

Renewable Energy in West Virginia: Research for 5-Year Energy Plan

DRAFT REPORT

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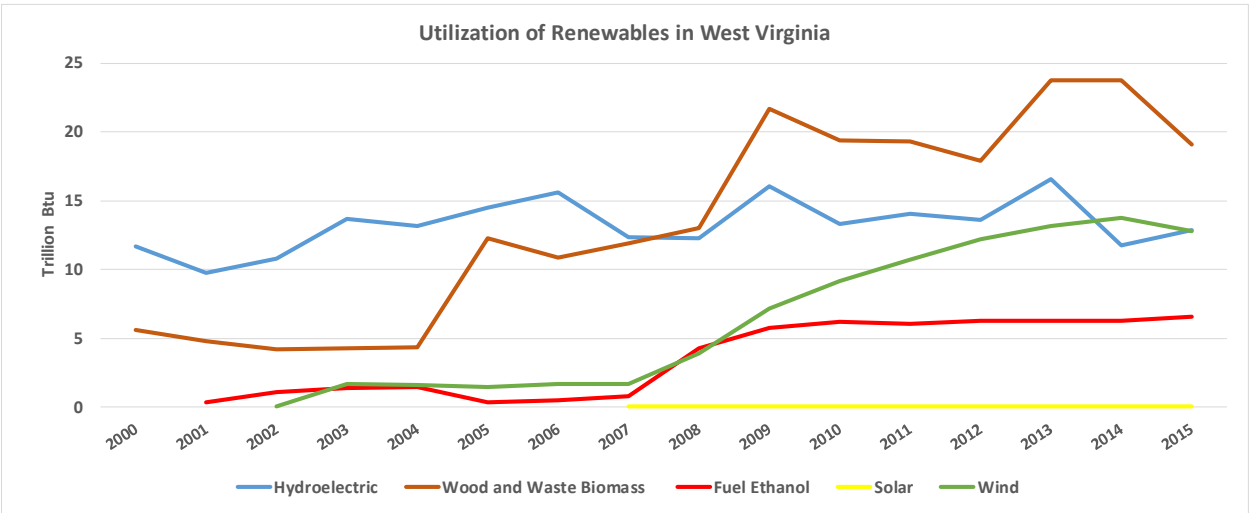
I. Introduction

Utilization of renewable energy in the State of West Virginia grew modestly between 2011 and 2016, led by growth in electricity generated from wind. Growth in solar generation, led by installation of medium-sized commercial PV arrays, also occurred but was outpaced by the large scale of commercial wind development. Efforts to add to the capacity of hydroelectric have continued with development projects on rivers in the northern part of the State.

Utilization of hydropower, wind and solar energy to produce electricity in West Virginia totaled 25.8 TBtu in 2015. When including consumption of wood biomass, the combined value of renewables utilized totaled 44.9 TBtu. This was almost six percent of total 2015 energy consumption of 774.9 TBtu. About 19.1 TBtu of this amount was in the form of wood biomass, with 15.6 TBtu being wood estimated by the U.S. Energy Information Administration (EIA) to have been consumed in the residential sector. West Virginia consumers used an additional 6.6 TBtu of renewables in the form of ethanol blended with gasoline (EIA, 2017).

West Virginia residents did not consume all the renewable energy produced in the State as most wind and hydroelectric output is sold to utilities in other states. West Virginia also does not produce any fuel ethanol, and imports that product in pre-blended gasoline. Production is shown below along with wood biomass and ethanol consumption to illustrate the scale of current utilization of various types of renewables. This data does not include the energy value of wood pellets produced in West Virginia but sold outside of the State.¹

Figure 1 Utilization of Renewable Resources in West Virginia



One of the more significant recent policy changes that has occurred in West Virginia is repeal of the West Virginia Alternative and Renewable Portfolio Standard. That rule was repealed in 2015 (WV Legislature, 2015) and would have required 10% of electricity supplied to consumers to be supplied from

¹ The energy value of wood pellet production was not tracked by the EIA prior to 2016.

renewable and alternatives sources by 2015. The impact of that repeal on development of the State's renewable resources is unknown, as the rule did not mandate use of in-state resources for compliance.

Since 2012, the West Virginia Legislature also allowed State income tax credits for solar PV installations and electric vehicles to expire. The impact of these policy changes has not been evaluated in terms of consumer response.

At the federal level, there have been several significant actions related to the production tax credit (PTC) and investment tax credit (ITC) available for development of commercial-scale renewable energy facilities. Both credits are still available but have phase-out periods. In addition, wind facilities are the only type of facility that qualifies to receive the PTC after 2016. Closed-loop biomass systems are no longer eligible for the ITC or the PTC.

Wind facilities commencing construction by December 31, 2019 qualify for the credits, but the value of the credit steps down in 2017, 2018 and 2019. Wind systems commencing construction in 2016 only receive \$0.0184 per kWh for first 10 years of operation rather than the \$0.023/kWh received before. The PTC amount is reduced by 40% in 2018 and by 60% in 2019 relative to \$0.023/kWh and will be totally phased out after 2019 (US DOE, 2016). Wind facilities electing to use the ITC instead of the PTC will reduce the credit by the same phase-down specified for the PTC.

Commercial-scale solar technologies are eligible to receive the ITC through 2022. The credit remains at 30 percent for projects started through 2019 and then declines to 10 percent in 2022 and thereafter (DSIRE USA, 2017). The 30 percent tax credit for residential solar systems was extended, but declines to 22 percent for systems placed in service in 2021 and currently is not available for installations made after 2021.

Another federal development was the classification of forest biomass as carbon-neutral in the latest U.S. Department of Energy (US DOE) budget. The budget includes the "Collins Amendment" which directs federal agencies to recognize biomass as carbon-neutral (E&E News, 2017). The Collins Amendment directs the U.S. Environmental Protection Agency (US EPA), U.S. Department of Agriculture (USDA), and U.S. DOE to harmonize their policies on woody biomass and to "establish clear and simple policies for the use of forest biomass as an energy solution, including policies that reflect the carbon-neutrality of forest bioenergy and recognize biomass as a renewable energy source." The amendment was originally proposed in 2016 and was co-sponsored by senators from the states of Maine, Minnesota, New Hampshire, Montana and Idaho (Environmental and Energy Study Institute, 2017).

II. Previous 5-Year Plan Goals and Actions Taken in Accordance with Recommendations

In 2012, the State of West Virginia established a series of recommendations directed toward promoting and expanding use of renewables. Since 2012, actions taken to further these goals have been varied.

A. Recommendations from 2012

Most of the previous recommendations apply to a specific resource, although recommendations regarding net metering and system integration apply to more than one type of resource.

1. Solar

- Maintain current income tax credit for PV installations.
- Monitor national solar integration activities, policies and research.
- Review the performance of photovoltaic systems installed at state and local government facilities.
- Monitor and update net metering policies as necessary.
- Provide support for community-based renewable energy activities.

2. Wind

- Maintain current state legislative policy for wind. The two existing state tax incentives for commercial wind development have allowed cost savings for developers while also assisting the development of wind resources in rural areas of West Virginia.
- Monitor national wind integration activities, policies and research.
- Given most of West Virginia wind projects are located on surface-mined lands, extend efforts to determine whether adequate wind resources exist to support commercial wind development on additional surface-mined sites.

3. Hydro

- Continue efforts with federal agencies and private companies to ensure that the current preliminarily licensed hydro projects are completed in a timely fashion.
- Regarding small-scale hydro power:
 - Determination should be made if there are public sites, such as recreational areas, which are not currently served by electrical connections for which development of mini- and micro- scale hydro is appropriate.
 - Current rules and regulations impacting small-scale hydro should be reviewed to determine which, if any, could be eliminated or modified for application specifically to small-scale hydro.
 - Similar tax incentives to those granted for direct-use solar and wind facilities should be considered for mini- and micro-hydro installations.

4. Geothermal

- Monitor technological advancements in geothermal heat recovery.
- Should commercial geothermal generation opportunities become economically feasible, tax credits similar to those provided to the wind industry could be considered in order to promote the development of commercial geothermal projects.

5. Biomass

- Continue data collection on woody biomass availability and site-specific evaluations of wood biomass utilization for industry-specific and electrical generation.
- Evaluate the feasibility of creating rural woody biomass industry centers as a form of rural community development.
- Determine if the use of small-scale, wood-powered systems would be beneficial or cost-effective for government-owned facilities.
- Promote the use of wood pellets in residential and commercial buildings.
- Review wood pellet incentive programs offered by other states.

6. Landfill Gas

- Continue monitoring developments in the utilization of landfill gas as a fuel is merited in light of the nine state landfills that are “candidates” for development as identified by the EPA’s Landfill Methane Outreach Program (LMOP). Continue to monitor whether any of these sites can be readied for use within the five-year timeframe of this plan.

7. Poultry Litter

- Support the utilization of poultry litter as a fuel source or value-added product.

B. Actions Taken on Recommendations

Several actions have been taken related to the recommendations made in the 2013 5-Year Energy Plan. Some of these actions are aligned with the recommendations while others are not. Two of these recommendations apply to multiple types of renewables: review of research on integration of variable resources and review of net-metering policy.

Review of Research on Integration of Variable Generating Resources

Research on the integration of solar and other variable resources was pursued by MU CBER. This information applies primarily to wind and solar resources due to output being a function of weather and time-of-day. Since the last five-year energy plan was published an important study was finalized that alleviates some concerns about the impact of variable generation on fossil units.

In 2013, the National Renewable Energy Laboratory (NREL) conducted a phase two study of its Western Wind and Solar Integration Study. This study sought to “determine the wear-and-tear costs and emissions impacts of cycling and to simulate grid operations to investigate the detailed impacts of wind and solar power on the fossil-fueled fleet in the West.” The study found that the negative impact of cycling on overall plant emissions is relatively small and that the increase in plant emissions from cycling to accommodate variable renewables is more than offset by the overall reduction in emissions (NREL, 2013).

The study found that operating costs increase by 2%–5% on average for fossil-fueled plants when high penetrations of variable renewables are added to the electric grid, with variation based on penetration level and the mix of wind and solar resources on the grid. The results of this study relieve much of the concern over magnitude of impacts caused by the variability of wind and solar output. While variable

resources do increase fossil power plant cycling and associated costs, the impact is quite small. Thus, even though the avoided fossil emissions allowed by integration of renewables on the grid is not one-to-one, the large majority of emissions from displaced fossil generation are avoided. Although this study was not conducted for the Eastern U.S., it is believed that results would be similar.

1. Review of Net Metering Policy

Changes to net-metering policy have occurred around the country in recent years. Several states are now moving away from net metering or are reducing the level of compensation to the electricity provider's "avoided cost." These changes are in response to concerns that net metering customers receiving credit at or close to the full retail rate are no longer paying their share of the fixed costs of delivering electricity. This issue is most pronounced in states with high levels of distributed solar, like Arizona and California, and is less of a concern in West Virginia where less energy is sold back to the grid.

In the third quarter of 2016, changes to net metering compensation were being considered or were enacted in 22 states. Value of solar studies or general evaluation of the costs and benefits of net metering were underway in 15 states, and new bill charges specific to solar owners were proposed in seven states (Utility Dive, 2016).

Two specific examples are the State of Indiana and the State of Arizona. In April 2017, the Indiana Legislature passed a bill to reduce the net metering compensation rate to the utility's marginal cost plus 25% (Utility Dive, 2017). In 2016, Arizona replaced its net metering system with a new temporary compensation rate using a Resource Comparison Proxy, determined by the average wholesale prices of generation from each utility's central station resources brought online during the previous five years (Utility Dive, 2017).

In West Virginia, net metering customers are reimbursed at the full retail rate, although the offset cannot be applied to reduce a "fixed monthly minimum bill, customer charge, demand charge or other charge not related to energy consumption (WVPSC, 2014)." A recent bill was passed that requires the West Virginia Public Service Commission (WVPSC) to prevent "cross-subsidization," defined as "the practice of charging costs directly incurred by the electric utility in accommodating a new metering system to retail customers who are not customer-generators (WV Legislature, 2015)." A Net Metering Task Force was organized by the WVPSC in response to H.B. 2201, but was unable to reach a consensus on how the PSC should address this mandate (WV Public Service Commission, 2015).

Regarding specific resources, actions taken regarding the previous 5-year energy plan evaluation recommendations were as follows.

2. Solar

Solar Tax Credit

The West Virginia Legislature allowed the income tax credit for PV installations to expire effective July 1, 2013 (West Virginia Code, 2013), and it has not been renewed.

Review of PV Systems at Government Facilities

No public review of the performance of PV systems installed at state and local government facilities has been conducted.

3. Wind

Current State-Level Incentives

The two tax credits available to wind are still in effect. However, legislation was introduced to remove the pollution abatement status granted to wind facilities that reduces the effective property tax rate for that equipment. This change would have applied to existing facilities as well as to future wind facilities.

The proposed SB 16 repeals §11-6A-5a of the Code of West Virginia relating to classifying wind power projects as pollution control facilities and providing a reduced valuation assessment for property tax purposes (WV Legislature, 2017). The bill was passed by the West Virginia Senate on March 18 and referred to the House Energy Committee, where the legislation then stalled.

Resource Evaluation on Surface-Mined Lands

Evaluation of wind resources on former surface-mined lands has occurred on eight former surface-mined properties through March 2016, led by Marshall University's Center for Environmental, Geotechnical and Applied Sciences (MU CEGAS). This project was funded by the Appalachian Regional Commission and the WV Division of Energy and has been ongoing since 2010.

The main purpose of the project was to identify surface mine lands and evaluate their potential for future wind energy generation based on existing industry specifications and industry trends. MU CEGAS used Sonic Detection and Ranging (SODAR) equipment to perform the assessments, which allow satellite transfer of data and use solar panels and deep-cycle batteries as power sources.

4. Hydro

No action has been taken on the recommendations regarding small-scale hydro power. Evaluation of small-scale hydro potential at recreational areas has not been undertaken. Rules and regulations have not been reviewed, nor have tax incentives been considered.

5. Geothermal

Monitoring of Technical Advancements

West Virginia University (WVU) has continued to support research on the State's geothermal resources by incorporating study of the resource in engineering coursework. The subject has also become the primary subject matter of several doctoral student dissertations. Research is led by Dr. Brian Anderson.

6. Biomass

Continue Data Collection and Evaluation

WVU is continuing work in this area under the direction of Dr. Jingxin Wang. Research includes evaluation of the entire production cycle of various resources including wood and energy crops. The research team has formed rural industry centers to coordinate work with various landowners and farmers.

Establish Rural Woody Biomass Industry Centers

WVU has created a West Virginia Statewide Wood Team to serve as a rural woody biomass industry center. With support from WVU and WVDOE, the team has been awarded competitive federal funds to study the opportunities to utilize woody biomass. Work has been conducted in conjunction with regional industry partners in the wood products industry.

Promote the Use of Wood Pellets in Residential and Commercial Buildings

No action has been taken on this recommendation, although wood pellet manufacturers have been invited to present information about their industry and operations at various State-sponsored events.

Review Wood Pellet Incentive Programs Offered by Other States

This information was researched by MU CBER. Wood waste is one of the most commonly utilized biomass resources in the region and West Virginia is the only state in the region that has established no incentives for biomass use. Direct use incentives are not uncommon in states with sizeable timber industries, although the larger incentives are found in states located further north. Many of these incentives are targeted toward residential heating.

7. Landfill Gas

Since 2012, a second landfill in West Virginia has begun producing electricity and another is developing a system for direct use of energy available at the fill. The Raleigh County Solid Waste Authority Landfill began producing electricity in 2017.

8. Poultry Litter

No specific action at the State level has been taken to support utilization of poultry litter as an energy resource. The Bioplex facility, an anaerobic digester previously located at West Virginia State University that was possibly the State's most innovative use of poultry litter, is no longer operating. However, other poultry litter-related efforts are ongoing. Recommendations made by WVU agricultural science professors have prompted the Frye Poultry Farm in Hardy County to expand use of its broiler litter. The Frye farm now produces a marketable biochar product in addition to reducing its propane costs using litter gasification equipment installed in 2007.

III. Regional Renewable Energy Policy and Development

Development of renewable resources in the region has continued at a strong pace over the last five years. The 11-state region in which West Virginia is centered has about 26 GW of utility-scale capacity including all types of renewables. Compared in 2011, this was growth of 40 percent. Fifteen GW of this amount is hydro capacity, making that resource the largest component of the regional renewable portfolio. Wind power is the second largest at 4.9 GW.

West Virginia has 1,060 MW of utility-scale renewable capacity, which is an increase of 11 percent over 2012. This amount is equal to renewable capacity installed in Maryland and Kentucky. When compared to state-level population, West Virginia is tied with Virginia as having the second-largest amount of renewable capacity per capita of regional states. When excluding hydro capacity, West Virginia has the largest amount of renewable capacity per capita of any state in the 11-state region. From the perspective of deployment as a function of population size, West Virginia has developed its renewable resources at a rate that is on-par with other states. As shown in the following table, this utilization is largely due to development of wind resources.

Table 1 Total Installed Utility-Scale Renewable Capacity (MW) at end of 2016

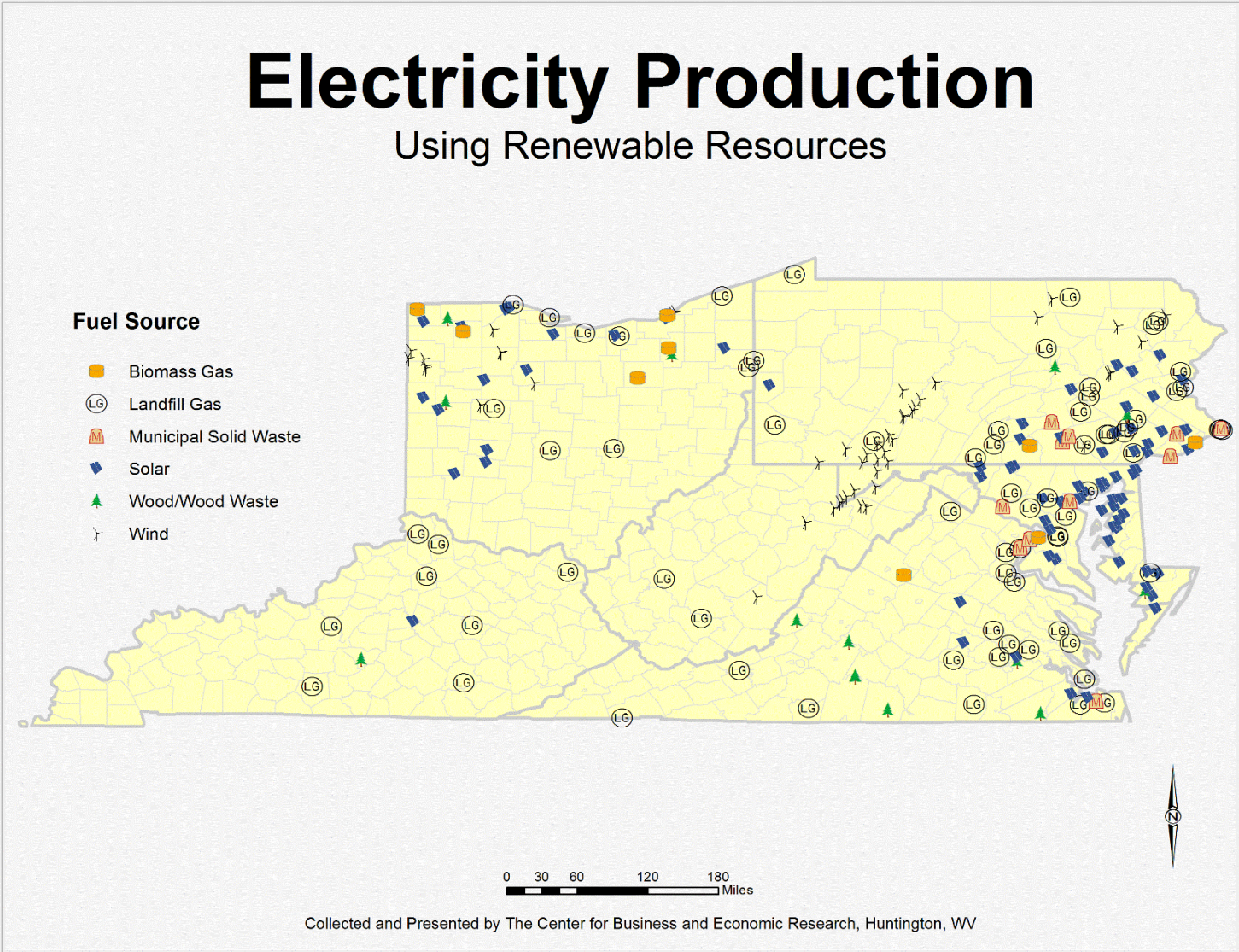
Table with 11 columns: State, Solar, Wind, MSW, Hydro, Wood, Landfill & Other Biomass, Total RE MW, Population July 2016, Watts per Capita, Non-Hydro Watts/Capita. Rows include DE, IN, KY, MD, NC, NJ, OH, PA, TN, VA, WV, Total, and Total MW by Resource in 2011.

Regional utility-scale capacity additions occurred for every resource type since 2011, with most additions in solar capacity concentrated in the State of North Carolina. Wind additions were led by Indiana. Several notable additions to biomass-based capacity occurred in the region. In 2013, five coal-fired power stations in Virginia were converted to burn wood-waste. Notable capacity additions in the agriculture sector include new anaerobic digester gas-to-electricity plants on dairy farms in Ohio (South Bend Tribune, 2016) and Indiana².

The following map depicts the location of regional power plants using renewable resources.

² This farm is a zero-discharge confined-animal feeding operation.

Figure 2 Map of Regional Utility-Scale Renewable Power Plants as of 2016



The development of renewable resources can be accelerated through creation of State incentives that reduce the cost of accessing the resource or that mandate use of a specific resource. West Virginia maintains several such policies, although the State has fewer options compared to other states.

Within the 11-state region, the extent of individual state policy directed at renewable resources is correlated with the size of the state and the status of the electricity industry. States that have pursued deregulation have more policy options that support renewables, as do states that are net importers of electricity.

One of the more significant recent policy changes that has occurred in West Virginia is the repeal of the West Virginia Alternative and Renewable Portfolio Standard. That rule was repealed in 2015 (WV Legislature, 2015) and would have required 10% of electricity supplied to consumers to be supplied from renewable and alternatives sources by 2015.

A. Net-Metering Policy

Per the DSIRE renewable energy policy database, West Virginia is one of 11 states that allow customers to receive net metering credits for excess generation at the retail rate with no expiration. Other states either allow credits at a lower rate or mandate that credits expire (N.C. Clean Energy Technology Center, 2017). This policy has allowed the State to maintain an “A” grade for net-metering policy by Vote Solar and the Interstate Renewable Energy Council (Vote Solar, 2015).

Table 2 Net-Metering Customers in West Virginia in 2016, kW and kWh

	# of Net-Metering Customers	Capacity (KW)	kWh Sold Back to the Grid
Solar	594	4,435	469,000
Wind	31	95	289

Source: EIA Form 861.

Research on net metering trends around the country reveal that many states are moving away from net metering, and replacing the compensation scheme based on retail rates with a rate based on avoided costs. The methodology to use for calculating avoided cost is currently under review at several state regulatory agencies.

For West Virginia, the fact that there are relatively few net-metering customers means the magnitude of shifted fixed costs is likely only a minor concern. In addition, the benefits of solar output may be more pronounced in the area in which net-metered PV is currently concentrated, i.e. FirstEnergy’s service territory. In 2014, 77 percent of net-metered PV capacity was in FirstEnergy’s territory.³

The FirstEnergy service territory is an area where demand for electricity is growing and where summer peak load may soon exceed winter peak load. The benefits of solar output in this part of West Virginia are potentially greater than in Appalachian Power’s territory, where demand is growing more slowly and summer load is considerably below winter load. Detailed information about hourly demand usage and the growth of summer and winter demand would need to be evaluated by the utility to determine this benefit.

³ EIA Form 861. Utility-level data not published for 2015.

B. Specific Renewable Resources

1. Solar

Since 2011, West Virginia's installed solar PV capacity has increased six-fold, from 0.75 MW to 4.4 MW at the end of 2016. As shown in the table below, regionally the State is last in total PV capacity and installed capacity per capita due to utility-scale capacity having been built in every other state in the region. In 2016, Virginia and Kentucky both added utility-scale solar capacity for the first time.

West Virginia is not lagging compared to most regional states in residential PV installation. The State has more residential PV per capita than some states with similar net-metering (N-M) reimbursement policy, e.g. Indiana and Kentucky. Residential installations are also not far behind North Carolina and Virginia, states which have better solar resources, more financial incentives to purchase solar and higher household income compared to West Virginia. Aside from Pennsylvania, other regional states are net importers of electricity which is another reason to invest in solar.

Table 3 Solar Net-Metering Data for Regional States, 2016

State	Avg. Solar kWh/sq. m /day	Utility-Scale MW	Residential N-M MW	Total N-M MW	# of Net Metering Customers	Res. N-M watts per Capita	Total PV watts per capita
Delaware	4.84	31	35.2	56.2	5,178	36.9	91.63
Indiana	4.56	160.6	7.6	13.3	969	1.2	26.22
Kentucky	4.70	10	4.2	5.9	505	0.9	3.58
Maryland	4.80	142.3	338.6	512.6	43,819	56.3	108.85
New Jersey	4.71	605.9	439.7	1197.6	66,716	49.2	201.63
N. Carolina	5.09	2,347	28.1	57.6	4,830	2.8	237.01
Ohio	4.43	48.8	17.1	88.7	2,832	1.5	11.84
Pennsylvania	4.39	50.7	93.2	230.7	13,132	7.3	22.01
Tennessee	4.85	71.5	0.1	0.3	16	0.0	10.79
Virginia	4.92	139	21.9	35.2	3,379	2.6	20.70
West Virginia	4.53	0	3.3	4.4	594	1.8	2.42
Total		3,607					

Sources: EIA Forms 860 and 861 (Preliminary 2016 data), NREL and U.S. Census.

A major factor needed to evaluate the benefits of solar is the concentration of demand for electricity and the timing of solar output. Annual peak demand for electricity occurs in the summer for the Mid-Atlantic region, an area that has had some of the greatest electricity transmission congestion issues anywhere in the U.S., and very high seasonal spikes in wholesale electricity prices. In 2007, the area was designated a National Interest Electric Transmission Corridor by US DOE due to persistent transmission congestion (USDOE, 2007). Solar energy output is likely to contribute more to avoided electricity costs in areas like the Mid-Atlantic than in West Virginia where peak demand occurs in the winter and where congestion is not as serious of an issue.

Utility-specific hourly load data is not available for West Virginia, but data for the broader Reliability First Reliability Council area shows that winter peak load largely occurs before 10am or after 6pm, most commonly between 6pm and 8pm. Solar energy is best suited to serve summer loads, particularly in places where summer peak exceeds winter peak, as it does throughout most of the Mid-Atlantic region. Projected peak demand by season for the major electric utilities in West Virginia is shown below.

Table 4 FirstEnergy West Virginia Projected Peak Demand (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Summer	2,970	3,040	3,150	3,270	3,280	3,290	3,300	3,310	3,320	3,330
Winter	3,000	3,080	3,160	3,300	3,340	3,350	3,360	3,370	3,380	3,390

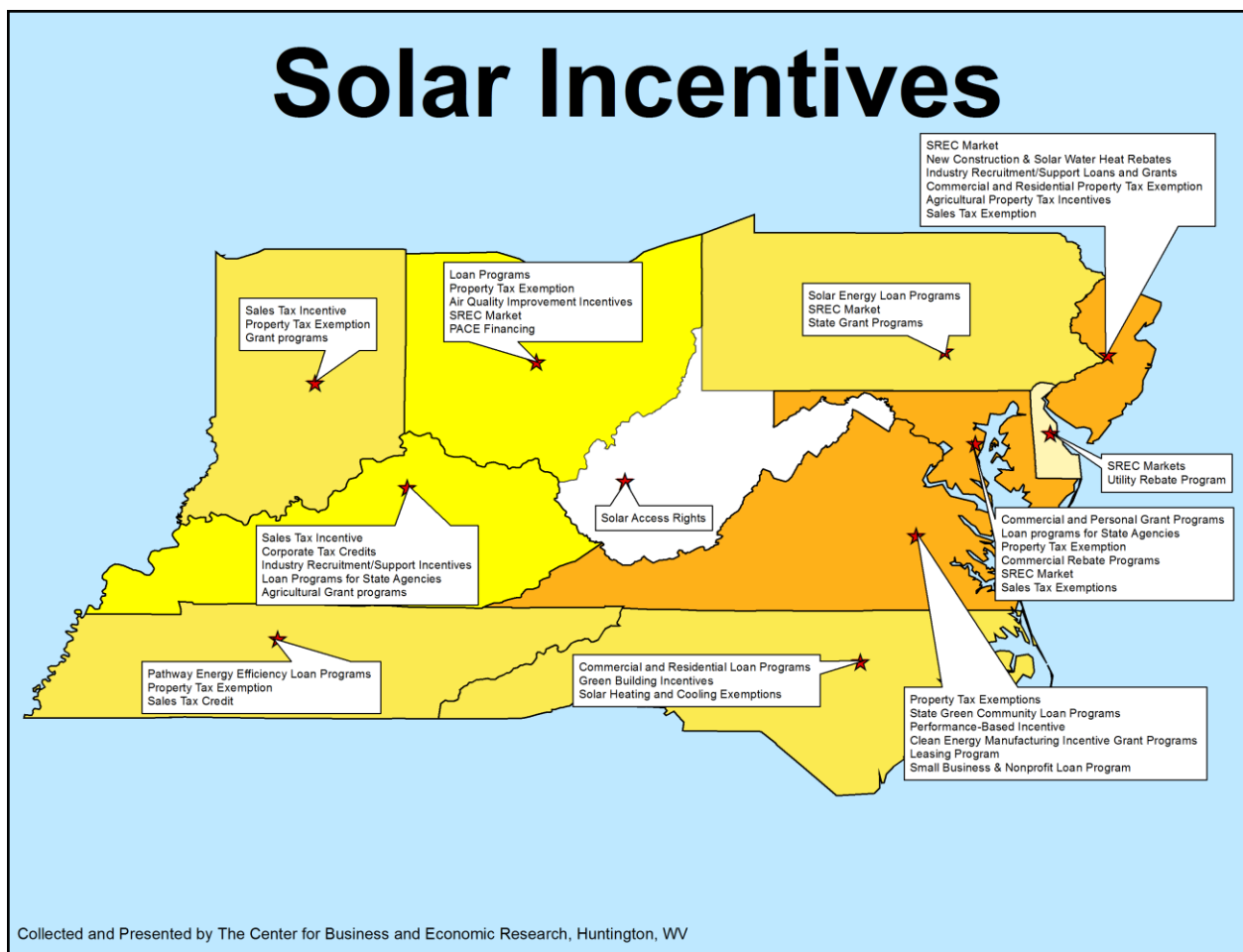
Source: FirstEnergy Integrated Resource Plan.

Table 5 Appalachian Power Projected Peak Demand (MW) in WV & VA

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Summer	5,978	6,026	6,042	6,053	6,055	6,091	6,119	6,152	6,168	6,212
Winter	7,490	7,529	7,527	7,515	7,491	7,527	7,546	7,566	7,561	7,606

Source: Appalachian Power Integrated Resource Plan.

Figure 3 Solar Policy Incentives in Regional States



With the exceptions of West Virginia and Pennsylvania, these 11 regional states shown above are all net-importers of electricity. The states of Delaware, Maryland, New Jersey, Ohio and Pennsylvania have also engaged in restructuring of the electricity industry and allow competition in generation. These same states have renewable portfolio standards with solar carve-outs and solar renewable energy credit (SREC) markets for compliance that financially incentivize solar development. Higher prices for SRECs

allow owners of the credits to recover system costs more quickly. Recent SREC price data is shown in the table below.

Table 6 Solar Renewable Energy Credit Prices

STATE	2017	2016	2015	Market Open To
Delaware	\$25	\$25	\$25	DE, PA, DC
Washington, DC	\$470	\$460 to \$480	\$470	DE, IN, IL, KY, MD, MI, NC, MI, NC, NJ, NY, PA, TN, VA, WV, WI
Maryland	\$6 to \$18	\$17 to \$70	\$125 to \$180	MD only
New Jersey	\$219 to \$260	\$197 to \$290	\$180 to \$280	NJ only
Ohio	\$15-\$20	\$16-\$30	\$30	Load Serving Entities can procure 50% of obligation from OH and 50% from IN, KY, MI, PA, and WV
Pennsylvania	\$5 to \$7	\$7 to \$12	\$12 to \$45	DC, DE, MD, NJ, VA, WV; specified parts of IL, IN, NC

Source: Flett Exchange.

States that import electricity also see clearer economic development benefits from siting a new power plant. In West Virginia, solar capacity would likely be redundant to other firm capacity, so output substitutes economic activity at one local plant for output from another.

Because of West Virginia’s near-term need for additional winter generating capacity, solar is a better fit for large-scale development in the long-term. If the State were to accept and internalize estimates of the economic value of avoided emissions the benefits of avoided variable costs would be larger. Without inclusion of such values the cost of solar capacity is expected to exceed the avoided costs from displaced fossil generation. In addition, as installed PV prices continue to decline, solar PV is likely to become even less expensive in the future.

The current cost of utility-scale solar PV development in West Virginia is unknown, but would likely be in the range of six to 12 cents/kWh. This range is based on a small sample of power purchase agreement (PPA) prices from contractual arrangements in the eastern U.S. While the lower end of the range is approaching the cost of coal-fired generation, solar capacity still can’t replace fossil generating capacity in West Virginia as suppliers must be able to meet peak electricity demand during hours when solar output is zero. The avoided costs of solar output are thus more reflective of avoided variable costs.

More may soon be known about the cost of utility-scale solar development in the area once Appalachian Power releases the results of an RFP for solar power issued in January. It is possible that solar-powered electricity may be able to be purchased more cheaply from arrays located further south. That factor should be considered when West Virginia decides to invest in large-scale solar capacity.

In the short-term, there are still benefits from small-scale adoption of solar technology. While net-metering may cost more per kWh than utility-scale solar, homeowners and businesses that invest in solar PV are investing in their property and utilizing a technology that will become more and more important in the future. This benefit may be difficult to quantify, but utilization of the technology will help West Virginia stay up-to-speed on emerging trends. The technical expertise that local solar installers maintain is also a valuable skill the State should encourage.

2. Wind

With the addition of the New Creek facility in 2016, West Virginia now has six operating commercial-scale wind facilities with a combined nameplate capacity of 686 MW (EIA, 2017). These facilities are:

- Dominion NedPower Mt. Storm - 264 MW
- Invenergy Beech Ridge - 100.5 MW
- AES Laurel Mountain - 97.6 MW
- Florida Power and Light/Mountaineer Wind Energy - 66 MW
- NRG Pinnacle Wind - 55.2 MW
- New Creek Wind LLC - 102.5 MW

West Virginia continues to have one of the highest rates of development of identified wind resources in the country. As shown in the table below, about 36 percent of the State's potential capacity on private land has been developed. Additional capacity is under assessment. Pennsylvania is in a similar situation. These high rates of development compared to other windier states in the broader region, i.e. Indiana and Illinois, reduce the opportunities to develop West Virginia's remaining wind resources.

The cost of wind development is also higher in the eastern U.S. compared to the Mid-West (LBNL, 2014, 2015 and 2016), and is likely a primary reason for slowed Eastern wind development in recent years.

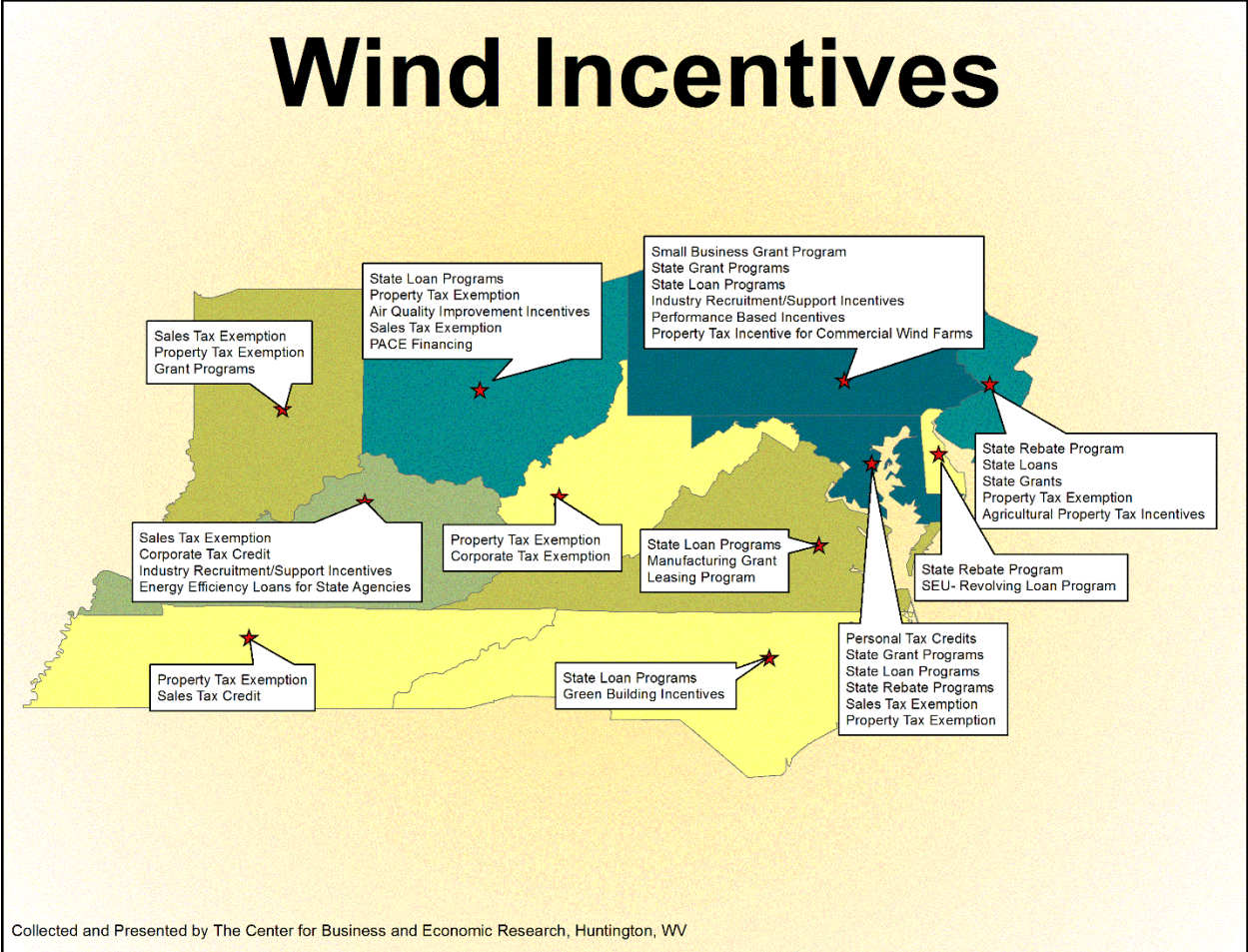
Table 7 Developed vs. Undeveloped Wind Potential in 2016

State	MW Installed Capacity	State Rank for Installed MW	Potential MW	Ratio Installed/Potential MW	Installed KW/ sq. mi	% of In-State MWh
Delaware	2	40 th	10	20.0%	1.02	0.0%
Illinois	4,026	6 th	249,882	1.6%	72.43	5.7%
Indiana	1,897	12 th	148,228	1.3%	52.89	4.8%
Kentucky	0	NA	61	0.0%	0.00	0%
Maryland	190	30 th	1,483	12.8%	19.44	1.4%
Michigan	1,611	14 th	59,042	2.7%	28.36	4.2%
New Jersey	9	38 th	132	6.8%	1.21	0.0%
New York	1,827	13 th	25,781	7.1%	38.70	2.9%
N. Carolina	0	NA	808	0.0%	0.00	0%
Ohio	545	26 th	54,920	1.0%	13.31	1.1%
Pennsylvania	1,369	16 th	3,307	41.4%	30.55	1.6%
Tennessee	29	37 th	310	9.4%	0.70	0.0%
Virginia	0	NA	1,793	0.0%	0.00	0%
West Virginia	686	23 rd	1,883	36.4%	28.49	1.9%

Sources: AWS TrueWind for potential capacity. AWEA for installed MW as of end of 2016.

West Virginia maintains two important tax incentives that support commercial wind development. Because of these incentives, West Virginia's effective property tax rate for wind turbines is one of the lowest in the nation. According to NREL's JEDI model, West Virginia, Pennsylvania and Wisconsin are the only states to have local taxes of less than \$2,000 per MW (NREL, 2014). Although most states in the region have more policy incentives that apply to wind, West Virginia has more installed wind capacity because its onshore wind resources are better than states located to the South.

Figure 4 Wind Policy Incentives in Regional States



Additional development of commercial-scale wind resources in West Virginia has recently become less likely due to the reduction of the PTC for projects that begin construction after 2016. The relatively high cost of development compared to Interior wind resources, which are often available for purchase in the PJM region, also makes West Virginia’s resources less competitive.

It is possible that technology that can take advantage of low-speed wind resources may eventually become viable and allow development of some of the West Virginia’s marginal wind resources. Wind speeds on some marginal sites have been tested in recent years by MU CEGAS.

A total of eight former surface-mined properties were evaluated using SODAR equipment through March 2016. Sites were only considered for assessment if models indicated wind speeds of at least six meters per second at the 80-meter height to match industry specifications. Sites included properties in Webster, Grant, Mingo, Raleigh, Wyoming and Fayette counties (MU CEGAS, 2017).

Results indicated a range of potential production outcomes for the properties. Sites assessed in Webster, Mingo and Wyoming counties were found to have marginal or below-commercial wind generation potential, while sites in Fayette and Raleigh counties had wind speeds approaching commercial development levels. The site in Grant County was found to have excellent wind potential.

3. Hydropower

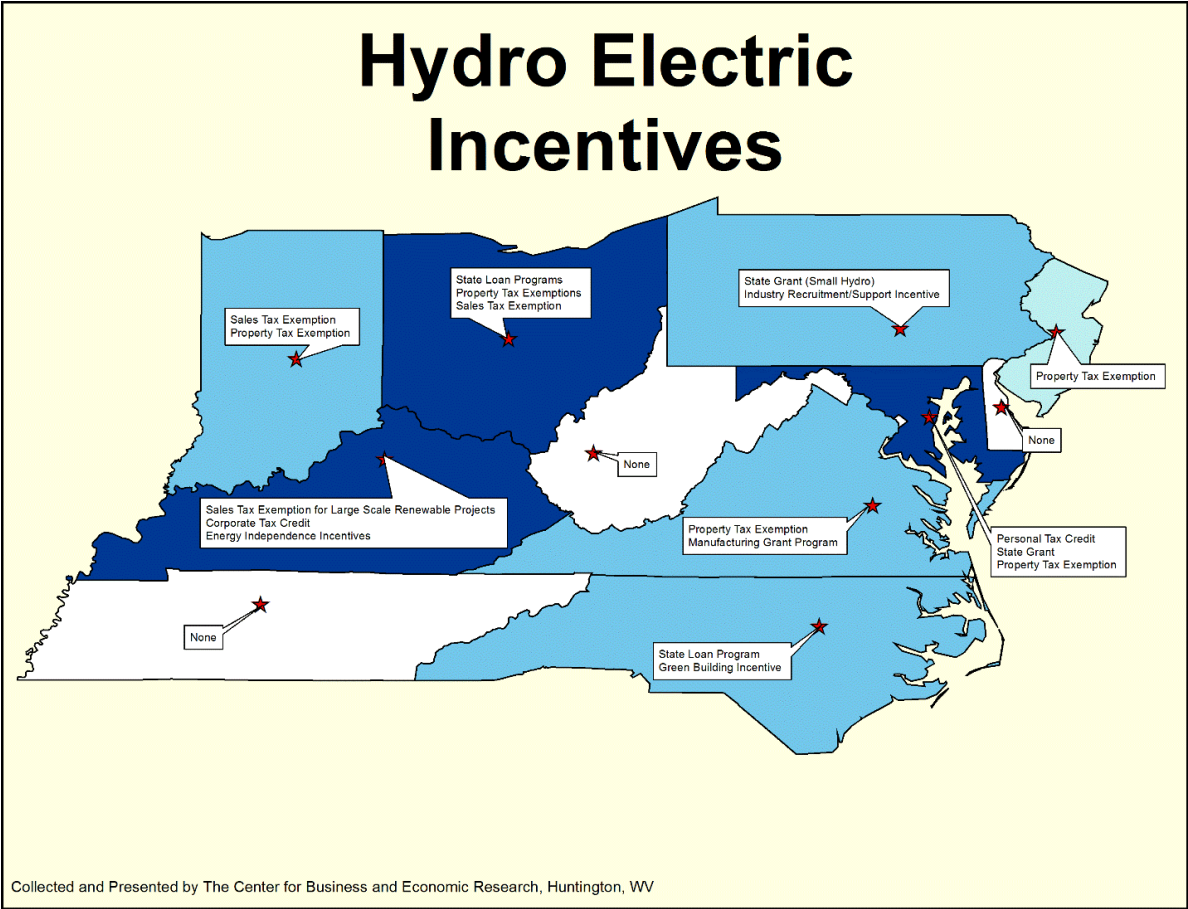
There is still untapped utility-scale generating capacity at existing dams in West Virginia. A 2012 study from Oak Ridge National Laboratory found that the Ohio River hydrologic region has the largest potential capacity of any region in the U.S., with potential capacity of 3,236 MW. West Virginia’s share of this potential is 210 MW. Kentucky has the largest share at 1,253 MW of potential capacity. Two West Virginia dams are in the top 50 non-powered dams with hydropower potential, the Tygart Dam (47 MW) and the Bluestone Dam (45 MW) (ORNL, 2012).

Two developers of hydroelectric projects are advancing four projects in the State. These projects are in northern West Virginia at existing dams operated by the U.S. Army Corps of Engineers (USACE).

Advanced Hydro Solutions, LLC has rights to develop the Jennings Randolph Dam (14.6 MW) and the Tygart Dam (30 MW) in West Virginia. The Jennings Randolph project received a FERC license in 2012, which was renewed in 2014, and is under final review at USACE headquarters. The Tygart project received Section 401 Water Quality Certification in 2015 and its FERC license in 2016.

FreeFlow Power New Hydro, which is managed by Rye Development for US Renewables Group, LLC is developing the Morgantown Lock & Dam (5 MW) and the Opekiska Lock & Dam (6 MW) on the Monongahela River. The firm received initial FERC licenses for both projects in 2016.

Figure 5 Hydro Policy Incentives in Regional States



4. Geothermal

West Virginia University (WVU) recently proposed a multi-phase project to engineer and demonstrate direct use of low-temperature geothermal resources in northern West Virginia. The proposal is currently under review by the US DOE. If awarded, grant money will be used to design an engineering plan with a series of go/no-go decision points, including the process to drill and develop an exploratory well on WVU property. The full plan is a 10-year project to design and build a system that will supply energy to directly heat and cool much of the WVU campus.

The proposed project is significant in several ways as it would be the first horizontal geothermal project of its kind in the world. The proposed design is currently to build a hybrid geothermal-natural gas system to mitigate risk that temperatures will vary by more than expected.

A separate project coordinated by both WVU and the National Energy Technology Laboratory (NETL) is proposed to provide energy to Camp Dawson in Pendleton County. That project is supported by the Army National Guard and furthers dual goals of reducing carbon emissions and using energy available at the camp (NETL, 2016).

5. Biomass

As a category of renewables, biomass is a diverse set of resources that includes landfill gas, liquid biofuels (namely corn ethanol, cellulosic ethanol and biodiesel), energy crops, wood-based materials and biogas that can be used to generate electricity. Biogases include methane gas produced from animal waste, municipal wastewater systems, and the by-products of food and beverage production.

Biomass fuels provided about five percent of the energy used in the United States in 2015. Of that share, about 43 percent was wood or wood-derived. Consumption of biomass in West Virginia is also led by wood, with the largest share used for residential heating (EIA, 2016). The estimated quantity of wood usage has increased, starting in 2004 following creation of a federal tax credit for pellet fuel stoves.

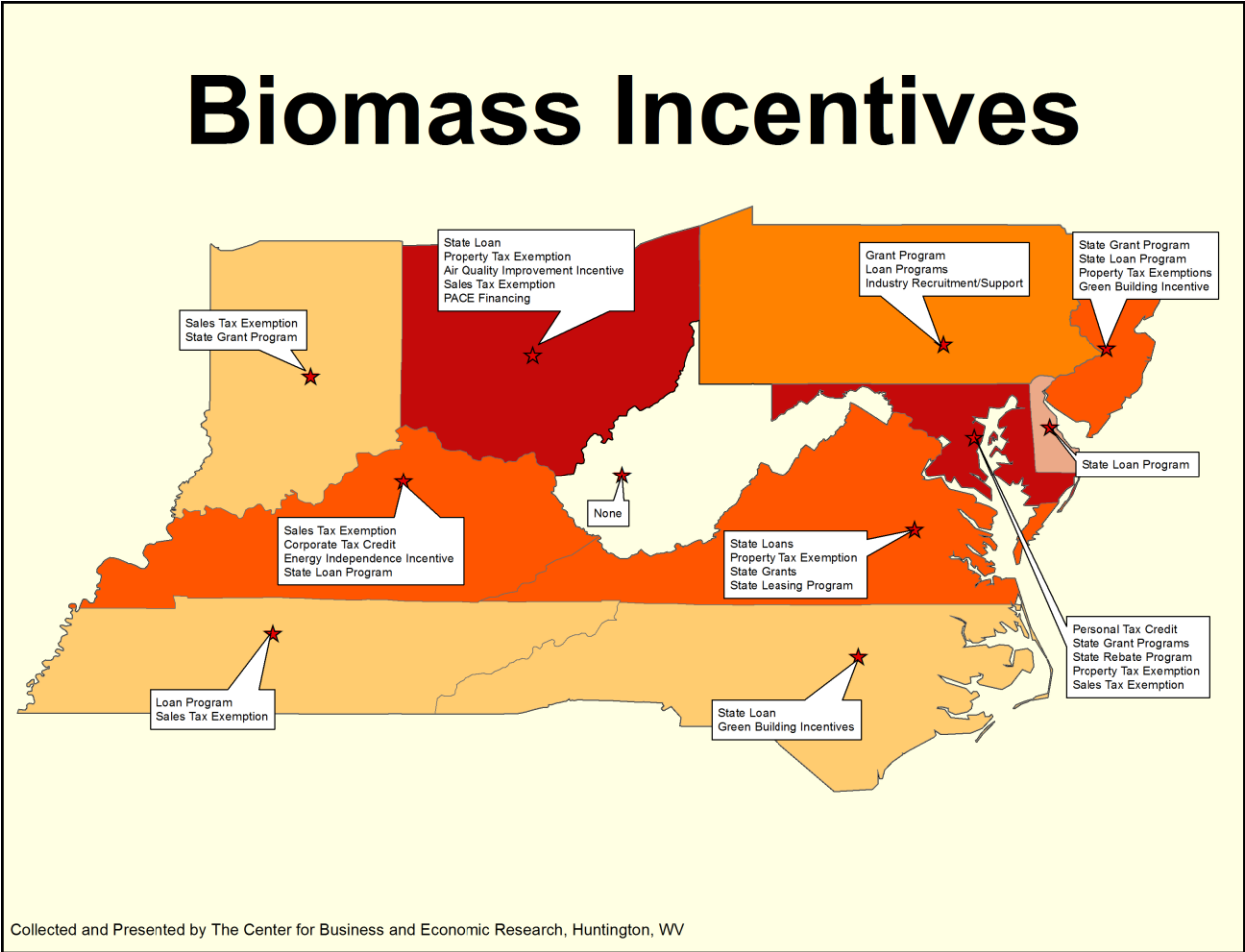
Consumption of ethanol jumped in 2007 following the mandate established by the Federal Renewable Fuel Standard (RFS2) within The Energy Independence and Security Act of 2007. The standard was enacted to promote the use of domestic biofuel and to help mitigate oil price volatility. RFS2 outlined an upper gallon limit for corn-based ethanol and target volume for the use of cellulosic ethanol; however, delays in production and the difficulty of commercialization have prevented consumption at the original target (US DOE, 2016).

West Virginia has explored usage of several types of biomass but has only developed commercial usage on a limited basis. The State has an established wood pellet manufacturing industry that repurposes wood residue from the lumber industry. Two landfills have been developed to produce electricity and broiler litter is being used for direct energy consumption at one location in the eastern part of the State. The Department of Education also subsidizes use of biodiesel in school buses.

West Virginia University is currently engaged in nine biomass-related research projects. These projects are funded by federal agencies and are partnerships with West Virginia farmers, major biomass companies and other research universities. Research encompasses the entire logistics chain of advanced biomass utilization and is evaluating use of poultry litter, forest residue and several energy crops. This work is headed by Dr. Jingxin Wang.

West Virginia is the only state in the region that has no incentives for the biomass industry. The most common type of incentive available in other states is low-interest loans.

Figure 6 Biomass Policy Incentives in Regional States



Wood Biomass

The national timber industry was greatly affected by the slump of new housing starts between 2008 and 2013. This slump slowed harvesting of saw timber stands in the South and shifted the stand age class distribution to older stands, and affected the economic availability of woody biomass (US DOE, 2016). The supply and price of wood waste is thus subject to this cyclical nature of new housing starts.

Manufacturers of wood products like cabinetry and container board are subject to similar market swings. Two industrial wood-waste fired power plants in Ohio closed in recent years due to demand for manufactured goods. The Stone Container Coshocton Mill closed in 2015 "to balance our overall supply of container board with our customers," per the firm (Coshocton Tribune, 2015). A Masco Cabinetry plant owned by Mills Pride that produced ready-to-assemble cabinetry closed in 2011 (The Telegram, 2010). Both generators were CHP plants and utilized wood waste from the manufacturing process to produce electricity (EIA, 2012 and 2015).

Despite these market-induced industrial closures, new development of several wood-fired power plants has occurred in the region. In Virginia, Dominion Power received approval to convert three 63 MW coal-fired power stations (Altavista, Hopewell and Southampton) to 51 MW woody biomass plants (The Center for Natural Capital, 2014). This implementation is part of a goal for the state to generate 15 percent of its electricity with renewables by 2025 (DSIRE, 2017). The biomass used in these facilities comes from tree tops and branches that are left behind after timbering operations.

Two other Virginia wood-fired facilities also came online in 2013, the Covington Facility and Halifax County Biomass. The Covington Facility is owned by MeadWestvaco and uses biomass from bark, limbs, and other materials not usable to make paper and from treetops, limbs, and other excess logging materials. The Northern Virginia Electric Cooperative owns the 50 MW Halifax County Biomass Plant, which utilizes forest residues harvested within 75 miles of the plant. That facility was funded by a \$3 million grant from the Virginia Tobacco Commission (Virginia Places, 2016).

In West Virginia, wood biomass is sourced largely from the waste from timbering operations and wood products manufacturing. Opportunities like the recent developments in Virginia may exist for West Virginia’s wood products industry in conjunction with recently closed coal-fired power plants. The feasibility of these potential opportunities should be explored.

Wood Pellets

Wood pellet manufacturing is an established industry in West Virginia with several producers located throughout the State. There are no special State incentives available to the industry or consumers of its products. In 2008 a bill was proposed in the WV legislature to provide a one-time \$300 tax credit for the purchase of wood pellets but it did not become law (Pellet Fuels Institute, 2017). A \$300 federal tax credit for purchase of a biomass-burning stove with a 75% or greater efficiency rating expired at the end of 2016 (Woodpellets.com, 2016).

In 2016, the US EIA began collecting monthly data on production of wood pellets and other densified biomass fuel from facilities with an annual capacity of 10,000 tons or more per year. Data includes production, sales, and inventory levels from approximately 90 operating pellet fuel manufacturing facilities in the United States. The following table shows aggregate state-level wood pellet production capacity for regional states for producers required to report to EIA.

Table 8 Wood Pellet Fuel Production Capacity in 2016 (tons per year)

State	# of Producers	Operating	Not in Operation	Planned
Indiana	1	8,000	61,000	
Kentucky	2	62,000		
North Carolina	5	1,599,821		
Ohio	2	80,000	63,500	
Pennsylvania	8	367,800		
Tennessee	2	50,800		120,000
Virginia	6	866,851	120,000	
West Virginia	3	250,680		

Source: EIA Monthly Densified Biomass Fuel Report for 2016.

Incentive programs in other states support the wood pellet industry. Examples include:

- New Hampshire - Residential consumers can receive assistance to install high-efficiency wood pellet furnaces that cover up to 40 percent or \$10,000 of system costs. The program is funded through the state's Renewable Energy Fund (Monadnock Ledger-Transcript, 2016).
- Maine – High-efficiency wood and pellet heating systems are eligible for incentives via the Home Energy Savings Program and Efficiency Maine Energy Loans (Efficiency Maine, 2017).
- Missouri – The State offers an energy production tax credit of \$5 per ton (or dry cord) of materials to any facility processing forestry residues into fuel within the state, with credits being carried over year to year (Alliance for Green Heat, 2009).
- Virginia – Sales of wood pellets are exempt from State sales tax if for domestic consumption (Virginia Tax, 1995).

A recent study conducted by Duke and North Carolina State universities evaluated the impact of the wood pellet industry on carbon emissions in the context of European demand for wood pellets produced in the U.S. The study found that increasing demand for wood pellets resulted in more forest area, more forest investment, large greenhouse gas reductions, and little change in forest carbon inventories (Galik & Abt, 2015). This finding is relevant given the ongoing debate on whether biomass-based energy should be considered carbon-neutral.

European demand for wood pellets produced in the U.S. has been driven by European Union (EU) climate policy that considers woody biomass energy to be as carbon-neutral as solar and wind energy. In the first half of 2016, US wood pellets exports to the EU were nearly 50% greater than the corresponding period of 2015 (Global Wood Markets Info, 2016). This made the US the supplier of almost a third of EU worldwide pellet purchases. This demand may be an opportunity for West Virginia pellet producers, although the future of these imports by the EU is uncertain. The EU's environmental department recently commissioned a study which concluded that "The growth of the industrial pellet industry has raised concerns about possible negative environmental impacts — direct and indirect (Climate Central, 2016)."

Energy Crops

WVU has been engaged in demonstrating the ability to grow energy crops for several years. This work has included test plots on former surface-mine lands, with variation in yield evaluated using different types of fertilizers. The university's initiatives have planted switchgrass, miscanthus and hybrid willow crops. Research covers the entire supply chain of activity, e.g. planting, harvesting, fertilizing, transporting, etc.

Energy crops have been explored for the opportunity to produce biodiesel and for co-firing at coal-fired power plants. Overall results indicate that the logistics of getting adequate volumes of energy crops to market are still a barrier to development of a commercially viable industry.

Biofuels

Biofuels are liquid transportation fuels produced from renewable resources. The most common forms of biofuels are corn-based ethanol and soybean-based biodiesel. Ethanol is blended with gasoline to produce E10, which is the standard gasoline blend of 10 percent ethanol sold at the pump today. Currently there are 17 stations that sell E85 in West Virginia and, as of 2017, no stations that sell 20 percent biodiesel (B20). This information is available online via the US DOE's Alternative Fuels Data Center.

Total national consumption of biodiesel was 2.1 billion gallons in 2016 (US EIA, 2017). Of this amount, 1.6 billion gallons were produced in the U.S., with zero commercial production in West Virginia.

Total national consumption of ethanol was 14.1 billion gallons in 2016 (US EIA, 2017). Ethanol is an export product, with 15.3 billion gallons produced in the U.S. in 2016. There is zero commercial production of ethanol in West Virginia.

State-level support for alternative transportation fuels is a common energy policy in the region and takes several forms. Regional states utilize the following types of support:

- (Uncapped) Producer Production Incentives are provided to producers primarily in the form of tax credits and reimbursements for the percentage of capital costs with no monetary limit (OH)
- (Capped) Producer Production Incentives are the same as above, but the amount of the credit or reimbursement is capped at a dollar amount (IN, KY, MD, VA).
- Government Renewable-Fuel Vehicle Purchase Mandates provide for the state to discount or reimburse for the cost of obtaining renewable fueled vehicles (VA)
- Grants, Subsidized Credit and Tax Concessions related to capital investment includes loans, loan guarantees and tax credits to increase renewable fuel plant development projects for new or existing facilities (IN, PA, MD, NC, OH, TN, VA)
- Government-Funded Research, Development, Demonstration Projects and Market Promotion encompass grants and rebates for biofuel research and demonstration projects (IN, KY)
- Consumption Subsidies provides rebates for state and local governments and private consumers who purchase alternative fuels (IN, NC)
- Subsidies for Infrastructure Related to Biofuel Distribution provide grants, tax credits and cost reimbursements for the installation costs of biofuel infrastructure (IN, KY, MD, OH, VA)
- Subsidies to Biofuel Consuming Capital including tax credits for the purchase of alternative fueled vehicles and/or mandates requiring the purchase of these (DE, WV)
- Support for Production of Feedstock/Renewable Fuel Mandates refer to expedited permits for biofuel plants and mandates or goals for government use of renewable fuels (DE, MD, NC, NJ, PA, TN, VA)

Biodiesel use in West Virginia continues to be subsidized by the State's Public School Support Program which provides an allowance for districts that use alternative fuels. "An additional allowance of 10% of the actual expenditures for operations, maintenance and contracted services, exclusive of salaries, for that portion of the bus fleet that uses alternative fuels" is allowed (MU CBER, 2012). The subsidy will be phased out by the end of the 2017-2018 school year. State code specifies that "...the additional percentage applicable to that portion of the bus system using bio-diesel shall be decreased by two and one-half percent per year for four consecutive school years beginning in school year 2014-2015 (WV State Code, 2015)."

In fiscal year 2011-12 about 250,000 gallons of biodiesel was purchased by the 48 (out of 55) districts which availed themselves of the option. For fiscal year 2015-16, 43 (out of 55) districts availed themselves of the option and consumed approximately 255,000 gallons of biodiesel (5.1 million gallons of B5) (WV Department of Education, 2017). Per the Alternative Fuels Data Center, the cost of B100 is currently between \$3-4 a gallon (US DOE, 2017). By comparison, the cost of B100 in 2011-12 was \$4-5 a gallon (MU CBER, 2012).

Landfill Gas

Since 2012, one West Virginia landfill stopped and one started producing electricity. The Raleigh County landfill gas-to-energy project began generating electricity in 2017 and currently has a capacity of 1.3 MW. This facility will soon double in size with the installation of a second engine. Once the second well is drilled and the engine installed, the facility will be able to produce 2.6 MW of power (Raleigh County Solid Waste Authority, 2017).

The City of Charleston landfill began producing electricity in 2011 but ceased in 2016 due to an inadequate quantity of gas. The gas supply became watered-in and the system will need to be redesigned to resume production. The system was recently sold to a new owner, who may have plans to redevelop it for electricity or direct use of the gas.⁴

Development is also occurring at the Berkeley County landfill. Berkeley County, in conjunction with the county's recycling program and via a partnership with Entsorga, began construction in 2017 on a facility to separate waste materials into usable products. Recyclable materials will be collected via a system that will increase recycling rates for the City of Martinsburg, with leftover burnable materials to be converted to a "solid recovered fuel" for use as a supplement for coal in cement production. The plant is set to open in 2017 and has a total investment for construction and equipment of approximately \$23 million (Entsorga, 2017).

The Wetzel County landfill has a direct use system that uses LFG to power a boiler which heats leachate, water that leaches from the landfill, for pretreatment. That project was put in place in 2003 (EPA, 2017).

Six West Virginia landfills are candidates for a gas-to-energy project as classified by the EPA's Landfill Methane Outreach Program. Four of these fills are currently flaring gas (EPA, 2017):

- LCS Services Landfill – 0.793 million standard cubic feet per day (mmscfd) flared
- Meadowfill Landfill – 1.66 mmscfd flared
- Mercer County Landfill
- Northwestern Landfill – 1.45 mmscfd flared
- Short Creek Sanitary Landfill
- Tucker County Solid Waste Authority LF – 1.12 mmscfd flared

Development of one or more of these fills to produce electricity may be feasible using a business model like that used by the City of Charleston and Raleigh County LFGTE projects.

Other Biogas

Biogas resources have been a largely untapped source of renewable energy in the region. There is currently only one project in West Virginia. However, in the last few years several new facilities have come online or have expanded use of their waste. There are several outstanding regional examples.

Frye Poultry Farm

The Frye Poultry Farm in Hardy County, WV, has been one of the most innovative users of poultry litter in the region. In 2007 the farm installed a gasifier to use litter to lower propane costs and reduce the

⁴ Personal interview with Sam Strickland, City of Charleston.

concentration of ammonia inside the broiler houses. The farm now markets biochar produced from the gasification process as a long-term soil amendment and fertilizer.

The product is produced using gasification to thermally convert poultry litter into black carbon. The resulting biochar has a negative surface charge, making it useable as a tool for remediation of heavy metals (Frye Poultry, 2016). Products are sold in five-gallon buckets that are a thermally converted blend of poultry litter and wood chips or in one-ton Super Sacks, screened to half-inch pieces or as an unscreened mix of litter and wood carbons (Frye Poultry, 2016).

MillerCoors Shenandoah Brewery

The MillerCoors Shenandoah Brewery in Virginia recently installed an anaerobic digester that can generate up to one MW of power from brewing by-products (The Center for Natural Capital, 2014). Due to this and other recycling measures the facility has not sent garbage to a landfill since 2011 (MillerCoors Blog, 2017).

City of Akron

The City of Akron uses anaerobic digesters to process wastewater biosolids from its municipal wastewater system (City of Akron, 2016). This combined heat and power (CHP) system began producing electricity in 2014 (EIA, 2017).

BioTown Ag

BioTown Ag is a cattle and swine farm in Ohio. The farm uses an anaerobic digester to process its animal manure and generates electricity with the resulting gas (BioTown Ag, 2017). The system has been operating since 2014.

Napoleon Biogas

Napoleon Biogas is credited with being the State of Ohio's first commercial biogas power plant. The system is a digester that receives mixed waste from a Campbell's plant as well as other area food processors, waste recyclers and local dairy farms. The project was financed with tax-exempt bonds issued by the Regional Port Authority of Northwest Ohio and by equity provided by the developers (Napoleon Biogas, 2016). The system has been operating since 2013.

6. Electric Vehicles

Electric vehicles (EVs) are an appealing alternative to conventional gasoline-powered vehicles because no emissions are produced in operation. As electricity generation moves further away from fossil-fuel fired power generation, EVs will provide an even bigger emissions benefit.

Because of the dominance of coal-fired electricity production West Virginia is not yet receiving the full emissions benefit that EVs using renewable-based electricity will eventually allow. However, there are other benefits to utilizing EVs due to the State's status as a net producer of electricity. In West Virginia displacement of conventional fuel with electricity creates an economic benefit as it is equivalent to switching from a largely imported product to a local product.

West Virginia no longer has any tax incentives for purchase of EVs, but the State has supported the EV infrastructure by securing grants to purchase charging stations. Several new EV charging stations were installed at West Virginia State parks in 2016, including Pipestem Resort, Twin Falls and Cacapon State

Parks. It is planned that all lodged state parks in West Virginia will receive Level 2 chargers, with the remainder to be installed in 2017 (WV Clean State Program, 2017). Charging is free to visitors.

Much of the state-level policy around EVs concerns development of infrastructure and the time of day that charging occurs. As EVs become more popular, electric utilities become engaged in the build-out of charging infrastructure. The time of day of charging is an important issue in areas with electricity congestion. Neither of these issues is particularly pressing in West Virginia, but that could change within a few years. In preparation for growth in use of charging infrastructure it may be useful to identify future locations for chargers (Level 2 or higher) that would create a seamless and connected EV charging infrastructure.

The following table shows the number of B20 biodiesel, E85 and EV charging stations for regional states as of 2016. West Virginia has fewer EV charging outlets per capita than most states in the region. However, when taking average household income and other demographic factors into consideration, the number of opportunities to charge EVs may be appropriate for the population of a state where traffic-induced pollution is a smaller issue than in states with large urban areas.

Table 9 Renewable and Electric Vehicle Fueling Stations by State in 2016

State	# of B20 Fueling Sites	# of E85 Fueling Sites	# of EV Charging Stations	# of Charging Outlets	# EV outlets/ million people
Delaware	1	1	30	65	68
Indiana	6	199	174	353	53
Kentucky	4	73	76	156	35
Maryland	9	33	460	1,036	172
New Jersey	5	5	236	478	53
N. Carolina	124	59	422	946	93
Ohio	14	146	263	465	40
Pennsylvania	6	45	331	600	47
Tennessee	35	79	413	947	142
Virginia	9	19	357	859	102
West Virginia	2	11	35	76	42

Source: ORNL, Transportation Energy Data Book Edition 35.

The above data has changed in 2017. For example, the US DOE's Alternative Fuel Data Center station locator currently shows 0 B20, 17 E85 and 41 EV stations with 106 outlets in West Virginia.

IV. Summary and Recommendations

It is valuable for the State of West Virginia to participate in the transition away from fossil fuels and adopt new technology that utilizes renewable resources. It may take longer for West Virginia to transition than it will for larger states with more diverse economies, greater economic growth, fewer fossil resources and better solar resources.

The perception that West Virginia is behind on renewable energy development is not entirely accurate. The State is not lagging with respect to the portion of wind resources that are already developed and the amount of residential solar PV capacity installed per capita. West Virginia's total utility-scale non-hydro renewable electricity generating capacity per capita is also the highest of all states in the region. While this population-based measure is not complete, it reveals the fact that significant amounts of renewable resources are being utilized for a state of its size.

There are still opportunities to utilize renewable resources more fully. These opportunities should be monitored with respect to ability to serve need. Solar technology continues to see cost declines, making it more and more cost-effective to serve load, especially in areas where peak electricity demand coincides with solar output. Important questions relate to when to develop and determination of what the benefits of investment are to West Virginia's electricity consumers.

Large-scale utilization of solar energy is currently more of a long-term economic opportunity, although there are likely as-of-yet unquantified benefits to small-scale utilization in the near-term. Wind resources are already significantly developed, and as Interior wind has become cheaper and more available the opportunities to sell wind generation from West Virginia have been reduced. Wood waste resources are underutilized, but entail risk of supply due to ties to the housing and wood products industries. The large-scale hydro resources that remain undeveloped are being pursued by developers and appear to be on-track for completion. Small-scale hydro has not been actively pursued.

West Virginia has fewer economic incentives to develop renewables than most states in the region. However, some of the incentives in place are more robust than in other states. Due to the nature of demand for and supply of electricity in the State, and without monetizing benefits from avoided emissions, the economic benefits from increasing subsidies for renewables are not clear.

Due to budgetary issues the State of West Virginia is probably not in a financial position to develop its own grant or loan programs right now. Such programs would align the State with others in terms of common types of incentives deployed by other states in the region. The State's near-term role may be best served maintaining current and reinstating recently expired policies that incentivize renewables.

This research contains both general and resource-specific recommendations.

A. General Recommendations

The advancement of renewable resources does not require direct subsidies. There are several consumer-oriented policies that offer increased choice for electricity customers.

RECOMMENDATION 1: Maintain the State's net metering policy.

The WVPSC and electric utilities should continue to monitor the size of the net metering customer segment relative to total electricity customer base. If the size of the segment becomes too large the

State could move to using a “value of solar” compensation method, whereby distributed solar is compensated based on the utility’s avoided costs of generation and infrastructure use.

RECOMMENDATION 2: Utilize utility-specific hourly load data for focused information-sharing, so more can be known about where and when peak demand occurs and the duration of peaks by time-of-day and season.

This activity most likely falls to the WVPSC due to its role in assimilating utility data and information in support of regulation and consumer protection. Hourly load data could be utilized internally by the WVPSC to support regulation or could be shared with other entities seeking to design and provide new services such as demand response programs.

B. Recommendations for Specific Renewable Resources

1. Solar

Solar energy is ubiquitous and over time will play a larger and larger role in West Virginia’s energy portfolio. Presently, a primary issue is the inability of solar installations to offset capacity needs because of the timing of peak demand. Peak demand in West Virginia occurs in the winter, and typically during the morning and evening hours when solar arrays are producing very little electricity.

RECOMMENDATION 1: Renew the income tax credit for solar PV.

This credit has allowed businesses and households to receive some savings from investing in solar installations, and rewards those willing to adopt an emerging technology.

RECOMMENDATION 2: Share data regarding PV system output and electricity cost savings for facilities owned by State and local governments, thus extending knowledge and experience with the technology.

Government facilities that have installed solar arrays include the WV Department of Environmental Protection, the City of Hurricane, Morgan County, and the City of Morgantown. Ideal venues for this type of information-sharing include the annual Governor’s Energy Summit and the biennial renewable energy conference sponsored by the WVDOE.

RECOMMENDATION 3: Promote development of former surface-mined lands for solar arrays.

Surface-mined lands may have a cost advantage from a land acquisition point, and have few alternatives to use the land. Although the solar resources in West Virginia are only moderate the insolation is best in the southern part of the state, where the largest former mine lands are located.

2. Wind

About one-third of the high-quality wind resources available on private land in West Virginia have already been developed, and additional resources are being assessed. If wind resources are to be developed in the future the production may need to come from areas that are now considered marginal.

RECOMMENDATION 1: Continue assessment of wind resources on surface-mined land by leveraging the State’s ability to receive grant funding to support this work.

This work can allow the wind resources of more marginal or near-commercial sites to be quantified.

3. Biomass

The wood industry has historic significance for the State of West Virginia and has available resources that have already been quantified. Biomass development for power generation has some benefits over solar as feedstock-based power plants are dispatchable, i.e. can serve load at any time of day and in any season.

RECOMMENDATION 1: Create a government-industry partnership for wood utilization that explores the opportunities in agriculture and power generation.

This could be an annual or biennial government-industry summit hosted by West Virginia University.

RECOMMENDATION 2: Consider making sale of wood pellets exempt from sales tax.

Such a policy would bring West Virginia in line with Virginia in terms of sales incentives, where wood pellets are exempt from the state sales tax if for domestic consumption.

4. Geothermal

The next step in utilization of West Virginia's geothermal resources is development of an engineering plan to more accurately measure the potential energy output from the resource.

RECOMMENDATION 1: Support West Virginia University's efforts to develop a direct use geothermal energy system on its campus.

If completed, this project will be the first of its kind in the world.

5. Hydro

Large hydro resources are already heavily developed in West Virginia, but small and micro-hydro resources are not.

RECOMMENDATION 1: Develop a procedure for State employees to assess small hydro opportunities at State parks and forest properties.

Small hydro is a very site-specific opportunity that can be assessed with a series of relatively simple measurements.

6. Electric Vehicles

The EV market is small in West Virginia but will likely grow as new vehicles with more competitive pricing are introduced to consumers.

RECOMMENDATION 1: Monitor purchases of EVs to determine when additional charging infrastructure is needed, and identify locations for new stations to improve the range of charging options for EV owners in West Virginia.

Once a critical mass of demand for EV charging infrastructure is achieved the electric utilities should be engaged in the build-out process.

Bibliography

- Alliance for Green Heat. (2009). *Residential Appliance Incentives*. Retrieved from <http://www.forgreenheat.org/appliance/fuel.html>
- BioTown Ag. (2017). Retrieved from <http://biotownag.com/>
- City of Akron. (2016). *Renewable Energy Facility*. Retrieved from http://www.akronohio.gov/cms/sewer/wrf_renewable_energy/index.html
- Climate Central. (2016, August 9). *Europe Aims to Close Loophole on Wood Energy*. Retrieved from <http://www.climatecentral.org/news/europe-aims-to-close-loophole-on-wood-energy-20591>
- Coshocton Tribune. (2015, October 16). Local and company leaders say WestRock plant will close.
- Courier-Journal. (2016, April 25). Kentucky's largest solar power plant unveiled in Mercer County.
- E&E News. (2017, May 2). Appropriations - Omnibus winners and losers .
- Efficiency Maine. (2017). *Energy Efficient Wood & Pellet Heating*. Retrieved from <http://www.efficiencymaine.com/home-energy-savings/energy-efficient-wood-pellet-heating/>
- EIA. (2016). *State Energy Data System*. Retrieved from https://www.eia.gov/state/seds/sep_use/total/pdf/use_WV.pdf
- Entsorga. (2017). Entsorga West Virginia.
- Environmental and Energy Study Institute. (2017, May 12). Despite Biomass Provisions in Omnibus, Biomass Woes Far From Over.
- EPA. (2017). Landfill Methane Outreach Program.
- Frye Poultry. (2016). *Poultry Litter Biochar*. Retrieved from <http://fryepoultry.com/shop/poultry-litter-biochar>
- Galik, C., & Abt, R. (2015, May 27). Sustainability Guidelines and Forest Market Response: An Assessment of European Union Pellet Demand in the Southeastern United States. *Global Change Biology-Bioenergy*.
- Global Wood Markets Info. (2016, September 26). *US Wood Pellets Exports to Europe Up 46%*. Retrieved from <https://www.globalwoodmarketsinfo.com/us-wood-pellets-exports-europe/>
- LBNL. (2014, 2015 and 2016). Wind Technologies Market Report.
- MillerCoors Blog. (2017). *Behind the Beer*. Retrieved from <http://www.millercoorsblog.com/brewing/millercoors-breweries/>
- Monadnock Ledger-Transcript. (2016, July 25). *Wood-pellet incentives boosted*. Retrieved from <http://www.ledgertranscript.com/burewoodpellets-ml-3587680>
- MU CBER. (2012). *Renewable Energy Policy: Opportunities for West Virginia*.

- MU CEGAS. (2017). Marshall University Center for Environmental, Geotechnical, and Applied Sciences. *Summary of Wind Analysis on WV Surface Mine Properties for Potential Wind Energy Generation Using Sonic Detection and Ranging Technology.*
- N.C. Clean Energy Technology Center. (2017). *DSIRE USA*. Retrieved from <http://www.dsireusa.org/>
- Napoleon Biogas. (2016). Retrieved from <http://ch4biogas.com/projects/napoleon-biogas/>
- NETL. (2016). Fossil and Geothermal Energy Resource Assessments and Energy Solution Options at Camp Dawson. *2016 West Virginia Governor's Energy Summit.*
- NREL. (2013). *The Western Wind and Solar Integration Study Phase 2.*
- NREL. (2014). Jobs and Economic Development Impact (JEDI) Model. *Release Number: W3.24.14.*
- ORNL. (2012). *An Assessment of Energy Potential at Non-Powered Dams in the United States.*
- Pellet Fuels Institute. (2017). *Legislation*. Retrieved from <http://www.pelletheat.org/legislation-regulations>
- Personal Interview with Sam Strickland. (2017, March). *City of Charleston.*
- South Bend Tribune. (2016, January 31). Goshen Company Turns Poop into Power.
- The Center for Natural Capital. (2014). *Biomass and Bioenergy in Virginia.*
- The Telegram. (2010, April 28). Masco to close Mill's Pride Plant in 2011; 1,216 jobs to be lost.
- US DOE. (2016, July). 2016 Billion-Ton Report. *Advancing Domestic Resources for a Thriving Bioeconomy.*
- US DOE. (2016). *Renewable Energy Production Tax Credit (PTC)*. Retrieved from <https://energy.gov/savings/renewable-electricity-production-tax-credit-ptc>
- US DOE. (2017). Alternative Fuels Data Center .
- US EIA. (2017). *April 2017 Monthly Energy Review.*
- USDOE. (2007, October 2). *DOE Designates Southwest Area and Mid-Atlantic Area National Interest Electric Transmission Corridors*. Retrieved from <https://energy.gov/oe/downloads/doe-designates-southwest-area-and-mid-atlantic-area-national-interest-electric>
- Utility Dive. (2016, November 10). Why 'a lot has become the new normal' in state solar policy debates.
- Utility Dive. (2017, April 6). *Indiana House approves bill to phase out retail net metering .*
- Utility Dive. (2017, January 26). *The lurking surprise for solar in Arizona's recent ruling to end net metering .*
- Virginia Places. (2016). *Biomass in Virginia*. Retrieved from <http://www.virginiaplaces.org/energy/biomass.html>
- Virginia Tax. (1995, June 2). *Rulings of the Tax Commissioner*. Retrieved from Document Number 95-141: <https://www.tax.virginia.gov/laws-rules-decisions/rulings-tax-commissioner/95-141>

West Virginia Code. (2013). §11-13Z-1. *Residential Solar Energy Tax Credit*.

West Virginia Division of Energy. (2012). *Energy Plan 2013-2017*. Retrieved from http://www.wvcommerce.org/App_Media/assets/3dissue/energy-plan/energyplan/index.html

Woodpellets.com. (2016, October 7). *\$300 Biomass Federal Tax Credit Expiring*. Retrieved from <https://www.woodpellets.com/blog/2016/10/07/300-biomass-federal-tax-credit-expiring-soon/>

WV Clean State Program. (2017). *WINTER 2016/2017 E-NEWSLETTER*.

WV Department of Education. (2017). Amy Willard . *Office of Finance*.

WV Legislature. (2015, January 27). H.B. 2001. *Repealing Portions of the Alternative and Renewable Energy Portfolio Act* .

WV Legislature. (2015, February 28). *H.B. 2201*.

WV Legislature. (2017, March 15). Retrieved from http://www.wvlegislature.gov/Bill_Text_HTML/2017_SESSIONS/RS/bills/SB16%20SUB1.pdf

WV Public Service Commission. (2015, September 30). General Investigation into Net metering in West Virginia. *CASE NO. 15-0682-E-GI*.

WV State Code. (2015). §18-9A-7. *Foundation allowance for transportation cost*.

WVPSC. (2014). A Primer on the PSC, Alternative and Renewable Energy Law and Net Metering.