Employment Effects of Investing in Select Electricity Resources in Washington State

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1. INTRODUCTION AND SUMMARY OF RESULTS

This study presents an overview of the current electricity portfolio in Washington State, a brief discussion of the state's potential for renewable energy and energy efficiency growth, and a comparison of the employment effects associated with investing in several types of resources in the state including solar, wind, energy efficiency, and natural gas. This analysis is intended to help readers understand the potential job creation of replacing the electricity from out-of-state coal generation.

Synapse developed estimates of spending on capacity, generation and energy efficiency measures based on current data for Washington generation and efficiency programs and our estimate of future costs. We used the IMPLAN input-output model to estimate the direct, indirect (i.e. suppliers) and induced (i.e. worker re-spending) activities that would occur in Washington from the construction and operation stages for these resources. Finally, the job impacts were developed on a per-average-megawatt (aMW)[1] basis to enable direct comparison between resources. Further detail on the assumptions and methodology is provided in subsequent sections of this report.

Another important consideration is the impact on rates associated with various energy resource portfolios. A recent study from the Beacon Hill Institute and Washington Policy Center estimated a large increase in rates due to the state's renewable portfolio standard.[2] However, previous work by Synapse evaluating the model used in that study shows why these impacts may be overstated.[3] Also, while our analysis does not include the impacts of increased costs on rates, it also does not include the decrease in energy bills that would accrue to energy efficiency participants and the impacts of the related re-spending of that savings in the state's economy. This study is simply meant to compare the job impacts of capital investments and operations and maintenance (O&M) for electricity resources.

The resulting job-year impacts (i.e. the equivalent of one job per year) per aMW for construction and installation are presented in Figure 1. These represent the impact from short-term activities of building new generating capacity and installing energy efficiency measures. Solar photovoltaic (PV) has the largest impact per aMW by far with 173 job-years for commercial and residential projects and 83 job-years for utility-scale projects—the latter is smaller due to economies of scale when installing large projects. The large impacts from solar PV (relative to other resources) come as a result of the labor-intensity of these installations. The utility-scale solar projects were assumed to be located in eastern Washington which has better solar resources than in the western part of the state. Energy efficiency installation--another labor-intensive activity--generates the next highest factor with an estimated 32

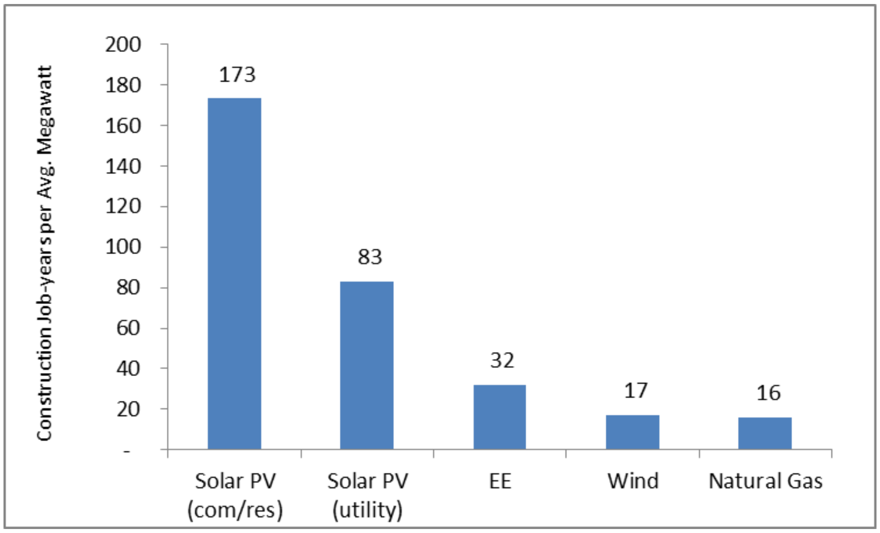
[1] An average megawatt (aMW) represents the average energy generated per hour over the course of a year (i.e. one aMW is equal to 8760 megawatt hours (MWh) per year).

[2] Beacon Hill Institute and Washington Policy Center. 2013. The Economic Impact of Washington State's Renewable Portfolio Standard. April 2013.

[3] Synapse Energy Economics, 2013. Not-so-smart ALEC: Inside the Attacks on Renewable Energy. Prepared for Civil Society Institute. Available here: http://www.synapse-energy.com/Downloads/SynapsePaper.2013-01.CSI.ALEC-Talking-Points.12-092.pdf

total job-years per aMW saved. Wind construction generates slightly more activity than natural gas—17 job-years per aMW compared to 16, respectively. Coal is not shown here since there are no new coal plants proposed in Washington.

Figure 1 – Plant Construction and EE Installation Job-years per Average Megawatt

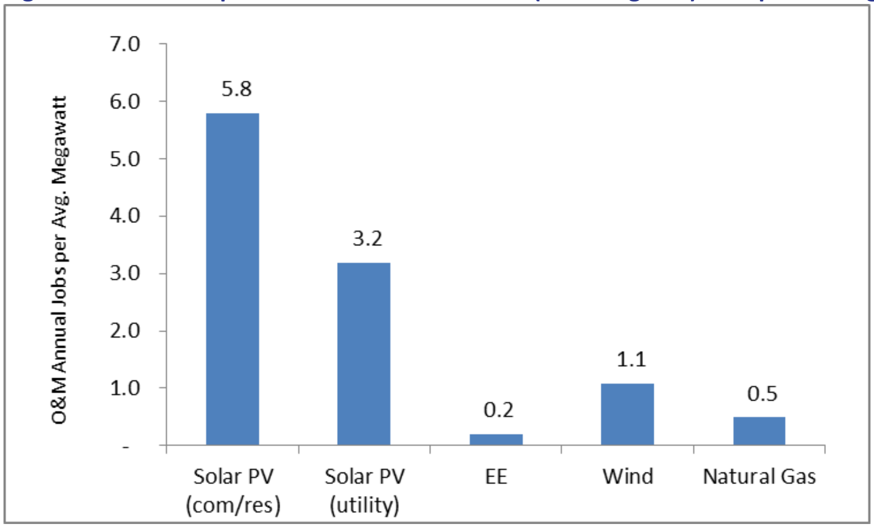


Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

The job impacts per average megawatt for O&M and fuel are presented in Figure 2. These represent the impact from long-term activities needed to run generating facilities each year. Again, solar PV has the largest impact of any resource with 5.8 jobs per aMW for residential and commercial projects and 3.2 jobs per aMW for utility-scale projects. Wind generation creates more O&M activity than natural gas in the state—1.1 to 0.5 jobs per aMW, respectively. Wind power involves more labor-intensive O&M activities and, unlike natural gas, requires no fuel spending (which would mostly leave the state). Energy efficiency incurs little O&M costs, those shown here represent the on-going marketing and administration of EE programs averaged over a twenty-year period.

This study did not evaluate the impacts of coal O&M since the only operating plant in Washington (Centralia) is slated to retire in 2025. Coal generation that is brought in from out-of-state (e.g. from the Colstrip plant in Montana) generates no direct jobs in Washington, by definition. Therefore, any replacement energy produced in Washington will bring in net new jobs to the state.

Figure 2 – Annual Operations and Maintenance (including fuel) Jobs per Average Megawatt



Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

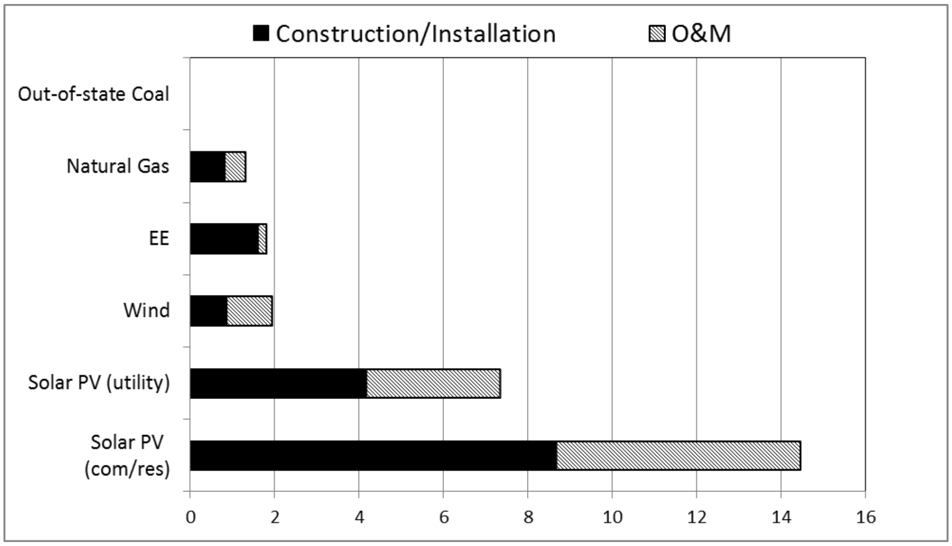
Table 1 and Figure 3 show the job factors for each resource when combining the construction and O&M stages. The "total" column in Table 1 combines the average impacts at both stages, averaged over a 20-year period to present a convenient comparison of the job impacts of each resource from "start to finish." Solar PV creates the highest impacts per aMW (14.4 for rooftop projects and 7.3 for utility-scale projects) while wind and EE have similar levels of job impacts—1.9 and 1.8, respectively. Natural gas creates the lowest average job impact of any new resource with 1.3 jobs per aMW. A state energy portfolio should not be based on these results alone--solar PV creates the most jobs per aMW but cannot fully replace lost generation from coal on its own. However, this analysis can be used to estimate the job impacts the state could expect from a cleaner energy portfolio by applying the impacts to the amount of aMW added for each resource.

Table 1 – Average Annual Job Impacts by Resource per aMW (20-year annual average)

	Construction	O&M	Total
Solar PV (com/res)	8.7	5.8	**14.4**
Solar PV (utility)	4.2	3.2	**7.3**
Wind	0.9	1.1	**1.9**
EE	1.6	0.2	**1.8**
Natural Gas	0.8	0.5	**1.3**

Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

Figure 3 - Average Annual Job Impacts by Resource per aMW (20-year period)



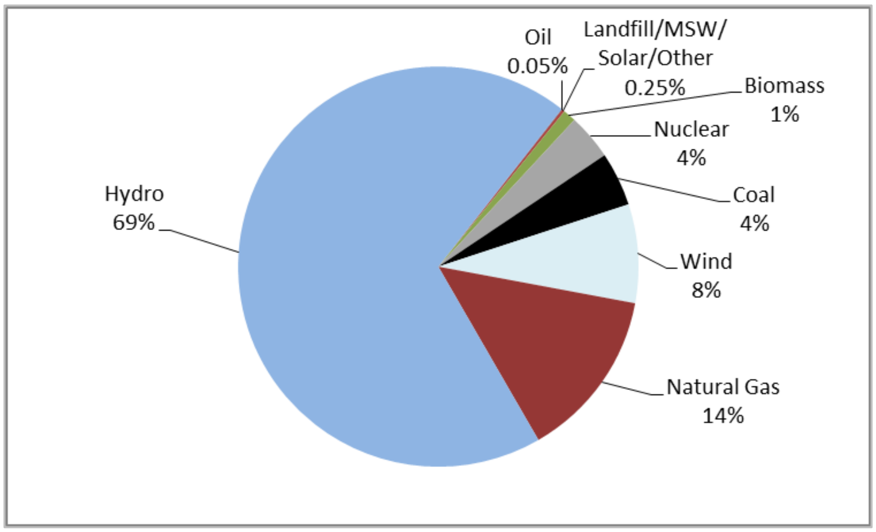
Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

2. EXISTING GENERATION AND ENERGY EFFICIENCY RESOURCES

2.1. Existing Generation Profile

The potential for Washington to replace out-of-state generation with its own resources will depend on support from state policies and the extent to which energy resources are readily available in the state. Washington currently has one of the cleanest energy portfolios of any state in the U.S. Nearly 70% of the state's generating capacity is hydropower (Figure 4). The state is the largest producer of hydropower and sixth largest producer of wind energy of any state in the U.S.[4] Washington will also upgrade hydropower and expand wind resources in the near future, in part, to comply with the its renewable energy goal of having 15% of energy come from new renewable sources by 2020.[5] Currently, only 4% of the state's in-state generating capacity is comprised of coal--from the Centralia plant--though this portion will soon be eliminated after that plant's retirement in 2025.

Figure 4 - Winter Generating Capacity by Resource (2011, % of total)



Source: Energy Information Administration

There has been a shift towards more renewable generation in Washington in recent years. As seen in Figure 5, wind generation has surpassed both coal and natural gas generation in the state in 2011 and 2012. There have been large fluctuations in natural gas and coal generation in Washington from year to year while wind has steadily increased as more turbines come on-line. The varying contributions of coal and natural gas occur because these resources are subject to market energy and fuel prices, whereas wind is not.

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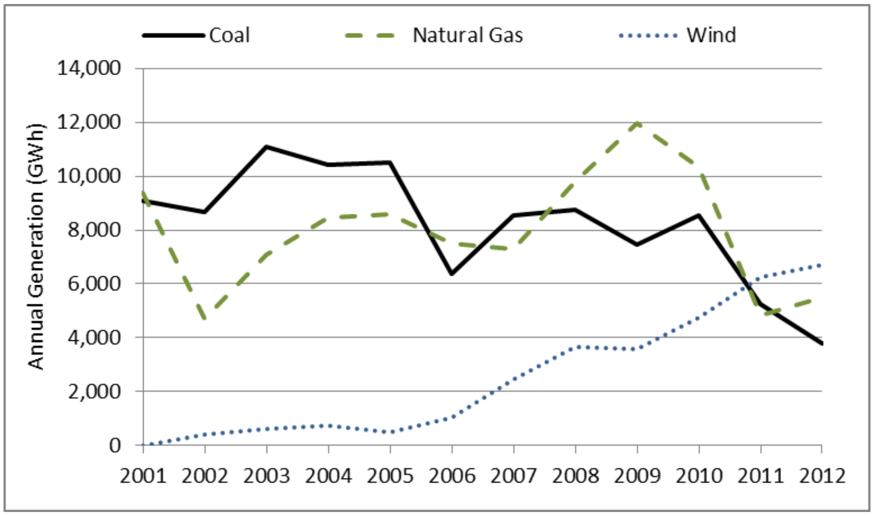
[4] Energy Information Administration (EIA), Washington - State Profile and Energy Estimates.
[5] Washington Initiative 937:
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=WA15R&re=0&ee=0

Figure 5 - In-state Generation by Select Resources (2001-2012, GWh)



Source: Energy Information Administration

The state also offers plenty of room for growth in new renewable energy—especially for wind. The National Renewable Energy Laboratory (NREL) estimated the potential for wind generation in Washington to be over 18,000 MW of capacity, producing 55,550 GWh of energy (after excluding 70% of windy land that was unavailable for development).[6] Much of this supply comes from the central and southeastern parts of the state.[7] Solar generation has historically been low in the state but has potential to grow if the costs continue to decrease. According to the 2012 Washington State Energy Strategy:

> The eastern half of the state is richer in this resource than the western half, but even the relatively low rate of solar radiation energy in the Puget Sound region is sufficient to support residential rooftop photovoltaic systems, residential water heating systems and other solar technologies… Since the potential of the solar resource is so vast, a sufficiently low cost, new technology would alter the energy landscape significantly.[8]

2.2. Existing Energy Efficiency Programs and Savings

Washington is one of the leading states in the nation in promoting energy efficiency among consumers and businesses. ACEEE recently ranked Washington eighth among all states in energy efficiency; this ranking is based on ratepayer funded energy efficiency programs and policies, transportation policies,

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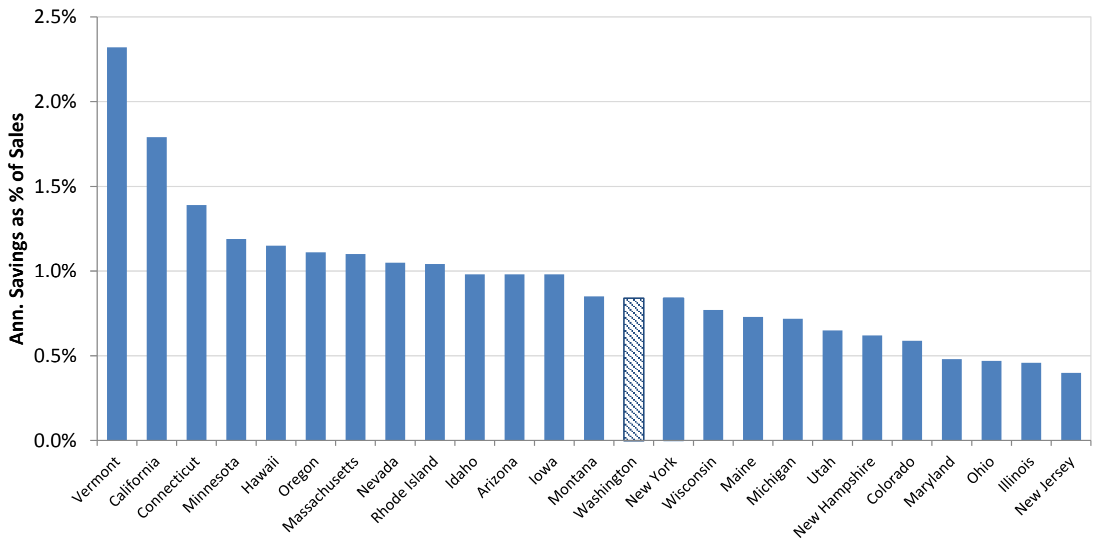
[6] National Renewable Energy Laboratory (NREL), 2011. Estimates of Windy Land Area and Wind Energy Potential by State

[7] Washington Department of Commerce (WA DOC), 2011. 2012 Washington State Energy Strategy with Forecasts 2012-2035: Issues and Analysis for the Washington State Legislature and Governor. December 2011. Found here: http://www.leg.wa.gov/documents/legislature/ReportsToTheLegislature/2012%20WSES_23140184-41ff-41d1-b551-4675573845db.pdf

[8] WA DOC, 2011.

building energy codes, state government initiatives, and appliance efficiency standards.[9] Washington reduced retail sales by about 0.85% in 2010 through energy efficiency (Figure 6) and was ranked eighth among states in the nation by ACEEE in their 2012 State Energy Efficiency Scorecard.

Figure 6 - Incremental Energy Savings as Percent of Retail Sales in 2010 for Top 25 States



Source: ACEEE 2012

Washington enacted the Energy Independence Act (known as I-937) in 2006, part of which required all state electric utilities serving 25,000 or more customers to undertake all achievable cost-effective energy conservation.[10] In the two years following I-937, the affected utilities saved 263 aMW. The costs of these efficiency programs are typically low compared to the cost of supply side resources. We estimate the cost over the lifetime of energy savings could be 1 to 3 cents per kWh savings, based on recent program costs and savings achieved by Seattle City Light and Puget Sound Energy and assuming that these measures typically last about 10 years on average.[11] In contrast, the average retail electricity price for the state is about 7 cents per kWh.[12]

The majority of utilities in Washington and the surrounding states are receiving significant technical and financial support from two regional energy efficiency providers, the Northwest Energy Efficiency Alliance (NEEA) and Bonneville Power Administration (BPA). NEEA is a regional nonprofit entity dedicated solely

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[9] Foster, Ben et al. (ACEEE), 2012. The 2012 State Energy Efficiency Scorecard. Research Report E12C. October 3, 2012.
[10] Washington Initiative 937: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=WA20R&re=0&ee=0
[11] Historical data were obtained from the Regional Technical Forum (RTF), available at http://rtf.nwcouncil.org/consreport/2011/
[12] U.S. EIA. "Sales and revenue data by state, monthly back to 1990 (Form EIA-826): http://www.eia.gov/electricity/data.cfm#sales

to promoting energy efficiency through market transformation initiatives. NEEA's activities involve identifying promising technologies and ideas, and developing and testing operational approaches to promote these ideas in the market.[13] Examples of this process are NEEA's early activity to promote compact fluorescent lamps (CFL's),[14] and recent activity to promote ductless heat pumps.[15] BPA has been acquiring energy efficiency savings as defined by the Northwest Power and Conservation Council (NWPCC) for about 30 years. While BPA supports market transformation activities, the agency mainly focuses on efficiency acquisition through various programs for the roughly 135 public power entities to which they sell bulk power.

These active energy efficiency programs have a long history dating back to the late 1970's. The Northwest region has saved significant amounts of energy through utility conservation programs, state codes, federal appliance standards, and regional energy programs by the Northwest Energy Efficiency Alliance (NEEA). Among these policies, utility programs have had the largest impact. Through 2010, regional savings were approximately 4,500 average megawatts--more than enough to power all of the state of Idaho and Western Montana that year.[16] This level of energy savings represents a decrease of 19% in regional electricity sales in 2010.

In addition to these achievements, the Northwest and Washington State still have plenty of untapped energy efficiency potential. Table 2 summarizes the results of two recent energy efficiency potential studies in the region. One of the studies, conducted by Cadmus for Puget Sound Energy (PSE), found that PSE had a maximum achievable potential of 18% relative to projected energy sales in 2031.[17] (An achievable potential is a subset of an economic potential and takes into account various barriers to adopting energy efficiency measures.) Another study, shown in Table 2, was conducted by the NWPCC as part of their Sixth Power Plan in 2010. The NWPCC has found a large amount of energy efficiency potential, equaling about 23% of projected sales in the region in 2030. Much of the additional potential found in the NWPCC study is relevant to Washington (such as savings from the agricultural sector, utility distribution and consumer electronics, which were not incorporated the in the same way in the Cadmus study).

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[13] Institute for Industrial Productivity, 2012. Energy Efficiency Resource Acquisition Program models in North America, p. 64 and 71
[14] Institute for Industrial Productivity, 2012.
[15] http://neea.org/initiatives/residential/ductless-heat-pumps
[16] NWPCC, 2010. 6th Power Plan Energy Efficiency Two-Pager:
http://www.nwcouncil.org/energy/powerplan/6/2010-08/
Regional Technical Forum 2012-Progress Update 2011 Annual Report:
http://rtf.nwcouncil.org/2011RTFAnnualReport.pdf
[17] Cadmus, 2011. Comprehensive Assessment of Demand-Side Resource Potentials (2012-2031). Prepared for Puget Sound Energy.

Table 2 - Comparison of Energy Efficiency Potential Estimates by Cadmus (for PSE) and NWPCC (% of Sector Demand) [18]

Sector	Cadmus	NWPCC
Residential	21%	29%*
Commercial	16%	17%*
Industrial	17%	15%
Agricultural		11%
Utility distribution**		2%
Total	**18%**	**23%**

Source: NWPCC 2011, Cadmus 2011.

** These numbers are rough approximations of potential that include savings from consumer electronics.*
*** Savings are compared to the total utility demand.*

Given Washington's historical performance on energy efficiency, the significant potential shown above and the continual support of efficiency measures through statewide policies--the state should continue to lead in this area in the future. Energy efficiency is the cheapest energy resource and, as the results from this report show, also a significant job-creator.

[18] NWPCC's estimates of achievable potential in 2029, screened at $100/MWh based on Table E-1 and Figure 4.8 of NWPCC (2010). Synapse estimated NWPCC's savings as % of forecasted load based on MWa potential data provided in the Plan and its sector-specific sales data for 2030 provided in Table 3-4 in the Plan.

3. Input Assumptions

This section presents the assumptions for renewable energy and energy efficiency costs used to develop the job impact results. These cost inputs include spending on:

- Construction of new natural gas, solar and wind facilities.
- Energy efficiency installations
- Operations and maintenance (O&M) of efficiency, natural gas, solar and wind facilities.

Synapse has developed customized spending patterns for each of the activities listed above and, along with the use of the IMPLAN model, developed job impacts specifically for Washington.

3.1. Natural Gas, Solar and Wind Generation Costs

Assumptions of capital, O&M costs and capacity factor for energy resources are presented in Table 3. These costs are assumed to take place in the near future (2015 to 2020).

- Natural gas capital and operating costs are also based on assumptions from the Energy Information Administration (EIA). The 51% capacity factor is based on the Pacific Northwest average assumed by the NWPCC.[19]
- Solar PV capital and operating costs are based on Synapse estimates from module price data, discussions with project developers and market data for utility-scale, commercial and residential rooftop projects. “Com/res” PV represents a mix of commercial and residential projects in western Washington, with an estimated cost of \$4,000 per kW_{DC}. “Utility” PV represents utility-scale projects in eastern Washington--which have a higher capacity factor and a lower cost—has an estimated cost of \$2,400 per kW_{DC}. The capacity factors for both types of projects were derived with NREL’s PV Watts tool for Washington.[20]
- Wind capital and operating costs are based on Synapse estimates for projects in Class 4 wind regimes and assume an 80-meter hub height and 82.5-meter rotor diameter. Costs are based on data from NREL and Lawrence Berkeley Laboratories (LBL) and on analysis of recent power purchase agreements.[21,22] We use a capacity factor of 38%, considerably higher than historical wind capacity factors in

[19] NWPCC, 2013. Sixth Power Plan: Mid-Term Assessment Report. March 13, 2013.
[20] NREL PV Watts for Washington: http://rredc.nrel.gov/solar/calculators/pvwatts/version1/US/Washington/. The capacity factor was calculated using the DC capacity rating and AC energy produced.
[21] Wiser, Ryan et al., 2012. Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Projects. National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Laboratory (LBNL).
[22] “Standard technology” is defined as 80 meter hub height and 82.5 meter rotor diameter and “low speed technology” is defined as 80 meter hub height and 100 meter rotor diameter.

Washington state, which are in the range of 30%.[23] Our capacity factor assumption is based on modeling of the wind technology being installed today. Our cost and capacity factor assumptions together produce levelized energy costs consistent with those seen in recent power purchase agreements.

Table 3 - Synapse Capital, O&M and Capacity Factor Cost Assumptions

Generation Type	Capital Cost in 2015 (2010$/kW)	Variable O&M (2010$/MWh)	Fixed O&M (2010$/kW)	Capacity Factor
Gas Combined Cycle	$1,100	$3.44	$14.5	51%
Solar PV (com/res)	$4,000	$0	$40	12%
Solar PV (utility)	$2,400	$0	$27.5	15%
Wind Land	$1,650	$0	$60	38%

Source: Synapse estimates based on EIA Annual Energy Outlook (AEO) 2011, Wiser 2012, NREL PV Watts (capital and O&M costs), and select natural gas generation.

3.2. Energy Efficiency Installation Costs

Synapse developed cost estimates for energy efficiency in Washington based on a review of current programs offered by state utilities and on previous research of efficiency measure spending in other states. Typically, energy efficiency program spending is reported at a sector or program level as well as for specific administrative tasks such as planning, marketing, evaluation, measurement and verification (EM&V). Because detailed measure-level data was not available for Washington, Synapse relied on measure level cost data from key utilities in Minnesota and Massachusetts which were selected because they offered data relevance and availability, existence of large energy savings, high program spending, and cold or temperate climates (ensuring that the types of measures would be comparable). Xcel Energy in Minnesota and NSTAR Electric in Massachusetts were selected because they had dominant electric energy efficiency programs in their respective states.[24] In order to generate Washington-specific data, Synapse performed the following additional steps:

1) We developed annual energy efficiency program savings and spending by sector based on recent historical program data for Puget Sound Energy and Seattle City Light, using data from the Regional Technical Forum. [25]

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[23] Based on historical generation at Wild Horse, Hopkins Ridge and Big Horn wind farms.

[24] Xcel Energy. 2011. Status Report & Associated Compliance Filings Minnesota Electric and Natural Gas Conservation Improvement Program Docket No. E. G002/CIP-09-198, http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/MN-DSM-CIP-2011-Status-Report.pdf; and NSTAR Electric Company. 2012. 2013-2015 Three-Year Energy Efficiency Plan, D.P.U. 12-110, Exh. 5, November 2012.

[25] The Regional Technical Forum is an advisory committee in the Northwest to develop standards to verify and evaluate energy conservation savings.

2) These program costs were then used to derive the total costs by sector (residential, commercial and industrial) for the state based on the mix of Xcel Minnesota program spending.

3) Synapse then developed material cost coefficients (as % of total efficiency investment) by allocating the estimate of Washington's total costs over each relevant program type and industry (for use in the IMPLAN model) based on the end-use data from Xcel Minnesota (e.g., lighting bulbs, appliances, and HVAC equipment for Home Performance with ENERGY STAR program).

4) We then adjusted these material cost coefficients by incorporating measure profiles from Nstar Massachusetts, comparing the incremental measure cost data as % of total "measure" cost available from Nstar with the incremental measure data we developed for Washington based on Xcel MN data. We have also reviewed administration and marketing spending data for Puget Sound Energy to develop Washington-specific cost coefficients for these sectors.

A summary of the costs of materials and the program administrative costs for efficiency measures is presented in Table 4 with each relevant IMPLAN industry. These costs accounted for 69% of the total energy efficiency investment spending. The rest of the spending was treated as labor spending, which represents payments to contractors to install the efficiency measures.

Table 4 - Washington Energy Efficiency Non-Labor Coefficient Vectors

IMPLAN industry		%
3104	Wood pulp	2%
3216	Air conditioning, refrigeration, and warm air heating equipment	16%
3259	Electric lamp bulbs and parts	27%
3261	Small electrical appliances	0.1%
3263	Household refrigerators and home freezers	0.4%
3265	Other major household appliances	0.4%
3416	Electronic and precision equipment repairs and maintenance	2%
3417	Commercial and industrial machinery and equipment repairs and maintenance	3%
3230	Other general purpose machinery	10%
3031	Electricity, and distribution services	3%
3377	Advertising and related services	4%
Total Materials		**69%**
Total Labor		**31%**

Source: Xcel Minnesota (MN Program Spending), Regional Technical Forum 2012 - Progress Update 2011 Annual Report (WA Annual Spending), Synapse estimate of WA Program spending

Finally, our review of the recent program savings and estimates of program spending by PSE and City of Seattle found that the average program cost in Washington is $0.22 per first year kWh saved (Table 5). Based on our analysis of estimated program and measure costs for Washington, we estimated that the program costs accounts for 46% of the total energy efficiency investment—the rest of the spending is paid out-of-pocket by participants. Applying this factor to the $0.22 per kWh program cost, we estimated the total efficiency investment cost for Washington to be $0.48 per kWh first year saved. However, little spending is needed in order to keep an efficiency measure operating once it has been installed, as opposed to generation resources which require frequent maintenance.

Table 5 - Annual Average Program Spending, Savings, and Cost of Saved Energy for PSE and City of Seattle[26]

Sector	WA Program Annual Average Spending	Savings (kWh)	$ per first year kWh saved
Residential	$34,517,497	197,023,241	$0.18
Low-Income	$2,434,815	2,295,630	$1.06
Commercial & Industrial	$45,524,454	176,187,763	$0.26
Others	$7,237,939	35,931,003	$0.20
Total Program Costs	**$89,714,704**	**411,437,636**	**$0.22**
Total Investment Costs			***$0.48***

Source: Regional Technical Forum 2012 - Progress Update 2011 Annual Report (WA Annual Spending), Synapse estimate of $ per kWh saved based on savings and spending from 2008 to 2010.

[26] The data is available at http://rtf.nwcouncil.org/consreport/2011/

4. EMPLOYMENT IMPACT METHODOLOGY

The costs discussed in this section provide the inputs for the employment impact factor analysis. In general, economic impacts are a measure of an investment or policy's stimulus (or footprint) on a local economy. They are composed of direct, indirect and induced impacts, described below:

- **Direct impacts** include contractors and workers during the construction period or that operate and maintain the generating facilities while they are up and running. Synapse first estimated the materials versus labor spending for each resource. The amount of labor spending for each resource divided by the associated industry wages in Washington results in the number of direct jobs.
- **Indirect impacts** include jobs associated with materials to support construction, operations and maintenance (e.g. wind farms purchase turbines from manufacturers). The extent to which these materials are produced in-state (e.g. the portion of wind turbines that are manufactured in Washington) is an important determinant of indirect impacts. Synapse relied on the IMPLAN model's estimates for the portion of each industry's demand that is met by in-state suppliers. Synapse has also improved on the standard IMPLAN assumptions for the electricity industry by using NREL's JEDI (Jobs and Economic Development Impacts model) to develop customized spending patterns for each technology.
- **Induced impacts** include jobs for goods and services that serve households. These occur when workers from both the direct and indirect activities re-spend their wages, further stimulating the local economy. This analysis does not include the re-spending of energy savings by energy efficiency participants.

The direct job impacts are estimated based on the share of spending on labor for each resource. The share that is dedicated to labor is then divided by the average wage for that sector to estimate the direct jobs. Table 6 shows the wage assumptions used for each resource. The O&M wages are the U.S. average taken from NREL's JEDI models for each resource type. These wages were then adjusted to be Washington-specific by taking the average wage in the IMPLAN "electric power generation, transmission, and distribution" industry from Washington relative to the U.S. and applying that factor to the individual salaries from NREL's JEDI models.[27] Construction wages were based on the "construction of other new nonresidential structures" IMPLAN industry in Washington and were not differentiated by resource. Labor spending is run through the IMPLAN model using the "labor income" vector which captures how income is typically re-spent—this produces "induced" impacts.[28]

[27] According to the 2011 IMPLAN model, the average wage in the Washington electric power generation, transmission, and distribution industry is 89% of the U.S average wage.
[28] These wages are an industry-wide average so represent a mix of union and non-union labor.

Table 6 – Worker Wage Assumptions for Direct Jobs by Resource

Generation Type	O&M	Construction
Natural Gas CC	$62,000	$62,000
Solar PV	$67,000	$62,000
Wind Land	$58,000	$62,000
Energy Efficiency	N/A	$62,000

Source: Synapse, NREL JEDI Model, and IMPLAN

Indirect impacts are generated by the spending on materials for construction and O&M that are produced in-state. This spending is allocated based on the composition of supplies needed by each resource type as developed by Synapse using the JEDI model and IMPLAN. The vector of materials spending is run through the IMPLAN model for each resource, generating "indirect" impacts for suppliers of the materials and their suppliers, etc.

The IMPLAN modeling for both labor and materials results in job impacts per amount of investment for each energy resource in Washington—shown in Tables 7 and 8. These include the direct, indirect, and induced jobs per million spent on construction, efficiency installations, O&M and fuel. In general, the more labor-intensive activities will provide the most jobs per investment dollar spent—particularly for solar PV and EE installations which consist mostly of small projects. Solar PV and wind O&M both have notably higher jobs per dollar spent compared to coal and natural gas since a higher share of O&M spending is dedicated to labor--22% for wind and 55% for solar PV compared to 6% for coal and 1% for natural gas. This is due, in part, to the fact that much of fossil fuel generation spending consists of fuel that is produced out-of-state rather than on materials and labor provided in-state.

Table 7 – Construction and Installation - Direct, Indirect and Induced Job Impacts per Million Dollars in Spending

Generation Type	Direct	Indirect & Induced	Total Construction/ Installation Impacts
Natural Gas CC	1.8	5.3	**7.1**
Solar PV	0.8	4.1	**4.9**
Wind Land	1.1	2.6	**3.7**
Energy Efficiency	5.6	3.2	**8.8**

Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

Table 8 – Operations and Maintenance - Direct, Indirect and Induced Job Impacts per Million Dollars in Spending

Generation Type	Direct	Indirect & Induced	Total O&M Impacts
Natural Gas CC	0.2	1.4	**1.6**
Solar PV	9.5	7.0	**16.5**
Wind Land	3.3	3.2	**6.5**
Energy Efficiency	4.1	5.5	**9.6**

Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

The spending per average megawatt is derived from the costs of generation and capacity factors (presented in Table 3) and the estimated total investment cost of energy efficiency in Washington (presented in Table 5). The spending per aMW for construction and efficiency installation was estimated by dividing the total cost by first year generation or efficiency savings, respectively. Wind is the cheapest generation resource to operate per aMW. Energy efficiency installation costs per aMW of annual savings are close to that of natural gas CC and wind for annual generation; however, unlike generation, efficiency resources have very little O&M costs. The administrative and marketing activities associated with efficiency were taken form part of the installation costs and spread over a 20-year period.

Table 9 – Capital and O&M/Fuel Spending per Annual Generation/Savings per Average Megawatt

Generation Type	Construction/ EE Installation	O&M and Fuel
Natural Gas CC	$2.27	$0.31
Solar PV (com/res)	$35.10	$0.35
Solar PV (utility)	$16.85	$0.19
Wind Land	$4.57	$0.17
Energy Efficiency	$3.78	$0.02

Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

Finally, Tables 10 and 11 show the job impacts per average megawatt, which were calculated by multiplying the results from Tables 7 and 8 with factors in Table 9. This measure offers a better comparison between resources than jobs per megawatt since it accounts for how often each resource operates (on average) throughout the year.

Table 10 shows the impact from short-term activities of building new generating capacity and installing energy efficiency measures. Solar photovoltaic (PV) has the largest impact per aMW by far with 173 job-years for commercial and residential projects and 83 job-years for utility-scale projects—the latter is smaller due to economies of scale when installing large projects. The large impacts from solar PV come as a result of the labor-intensity of these installations. The utility-scale solar projects were assumed to be located in eastern Washington which has better solar resource than in the western part of the state. Energy efficiency installation--another labor-intensive activity--generates the next highest factor with an estimated 32 total job-years per aMW saved. Wind construction generates slightly more activity than natural gas—17 job-years per aMW compared to 16, respectively.

Table 11 shows the job impacts per average megawatt for O&M and fuel. These represent the impact from long-term activities needed to run generating facilities each year. Again, solar PV has the largest impact of any resource with 5.8 jobs per aMW for residential and commercial projects and 3.2 jobs per aMW for utility-scale projects. Wind generation generates more O&M activity than natural gas in the state—1.1 to 0.5 jobs per aMW, respectively. Wind power involves more labor-intensive O&M activities and, unlike natural gas, requires no fuel spending (which would mostly leave the state).

Table 10 – Construction and Installation - Direct, Indirect and Induced Job Impacts per Average Megawatt

Generation Type	Direct	Indirect & Induced	Total Construction/ Installation Impacts
Natural Gas CC	4	12	**16**
Solar PV (com/res)	28	145	**173**
Solar PV (utility)	14	70	**83**
Wind Land	5	12	**17**
Energy Efficiency	24	8	**32**

Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers. Coal construction impacts were excluded since there are no new coal plants proposed in Washington.

Table 11 – Operations and Maintenance - Direct, Indirect and Induced Job Impacts per Average Megawatt

Generation Type	Direct	Indirect & Induced	Total O&M Impacts
Natural Gas CC	0.1	0.4	**0.5**
Solar PV (com/res)	3.3	2.5	**5.8**
Solar PV (utility)	1.8	1.4	**3.2**
Wind Land	0.6	0.5	**1.1**
Energy Efficiency	0.1	0.1	**0.2**

Source: Synapse and NREL JEDI Model (industry spending patterns), IMPLAN (industry multipliers)

5. CONCLUSION

Investment in new natural gas, wind, solar, or EE will result in net new jobs in Washington. However, new solar PV, wind and EE create more jobs than natural gas generation per unit of energy used in the state, on average. The annual average job impacts per aMW over a 20-year period, when combining construction and O&M activities, show that small and large-scale solar PV have the largest impact of the energy resources. The difference in impacts between small and large-scale PV installations is largely due to economies of scale—less labor is required and panels are cheaper for large-scale projects, per aMW. Wind generation and energy efficiency installations create impacts of 1.9 and 1.8 average annual jobs per aMW, respectively. Natural gas generation creates 1.3 average annual jobs per aMW.

A state energy portfolio should not be based on these results alone--solar PV creates the most jobs per aMW but cannot fully replace lost generation from coal on its own. However, this analysis can be used to estimate the job impacts the state could expect from a cleaner energy portfolio once one is chosen. Washington State has already made considerable progress in developing energy efficiency and renewable energy (especially hydropower and wind). This study shows that expanding clean energy activity further in the state will bear significant fruit in the form of new job activity.