# Employment Effects of Clean Energy Investments in Montana

## Prepared for Montana Environmental Information Center and Sierra Club

June 5, 2014

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# 1. INTRODUCTION AND SUMMARY OF RESULTS

Montana is poised to transition further to cleaner electricity resources to both serve its residents and other states that have increasing renewable energy requirements. The state has ample potential for growth in clean energy production and already exports about half of its generation—mostly to western states.[1] One important factor to consider in this transition is the job impacts of clean energy investments. This report presents an analysis of the employment impacts associated with the construction, operation, and maintenance of four resources likely to play a role in Montana's clean energy future: large-scale wind, large-scale solar photovoltaic (PV), small-scale solar PV (e.g. rooftop), and energy efficiency (EE). It focuses on clean energy resources; therefore we do not evaluate coal or natural gas generation.

In order to provide an apples-to-apples comparison across resources, employment impacts are measured in terms of jobs created per "average megawatt" (aMW)[2] of energy produced over the next 20 years—using Montana information, where available. This report also discusses the significant renewable energy and energy efficiency potential in Montana; however, it does not make any determination of or recommendation for the size of investments or capacity targets for these resources in the state. Our analysis does not measure the impacts of resource investments on electricity rates and also does not account for the decrease in energy bills that would accrue to energy efficiency participants, or the impacts of the related re-spending of that savings in the state's economy.[3]

First, the job impacts associated with construction and installation of the various resources—measured in "job-years," or the equivalent of one job per year—per aMW are displayed in Figure 1. These results represent the impact from short-term activities of installing new solar, wind, and EE in the near future (2016-2017). Initial construction and installation typically creates more jobs than ongoing operations and maintenance because of the upfront equipment and labor involved. Solar PV generates the largest job impact per aMW, by far, with 136 job-years for small-scale projects (i.e., commercial and residential) and 69 job-years for large-scale projects (i.e., utility); this difference is largely due to economies of scale. The large impacts from solar PV result from the labor-intensity of these installations—especially for small projects. EE installation, another labor-intensive activity, generates the next highest factor with an

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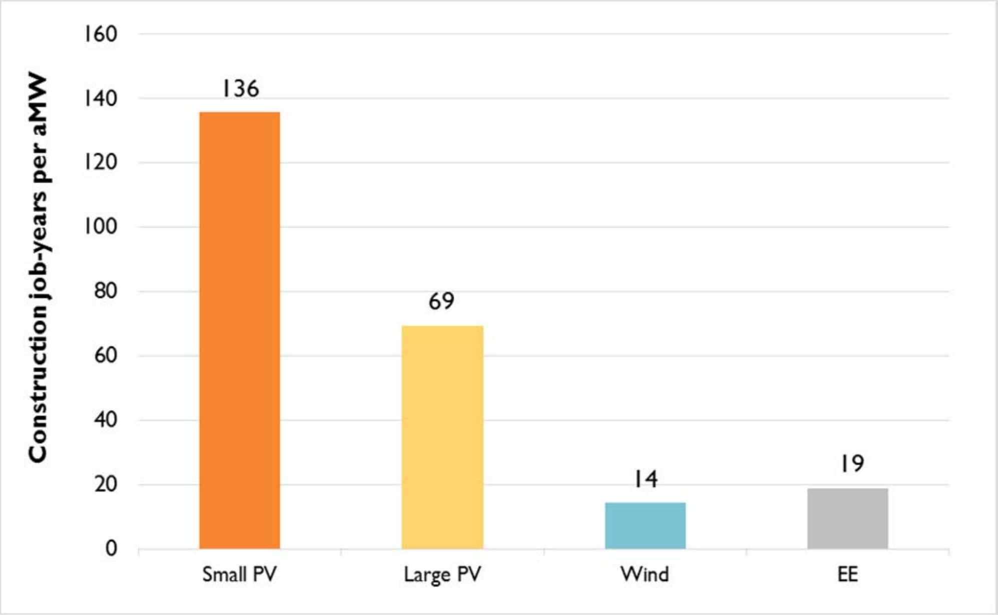
[1] Energy Information Administration: State Profile and Energy Estimates. Available here: http://www.eia.gov/state/analysis.cfm?sid=MT

[2] 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).

[3] Previous work by Synapse has shown that opposition to renewable portfolio standards often overstates the rate impacts from these policies. See 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

estimated 19 total job-years per aMW saved.[4] Wind construction generates the least with 14 job-years per aMW.

**Figure 1: Construction and Installation Job-Years per Average Megawatt**



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

Second, the job impacts associated with annual operations and maintenance (O&M) of the various resources—measured in jobs per aMW are displayed in Figure 2. These job impacts are assumed to last for the lifetime of a resource. Similar to the construction jobs produced by each resource, solar projects create the most jobs with 2.4 and 1.5 jobs per aMW for small- and large-scale projects, respectively. Wind generation creates 0.7 jobs per aMW, and EE creates 0.2 jobs per aMW; this is largely due to more maintenance activity being required for solar and wind projects.

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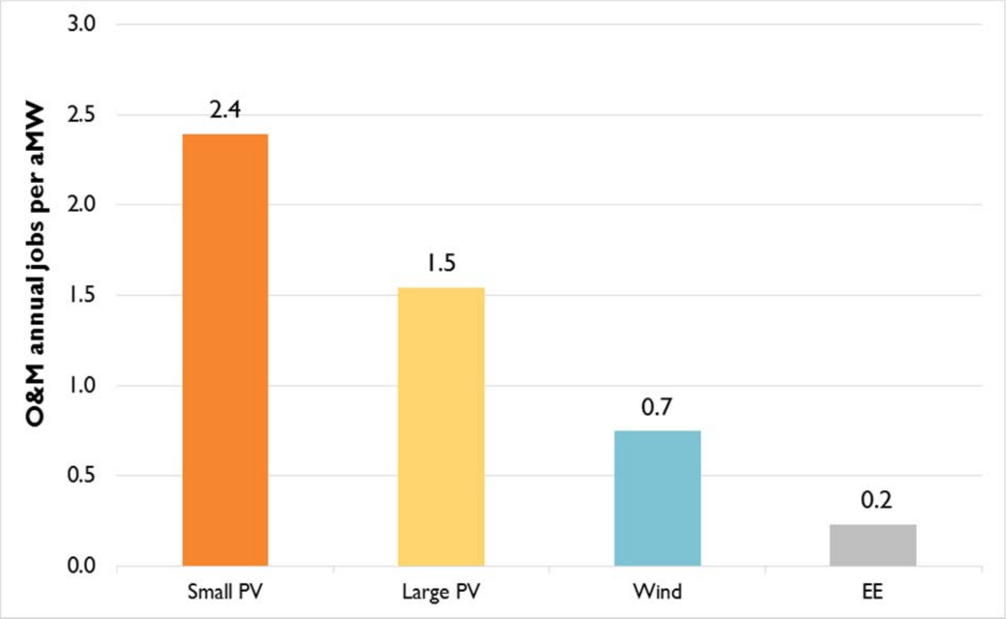
[4] All resources are assumed to have a 20-year measure life. Most efficiency measures have useful lives that are shorter than 20 years; therefore the impacts for efficiency are likely understated.

**Figure 2: Annual Operations and Maintenance Jobs per Average Megawatt**



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

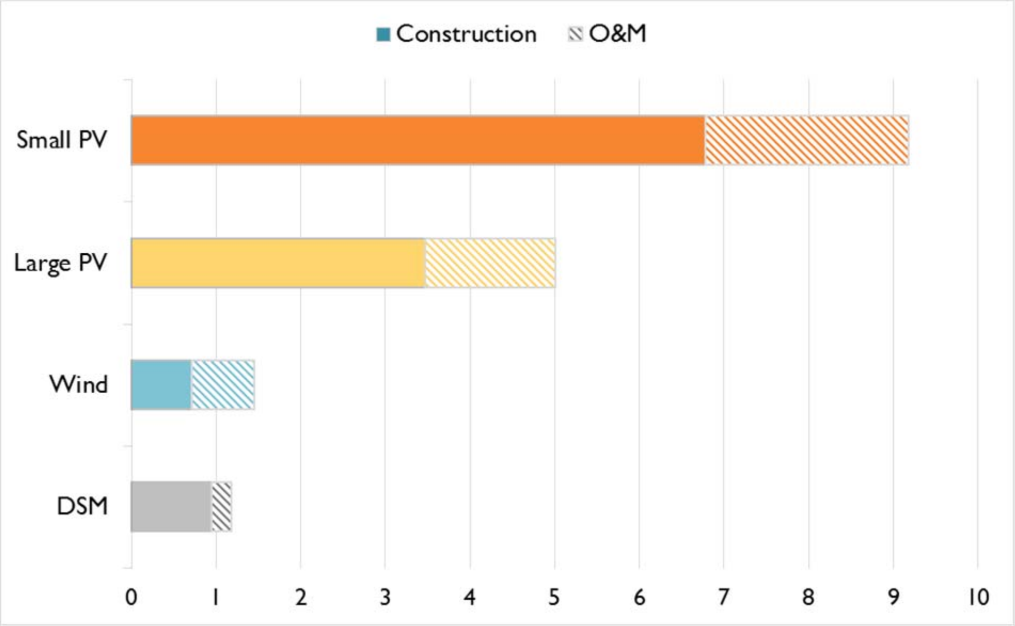
Finally, the job impacts for construction (Figure 1) and O&M (Figure 2) are combined into one cumulative employment impact per aMW by resource. This was done by dividing the construction jobs over a 20-year period (the assumed operating life of each resource) and adding the O&M jobs, which are assumed to persist for each year that the resource is available. Therefore, Table 1 and Figure 3 provide a "start to finish" measure of the 20-year annual average jobs created by resource per aMW. Small solar PV generates the most jobs with 9.2 jobs per aMW each year (on average). Large PV generates less, mostly due to economies of scale, with 5 jobs per aMW each year. Wind and EE generate 1.5 and 1.2 jobs per aMW each year, respectively.

**Table 1: Average Annual Job Impacts by Resource per aMW (20-year period)**

| Jobs/aMW | Construction | O&M | Total |
|---|---|---|---|
| Small PV | 6.8 | 2.4 | **9.2** |
| Large PV | 3.5 | 1.5 | **5.0** |
| Wind | 0.7 | 0.7 | **1.5** |
| EE | 0.9 | 0.2 | **1.2** |

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

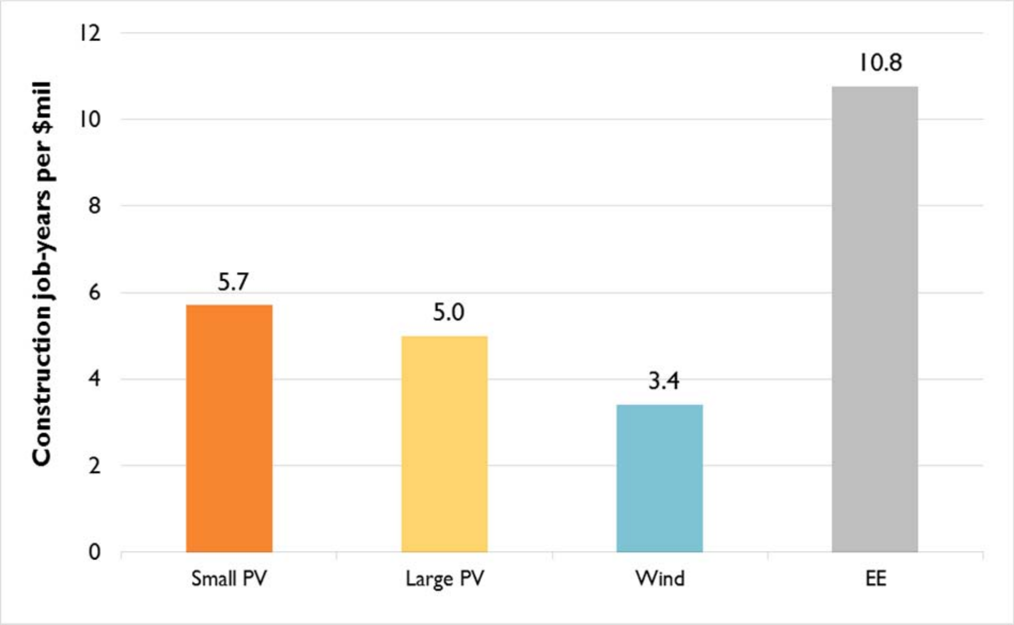
**Figure 3: Average Annual Job Impacts by Resource per aMW (20-year period)**



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

The job impacts presented above are calculated from both cost estimates of procuring each resource and the job activity generated by this spending. Looking solely at jobs per dollar spent (as opposed to per aMW) paints a different picture and should also be given weight. The job impacts in construction, shown in Figure 4, show that EE clearly creates the most jobs per dollar with nearly 11 job-years per million spent.

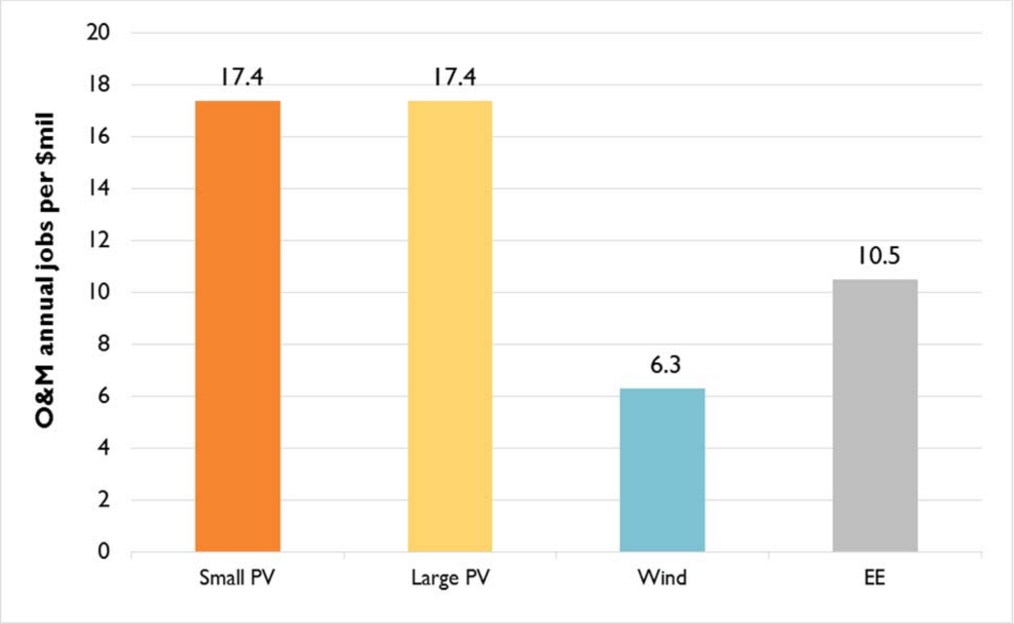
**Figure 4: Construction and Installation Job-Years per Million Dollars in Spending**



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

The O&M impacts per dollar spent, displayed in Figure 5, show that solar PV is the highest job-creator for this activity with 17 jobs per million. This is due to a higher mix of spending on labor than supplies—as opposed to installation costs which mostly go to hardware.

**Figure 5: Operations and Maintenance Jobs per Million Dollars in Spending**



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

# 2. EXISTING AND POTENTIAL GENERATION AND ENERGY EFFICIENCY

## 2.1. Generation

Montana is a net exporter of electricity, sending about half of all generation out-of-state. Currently, four-fifths of electric generation capacity in Montana is split almost evenly between hydropower and coal, with wind and gas accounting for the bulk of the remaining 20% of statewide capacity, as seen in Figure 6. Hydropower facilities in Montana range in size from less than 5 MW to greater than 500 MW for a total winter capacity of nearly 2,800 MW, placing the state 11th in the country in installed hydro capacity.[5] Northwestern Energy is the largest utility in the state, representing almost 60% of Montana's retail electricity sales. However, the largest generator of electricity is PPL Montana which operates and, partially owns, Colstrip, the largest coal plant in the state. This plant has a winter capacity of 2,094 MW, which is more than 85% of coal capacity in the state.[6] Much of the power generated from this plant is sent out-of-state.

Northwestern Energy is moving towards more self-generation and cleaner resources, announcing the proposed acquisition of large hydropower facilities from PPL Montana that (along with its existing generation) would cover 63% of customer needs with owned resources.[7] Meanwhile, installed wind capacity jumped significantly in recent years, with nearly 500 MW of additions from 2008 through 2012.[8] This increased investment in renewables was partially spurred by the Montana Renewable Power Production and Rural Economic Development Act of 2005, which established a renewable portfolio standard that requires utilities to procure 15% of sales from renewable resources by 2015. Utilities will also have to procure more renewable generation in the coming years, beyond 2015 assuming there is load growth.[9]

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[5] We report in terms of winter capacity since Montana is typically a winter-peaking system.

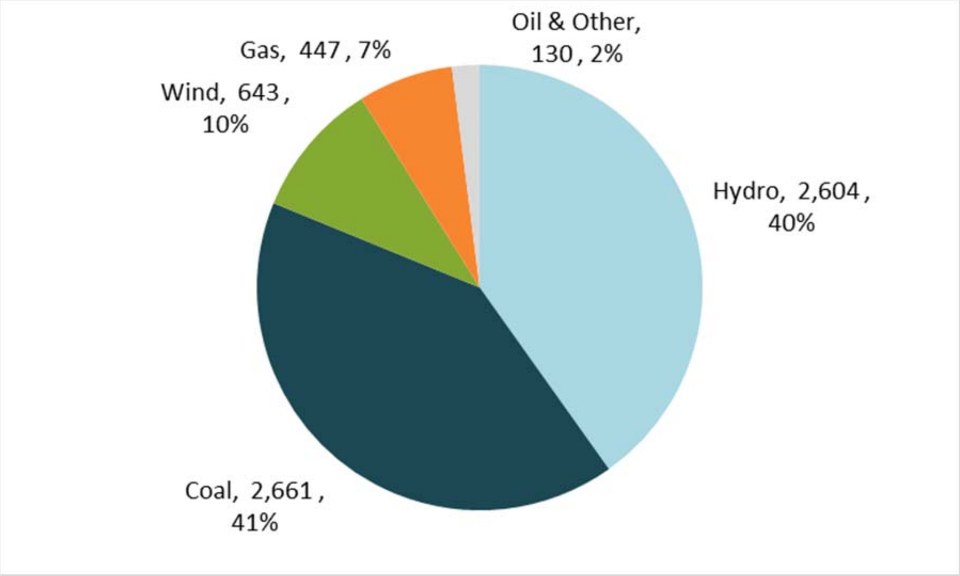
[6] See Northwestern Energy Operations: http://www.northwesternenergy.com/our-company/about-us/operations

[7] Northwestern Energy (2013) "Electricity Supply Resource Procurement Plan."

[8] This push coincides with the original schedule for the sunset of the federal wind production tax credit, which was renewed for 2013.

[9] Montana Statute MCA 69-3-2004. Available at: http://leg.mt.gov/bills/mca/69/3/69-3-2004.htm

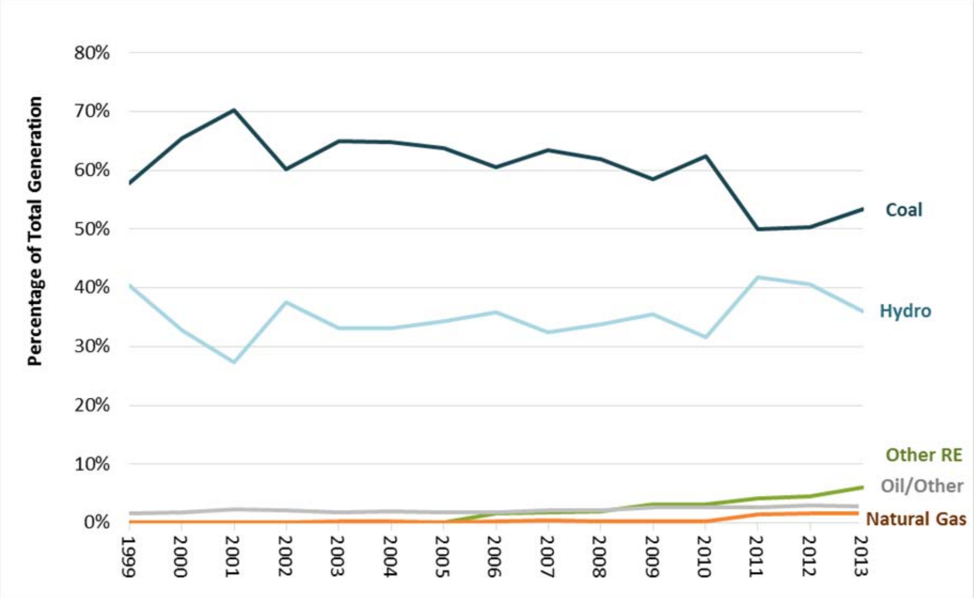
**Figure 6: 2012 Winter Capacity in Montana by Resource, MW**



*Source: EIA form 860, released October 10, 2013. Available at: http://www.eia.gov/electricity/data/eia860/.*

Although Montana's energy portfolio appears diverse from a capacity perspective, historical generation data for the state paints a different picture. In fact, as seen in Figure 7, coal has historically provided over 60% of statewide generation, only dropping recently as a result of two years of strong hydroelectric output and an increasing contribution from wind. As the rest of the nation has seen coal displaced by natural gas generation in the last few years, Montana has only experienced marginal increases in natural gas generation.

**Figure 7: Montana Generation by Fuel, as % of State Generation**

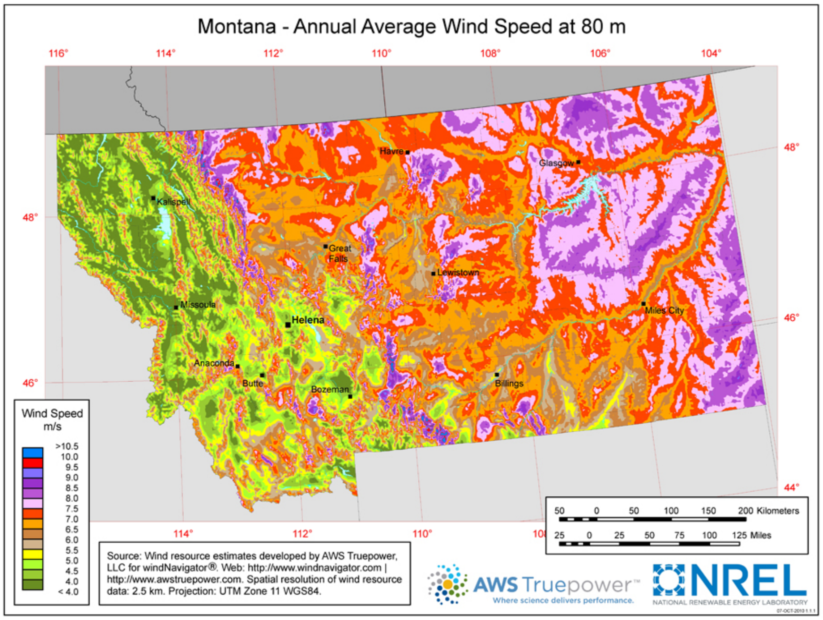


*Source: EIA form 923, released April 28, 2014. Available at: http://www.eia.gov/electricity/data/eia923/. "Other RE" is mostly wind generation.*

## Renewable Energy Potential in Montana

Multiple studies have estimated significant potential for renewable resources in Montana. For instance, a recent National Renewable Energy Laboratory (NREL) study arrived at a similar conclusion, employing GIS software to demonstrate the extensive wind resources available in the state. A map of average wind speed by location produced by the study is included below as Figure 8, supporting the conclusion that the state has 944 gigawatts (GW) of technical wind potential.[10] Montana's annual peak load is approximately 3 GW but it is third in the nation in wind potential behind only Texas and Kansas.[11] A major bottleneck for wind development in Montana has been transmission access. However, several transmission projects going west (Washington) and north (Alberta) are in the works or completed.[12] Additionally, although Montana does not currently have any utility-scale solar installations,[13] the 2012 NREL study estimates that the state has 4,409 GW of utility-scale and 2 GW of rooftop solar PV potential.[14] Both NREL wind and solar figures are much higher than what would actually occur in Montana but illustrate the vast potential in the state.

**Figure 8: Average Wind Speed at 80 Meter Hub Height in Montana, from NREL**



Source: Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. Web: http://www.windnavigator.com | http://www.awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 11 WGS84.

*Source: NREL "Wind Powering America."*

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[10] Lopez, A. et al. (2012) "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis" *National Renewable Energy Laboratory*.

[11] This calculation is based on an extrapolation of the 2012 Montana peak reported by Northwestern Energy (1784 MW).

[12] Montana-Alberta line is described here: http://www.marketwired.com/press-release/enbridge-undertake-300-million-montana-alberta-tie-line-power-transmission-project-tsx-enb-1550149.htm

Montana-Washington upgrade is described here: http://efw.bpa.gov/environmental_services/Document_Library/M2W/

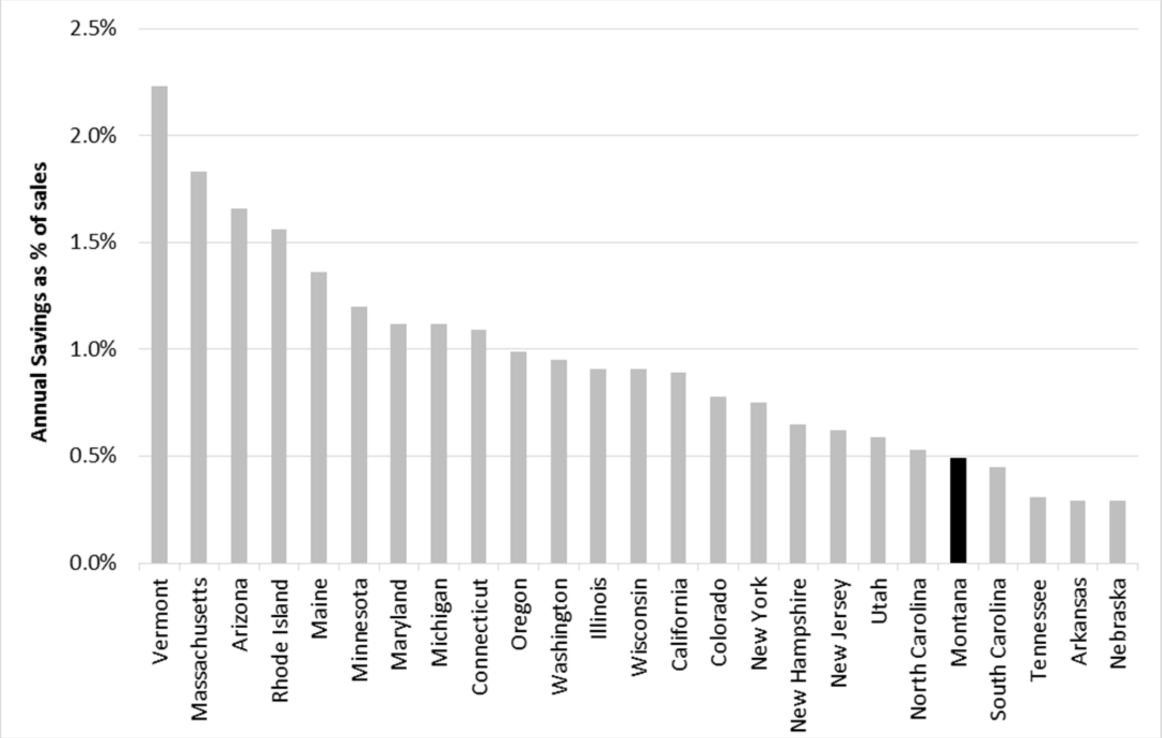
[13] Dutzik, T. and R. Sargent (2013) "Lighting the Way: What We Can Learn from America's Top 12 Solar States" *Environment America*.

[14] Lopez, A. et al. (2012).

## 2.2. Energy Efficiency

According to the American Council for an Energy-Efficient Economy's (ACEEE) 2013 State Energy Efficiency Scorecard, Montana's existing energy efficiency portfolio ranks 29th among all states. The ranking, which is based on ratepayer funded efficiency programs and policies, transportation policies, building energy codes, state government initiatives, and appliance efficiency standards, demonstrates that Montana's efficiency performance is just below the national average. Shown in Figure 9, the state's incremental energy savings was 0.5% percent of its retail sales in 2012, placing it 21st in the U.S.

**Figure 9: Incremental Energy Savings as Percent of Retail Sales in 2012 for Top 25 States**



*Source: ACEEE 2013 State Energy Efficiency Scorecard.*

According to the Northwest Power and Conservation Council (NWPCC), the regional savings through 2010 was more than enough to power all of Idaho and Western Montana: 4,500 aMWs saved or a decrease of 19% in regional electricity sales in 2010, relative to a baseline.[15] Despite all of the efficiency achievements to date, the Northwest—and in particular the state of Montana—still have plenty of untapped EE potential. The NWPCC recently estimated EE potential in the region could equal nearly 23% of projected regional sales in 2030; unlocking this potential would result in significant investment and

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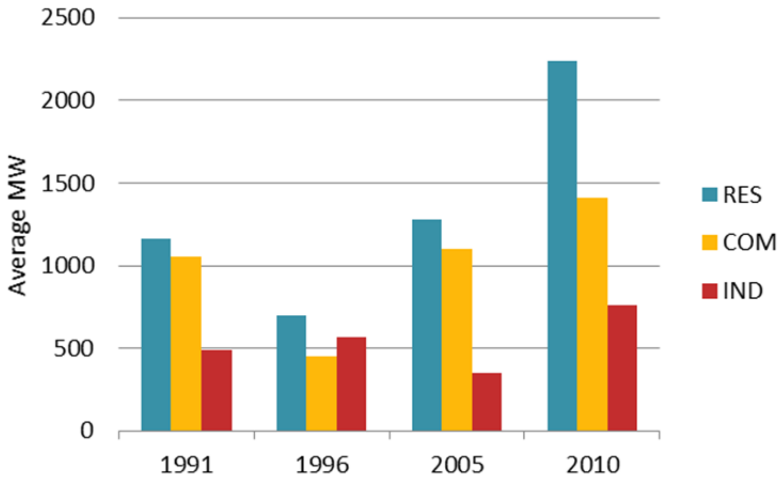
[15] NWPCC, 2010. Sixth Northwest Conservation and Electric Power Plan. February 1, 2010. Available here: http://www.nwcouncil.org/energy/powerplan/6/plan/

job creation in Montana. While 23% of projected regional sales is certainly substantial, it should not be viewed as the upper limit for achievable potential. Technologies are likely to continue evolving in the future, as demonstrated by past experience. Figure 10 shows that NWPCC's EE potential estimates have generally increased over time, instead of diminishing, despite the fact that the region has tapped into substantial efficiency potential over the past two decades.

**Figure 10: Comparison of Historical Energy Efficiency Potential Estimates by NWPCC (aMW)**



*Source: NWPCC 2010 and Gordon et al 2008. "Beyond Supply Curves." Proceedings of 2008 ACEEE Summer Study on Energy Efficiency in Buildings, August 17, 2008. "Res"=Residential, "Com"=Commercial, and "Ind"=Industrial.*

# 3. COST ASSUMPTIONS

For this report, Synapse developed Montana-specific estimates of the current capital and ongoing costs of large-scale wind, small- and large-scale solar PV, and a range of EE programs. These cost estimates were then applied to the "jobs per million dollars of spending" figures produced by IMPLAN. An economic input-output model, IMPLAN is able to estimate the direct, indirect (i.e., suppliers), and induced (i.e., worker re-spending) impacts of spending on construction (or installation) and operation of different electricity resources within the state of Montana. These concepts are explained in further detail in the next section. Below we provide current Montana-specific estimates of the cost of construction for new wind and solar facilities, the cost of EE installations, and forward-going fixed operations and maintenance (O&M) costs for each resource. We relied on data from Northwestern Energy since the utility had readily available data and represents a majority of Montana's ratepayers.

## 3.1. Renewable Energy Costs

Assumptions of capital, O&M costs, and capacity factor for energy resources are presented in Table 2. These costs are assumed to take place in the near future (2016-2017).

### Wind

Synapse developed assumptions for wind energy based on the inputs for NREL's 2014 *Wind Vision* study. To develop these inputs, NREL relied on its database of wind energy project costs and contract prices and on input from a wide range of wind industry participants and experts. Recent projects in Montana have carried a capacity factor of 40% but we have reason to assume that they will be slightly higher in the near future (42%). Specifically, our assumptions are based on an IEC class II turbine, with a rotor diameter of 80 meters and a hub height between 65 and 80 meters.

### Solar Photovoltaic (PV)

Solar PV capital and operating costs are based on PV module price data, publicly available data on system costs, confidential data Synapse accesses through state utility proceedings, and discussions with project developers and other experts. It is important to note that PV costs have been falling rapidly in recent years, and forecasts of future costs are uncertain. These assumptions should be updated as new information becomes available.[16] The capacity factors for PV projects were derived by assessing projects in Helena with NREL's PV Watts tool.[17]

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[16] Because there is currently little interest in large utility-scale PV projects in Montana, our utility-scale cost assumption reflects a smaller ground-mounted project (e.g., 1 to 10 MW). The installed cost of larger projects is likely to be lower than in 2016-17. The capacity factors are calculated using the DC capacity rating and the amount of AC energy produced.

[17] Available here: http://www.nrel.gov/rredc/pvwatts/

**Table 2: Synapse Capital, Fixed Operations and Maintenance, and Capacity Factor Assumptions**

| | Construction | Fixed O&M | Capacity Factor |
|---|---|---|---|
| | $/kW | $/kW-yr | % |
| Small PV | 3,450 | 20 | 14.5% |
| Large PV | 2,500 | 16 | 18% |
| Wind | 1,750 | 50 | 42% |

*Source: NREL PV Watts, NREL Wind Vision, Synapse.*

## 3.2. Energy Efficiency Installation Costs

Synapse developed cost estimates for energy efficiency in Montana based on a review of current programs offered by state utilities and on previous research of efficiency spending in other states. Typically, EE program spending is reported at a sector or program level as well as for specific administrative tasks such as planning, marketing, and evaluation, measurement and verification (EM&V). Because this data was not available for Montana, Synapse relied on data from utilities in Minnesota and Massachusetts that offered data relevance, availability, existence of large energy savings, high program spending, and cold 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.[18] In order to generate Montana-specific assumptions, Synapse performed the following additional steps:

1) We developed annual energy efficiency program savings and spending estimates by sector (residential, commercial, and industrial) based on recent historical program data for Northwestern Energy as reported to the Regional Technical Forum.[19]

2) We estimated program costs for the state based on Xcel Minnesota program spending patterns including: delivery cost, rebates, administration, and marketing.

3) We allocated  a mix of this program spending across types of materials and services based on end-use data from Xcel Minnesota (e.g., lighting bulbs, appliances, and HVAC equipment).

4) We then adjusted this mix of program spending based on Montana's efficiency measures.

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[18] 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.

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

A summary of the costs of materials and the program administrative costs for efficiency measures is presented in Table 3 with each relevant IMPLAN industry. These costs accounted for 70% of the total energy efficiency investment spending. The rest of the spending was treated as labor income, which represents payments to contractors to install the efficiency measures.

**Table 3: Montana Energy Efficiency Non-Labor Coefficient Vectors**

| IMPLAN commodity | | Share (%) |
|---|---|---|
| 3104 | Wood pulp | 1.6% |
| 3216 | Air conditioning, refrigeration, and warm air heating equipment | 14.8% |
| 3234 | Electronic computers | 0.3% |
| 3259 | Electric lamp bulbs and parts | 23.2% |
| 3261 | Small electrical appliances | 0.5% |
| 3263 | Household refrigerators and home freezers | 0.5% |
| 3265 | Other major household appliances | 0.4% |
| 3416 | Electronic and precision equipment repairs and maintenance | 2.0% |
| 3417 | Commercial and industrial machinery and equipment repairs and maintenance | 3.0% |
| 3230 | Other general purpose machinery | 8.6% |
| 3031 | Electricity, and distribution services | 5.5% |
| 3377 | Advertising and related services | 9.2% |
| **Total Materials** | | **70%** |
| **Total Labor** | | **30%** |

*Source: Synapse and IMPLAN.*

Finally, our review of the recent program savings and estimates of program spending by Northwestern Energy found that the average program cost is $0.25 per first year kWh saved—shown in Table 4. Based on our analysis of estimated program and measure costs for Montana, we estimated that the program costs account for 66% of the total energy efficiency investment—the rest of the spending is paid out-of-pocket by participants. Applying this factor to the $0.25 per kWh program cost, we estimated the total efficiency investment cost for Montana to be $0.38 per first year kWh saved.

**Table 4: Annual Average Program Spending, Savings, and Cost of Saved Energy for NorthWestern Energy**

| Sector | Program Annual Average Spending | Savings (kWh) | $ per first year kWh saved |
|---|---|---|---|
| Residential | $4,920,451 | 24,019,677 | $0.20 |
| Low-Income Weatherization | $1,838,419 | 400,551 | $4.59 |
| Commercial | $6,795,037 | 33,486,701 | $0.20 |
| Agriculture/Irrigation | $306,409 | 1,418,837 | $0.22 |
| Other | $2,167,228 | 1,075,869 | $2.01 |
| NEEA | $1,453,559 | 10,333,601 | $0.14 |
| **Total Program Costs** | $17,481,101 | 70,735,235 | **$0.25** |
| **Total Investment Costs** | | | **$0.38** |

*Source: Regional Technical Forum 2014. "2012 Utility Conservation Achievements Report"; Synapse estimate of $ per kWh saved based on savings and spending from 2012 and 2013.*

# 4. EMPLOYMENT IMPACT METHODOLOGY AND RESULTS

IMPLAN, a standard economic input-output model utilized in this study, estimates the indirect and induced impacts (also known as spin-off or multiplier impacts) from spending on a given industry for a customized region, and provides detailed industry data for that region (such as jobs, income and output). The input-output aspect of the model estimates how much a given industry relies on supplies from other industries for its output. However, the model represents all types of electricity generation as a single industry, which we know to be an inaccurate representation of reality: operating a coal plant is far different than running a wind farm. As such, Synapse partially relies on the electric resource-specific spending patterns produced for NREL's JEDI model to develop our own spending patterns for each energy resource.[20] Therefore, in this study, we employed our own spending patterns on construction and O&M for each type of energy resource, and used the relationships between those industries in the IMPLAN model to estimate the indirect and induced impacts of each resource.

The direct, indirect, and induced impacts that initially come out of this process are in terms of jobs per million dollars of spending on construction and O&M for each resource. We then translated the impacts to jobs per aMW by developing factors of millions of dollars spent per aMW based on each resource's and operating characteristics. The following describes this process in further detail.

## 4.1. Job Impact Assumptions and Inputs

### Direct Impacts

Direct impacts are comprised of jobs for contractors, construction workers, and plant operators (among others) working on the building or operations of each energy resource. The development of direct job impacts relies primarily upon three main inputs: investment level (i.e., dollars spent), share of that investment spent on labor, and state- and industry-specific wages. For each resource, Synapse estimated the portion of the investment spent on materials versus labor based on data provided from NREL.[21] Additionally, Synapse used average annual wage assumptions for operations and maintenance jobs by adjusting the national average wages provided for each resource in NREL's JEDI model to be Montana-specific. Construction wage assumptions were taken from the "construction of other new nonresidential structures" industry that IMPLAN provides for Montana; these were not differentiated by

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[20] Given that costs of solar PV panels have dropped significantly recently, Synapse altered the spending assumptions for the solar PV vector from the JEDI model, creating both Small PV and Large PV resource vectors. Taking the data from NREL's recent review of PV module costs as a portion of the installed cost of solar, Synapse re-scaled all of the solar spending vectors from the JEDI model based on updated hardware cost percentages. For the Small PV spending assumptions, we averaged the percentages for residential and small commercial systems; for Large PV, we used spending for large commercial systems.

[21] An example of this breakdown of costs can be seen in Table 1 of Friedman et al. (2013).

resource. The final wage assumptions shown in Table 5 were used to calculate direct jobs by dividing the labor-specific portion of spending on each resource by the corresponding wage.[22]

Table 5: Worker Wage Assumptions by Resource ($2012)[23]

| Resource Type | O&M | Construction |
|---|---|---|
| Small PV | $55,000 | $47,000 |
| Large PV | $55,000 | $47,000 |
| Wind | $63,000 | $47,000 |
| EE | N/A | $47,000 |

*Source: Synapse, NREL JEDI Model, and IMPLAN.*

### Indirect Impacts

Indirect impacts are the activities needed to support the construction and operations jobs. For instance, an investment in a new wind farm not only creates jobs at the wind farm, but also down the supply chain, increasing jobs for turbine and other component manufacturers. Synapse adjusted the IMPLAN model's base resource spending allocation assumptions for the entire electric industry based on NREL data on requirements for each individual resource. Of course, the supplies for each resource are not entirely located within Montana. To capture this effect, Synapse used IMPLAN's estimates of the portion of each industry's demand that is met by in-state suppliers.

### Induced Impacts

Induced impacts result from employees in newly created direct and indirect jobs spending their paychecks locally on restaurants, auto-mechanics, and other consumer goods and services. Synapse estimated induced impacts by running a "labor income" spending vector through the IMPLAN model, capturing how income is typically re-spent. This labor income vector is not differentiated by resource or income level. Importantly, the induced jobs do not include the re-spending of energy bill savings by participants in energy efficiency programs.

## 4.2. Job Impact Results

Construction and O&M jobs are inherently different: construction jobs are assumed to be temporary jobs associated with the initial investment and installation of a given project, while O&M jobs are spread across the entire lifetime of a resource. The following sections present job impacts by several different metrics—jobs per million dollars of investment, which (along with investment per aMW) leads to the

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[22] Wages presented in Table 5 are an industry-wide average, and represent a mix of union and non-union labor.

[23] Dollar figures in this report are all in 2012 dollars.

estimation of jobs per aMW—and are accompanied by a description of the calculation steps used to arrive at the cumulative results.

### Construction Job Impacts

The results for construction job impacts, presented in Table 6, rely upon a few key inputs and assumptions within the IMPLAN model. As mentioned above, the direct and induced jobs are highly dependent on both average assumed worker wages and spending on labor versus materials. Indirect impacts are more dependent upon resource-specific supply spending and the extent to which those supplies are provided in Montana. As mentioned previously, EE is typically the cheapest resource to procure. It is also the clear winner in terms of job creation, at 10.8 job-years per million dollars spent.

**Table 6: Construction and Installation Impacts per Million Dollars in Spending**

| Job-Years/$mil | Direct | Indirect/Induced | Total Construction |
|---|---|---|---|
| Small PV | 1.1 | 4.6 | **5.7** |
| Large PV | 1.1 | 3.9 | **5.0** |
| Wind | 1.5 | 1.9 | **3.4** |
| EE | 7.5 | 3.2 | **10.8** |

*Source: Synapse, NREL JEDI Model, and IMPLAN.*

### Operation and Maintenance Job Impacts

The O&M impacts, displayed below in Table 7, rely on many of the same key inputs as the construction job impacts. One major difference, however, is that the spending allocation for the renewable resources no longer centers around hardware costs, such as PV modules and wind turbines. Further differences between construction and O&M job impacts are attributable to different wage assumptions and the split of labor versus material spending. Solar PV has the highest impact per dollar spent on O&M, largely because of the labor-intensity of that activity.

**Table 7: Operations and Maintenance Impacts per Million Dollars in Spending**

| Jobs/$mil | Direct | Indirect/Induced | Total O&M |
|---|---|---|---|
| Solar PV | 10.0 | 7.4 | **17.4** |
| Wind | 3.5 | 2.8 | **6.3** |
| EE | 5.5 | 5.0 | **10.5** |

*Note: Synapse, NREL JEDI Model, and IMPLAN.*

### Calculation of Jobs per Average Megawatt

Synapse converted the job impacts per million dollars (presented above) into estimates of average annual jobs per aMW. First, we calculated the cost per aMW based on the resource assumptions outlined in Section 3. These results are a product of construction and O&M costs per MW with assumed capacity factors[24]—shown in Table 8. EE is the cheapest to install and operate of any resource. The capital costs associated with wind development are significantly lower per aMW than those for solar resources, while the O&M costs are relatively comparable across all three renewable resources.

**Table 8: Capital and O&M Spending per Average Megawatt, $mil**

| $mil/aMW | Construction | O&M |
|---|---|---|
| Small PV | $23.79 | $0.14 |
| Large PV | $13.89 | $0.09 |
| Wind | $4.17 | $0.12 |
| EE | $1.76 | $0.04 |

*Source: Synapse, NREL JEDI Model, and IMPLAN. Although the cost per aMW for EE is $2.2MM, that is split 80-20 between construction and administrative costs. EE assumes a 10-year measure-life. Solar PV O&M costs include cleaning the panels and assumed inverter replacement before the end of the project life.*

The final jobs per aMW figures are simply a product of the jobs per million dollars results in Table 6 and Table 7, and the million dollars per aMW assumptions in Table 8. The construction impacts per aMW presented in Table 9 demonstrate that small-scale solar PV projects have the largest impact per aMW by far, creating 136 total job-years. Although small PV projects produce twice the job impacts per million dollars as wind projects, the results below are amplified by significantly higher spending required per aMW on solar projects than wind projects.

**Table 9: Construction and Installation Job Impacts in Job-Years per Average Megawatt**

| Job-Years/aMW | Direct | Indirect/Induced | Total Construction |
|---|---|---|---|
| Small PV | 26 | 110 | **136** |
| Large PV | 15 | 54 | **69** |
| Wind | 6 | 8 | **14** |
| EE | 13 | 6 | **19** |

*Source: Synapse, NREL JEDI Model, and IMPLAN.*

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[24] The megawatts (MW) multiplied by the annual capacity factor equals the average megawatts (aMW)—e.g., a 100 MW wind farm operating at a 40% annual capacity factor generates 40 aMW.

Operations and maintenance jobs per aMW, presented below in Table 10, paint a similar picture. In this case, however, the total ongoing O&M job impacts are lower across the board due to lower, and comparable, spending on O&M per aMW.

**Table 10: Operations and Maintenance Job Impacts in Annual Jobs per Average Megawatt**

| Jobs/aMW | Direct | Indirect/Induced | Total O&M |
|---|---|---|---|
| Small PV | 1.4 | 1.0 | **2.4** |
| Large PV | 0.9 | 0.7 | **1.5** |
| Wind | 0.4 | 0.3 | **0.7** |
| EE | 0.1 | 0.1 | **0.2** |

*Source: Synapse, NREL JEDI Model, and IMPLAN.*

Finally, in order to estimate the overall average annual job impact per aMW for each resource, Synapse dispersed the construction job-years over 20 years (in line with the assumed lifetime of resource additions) and added the long-term O&M annual jobs. Small solar PV generates the most jobs with 9.2 jobs per aMW each year (on average). Large PV generates less, mostly due to economies of scale, with 5 jobs per aMW each year. Wind and EE generate 1.5 and 1.2 jobs per aMW each year, respectively.

**Table 11: Average Annual Job Impacts per aMW (20-year period)**

| Jobs/aMW | Construction | O&M | Total |
|---|---|---|---|
| Small PV | 6.8 | 2.4 | **9.2** |
| Large PV | 3.5 | 1.5 | **5.0** |
| Wind | 0.7 | 0.7 | **1.5** |
| EE | 0.9 | 0.2 | **1.2** |

*Source: Synapse, NREL JEDI Model, and IMPLAN.*

# 5. CONCLUSION

Investment in wind, solar, and EE will create new jobs in Montana. 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 procured. 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 1.5 and 1.2 average annual jobs per aMW, respectively. However, efficiency generates the most jobs for every dollar invested at the installation stage with 11 job-years per million dollars.

A state energy portfolio should not be based on these results alone--solar PV creates the most jobs per aMW but should be complemented by other resources like wind and EE. However, this analysis can be used to estimate the job impacts the state could expect from a cleaner energy portfolio once one is chosen. Montana has already begun to transition to a cleaner resource mix but also has immense potential for more EE and renewable energy. Efficiency is the cheapest resource, a significant job-creator in terms of dollars spent and reduces generation required to serve in-state customers. Renewable energy is also an effective job creator and would provide myriad benefits to the state. Moreover, Montana could capitalize on its existing export position by fulfilling demand for renewable energy out-of-state, particularly as those requirements increase for western states. In sum, this study shows that expanding clean energy activity further in Montana will bear significant fruit in the form of new job creation.