.75	-662.77	-606.64	-567.75	-527.76	-480.61
Utilities	57.16	76.26	69.81	65.33	60.73	55.30
Total	-669.59	-893.37	-817.72	-765.29	-711.40	-647.83

Table 61: Impacts of RPS on Rhode Island Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-71	-94	-86	-81	-75	-68
Paper	-86	-114	-105	-98	-91	-83
Wood	-42	-56	-52	-48	-45	-41
Other Man	-554	-739	-676	-633	-588	-536
Textiles	-52	-69	-63	-59	-55	-50
Minerals	-8	-11	-10	-9	-9	-8
Const.	-520	-694	-635	-594	-552	-503
Trans.	-365	-487	-445	-417	-388	-353
Services	-2,978	-3,973	-3,637	-3,403	-3,164	-2,881
Utilities	128	171	156	146	136	124
Total	-4,548	-6,068	-5,554	-5,198	-4,832	-4,401

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Rhode Island value added and employment are summarized in Table 62. For example, in 2020 RPS investments contributed $4.1 million in value added and 53 jobs.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Rhode Island's RPS goals are $629 million in 2016, $890 million in 2020, $813 million in 2025, and remain over $640 million through the end of the forecast horizon. Employment levels are over 4-5.5 thousand lower during the forecast period compared to the base case.

Table 62: Net Impacts of RPS on Rhode Island Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	230.48	20.97	23.23	24.36	24.54	24.40
Value Added						
Electric prices	-669.59	-893.37	-817.72	-765.29	-711.40	-647.83
RPS Invest.	45.39	4.12	4.56	4.78	4.81	4.77
NGCC Invest.	-5.26	-0.97	-0.01	0.02	0.04	0.09
Net Change	-629.46	-890.22	-813.16	-760.50	-706.55	-642.97
Employment	**Number of Jobs**					
Electric prices	-4,548	-6,068	-5,554	-5,198	-4,832	-4,401
RPS Invest.	587	53	59	61	61	61
NGCC Invest.	-42	-8	0	0	0	1
Net Change	-4,003	-6,023	-5,496	-5,137	-4,771	-4,339

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Rhode Island are much higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate and even assuming a 3 percent discount rate after 2025. From a global perspective, therefore, whether renewable energy portfolio standards in Rhode Island are an inefficient means to address global climate change.

Households and businesses in Rhode Island pay a price for renewable portfolio standards. RPS policies raise electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus from building and operating renewable energy facilities. These economic impacts are significant because wind and solar capacity factors in Rhode Island are low and nearly all existing generation is from natural gas. As renewable goals are met, wind and solar generation displaces relatively low emission natural gas generation. Hence, the emissions savings are relatively small and, therefore, the unit abatements costs are large.

11. South Carolina

South Carolina generates a significant amount of electric power from a diverse portfolio of generation assets. More than 60 percent of the total 95.2 million Mwh of total generation is supplied by the greenhouse gas emission free sources, hydroelectric (3%) and nuclear generation (57%). Coal provides 25 percent and natural gas provides 12.4 percent of total generation. There is currently no wind generation and a very small amount of solar capacity in place as of 2013 (see Table 63). The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and the economy in South Carolina.

Table 63: Capacity, Generation, and Utilization Rates for South Carolina 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	7,712	24,407,148	0.3613
Geothermal	0	0	0.0000
Hydroelectric	1,364	3,160,274	0.2645
Natural gas	6,496	11,834,074	0.2080
Nuclear	6,875	54,251,968	0.9008
Other	0	62,007	0.0000
Other biomass	47	212,896	0.5227
Other gas	0	0	0.0000
Petroleum	871	103,346	0.0135
Pumped storage	2,581	-794,922	-0.0352
Solar	3	115	0.0053
Wind	0	0	0.0000
Wood	425	2,012,988	0.5412
Total	26,373	95,249,894	0.4123

11.1 Impacts on Electricity Sector

The RPS goal for South Carolina is 2.1 percent of total consumption by 2021. The impacts on electricity markets from the enactment of these goals are presented in Table 64. The RPS goals reduce the need for additional new NGCC as these goals are met. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 46.1 MW in the base case and under the RPS incremental there is no new NGCC capacity required in 2025 (see Table 64).

Fifty percent new RPS capacity for South Carolina is supplied by solar power with the remainder met by new offshore wind generating plants. RPS wind and solar capacity to meet the RPS goals are 45.6 and 121 MW respectively in 2020 and 4.3 and 11.3 MW respectively in 2025. The electricity generation from these new facilities rises from 0.3 million MWh in 2016 to 2.5 million MWh in 2040 (see Table 64).

The increases in average electricity costs from new RPS capacity additions are 1.28 percent in 2016, 4.2 percent in 2020, and between 4.75 and 5.75 percent after 2025 (see Table 64). With legacy costs average electricity rates in South Carolina increase 0.39 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 1-2 percent thereafter compared to the base case without RPS standards. These modest rate increases reflect relatively low RPS goals and relatively small incremental cost additions to a large relatively low cost generation fleet.

Table 64: Impacts of RPS on South Carolina Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	230.1	0.0	46.2	181.0	189.9	206.5
With RPS	234.4	0.0	0.0	180.9	190.0	206.3
New RPS Capacity						
Wind	0.0	45.6	4.3	4.6	4.8	5.2
Solar	0.0	121.1	11.3	12.2	12.8	13.9
	Million Megawatt hours					
New NGCC Generation						
Without RPS	6.9	0.0	0.3	6.9	13.9	21.3
With RPS	6.7	0.0	0.0	6.5	13.5	20.9
Legacy RPS Generation	0.0	0.0	0.0	0.0	0.0	0.0
New RPS Generation	0.3	1.4	2.1	2.2	2.4	2.5
	Percentage Changes from Base Case					
Average Costs	1.28	4.20	5.70	5.37	5.01	4.75
Electricity Consumption	-0.12	-0.19	-0.28	-0.26	-0.25	-0.23
Average Rates	0.39	1.52	2.08	1.97	1.85	1.75
Average Rates + Legacy Costs	0.39	1.52	2.08	1.97	1.85	1.75

The decomposition of RPS costs for the South Carolina electricity sector appears in Table 65. The direct costs to achieve 2.1 percent of electricity consumption supplied by renewable energy are $48.2 million in 2016 and rise to over $216.7 million in 2020, $305.2 million in 2025 and remain above $300 million after 2030 (see Table 65). After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $22 million in 2016, $122.3 million in 2020, $176.9 million in 2025, and over $175 million per year thereafter. With subsidies, the total costs of South Carolina's renewable energy portfolio standards are $31.9 million in 2016, $175 million in 2020, $251.7 million in 2025 and more than $250 million per year from 2030 to 2040 (see Table 65).

Table 65: Costs of South Carolina RPS

	2016	2020	2025	2030	2035	2040
	Millions of 2013 Dollars					
RPS Legacy Costs						
Direct	0.0	0.0	0.0	0.0	0.0	0.0
Cycling Costs	0.0	0.0	0.0	0.0	0.0	0.0
less Fuel Costs	0.0	0.0	0.0	0.0	0.0	0.0
Net RPS Legacy Costs	0.0	0.0	0.0	0.0	0.0	0.0
New RPS Costs						
Direct	48.2	216.7	305.2	312.1	319.3	327.0
Cycling Costs	0.6	0.9	1.2	1.4	2.0	3.3
less Fuel Costs	20.4	95.3	118.0	123.6	130.5	137.0
less NGCC Costs	6.4	0.0	11.5	11.9	12.2	12.3
Net New RPS Costs	22.0	122.3	176.9	177.9	178.5	180.9
RPS Tax Subsidies	9.9	52.9	74.7	75.8	77.0	78.3
Total RPS Cost	31.9	175.2	251.7	253.8	255.5	259.2
	Million Tons					
CO2 Reductions	0.31	1.12	1.88	2.00	2.12	2.25
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	71.30	109.08	94.12	89.10	84.26	80.46
Subsidy Costs	32.08	47.14	39.76	37.97	36.34	34.81
Total Costs	103.38	156.21	133.88	127.07	120.60	115.27

The RPS policies in South Carolina reduce carbon dioxide emissions by 0.31 million tons in 2016 to over 2.25 million tons per year by 2040 (see Table 65). The direct costs per ton of avoided emissions are $71.30 per ton in 2016, $109 per ton in 2020, $94 per ton in 2025 and $80.46 per ton in 2040. Tax subsidies are over $32.08 per ton in 2016 and remain over $34 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $103.38 per ton in 2016, $156.21 per ton in 2020 and gradually decline to $115.27 per ton in 2040 (see Table 65). These large unit costs of carbon emission reductions reflect the low capacity utilization rates for wind and solar in South Carolina. Another factor is the predominance of low cost natural gas and nuclear capacity in total generation so that any generation displaced by renewables has relatively low emissions.

These RPS carbon abatement costs are far above the EPA social cost of carbon of $12 to $24 per ton, assuming a 5 percent discount rate, suggesting that RPS policies in South Carolina are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in South Carolina is clearly not cost effective. There are also economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

11.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the South Carolina economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 66. Annual losses in South Carolina value added range from $64 million in 2016 to $340 million in 2025, and remain over $287 million per year out to 2040. Employment levels are 2-3 thousand below employment in the base case without renewable energy portfolio standards after 2020 (see Table 67).

Table 66: Impacts of RPS on South Carolina Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-3.64	-14.16	-19.38	-18.30	-17.17	-16.31
Paper	-7.44	-28.93	-39.60	-37.38	-35.09	-33.32
Wood	-1.41	-5.48	-7.50	-7.08	-6.65	-6.31
Other Man	-7.28	-28.32	-38.77	-36.59	-34.35	-32.62
Textiles	-2.23	-8.68	-11.88	-11.21	-10.53	-10.00
Minerals	-0.94	-3.65	-5.00	-4.72	-4.43	-4.21
Const.	-9.87	-38.37	-52.53	-49.58	-46.53	-44.19
Trans.	-3.21	-12.49	-17.09	-16.13	-15.14	-14.38
Services	-40.84	-158.80	-217.40	-205.20	-192.60	-182.90
Utilities	12.80	49.79	68.16	64.33	60.38	57.34
Total	-64.13	-249.40	-341.42	-322.26	-302.47	-287.24

Table 67: Impacts of RPS on South Carolina Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-8	-31	-43	-40	-38	-36
Paper	-27	-105	-143	-135	-127	-120
Wood	-16	-63	-86	-81	-76	-72
Other Man	-74	-288	-395	-373	-350	-332
Textiles	-50	-196	-269	-254	-238	-226
Minerals	-3	-11	-15	-14	-13	-13
Const.	-72	-281	-385	-364	-341	-324
Trans.	-54	-210	-287	-271	-254	-241
Services	-298	-1,160	-1,588	-1,499	-1,407	-1,336
Utilities	31	121	166	157	147	140
Total	-572	-2,224	-3,044	-2,873	-2,697	-2,561

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on South Carolina value added and employment are summarized in Table 68. For example, in 2020 RPS investments contributed $51.1 million in value added and 893 jobs in 2020.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from South Carolina's RPS goals are $63 million in 2016, $198 million in 2020, $348 million in 2025, and remain over $280 million through the end of the forecast horizon. Employment levels are over 1-3 thousand lower during the forecast period compared to the base case after 2020.

Table 68: Net Impacts of RPS on South Carolina Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	0.00	287.82	25.50	26.03	25.93	26.72
Value Added						
Electric prices	-64.13	-249.40	-341.42	-322.26	-302.47	-287.24
RPS Invest.	0.00	51.13	4.52	4.61	4.58	4.71
NGCC Invest.	1.12	0.00	-12.08	-0.02	0.03	-0.05
Net Change	-63.02	-198.26	-348.97	-317.67	-297.86	-282.57
Employment	**Number of Jobs**					
Electric prices	-572	-2,224	-3,044	-2,873	-2,697	-2,561
RPS Invest.	0	893	79	80	79	81
NGCC Invest.	11	0	-118	0	0	0
Net Change	-561	-1,331	-3,084	-2,794	-2,617	-2,480

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in South Carolina are much higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate and even assuming a 3 percent discount rate. From a global perspective, therefore, renewable energy portfolio standards in South Carolina are an inefficient means to address global climate change. The incremental environmental improvement from RPS in South Carolina is minimal because the state generates more than 60 percent of it's power from greenhouse gas emission free hydroelectric and nuclear power.

While the RPS goal in South Carolina is modest at 2.1 percent, households and businesses in South Carolina pay a price for this policy. South Carolina's RPS policy raises electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus from building and operating renewable energy facilities.

12. Utah

Utah generates a significant amount of electric power from a diverse portfolio of generation assets. More than 80 percent of the total 42.5 million Mwh of total generation, however, is supplied by coal and 15.5 percent from natural gas. Hydroelectric and geothermal facilities provide 1.2 and 0.8 percent of total generation respectively. Wind generates 1.43 percent of total generation. There is a very small amount of solar capacity in place as of 2013. The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in Utah.

Table 69: Capacity, Generation, and Utilization Rates for Utah 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	5,036	34,284,957	0.7772
Geothermal	77	318,908	0.4722
Hydroelectric	262	504,996	0.2199
Natural gas	2,301	6,606,423	0.3277
Nuclear	0	0	0.0000
Other	32	160,864	0.5775
Other biomass	13	70,926	0.6325
Other gas	0	1,770	0.0000
Petroleum	29	26,001	0.1013
Pumped storage	0	0	0.0000
Solar	1	2,100	0.1844
Wind	324	539,806	0.1900
Wood	0	0	0.0000
Total	8,076	42,516,751	0.6010

12.1 Impacts on Electricity Sector

The RPS goal for Utah is 20 percent of total consumption by 2025. The impacts on electricity markets from the enactment of these goals are presented in Table 70. The RPS goals reduce the need for additional new NGCC as these goals are met. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 52.1 MW in the base case and under the RPS there is no new NGCC capacity required in 2020 (see Table 70).

Solar power provides more than 73 percent of new capacity to meet the RPS in Utah with the remainder met by new wind generating plants. RPS solar and wind capacity to meet the RPS goals are 434 and 133 MW respectively in 2016 and 284 and 87 MW respectively in 2025. The electricity generation from these new facilities rises from 1.6 million MWh in 2016 to 8 million MWh in 2040 (see Table 70). Legacy RPS generation is 0.5 million MWh (see Table 70).

The increases in average electricity costs from new RPS capacity additions are 8.72 percent in 2016, 19 percent in 2020, and over 20 percent after 2025 (see Table 70). With legacy costs average electricity rates in Utah increase 5 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase 9-13 percent thereafter compared to the base case without RPS standards. These significant rate increases reflect the rather ambitious RPS goals of 20 percent and an existing generation base dominated by low-cost coal generation.

Table 70: Impacts of RPS on Utah Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	38.6	52.1	54.3	57.8	60.8	63.9
With RPS	0.0	0.0	51.4	57.4	61.0	64.3
New RPS Capacity						
Wind	133.0	78.6	87.0	11.9	12.7	13.3
Solar	434.5	256.9	284.4	38.9	41.3	43.5
	Million Megawatt hours					
New NGCC Generation						
Without RPS	0.8	1.7	3.6	5.7	8.0	10.3
With RPS	0.0	0.0	1.8	3.9	6.1	8.5
Legacy RPS Generation	0.5	0.5	0.5	0.5	0.5	0.5
New RPS Generation	1.6	3.7	6.7	7.1	7.5	8.0
	Percentage Changes from Base Case					
Average Costs	8.72	19.04	28.84	26.44	23.69	20.50
Electricity Consumption	-0.11	-0.37	-0.67	-0.73	-0.69	-0.62
Average Rates	3.32	7.23	11.11	10.23	9.25	8.17
Average Rates + Legacy Costs	5.13	9.07	12.78	11.78	10.67	9.47

The decomposition of RPS costs for the Utah electricity sector appears in Table 71. Net RPS legacy costs or the costs of the existing wind and solar facilities are more than $40 million per year. The costs associated adding new RPS capacity to reach the goals also appear in Table 71. The direct costs to achieve 20 percent of electricity consumption supplied by renewable energy are $146.8 million in 2016 and rise to over $329.2 million in 2020, $564.2 million in 2025 and remain above $560 million after 2030 (see Table 71). After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $79.7 million in 2016, $177.2 million in 2020, $286.5 million in 2025, and over $250 million per year thereafter. With subsidies, the total costs of Utah's renewable energy portfolio standards are $137 million in 2016, $310.9 million in 2020, $513.3 million in 2025 and more than $480 million per year from 2030 to 2040 (see Table 71).

Table 71: Costs of Utah RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	46.9	46.2	45.2	44.3	43.4	42.5
Cycling Costs	6.3	9.5	9.6	9.8	10.2	10.9
less Fuel Costs	8.5	8.1	8.6	8.8	9.3	10.0
Net RPS Legacy Costs	44.8	47.5	46.2	45.3	44.3	43.4
New RPS Costs						
Direct	146.8	329.5	564.2	563.9	564.5	565.1
Cycling Costs	6.6	9.8	9.9	10.2	10.6	11.3
less Fuel Costs	52.0	122.0	243.3	251.9	262.1	275.9
less NGCC Costs	21.7	40.1	44.4	45.8	48.0	50.1
Net New RPS Costs	79.7	177.2	286.5	276.5	265.0	250.6
RPS Tax Subsidies	12.5	86.2	180.5	183.3	186.3	189.2
Total RPS Cost	137.0	310.9	513.3	505.1	495.7	483.2
	Million Tons					
CO2 Reductions	1.41	3.64	6.22	6.58	6.95	7.33
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	88.34	61.73	53.51	48.89	44.52	40.12
Subsidy Costs	8.88	23.68	29.03	27.85	26.81	25.82
Total Costs	97.22	85.42	82.54	76.74	71.33	65.94

The RPS policies in Utah reduce carbon dioxide emissions by 1.41 million tons in 2016 to over 7.33 million tons per year by 2040 (see Table 71). The direct costs per ton of avoided emissions are $88.34 per ton in 2016, $61.73 per ton in 2020, $53.41 per ton in 2025 and $40.12 per ton in 2040. Tax subsidies are over $23 per ton in 2020 and remain over $25 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $97.22 per ton in 2016, $85.42 per ton in 2020 and gradually decline to $65.94 per ton in 2040 (see Table 71). These large unit costs of carbon emission reductions reflect the low capacity utilization rates for wind and solar in Utah. Another factor is the predominance of low cost coal and natural gas capacity in total generation.

These RPS carbon abatement costs are far above the EPA social cost of carbon of $12 to $24 per ton, assuming a 5 percent discount rate, suggesting that RPS policies in Utah are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Utah is not cost effective. There are also economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

12.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Utah economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 72. Annual losses in Utah value added range from $862 million in 2016 to $2.1 billion in 2025, and remain over $1.5 billion per year out to 2040. Employment levels are 5-12 thousand below employment in the base case without renewable energy portfolio standards after 2020 (see Table 73).

Table 72: Impacts of RPS on Utah Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-188.75	-333.72	-470.32	-433.50	-392.63	-348.40
Paper	-23.08	-40.81	-57.51	-53.01	-48.01	-42.60
Wood	-2.05	-3.63	-5.11	-4.71	-4.27	-3.79
Other Man	-58.98	-104.29	-146.97	-135.47	-122.70	-108.87
Textiles	-1.03	-1.81	-2.56	-2.36	-2.13	-1.89
Minerals	-10.77	-19.04	-26.84	-24.74	-22.41	-19.88
Const.	-114.38	-202.23	-285.00	-262.69	-237.93	-211.12
Trans.	-47.70	-84.34	-118.86	-109.55	-99.23	-88.05
Services	-462.13	-817.07	-1,151.51	-1,061.36	-961.31	-853.01
Utilities	47.19	83.43	117.58	108.37	98.16	87.10
Total	-862.20	-1,524.41	-2,148.38	-1,980.19	-1,793.52	-1,591.47

Table 73: Impacts of RPS on Utah Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-79	-140	-197	-181	-164	-146
Paper	-76	-135	-190	-176	-159	-141
Wood	-52	-92	-130	-120	-109	-97
Other Man	-600	-1,060	-1,494	-1,377	-1,247	-1,107
Textiles	-43	-76	-107	-99	-90	-80
Minerals	-26	-46	-65	-60	-54	-48
Const.	-846	-1,495	-2,107	-1,942	-1,759	-1,561
Trans.	-653	-1,155	-1,628	-1,501	-1,359	-1,206
Services	-2,725	-4,817	-6,789	-6,257	-5,668	-5,029
Utilities	142	250	353	325	294	261
Total	-4,959	-8,768	-12,357	-11,390	-10,316	-9,154

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Utah value added and employment are summarized in Table 74. For example, in 2020 RPS investments contributed $119.3 million in value added and 1,775 jobs in 2020.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Utah's RPS goals are $662 million in 2016, $1.4 billion in 2020, $2.0 billion in 2025, and remain over $1.5 billion through the end of the forecast horizon. Employment levels are more than 10 thousand lower in 2025, during the forecast period compared to the base case after 2020 (see Table 74).

Table 74: Net Impacts of RPS on Utah Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	1,012.16	571.26	596.94	77.20	77.55	77.30
Value Added						
Electric prices	-862.20	-1,524.41	-2,148.38	-1,980.19	-1,793.52	-1,591.47
RPS Invest.	211.43	119.31	124.64	16.12	16.18	16.13
NGCC Invest.	-11.24	-15.19	-0.86	-0.12	0.06	0.12
Net Change	-662.01	-1,420.29	-2,024.60	-1,964.19	-1,777.28	-1,575.22
Employment	**Number of Jobs**					
Electric prices	-4,959	-8,768	-12,357	-11,390	-10,316	-9,154
RPS Invest.	3,154	1,775	1,849	238	239	237
NGCC Invest.	-106	-144	-8	-1	1	1
Net Change	-1,912	-7,137	-10,517	-11,153	-10,077	-8,916

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Utah are much higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate and even assuming a 3 percent discount rate. From a global perspective, therefore, renewable energy portfolio standards in Utah are an inefficient means to address global climate change. The incremental costs of environmental improvement from RPS in Utah are significant because the state generates more than 80 percent of its power from low-cost coal generation.

The ambitious RPS goal in Utah of 20 percent imposes significant costs on the economy of Utah. Utah's RPS policy raises electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus from building and operating renewable energy facilities.

13. Virginia

Virginia generated 76.9 million MWh of electric power in 2013 from a balanced portfolio of generation assets (see Table 75). Nuclear power plants provide 38 percent of the total generation. Natural gas plants provide 29.5 percent while coal supplied 27.5 percent of total generation in 2013. Hydroelectric facilities provide 1.6 percent of total generation. There is no wind or solar energy generation capacity in Virginia. The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in Virginia.

Table 75: Capacity, Generation, and Utilization Rates for Virginia 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	6,292	21,160,501	0.3839
Geothermal	0	0	0.0000
Hydroelectric	822	1,253,670	0.1740
Natural gas	9,219	22,651,167	0.2805
Nuclear	3,654	29,326,231	0.9161
Other	96	474,767	0.5646
Other biomass	346	959,725	0.3168
Other gas	0	0	0.0000
Petroleum	2,745	313,288	0.0130
Pumped storage	3,109	-1,189,000	-0.0437
Solar	0	0	0.0000
Wind	0	0	0.0000
Wood	662	1,946,217	0.3357
Total	26,945	76,896,565	0.3258

13.1 Impacts on Electricity Sector

The RPS goal for Virginia is 6 percent of total consumption by 2025. The impacts on electricity markets from the enactment of these goals are presented in Table 76. The RPS goals reduce the need for additional new NGCC as these goals are met. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 214 MW in the base case and under the RPS incremental NGCC capacity required is 200.3 MW in 2025 (see Table 76).

Solar power provides more than 83 percent of new capacity to meet RPS in Virginia with the remainder met by new wind generating plants. RPS wind and solar capacity to meet the RPS goals are 83.2 and 227.8 MW respectively in 2016 and 153 and 419 MW respectively in 2025. The electricity generation from these new facilities rises from 3.5 million MWh in 2016 to 9.8 million MWh in 2040 (see Table 76). As expected, new NGG generation is lower in the RPS scenario than the base case.

The increases in average electricity costs from new RPS capacity additions are 15.6 percent in 2016, 23 percent in 2020, and over 20 percent after 2025 (see Table 76). Average electricity rates in Virginia increase over 5 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase almost 10 percent in 2025 and increase between 7 to 9 percent thereafter compared to the base case without RPS standards. These significant rate increases reflect low capacity utilization rates for wind and solar in Virginia and RPS generation displacing low cost coal and natural gas fired electric power generation.

Table 76: Impacts of RPS on Virginia Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	0.0	0.0	214.0	221.7	230.6	249.4
With RPS	0.0	0.0	200.3	220.9	232.9	251.3
New RPS Capacity						
Wind	83.2	121.5	153.0	24.1	25.4	27.4
Solar	227.8	332.7	419.2	66.0	69.6	75.1
	Million Megawatt hours					
New NGCC Generation						
Without RPS	3.7	3.5	11.6	19.6	28.1	37.1
With RPS	3.3	2.4	10.0	17.9	26.4	35.5
Legacy RPS Generation	0.0	0.0	0.0	0.0	0.0	0.0
New RPS Generation	3.5	5.4	8.3	8.8	9.3	9.8
	Percentage Changes from Base Case					
Average Costs	15.59	23.15	28.60	25.01	21.69	19.32
Electricity Consumption	-0.33	-0.78	-1.13	-1.18	-1.08	-0.97
Average Rates	5.45	7.75	9.85	8.76	7.74	6.93
Average Rates + Legacy Costs	5.45	7.75	9.85	8.76	7.74	6.93

The decomposition of RPS costs for the Virginia electricity sector appears in Table 77. Net RPS legacy costs are zero because there is no existing wind and solar capacity in Virginia. The costs associated adding new RPS capacity to reach the RPS goals also appear in Table 77. The direct costs to achieve 6 percent of electricity consumption supplied by renewable energy are $510.7 million in 2016 and rise to over $1.1 billion in 2020 and subsequent years (see Table 77). After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $534 million in 2016, $748 million in 2020, $1 billion in 2025, and over $833 million per year thereafter. With subsidies, the total costs of Virginia's renewable energy portfolio standards are $712 million in 2016, $1 billion in 2020, $1.4 billion in 2025 and more than $1.2 billion per year from 2030 to 2040 (see Table 77).

Table 77: Costs of Virginia RPS

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Legacy Costs						
Direct	0.0	0.0	0.0	0.0	0.0	0.0
Cycling Costs	0.0	0.0	0.0	0.0	0.0	0.0
less Fuel Costs	0.0	0.0	0.0	0.0	0.0	0.0
Net RPS Legacy Costs	0.0	0.0	0.0	0.0	0.0	0.0
New RPS Costs						
Direct	510.7	760.5	1,101.9	1,100.7	1,101.4	1,102.8
Cycling Costs	4.7	5.6	8.1	8.3	8.6	9.5
less Fuel Costs	-33.1	-14.7	53.6	120.1	178.1	225.1
less NGCC Costs	14.7	31.9	50.4	56.6	56.5	53.4
Net New RPS Costs	533.8	748.9	1,006.0	932.4	875.4	833.8
RPS Tax Subsidies	179.0	265.3	383.2	380.7	378.9	377.4
Total RPS Cost	712.8	1,014.2	1,389.2	1,313.1	1,254.2	1,211.2
	Million Tons					
CO2 Reductions	3.03	4.97	7.64	8.12	8.51	8.90
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	175.92	150.61	131.73	114.83	102.83	93.65
Subsidy Costs	58.99	53.36	50.18	46.88	44.51	42.38
Total Costs	234.91	203.97	181.92	161.71	147.34	136.03

The RPS policies in Virginia reduce carbon dioxide emissions by 3 million tons in 2016 to over 8.9 million tons per year by 2040 (see Table 77). The direct costs per ton of avoided emissions are $175.92 per ton in 2016, $150.61 per ton in 2020, $131.73 per ton in 2025 and $93.65 per ton in 2040. Tax subsidies are nearly $60 per ton in 2020 and remain over $42 per ton in 2040. The total costs of avoided carbon emissions, therefore, are $234.91 per ton in 2016, $203.97 per ton in 2020 and gradually decline to $136.03 per ton in 2040 (see Table 71). These large unit costs of carbon emission reductions reflect the low capacity utilization rates for wind and solar in Virginia. Another factor is the predominance of low cost coal and natural gas capacity in total generation.

These RPS carbon abatement costs are far above the EPA social cost of carbon of $12 to $24 per ton, assuming a 5 percent discount rate, suggesting that RPS policies in Utah are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Virginia is not cost effective. There are also economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

13.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Virginia economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 78. Annual losses in Virginia value added range from $1.9 billion in 2016 to $3.5 billion in 2025, and remain over $2.5 billion per year out to 2040. Employment levels are 14-26 thousand below employment in the base case without renewable energy portfolio standards after 2020 (see Table 79).

Table 78: Impacts of RPS on Virginia Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-21.27	-30.24	-38.42	-34.15	-30.17	-27.04
Paper	-41.46	-58.93	-74.88	-66.54	-58.79	-52.70
Wood	-31.09	-44.20	-56.16	-49.91	-44.09	-39.52
Other Man	-106.37	-151.20	-192.12	-170.73	-150.83	-135.20
Textiles	-19.64	-27.91	-35.47	-31.52	-27.85	-24.96
Minerals	-14.18	-20.16	-25.62	-22.76	-20.11	-18.03
Const.	-291.29	-414.06	-526.13	-467.54	-413.05	-370.25
Trans.	-119.46	-169.81	-215.77	-191.74	-169.40	-151.85
Services	-1,545.88	-2,197.47	-2,792.21	-2,481.27	-2,192.13	-1,964.98
Utilities	210.55	299.30	380.31	337.96	298.57	267.64
Total	-1,978.99	-2,813.13	-3,574.50	-3,176.44	-2,806.29	-2,515.50

Table 79: Impacts of RPS on Virginia Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-80	-114	-145	-129	-114	-102
Paper	-229	-325	-413	-367	-324	-291
Wood	-393	-559	-710	-631	-558	-500
Other Man	-1,206	-1,714	-2,177	-1,935	-1,709	-1,532
Textiles	-284	-403	-512	-455	-402	-361
Minerals	-47	-67	-85	-75	-67	-60
Const.	-2,297	-3,265	-4,149	-3,687	-3,257	-2,920
Trans.	-1,578	-2,242	-2,849	-2,532	-2,237	-2,005
Services	-8,892	-12,640	-16,062	-14,273	-12,610	-11,303
Utilities	363	516	656	583	515	462
Total	-14,642	-20,814	-26,447	-23,502	-20,763	-18,612

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Virginia value added and employment are summarized in Table 80. For example, in 2025 RPS investments contributed $188 million in value added and 2.420 jobs in 2020.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Virginia's RPS goals are $1.8 billion in 2016, $2.6 billion in 2020, $3.4 billion in 2025, and remain over $2.4 billion through the end of the forecast horizon. Employment levels are more than 24 thousand lower in 2025 compared to the base case after 2020 (see Table 80).

Table 80: Net Impacts of RPS on Virginia Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	560.20	782.21	932.61	139.13	139.05	142.29
Value Added						
Electric prices	-1,978.99	-2,813.13	-3,574.50	-3,176.44	-2,806.29	-2,515.50
RPS Invest.	113.62	158.52	188.80	28.13	28.09	28.71
NGCC Invest.	0.00	0.00	-3.86	-0.23	0.66	0.54
Net Change	-1,865.37	-2,654.61	-3,389.56	-3,148.54	-2,777.55	-2,486.26
Employment	**Number of Jobs**					
Electric prices	-14,642	-20,814	-26,447	-23,502	-20,763	-18,612
RPS Invest.	1,460	2,035	2,420	360	359	366
NGCC Invest.	0	0	-32	-2	5	4
Net Change	-13,182	-18,779	-24,060	-23,144	-20,399	-18,241

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Virginia are much higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate and even assuming a 3 percent discount rate. From a global perspective, therefore, renewable energy portfolio standards in Virginia are an inefficient means to address global climate change. The incremental costs of environmental improvement from RPS in Virginia are significant because the state generates more than 95 percent of its power from low-cost coal, gas, and nuclear generation.

The ambitious RPS goal of 6 percent imposes significant costs on the economy of Virginia. The existing renewable energy portfolio standard raises electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus from building and operating renewable energy facilities.

14. Wisconsin

Wisconsin generated 65.9 million MWh of electric power in 2013 from a diverse portfolio of generation assets (see Table 81). Coal power plants provide more than 61 percent of total generation. Nuclear facilities provide almost 18 percent of generation while natural gas plants provide 12 percent. Hydroelectric facilities provide 3 percent of total generation. Wind power contributes 2.4 percent of total generation. The following two sub-sections summarize the impacts of existing and future RPS goals on the electricity market and state value added and employment in Wisconsin.

Table 81: Capacity, Generation, and Utilization Rates for Wisconsin 2013

Energy Source	Capacity MW	Generation MWh	Capacity Utilization %
Coal	8,263	40,645,181	0.5615
Geothermal	0	0	0.0000
Hydroelectric	519	1,978,872	0.4353
Natural gas	7,067	8,102,491	0.1309
Nuclear	1,286	11,675,194	1.0364
Other	21	66,017	0.3623
Other biomass	101	484,340	0.5458
Other gas	0	0	0.0000
Petroleum	849	303,055	0.0407
Pumped storage	0	0	0.0000
Solar	0	0	0.0000
Wind	635	1,557,924	0.2803
Wood	325	1,149,717	0.4043
Total	19,066	65,962,792	0.3950

14.1 Impacts on Electricity Sector

The RPS goal for Wisconsin is 10 percent of total consumption. The impacts on electricity markets from the enactment of these goals are presented in Table 82. The RPS goals reduce the need for additional new NGCC as these goals are met. For instance, in the base case without additional RPS capacity, new NGCC capacity required to balance the market is 178.6 MW in the base case and under the RPS incremental NGCC capacity required is 164 MW in 2016 (see Table 82).

Wind power provides more than 98 percent of new capacity to meet RPS in Wisconsin with the remainder met by solar generating plants. RPS wind and solar capacity to meet the RPS goals are 197 and 8.6 MW respectively in 2016 and 44.6 and 1.9 MW respectively in 2025. The electricity generation from these new facilities rises from 5.7 million MWh in 2016 to 8.9 million MWh in 2040 (see Table 82). As expected, new NGG generation is lower in the RPS scenario than the base case.

The increases in average electricity costs from new RPS capacity additions are 9.6 percent in 2016, 10 percent in 2020, and 7-9 percent after 2025 (see Table 82). With legacy costs average electricity rates in Virginia increase over 4 percent in 2016 due to renewable energy portfolio standards. After 2016, rates increase between 3 to 4 percent thereafter compared to the base case without RPS standards. These rate increases reflect relatively high capacity utilization rates for wind in Wisconsin, which lowers the levelized cost of wind.

Table 82: Impacts of RPS on Wisconsin Electricity Market

	Megawatts					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
New NGCC Capacity						
Without RPS	178.6	147.5	150.2	161.3	169.2	181.9
With RPS	164.2	146.1	150.2	161.4	169.5	182.1
New RPS Capacity						
Wind	197.7	43.4	44.6	48.0	50.4	54.1
Solar	8.6	1.9	1.9	2.1	2.2	2.3
	Million Megawatt hours					
New NGCC Generation						
Without RPS	5.1	10.4	15.9	21.8	28.0	34.5
With RPS	4.8	9.8	15.3	21.1	27.3	33.9
Legacy RPS Generation	1.6	1.6	1.6	1.6	1.6	1.6
New RPS Generation	5.7	6.5	7.1	7.7	8.3	8.9
	Percentage Changes from Base Case					
Average Costs	9.64	9.99	9.38	8.65	7.84	7.03
Electricity Consumption	-0.36	-0.50	-0.48	-0.45	-0.41	-0.37
Average Rates	3.07	3.14	2.95	2.74	2.51	2.28
Average Rates + Legacy Costs	4.34	4.29	4.01	3.70	3.39	3.08

The decomposition of RPS costs for the Wisconsin electricity sector appears in Table 83. Net RPS legacy costs are $97 million in 2016 and gradually decline to $84 million in 2040. The costs associated adding new RPS capacity to reach the RPS goals also appear in Table 83. The direct costs to achieve 10 percent of electricity consumption supplied by renewable energy are $361.6 million in 2016 and rise in subsequent years to over $500 million in 2040 (see Table 83). After adding cycling costs and deducting for fossil fuel and NGCC capacity costs, the net costs to bring meet the RPS goal are $206 million in 2016, $211 million in 2020 and 2025, and over $200 million per year thereafter. With subsidies, the total costs of Wisconsin's renewable energy portfolio standards are $474 million in 2016, $488 million in 2020, almost $500 million in 2025 and more than $500 million per year from 2030 to 2040 (see Table 83).

Table 85: Costs of Wisconsin RPS

	2016	2020	2025	2030	2035	2040
	Millions of 2013 Dollars					
RPS Legacy Costs						
Direct	96.5	94.8	92.7	90.7	88.6	86.7
Cycling Costs	29.6	27.2	28.2	29.2	30.8	32.4
less Fuel Costs	29.1	29.2	30.1	31.5	33.0	34.6
Net RPS Legacy Costs	97.0	92.7	90.8	88.3	86.5	84.5
New RPS Costs						
Direct	361.6	405.8	429.5	453.7	478.6	504.3
Cycling Costs	33.6	30.8	31.9	33.0	34.9	36.7
less Fuel Costs	181.3	209.0	233.0	260.0	290.2	322.9
less NGCC Costs	7.6	16.5	17.3	17.3	17.8	18.0
Net New RPS Costs	206.4	210.9	211.2	209.3	205.6	200.1
RPS Tax Subsidies	171.0	184.4	196.9	210.1	224.1	238.9
Total RPS Cost	474.4	488.1	498.8	507.8	516.2	523.6
	Million Tons					
CO2 Reductions	8.75	9.54	10.09	10.65	11.25	11.88
	2013 Dollars per ton of CO2 Reduced					
Direct RPS Costs	34.67	31.82	29.94	27.95	25.96	23.95
Subsidy Costs	19.55	19.33	19.52	19.72	19.92	20.11
Total Costs	54.22	51.15	49.46	47.67	45.88	44.06

The RPS policies in Wisconsin reduce carbon dioxide emissions by 8.7 million tons in 2016 to nearly 12 million tons per year by 2040 (see Table 83). The direct costs per ton of avoided emissions are $34.67 per ton in 2016, $31.82 per ton in 2020, $29.94 per ton in 2025 and $23.95 per ton in 2040. Tax subsidies are nearly $20 per ton. The total costs of avoided carbon emissions, therefore, are $54.22 per ton in 2016, $51.15 per ton in 2020 and gradually decline to $44.06 per ton in 2040 (see Table 71). These unit costs of carbon emission reductions reflect the relatively high capacity utilization rates for wind in Wisconsin as well as the predominance of low cost coal and natural gas capacity in total generation.

These RPS carbon abatement costs are above the EPA social cost of carbon of $12 to $24 per ton, assuming a 5 percent discount rate, suggesting that RPS policies in Utah are an inefficient greenhouse gas emission strategy. Under a 3 percent discount rate, EPA's social cost of carbon is around $40 per ton in 2016 and gradually increases to $60 per ton in 2040. So from a global cost-benefit perspective, adopting RPS policies in Virginia is not cost effective at a 5 percent discount rate. There are also economic impacts resulting from higher electricity rates that lead to losses in economic output and employment. These impacts are now presented and discussed.

14.2 Economic Impacts

By raising retail prices for electricity, RPS goals increase consumer electricity bills and the costs of providing goods and services in the Wisconsin economy. These impacts of higher electricity prices are summarized by sector from 2016 to 2040 in Table 84. Annual losses in Wisconsin value added range from $1.1 billion in 2016 to $1 billion in 2025, and remain over $800 million per year out to 2040. Employment levels are 7 and 10 thousand below employment in the base case without renewable energy portfolio standards (see Table 85).

Table 83: Impacts of RPS on Wisconsin Value Added by Sector

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-60.79	-60.09	-56.15	-51.79	-47.41	-43.07
Paper	-141.55	-139.93	-130.74	-120.60	-110.41	-100.30
Wood	-28.66	-28.33	-26.47	-24.42	-22.35	-20.31
Other Man	-83.80	-82.84	-77.40	-71.40	-65.36	-59.38
Textiles	-3.91	-3.86	-3.61	-3.33	-3.05	-2.77
Minerals	-18.24	-18.03	-16.84	-15.54	-14.22	-12.92
Const.	-132.43	-130.91	-122.32	-112.84	-103.29	-93.84
Trans.	-68.17	-67.39	-62.96	-58.08	-53.17	-48.31
Services	-744.24	-735.69	-687.38	-634.10	-580.48	-527.36
Utilities	135.47	133.92	125.12	115.42	105.67	96.00
Total	-1,147.62	-1,134.44	-1,059.94	-977.78	-895.11	-813.19

Table 85: Impacts of RPS on Wisconsin Employment by Sector

	Number of Jobs					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Metals	-269	-266	-249	-229	-210	-191
Paper	-724	-716	-669	-617	-565	-513
Wood	-399	-395	-369	-340	-312	-283
Other Man	-1,983	-1,960	-1,832	-1,690	-1,547	-1,405
Textiles	-92	-91	-85	-78	-71	-65
Minerals	-39	-38	-36	-33	-30	-27
Const.	-968	-957	-894	-825	-755	-686
Trans.	-1,092	-1,080	-1,009	-931	-852	-774
Services	-4,909	-4,852	-4,534	-4,182	-3,829	-3,478
Utilities	253	250	234	216	197	179
Total	-10,223	-10,105	-9,442	-8,710	-7,973	-7,244

These losses from higher electricity prices are partially offset by output and employment gains from building and operating electricity capacity needed to meet RPS goals. These different impacts of RPS on Wisconsin value added and employment are summarized in Table 86. For example, in 2016 RPS investments contributed $86.8 million in value added and 1,140 jobs in 2020.

Like the other states, the stimulus from RPS investment, however, is not large enough to offset the negative impacts of higher electricity prices. On balance, therefore, net annual losses in value added from Wisconsin's RPS goals are $1 billion in 2016, $1.1 billion in 2020, $1 billion in 2025, and remain over $800 million per year through the end of the forecast horizon. Employment levels are almost 10 thousand lower in 2020 compared to the base case (see Table 86).

Table 86: Net Impacts of RPS on Wisconsin Value Added and Employment

	Millions of 2013 Dollars					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
RPS Invest.	447.54	96.91	97.87	103.32	106.63	112.56
Value Added						
Electric prices	-1,147.62	-1,134.44	-1,059.94	-977.78	-895.11	-813.19
RPS Invest.	86.84	18.80	18.99	20.04	20.68	21.83
NGCC Invest.	-4.19	-0.41	0.01	0.02	0.10	0.08
Net Change	-1,064.97	-1,116.05	-1,040.95	-957.72	-874.33	-791.27
Employment	**Number of Jobs**					
Electric prices	-10,223	-10,105	-9,442	-8,710	-7,973	-7,244
RPS Invest.	1,140	247	249	263	271	286
NGCC Invest.	-38	-4	0	0	1	1
Net Change	-9,121	-9,862	-9,193	-8,447	-7,701	-6,957

In summary, the costs of avoiding carbon dioxide emissions using renewable portfolio standards in Wisconsin are much higher than EPA estimates of the social cost of carbon assuming a 5 percent discount rate. From a global perspective, therefore, renewable energy portfolio standards in Wisconsin are an inefficient means to address global climate change. The incremental costs of environmental improvement from RPS in Wisconsin are significant because RPS generation displaces relatively low-cost coal, gas, and nuclear generation.

The 10 percent RPS goal imposes significant costs on the economy of Wisconsin. The existing renewable energy portfolio standard raises electricity costs that on balance result in a net reduction in the state's value added and employment even after accounting for the economic stimulus from building and operating renewable energy facilities.

15. Conclusions

As the prior discussion reveals there are a number of factors that affect the burden of Renewable Energy Portfolio Standards by raising electricity rates for customers. Two of the more prominent factors in determining the size of these impacts − the RPS goals and the cost of renewable energy − are illustrated in Figure 3. The cost of renewable energy in Figure 3 (gray line) is a weighted average wind and solar costs for each state over the entire forecast period, 2016 to 2040. The percentage change in electricity rates for each state are also plotted in Figure 3.

As the Figure 3 illustrates, at the RPS goal increases so doe electricity rates with three notable exceptions: Virginia, North Carolina, and Rhode Island. For these three states, RPS goals are low relative to the targets adopted by other states in the sample but the cost of renewable energy is quite high, primarily given a reliance on new solar capacity to meet the RPS goals and relatively low solar capacity utilization rates for those states, both of which drive up the cost of solar. Conversely there are other states where RPS goals are relatively high but electricity rates increase moderately, such as Colorado, primarily due to relatively lower renewable energy costs due to high efficiency and a greater emphasis using lower cost wind power. The economic burdens of RPS policies, therefore, varies considerably by state based upon solar and wind capacity availability and utilization.

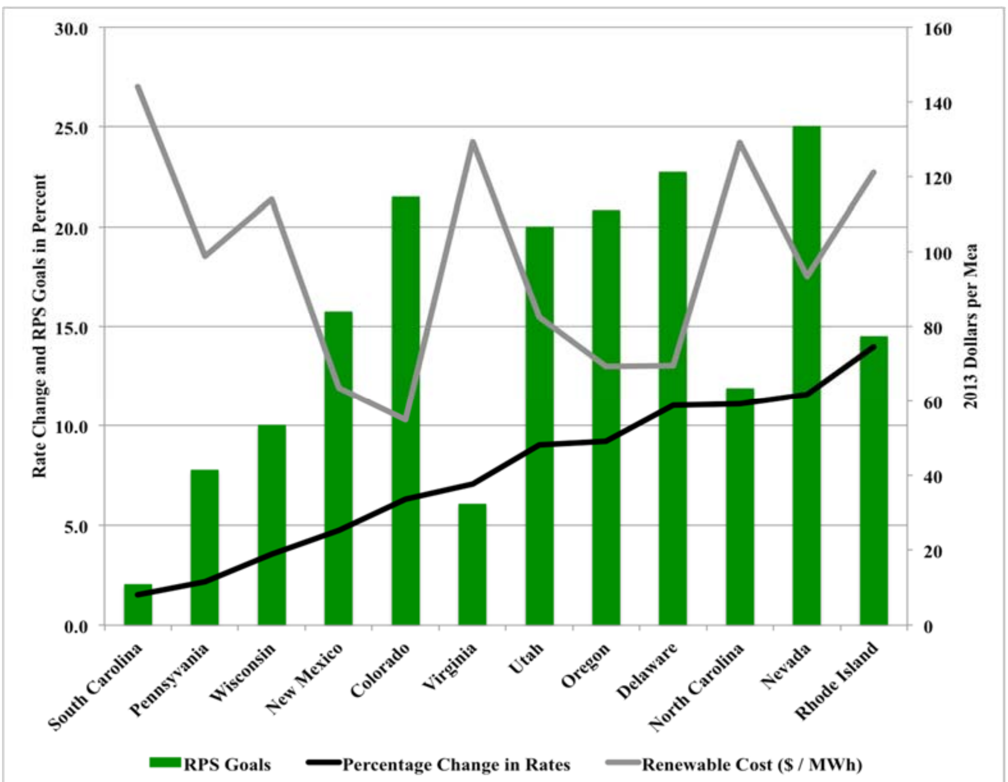

Figure 3: Average Rate Increases, RPS Goals, and Renewable Energy Costs

The economic merits of RPS policies can be evaluated on two margins. The first compares the marginal abatement cost of carbon emissions using RPS policies to the social cost of carbon. At discount rates of 3 and 5 percent, the average cost of cutting greenhouse gas emissions across all 12 states is above the social cost of carbon through at least 2035. This suggests that RPS policies are premature, imposing a deadweight loss on society from their early implementation. Even from a global environmental and economic perspective, RPS policies at least for the 12 states examined in this study are inefficient.

These inefficiencies are compounded by the losses in value added and employment incurred by higher electricity rates. Proponents of RPS policies often cite the employment opportunities created by building and operating wind and solar energy facilities. A careful analysis that balances these two opposing forces reveals that lost economic growth and employment from higher electricity prices are greater than the gains economies realized from renewable energy development.

If RPS goals are pushed upward in future years, the problems with RPS policies identified in this study, which heretofore have been largely hidden by average cost pricing of electricity by state public utility commissions, will become more evident.

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Appendix A: Econometric Results for Alternative Demand Models

Table A1: Electricity Demand First Difference Model Parameter Estimates by State

State	Estimates	Log Real Price	Log GSP
Colorado	Estimate	-0.161	0.682
	t-Statistic	-2.677	11.640
	P-Value	[.011]	[.000]
Delaware	Estimate	-0.219	0.378
	t-Statistic	-3.334	3.040
	P-Value	[.002]	[.004]
North Carolina	Estimate	-0.222	0.610
	t-Statistic	-2.706	6.007
	P-Value	[.010]	[.000]
New Mexico	Estimate	-0.350	0.421
	t-Statistic	-2.806	3.603
	P-Value	[.008]	[.001]
Nevada	Estimate	-0.217	0.673
	t-Statistic	-3.203	8.735
	P-Value	[.003]	[.000]
Oregon	Estimate	-0.323	0.584
	t-Statistic	-4.133	5.903
	P-Value	[.000]	[.000]
Pennsylvania	Estimate	-0.204	0.519
	t-Statistic	-3.373	4.512
	P-Value	[.002]	[.000]
Rhode Island	Estimate	-0.118	0.363
	t-Statistic	-2.934	3.661
	P-Value	[.005]	[.001]
South Carolina	Estimate	-0.259	0.783
	t-Statistic	-3.532	8.175
	P-Value	[.001]	[.000]
Utah	Estimate	-0.145	0.752
	t-Statistic	-2.100	11.473
	P-Value	[.042]	[.000]
Virginia	Estimate	-0.188	0.652
	t-Statistic	-3.362	7.937
	P-Value	[.002]	[.000]
Wisconsin	Estimate	-0.302	0.720
	t-Statistic	-3.795	7.415
	P-Value	[.000]	[.000]

Table A2: Elasticities of Electricity Demand for First Difference Model

State	Own Price Elasticity	Gross State Product Elasticity
Colorado	-0.161	0.682
Delaware	-0.219	0.378
North Carolina	-0.222	0.610
New Mexico	-0.350	0.421
Nevada	-0.217	0.673
Oregon	-0.323	0.584
Pennsylvania	-0.204	0.519
Rhode Island	-0.118	0.363
South Carolina	-0.259	0.783
Utah	-0.145	0.752
Virginia	-0.188	0.652
Wisconsin	-0.302	0.720
Average	-0.226	0.595

Table A3: Panel Data Estimates for Electricity Demand

	Constant	Log real Price	Log GSP
Pooled OLS*			
Estimate	0.0118	-0.2011	0.4329
t-Statistic	5.3474	-10.2083	10.6906
P-Value	[.000]	[.000]	[.000]
Fixed Effects			
Estimate		-0.1943	0.4008
t-Statistic		-9.9058	9.7130
P-Value		[.000]	[.000]
Random Effects			
Estimate	0.0124	-0.1983	0.4197
t-Statistic	4.9162	-10.1332	10.3339
P-Value	[.000]	[.000]	[.000]

Hausman test: Ho: RE vs. FE: Chisq(2) - 9.0028, Prob. Value = 0.0111

* Best Schwarz-Bayes Information Criterion

Appendix B: Comparison of RPS Impacts

	% Change in Prices		% in Value Added		% Change in Jobs	
Colorado	HOG	REF	HOG	REF	HOG	REF
2016	6.12	5.78	-1,442	-1,354	-8,060	-7,507
2020	8.23	7.10	-1,996	-1,703	-11,619	-9,774
2025	7.69	6.23	-1,992	-1,612	-12,445	-10,048
2030	7.32	5.89	-1,895	-1,520	-11,823	-9,458
2035	6.69	5.14	-1,730	-1,323	-10,779	-8,214
2040	5.93	4.10	-1,530	-1,052	-9,516	-6,501
Delaware						
2016	11.02	10.20	-603	-556	-2,705	-2,479
2020	14.50	11.89	-812	-663	-3,845	-3,108
2025	14.99	11.46	-839	-635	-3,970	-2,953
2030	12.50	9.27	-715	-528	-3,536	-2,588
2035	10.14	6.78	-578	-384	-2,846	-1,871
2040	8.20	4.23	-466	-238	-2,272	-1,143
North Carolina						
2016	10.04	9.50	-3,899	-3,641	-17,821	-16,103
2020	16.06	13.77	-7,145	-6,060	-43,277	-36,048
2025	14.12	11.46	-6,664	-5,399	-44,093	-35,644
2030	12.55	10.08	-5,918	-4,740	-39,107	-31,227
2035	11.03	8.28	-5,196	-3,887	-34,289	-25,541
2040	9.79	6.22	-4,606	-2,908	-30,345	-19,009
New Mexico						
2016	6.18	5.71	-239	-208	-743	-500
2020	6.77	5.29	-444	-347	-3,483	-2,719
2025	5.95	4.13	-390	-271	-3,060	-2,122
2030	5.30	3.60	-348	-237	-2,724	-1,853
2035	4.54	2.82	-298	-185	-2,333	-1,450
2040	3.92	1.88	-251	-117	-1,921	-874
Nevada						
2016	14.77	13.86	-1,711	-1,601	-11,827	-11,064
2020	15.60	13.08	-1,792	-1,499	-12,540	-10,484
2025	15.14	11.48	-1,715	-1,285	-11,868	-8,803
2030	13.28	9.82	-1,534	-1,124	-10,813	-7,869
2035	11.21	7.69	-1,287	-873	-9,037	-6,071
2040	9.12	5.26	-1,038	-585	-7,237	-4,014
Oregon						
2016	9.41	9.08	-1,451	-1,399	-12,309	-11,866
2020	10.00	9.08	-1,571	-1,427	-13,459	-12,226
2025	11.09	9.32	-1,636	-1,366	-13,547	-11,236
2030	10.55	8.77	-1,646	-1,365	-14,048	-11,646
2035	9.83	7.86	-1,532	-1,222	-13,077	-10,423
2040	9.11	6.82	-1,418	-1,060	-12,095	-9,034

HOG = Adjusted EIA High Oil and Gas Scenario

REF = Adjusted EIA Reference Case Scenario

	% Change in Prices		% in Value Added		% Change in Jobs	
Pennsylvania	HOG	REF	HOG	REF	HOG	REF
2016	2.02	2.01	-1,142	-1,140	-7,138	-7,121
2020	2.39	2.24	-1,385	-1,287	-8,827	-8,158
2025	2.34	2.10	-1,508	-1,351	-10,458	-9,366
2030	2.20	1.99	-1,412	-1,274	-9,784	-8,812
2035	2.04	1.79	-1,308	-1,146	-9,046	-7,913
2040	1.86	1.52	-1,187	-966	-8,194	-6,660
Rhode Island						
2016	12.60	12.37	-579	-568	-3,649	-3,574
2020	16.47	14.10	-805	-689	-5,423	-4,651
2025	14.75	11.38	-718	-554	-4,831	-3,720
2030	13.59	11.08	-661	-537	-4,442	-3,600
2035	12.43	9.59	-604	-465	-4,059	-3,116
2040	11.04	7.34	-536	-355	-3,598	-2,377
South Carolina						
2016	2.40	2.39	-312	-312	-2,063	-2,057
2020	2.94	2.67	-330	-288	-1,668	-1,293
2025	3.75	3.23	-435	-346	-2,325	-1,534
2030	3.14	2.62	-485	-400	-4,073	-3,318
2035	2.54	1.92	-389	-286	-3,232	-2,321
2040	2.05	1.14	-309	-160	-2,522	-1,217
Utah						
2016	4.81	4.79	-818	-815	-4,745	-4,728
2020	8.28	7.68	-1,147	-1,046	-4,049	-3,471
2025	11.19	9.78	-1,618	-1,382	-6,683	-5,331
2030	9.97	8.57	-1,644	-1,408	-9,126	-7,772
2035	8.64	7.14	-1,421	-1,168	-7,854	-6,402
2040	7.28	5.47	-1,192	-888	-6,551	-4,807
Virginia						
2016	4.95	4.94	-1,601	-1,599	-10,800	-10,784
2020	6.96	6.24	-2,241	-1,982	-15,040	-13,146
2025	8.52	7.28	-2,769	-2,322	-18,731	-15,444
2030	7.32	6.23	-2,608	-2,212	-19,042	-16,121
2035	6.22	4.96	-2,213	-1,758	-16,133	-12,773
2040	5.38	3.61	-1,906	-1,271	-13,873	-9,197
Wisconsin						
2016	4.13	4.13	-1,014	-1,014	-8,694	-8,699
2020	4.03	3.91	-1,048	-1,017	-9,257	-8,992
2025	3.73	3.52	-966	-912	-8,533	-8,052
2030	3.41	3.18	-881	-821	-7,764	-7,232
2035	3.07	2.80	-790	-722	-6,958	-6,348
2040	2.74	2.41	-703	-617	-6,176	-5,414

HOG = EIA High Oil and Gas Scenario

REF = EIA Reference Case Scenario

The Nevada Policy Research Institute

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