Utility Scale Solar in Wyoming

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Executive Summary

Wyoming has an above average solar resource with its global horizontal irradiance (GHI) peaking near Rock Springs in Sweetwater County. While Wyoming's solar potential rivals parts of other states such as Arizona and California, Wyoming does not have a single utility-scale solar facility within its borders. However, if a 500MW solar farm (the size of an average coal-fired power plant) were to be developed in the state, it would result in the creation of 1,632 full-time equivalent (FTE) job-years, paying its employees over $89.6 million in wages over the 30-year life of the project. These solar employees and their households would contribute over $2.5 million in state and local taxes. Furthermore, over the life of the project, Wyoming would receive between $109.5 and $174.4 million in sales and property tax from the solar developer, depending upon power purchase agreement (PPA) price. Though there are several factors impeding the development of utility-scale solar in Wyoming, the single largest issue is the lack of electrical transmission capacity. Wyoming exports 2/3 of the electricity it produces. Therefore, any additional generation will need to be exported to other states. Because of the high costs associated with building new transmission lines, Wyoming's electricity generation is limited by its transmission capability, which is currently operating at maximum capacity. Without building additional power lines to export Wyoming electricity to neighboring states, it is unrealistic to expect any large solar project to locate itself in the state. Other obstacles to developing a utility-scale solar facility in Wyoming include no state-based solar incentives, stringent BLM permitting requirements, and an unfavorable legislative attitude towards solar. Under the Public Utility Regulatory Policies Act of 1978 (PURPA), electric utilities are required to accept electricity from small (<80MW) utility-scale solar facilities. However, utilities are only obligated to purchase power from a qualifying facility at their "avoided costs", which are often less than the levelized cost of electricity for the average utility-scale solar project, making PURPA projects uneconomic.

Introduction

In 2006, solar in the US generated only 0.5 TWh, equivalent to 0.012% of the total electricity generated. Ten years later, in 2016, solar capacity increased over 100-fold. Of the 4,079 TWh of electricity generated in 2016, solar was responsible for 56.2 TWh of generation, or 1.37% of all electricity in the country (US Energy Information Administration 2017). Sharp decreases in solar panel prices along with various tax incentives have contributed to the rapid growth of installed solar power in the United States. When comparing these national averages to the state of Wyoming, the story varies drastically. In 2006, Wyoming generated 45.4 TWh of electricity, 94.4% from coal and 0% from utility-scale solar. Ten years later in 2016, though the total Wyoming-based generation increased to 46.3 Twh (peaking at 52.5 TWh in 2013), utility-scale solar was still non-existent in the state (US Energy Information Administration 2017). Wyoming exports 2/3 of their electricity generation to other states, which may be a reason why the state's total electrical generation has decreased in recent years (US Energy Information Administration 2016). Though Wyoming has no utility-scale solar farms, several small projects are present throughout the state, the largest of which is 111 kW, located in Teton County (Energy Conservation Works). The majority of the installed solar capacity is composed of privately owned DER projects (Distributed Energy Resource). It is clear that Wyoming has not followed national trends on the solar installation front. However, this is not due to a poor solar resource on Wyoming's part. In fact, over 4 million acres in Wyoming have a solar resource equivalent to some areas of California, Nevada, Utah, Idaho, Oregon, Colorado, Kansas, Oklahoma, Texas, Louisiana, Alabama, Georgia, South Carolina and Florida (Esri 2017). Furthermore, photovoltaic solar cells operate at a higher efficiency level when

exposed to low temperatures (Bolinger 2016). With the average temperature hovering around 42.6°F degrees, Wyoming has an advantage over its warmer, southern neighbors (National Solar Radiation Database). This report seeks to determine factors why Wyoming solar has not followed national trends and to quantify the revenue to the state from a utility-scale solar farm installation.

Wyoming Solar

Wyoming's Solar Resource

The main measurement used to describe a particular region's solar resource is global horizontal irradiance or GHI. GHI is the strength and concentration of the solar energy hitting a panel, and it accounts for 71.6% of performance variations in capacity factors (Bolinger, Seel and Wu, Maximizing MWh: A Statistical Analysis of the Performance of Utility-Scale Photovoltaic Projects in the United States 2016). The most concentrated solar resource in Wyoming occurs mainly around Sweetwater County, near the town of Rock Springs. At these locations, GHI ranges between 4.7 - 4.8 kWh/m^2/day. As can be seen in Figure 1, some parts of California, Nevada, Utah, Idaho, Oregon, Colorado, Kansas, Oklahoma, Texas, Louisiana, Alabama, Georgia, South Carolina and Florida have equivalent GHI as Sweetwater County (Esri 2017). Figure 2 shows a more detailed map of Wyoming's solar resource (Esri 2017).

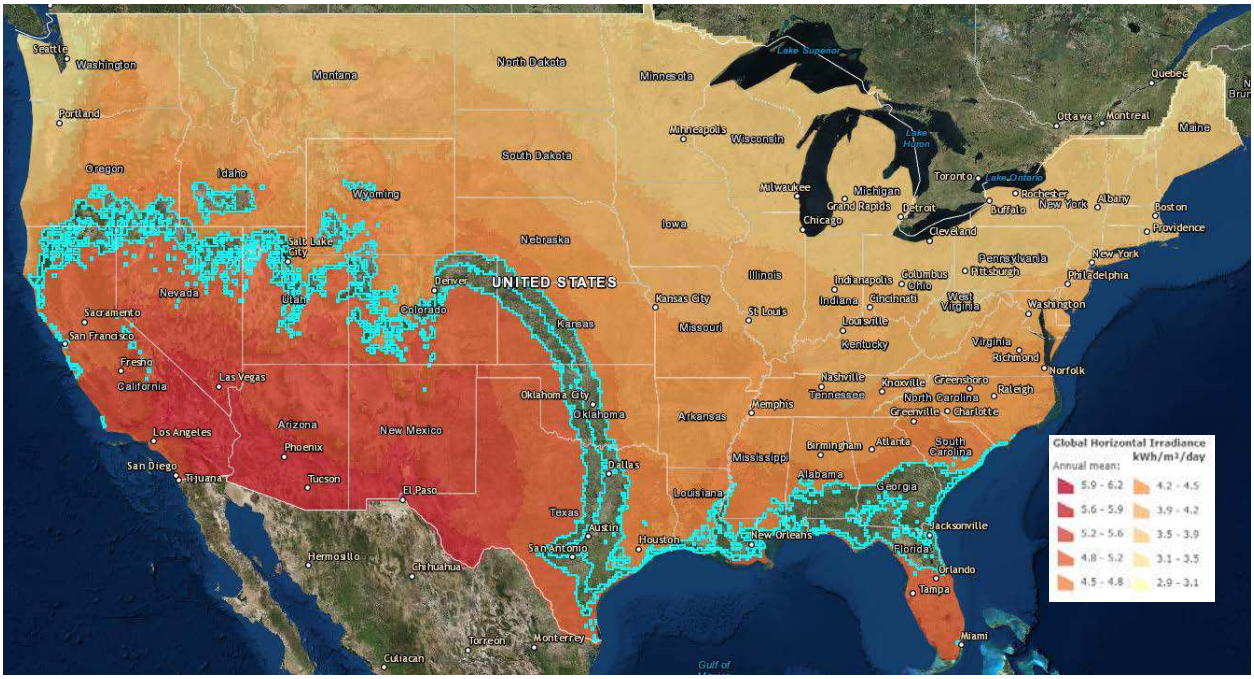

Figure 1 shows the Esri ArcGIS map of the United States. Highlighted areas are regions with a GHI of 4.7 - 4.8 kWh/m2/day (Esri 2017).

Though many geographical regions, mainly in the southwest, have GHI levels over 5.5 kWh/m^2/day, Wyoming has a distinct environmental competitive advantage over the southwest. All photovoltaic cells perform better at lower temperatures and lose capacity factor at higher temperatures (Bolinger 2016). With notoriously harsh winters and high elevations, the average temperature in Sweetwater County is 5.9°C (42.62°F). For comparison, the average temperature in Phoenix, AZ is 23.8°C (74.84°F) (National Solar Radiation Database). The "temperature coefficient" attribute of solar panels describes the power loss per increase in 1°C over 25°C (Schoder 2011). A typical solar panel may have a temperature

coefficient of -.45%. On an average summer day in Phoenix, at a temperature of 35°C, this would translate to a decrease in power output of -4.5%. Conversely, during a cold Wyoming day, it is common for the temperature to drop to -17°C. This would increase the power output of that same solar panel by 18.9%.

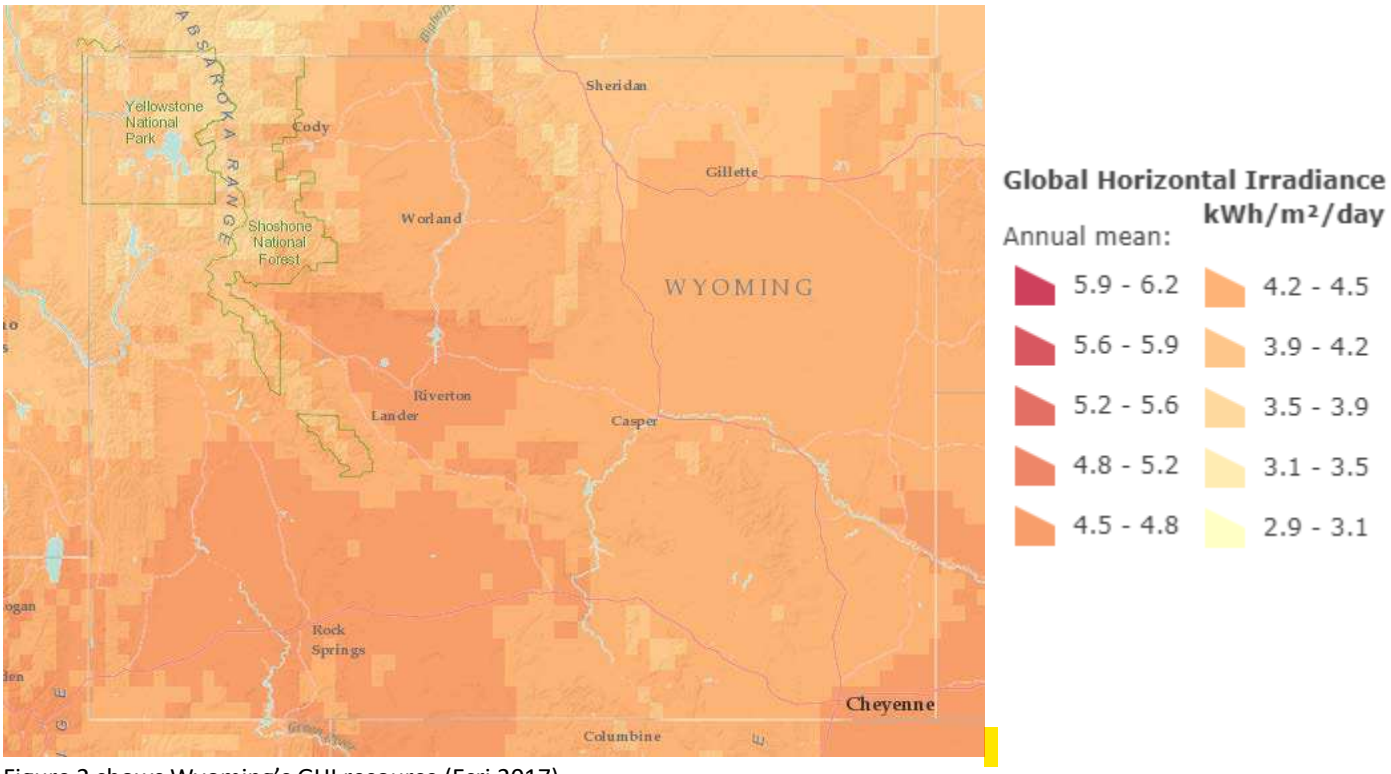

Figure 2 shows Wyoming's GHI resource (Esri 2017).

However, one must also consider the average amount of snow cover that a particular region would have. Solar panels partially or completely covered in snow, lose a significant amount of power output. According to a simulation run on NREL's System Advisor Model (SAM), a utility-scale solar farm located in Sweetwater County Wyoming could expect a 7.2% yearly energy loss due to snow. As can be expected, an identical solar farm located in the southwest of the United States should expect a virtually 0% energy loss due to snow (NREL 2010). Figure 3 shows a detailed NREL map of GHI within the United States (NREL 2009).

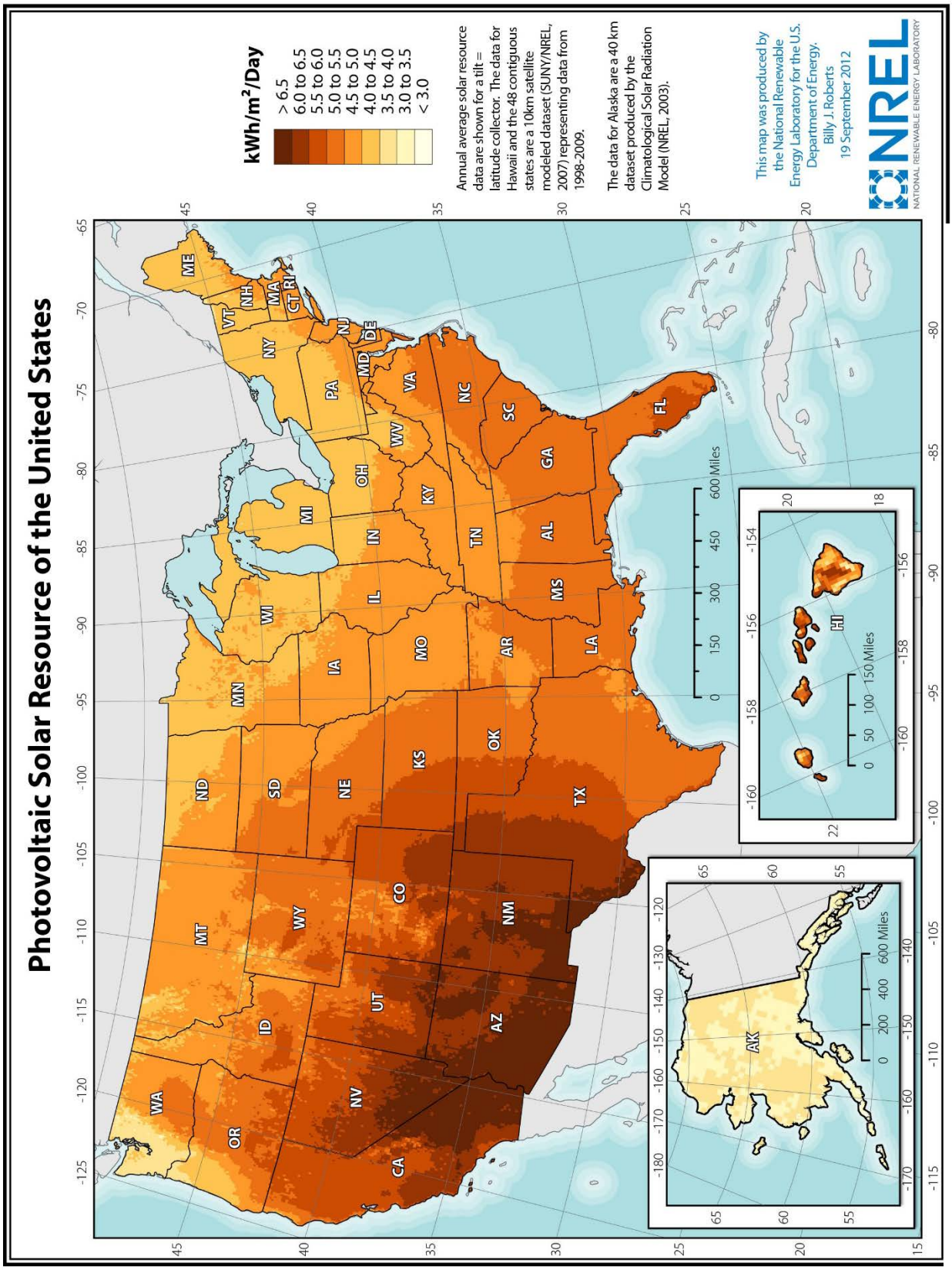

Figure 3 shows an NREL map of the Global horizontal irradiance levels within the United States (NREL 2009).

The Public Utility Regulatory Policies Act of 1978 (PURPA)

According to the Federal Energy Regulatory Commission (FERC), the Public Utility Regulatory Policies Act of 1978, known colloquially as PURPA, was created to promote:

- Electric energy conservation;
- Increased efficiency by the electric utilities;
- Fair electricity retail rates for customers;
- Swift development of hydroelectric power at existing dams; and
- Conservation of natural gas
  (Federal Energy Regulatory Commission 2016).

In addition to these goals, PURPA created a new class of energy generating facilities, known as a qualifying facility (QF). In order to qualify as a small power production facility, the primary source of energy must stem from renewable (hydro, wind or solar), biomass, waste or geothermal sources. Furthermore, these QFs must limit their size to 80 MW or less (Federal Energy Regulatory Commission 2016). This becomes especially important when analyzing new utility-scale solar projects. PURPA obligates a utility company to purchase a QF's power at the utility's avoided cost. The avoided cost is "the cost the utility would have incurred had it supplied the power itself or obtained it from another source" (The Bureau of Land Management 2017). If transmission lines are at or near their maximum capacity, because the utility cannot turn away a QF's electricity contribution, the utility may be forced to reduce their own electricity generation in order to make room for the QF's.

Ongoing Projects

There are several ongoing solar projects in the State of Wyoming. Though the largest of these proposed projects is only 80 MW, it is proof that Wyoming has not been entirely forgotten by the solar power community. Each of these individual projects has unique issues they must overcome in order to lift their projects off the ground. However, they all share many common issues which will be summarized in the "Development Issues" section.

Sweetwater Solar

Overview

Arguably the most significant solar project in Wyoming history, the first utility-scale solar farm in the state has been proposed in Sweetwater County. The company heading the 80 MW solar farm is Sweetwater Solar, LLC, which is a subsidiary of the Korean company Hanwha Q Cells. With a solar cell and module production capacity of 6.8GW, Hanwha Q Cells is one of the biggest solar manufacturers in the world (Hanwha Q Cells 2016). The proposed project will be located 11 miles NW of Green River, WY on 703 acres, 638 of which are on federal BLM land, as shown in Figure 4 (Sweetwater Solar Energy Project 2016, Hanwha 2017). The project is planned to include:

- The solar generation area made up of photovoltaic (PV) arrays, combining switchgear and the electrical substation;
- Monitoring and maintenance facilities;
- Access roads;
- A sub terrain 34.5-kV electrical collection system;

- A 2.5 mile, 150 foot wide, interconnection transmission line to tie the project to the existing Rocky Mountain Power Raven Substation; and
- Security and fencing (Hanwha Q Cells 2016).

Once the Sweetwater Solar energy project is fully operational, the 80 MW project would convert solar energy into an estimated 186,575 megawatt hours of electricity per year for a project life of 30 years. This translates to the amount of electricity needed to power almost 17,000 Wyoming homes each year. Depending on the individual capacity of the PV panels, the 80 MW farm could be composed of up to 250,000 solar panels, as is detailed in Figure 5. Including the frame, each panel would have dimensions of 6 feet 6 inches × 3 feet 3 inches x 1.5 inches (The Bureau of Land Management 2017).

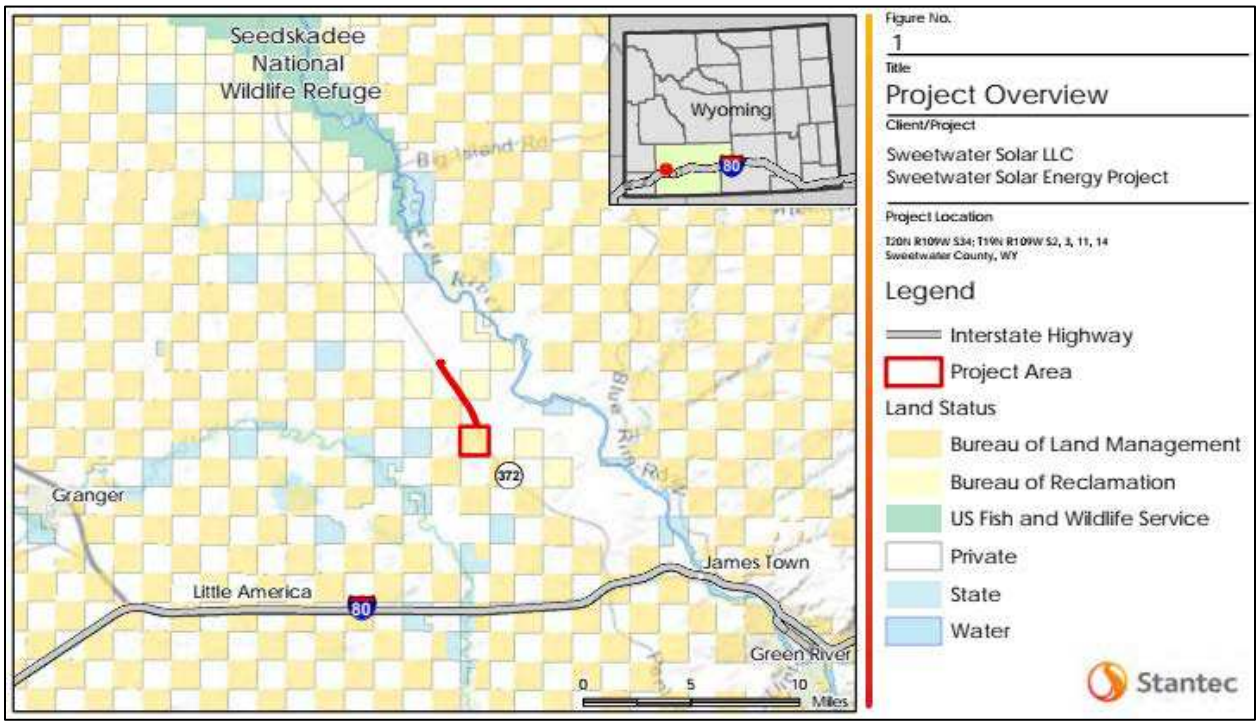

Figure 4 shows the Sweetwater Solar project overview (Stantec 2016).

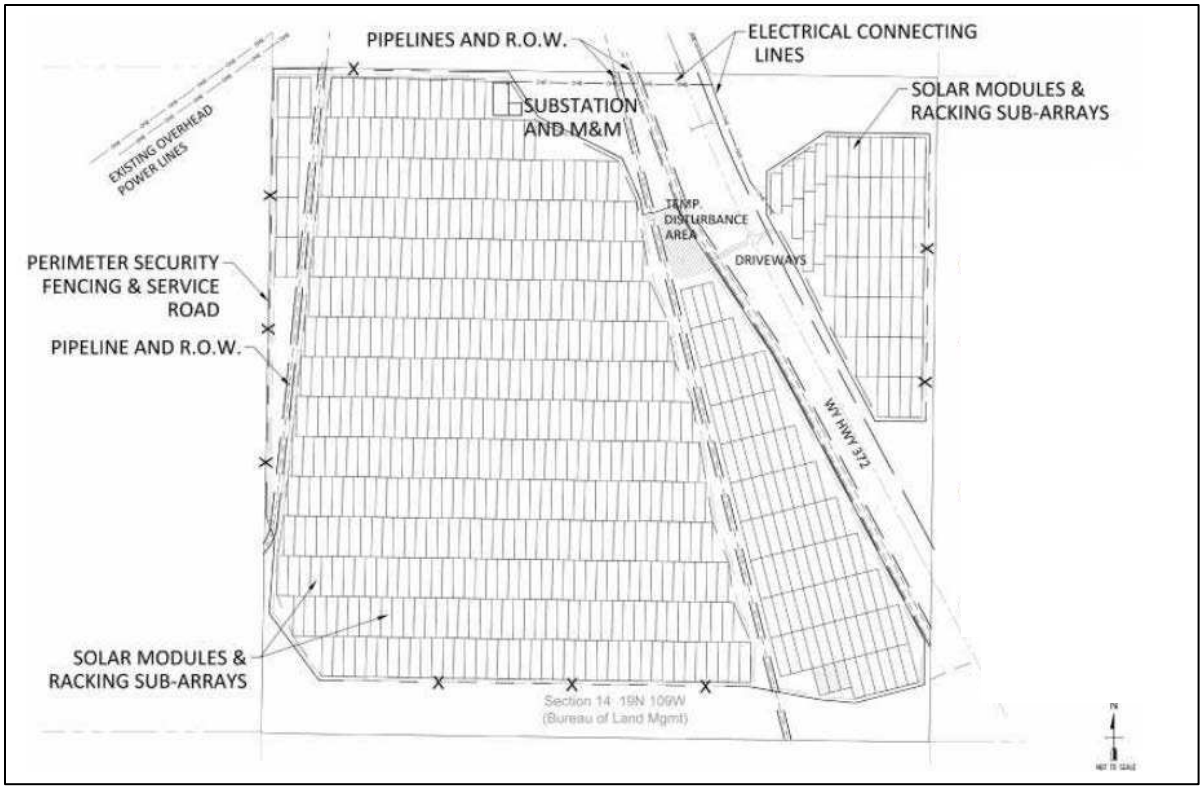

Figure 5 shows a detailed blueprint of the Sweetwater Solar project (Hanwha 2017).

Economic Impact

The Sweetwater solar project falls at the Qualifying Facility (QF) threshold of 80 MW set by the Public Utility Regulatory Policy Act of 1978 (PURPA). Therefore, the local utility, Rocky Mountain Power, is obligated to enter into a power purchase agreement (PPA) with Sweetwater Solar, LLC (Federal Energy Regulatory Commission 2016). Under the PURPA rules, Sweetwater Solar will have to sell the power generated by the solar project at the local utility's avoided cost. Currently, Rocky Mountain Power's average avoided cost for solar QFs are 3.025 ¢/kWh for peak energy times and 2.255 ¢/kWh for off-peak energy times (Rocky Mountain Power 2015). While levelized costs of solar power vary from project to project, the latest unsubsidized utility-scale cost range for solar power is 4.6 - 6.1 ¢/kWh. When taking federal tax subsidies into consideration, that same price range drops to 3.6 - 4.9 ¢/kWh (Lazard 2016). Comparing the levelized cost estimates with the avoided costs for Rocky Mountain Power, there appears to be a significant discrepancy in prices, not in favor of the solar producing company.

Sweetwater Solar, LLC estimates it will take 10 months for the project to be completed (Hanwha 2017). Over the life of the construction period, an average of 50 workers will be employed with a peak of 125 workers. The majority of the construction workforce will come in the form of construction workers and electrical company workers that will be hired under contract to Sweetwater Solar. After the construction phase is complete and the solar farm becomes operational, four to six full-time workers will be required to operate the farm over the 30-year life of the project (The Bureau of Land Management 2017). In addition to the full-time workers and their families that would more than likely reside in Sweetwater County for the 30-year life of the project, Sweetwater County is expected to receive approximately $20 million in tax revenue over the first 20 years of the project's life (The Bureau of Land Management 2017).

Status of Project

Though the original project roadmap had the Sweetwater solar project starting construction in mid to late 2017, they are currently still working on the overall environmental assessment (EA). These environmental studies and surveys are required by the federal BLM and include biological baseline surveys, cultural pedestrian surveys, pygmy rabbit field survey, and breeding bird field surveys. The biological baseline survey includes an analysis of the vegetation habitat, a survey of the permanent surface water and detailed observations of various wildlife living in the area such as pygmy rabbits, burrowing owls, sage grouse, and white-tailed prairie dogs (Hanwha 2017). If the EA concludes that the proposed solar farm would not have significant impacts on the environment, the BLM will issue a "Finding of No Significant Impact." At that point, the project would be officially approved and a right-of-way (ROW) grant would be issued allowing the company to "construct, operate, maintain, and decommission the Project" (The Bureau of Land Management 2017). As of the writing of this report, Crystal Hoyt, the realty specialist of the Rock Springs BLM office, estimates that a decision on the overall environmental assessment will not be made until late February of 2018. This highlights one example of the unanticipated setbacks that solar projects can encounter when permitting on federal land.

Another concern for solar developers in the Sweetwater County area is the issue of trona mining. Historically, trona has been mined in and around Sweetwater County since 1946 (City of Green River). The Sweetwater Solar energy project is located within the Known Sodium Leasing Area (KSLA) but outside the Mechanically Mineable Trona Area (MMTA). The KSLA and the MMTA are geologic boundaries where trona deposits are present in at least four and eight feet of thickness, respectively. Additionally, the MMTA is defined as trona deposits that must be at a "depth of less than 2000' and composed of at least 85% trona with less than 2% halite content" (Bureau of Land Management Rock Springs Field Office 2012). This means that though the land upon which the solar project is proposed is eligible for trona mining, the likelihood remains small that an operator would come in and mine that particular area. "By current mining methods, the MMTA is a more likely mining target. However, as solution mining technology advances, all lands within the KSLA become mining targets. At present all trona leases lie within the MMTA, however, there have been leases that were outside of it" (Nara-Kloepper 2017). Therefore though subsurface mining could still occur, the subsidence that occurs as a result of the mining would need to be kept to a minimum. However, the proposed project section is not leased for trona mining and there are no active applications for leasing on this land (The Bureau of Land Management 2017).

Jackson Community Solar

Overview

Currently, Teton County and the town of Jackson, WY are home to the largest concentration of solar panels in the state. Mostly owned by the Town of Jackson and Teton County, the total solar infrastructure in the area amounts to 512kW (Bruderer, et al. 2017). An example of one of Teton County's solar facilities is shown in Figure 6. The Jackson-based entity, Energy Conservation Works, has plans to add to this solar infrastructure by building Wyoming's first shared solar farm. Energy Conservation Works is a joint powers board made up of the Town of Jackson, Teton County, Lower Valley Energy (the local electric utility) and members of the public (Energy Conservation Works). Funded through private sources as well as energy specific public tax funds, Energy Conservation Works is proposing a 350-400kW shared solar project where individual members of the community could "buy-in" to the project. This proposed solar project is government owned by the Town of Jackson, and would,

therefore, be tax exempt. However, being tax-exempt does have its drawbacks as it would not be eligible for the federal tax subsidies such as the ITC or PTC (Cameron, Executive Director of Energy Conservation Works 2017). The Town of Jackson will own and operate the solar farm under a virtual net metering interconnection agreement with Lower Valley Energy. Other government agencies that operate in the local area will be given the option to buy-in to the energy project. As of October 2017, Teton County is expected to be the first government agency to join the shared solar project. It will then be opened to other public and government agencies such as Game and Fish, National Park Services, USFS, and BLM (Cameron, Executive Director of Energy Conservation Works 2017).

Figure 6 shows a solar generation facility built at the Integrated Solid Waste and Recycling Center in Teton County (Bruderer, et al. 2017).

Economic Impact

A project cost of $1 million for a ~375kW farm corresponds to roughly $2.66 per watt, which is slightly less than NREL's Q1 2017 cost benchmark for residential solar systems of $2.80 per watt. However, a 350-400kW solar farm falls under NREL's definition of "commercial" solar, which has a cost benchmark of $1.85-$2.13 per watt (Fu, et al. 2017). Therefore, upon initial inspection, it seems that the anticipated cost of shared solar in Teton county is significantly higher than the benchmark prices.

Because of the relatively small scale of the project and its tax-exempt status, there would not be a direct source of revenue to the county or state because of the project. Other than the initial jobs stemming from the construction of the solar farm, one could envision that at least one full-time job could be created to maintain and monitor the farm for the life of the project.

Status of Project

Still in the planning phase of the project, Energy Conservation Works has secured half of the estimated $1 million total budget for the solar project. Unlike solar projects proposed on federal BLM land, this project is being proposed on private land owned by the City of Jackson and Teton County. Therefore, there is significantly less bureaucracy to navigate. However, an issue that appeared early on was that of Virtual Net Metering (VNM). This concern has to do with the local utility, Lower Valley Energy (VLE).

VNM is an agreement between the solar farm owner and the local utility that outlines how credits for off-site solar energy production are processed (Bruderer, et al. 2017). Figure 7 shows an example of how VNM functions between the utility and an individual customer.

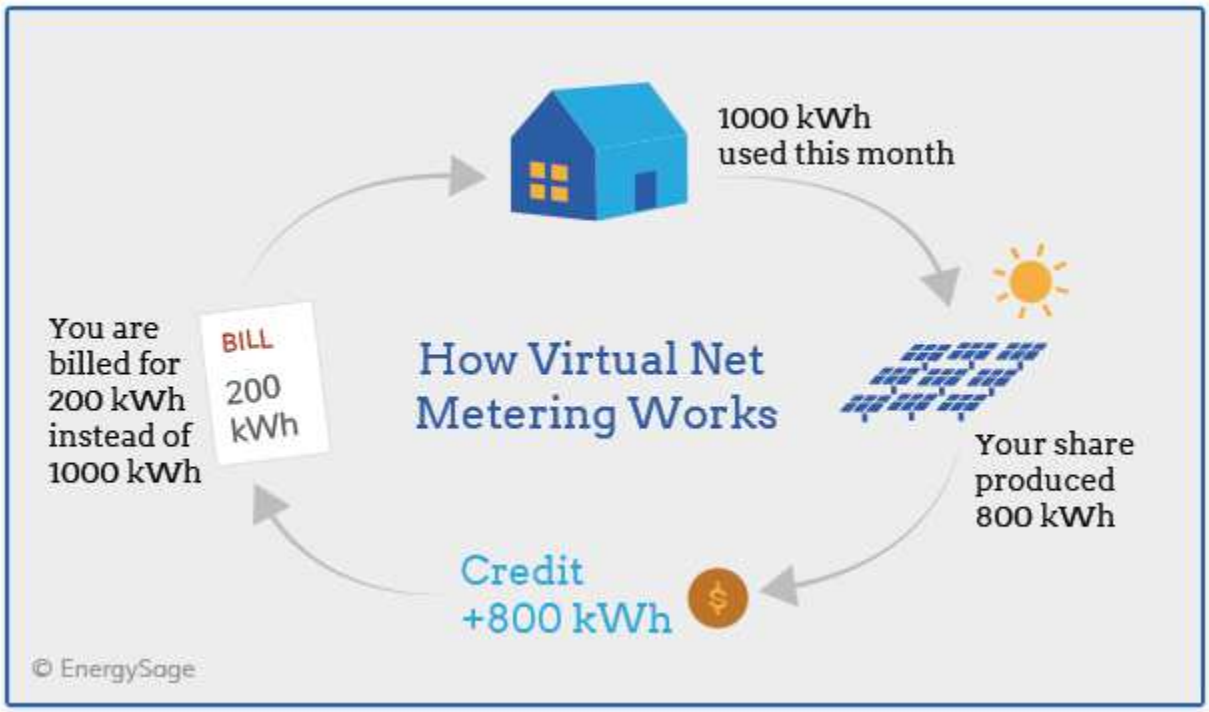

Figure 7 shows a Virtual Net Metering example (Richardson 2016).

However, laws allowing Virtual Net Metering are passed on a state-by-state basis. Currently, Wyoming neither explicitly allows nor denies VNM. However, Wyoming Statute 37-16-101 states that to be considered a "Net Metering System" the facility must have "a generating capacity of not more than twenty-five (25) kilowatts" (Wyoming State Statute). This is a potential concern for solar projects such as the 350-400kW one proposed by Energy Conservation Works. However, it seems that this law has not hindered the Town of Jackson and Teton County. Thanks to a positive relationship between Energy Conservation Works and Lower Valley Energy (the utility), both parties have reached an agreement for VNM for the proposed solar project and their existing ones. Under the current agreement, Lower Valley Energy agrees to purchase the solar kilowatt-hours produced by the Town of Jackson and Teton County at retail rate, up to their consumption threshold. Everything that is sold back to Lower Valley Energy over the consumption threshold of each individual facility is purchased at avoided cost (Cameron, Executive Director of Energy Conservation Works 2017). As an example, a 45 kW solar system installed at the Teton Country Recycling Center, generates 75,000 kWh per year. If the yearly total power consumption for the Recycling Center is 70,000 kWh, then the first 70,000 kWh would be bought by Lower Valley Energy at retail rate (a higher rate) while the remaining 5,000 kWh would be net metered back at avoided cost (a lower rate).

Orion Energy Renewables

Overview

Orion Renewable Energy Group LLC (Orion) is an energy developer with nearly 4,700 MW of renewable energy operating worldwide. The majority of their projects, 3,700 MW, come from US-based wind

energy development. In Wyoming alone, Orion has developed two wind energy projects in Carbon and Uinta County, totaling 185 MW (Orion Renewable Energy Group LLC 2017). With no currently operating solar projects in Wyoming, Orion is working to propose several 20MW solar installations in Sweetwater County. Orion originally chose Sweetwater County for the location of their project due to the area having one of the better solar resources in the state (Kurnick 2017).

Economics

Orion estimates that a 20MW solar project would take roughly 9 months to complete and would cost around $20-$25 million. It would require about 100 full-time positions during the construction period, and 5 ongoing positions for Operation and Maintenance (O&M), power sales and other employment (Kurnick 2017).

Status of Project

The project is still in the evaluation phase. Orion expects several of their 20MW projects to fall by the wayside while it is still hopeful that others will make it past the evaluation phase (Kurnick 2017). Though not constraining themselves with the 80 MW PURPA limitation, Orion recognizes the opportunity PURPA qualifying facilities provides smaller operations like the ones they are evaluating. However, one hurdle they must overcome is the fact that even though PURPA forces the utility to accept projects under 80 MW, the solar project is still responsible for interconnecting into the system. Interconnecting to an existing substation requires several costly upgrades and transmission costs that would be the financial responsibility of the solar project developer. Orion has had discussions with several private landholders and has looked into potentially locating their solar farms on state land. However, as they get deeper into the evaluation phase, they have encountered issues that they did not initially anticipate. These issues include soil subsidence, trona mining right of way, and environmental concerns. The Wyoming Game and Fish Department has objected to some of their locations due to sage-grouse habitats and crucial winter range for various species. Wyoming Game and Fish has been known to require up to two years of monitoring before construction can begin in addition to ongoing monitoring once the project is operational. Orion is “still investigating Wyoming as a whole” but “not necessarily in the same place as they originally thought” (Kurnick 2017).

Solar Financial Incentives

Renewable incentives are usually classified into two broad categories, local/state and federal.

Federal Incentives

Prior to January 1, 2017, solar developers could choose the Production Tax Credit (PTC) instead of the Investment Tax Credit (ITC). The ITC is now the only federal tax incentive program that can be applied to solar projects.

Investment Tax Credit (ITC)

Started under The Energy Policy Act of 2005, the ITC has been extended multiple times to allow for a dollar-for-dollar reduction in the income tax that a person or company would otherwise have to pay the federal government. The ITC is calculated based on the investment amount in the solar property or project. Under the current law, a qualifying residential, commercial or utility solar project that begins construction before the end of 2019 is eligible for an ITC equal to 30% of the amount invested in the solar property. For projects beginning construction in 2020, the ITC steps down to 26%, and then 22% in 2021. After 2021, the ITC for residential solar goes away completely while the ITC for commercial and

utility projects remains at 10% in perpetuity. Advocates of the federal incentive point to the fact that since the ITC was signed into law in 2006, "annual solar installations have grown by over 1,600% - a compound annual growth rate of 76%" (The Solar Energy Industries Association 2017).

Wyoming-Based Incentives

While 28 states have enacted regulations in the form of renewable portfolio standards (RPS), Wyoming has yet to adopt any such regulation, as seen in Figure 8. Renewable portfolio standards require utilities within a state to sell a predetermined amount of renewable electricity from sources such as wind, solar, biomass, or geothermal. This forces the hands of utilities that might otherwise prefer non-renewable means of electricity generation due to low costs. However, because Wyoming does not have a state income tax, it offers a financial advantage over states that do. In addition to RPSs, some states have "solar carve-outs" which require a certain percentage of renewable energy to be generated from solar projects; Wyoming has no carve-outs (National Renewable Energy Laboratory). Proponents of RPS's argue that these policies "can be integral to many state efforts to diversify their energy mix, promote economic development and reduce emissions" (Durkay 2017). Conversely, opponents of such regulations maintain that forcing RPSs on utilities unfairly burdens them, increases the price of electricity for consumers, and punishes more affordable forms of power generation such as coal and natural gas.

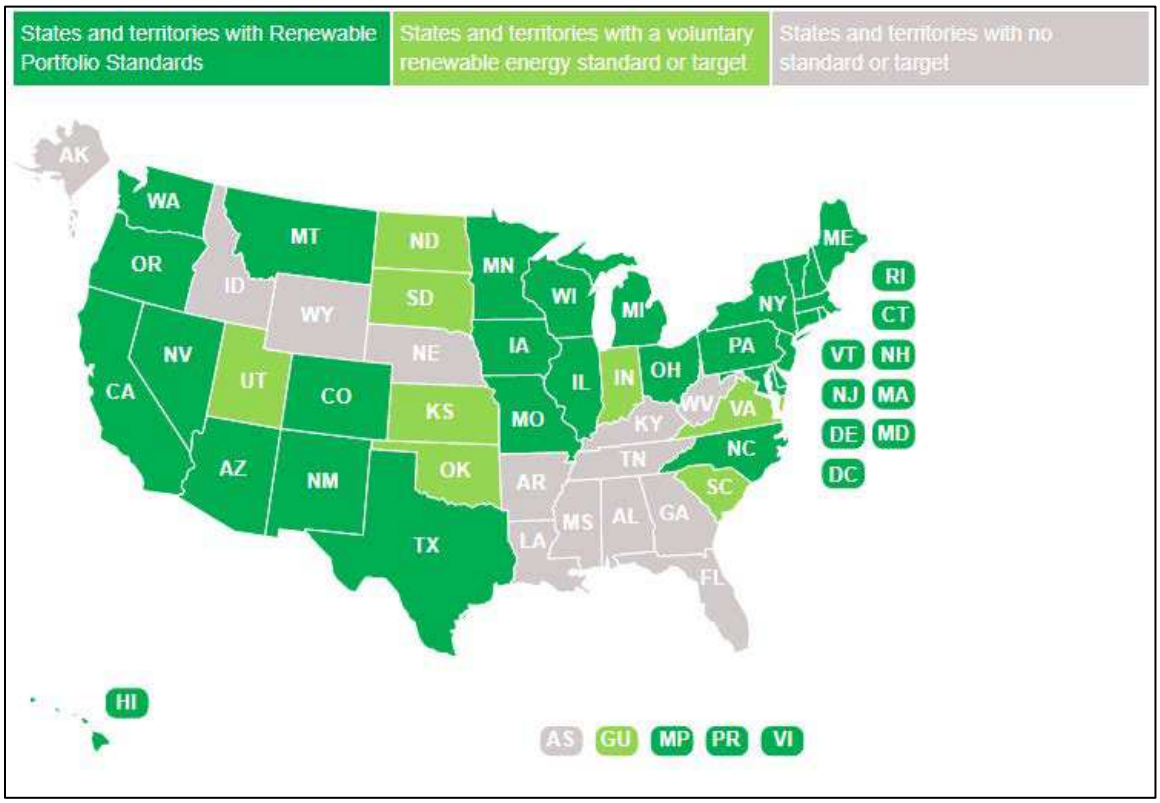

Figure 8 shows a map of the US detailing whether or not each state has adopted a RPS (Durkay 2017).

Development Issues

Often times, no single issue determines the profitability or feasibility of a solar project. Instead, one must take into consideration a multitude of issues from many different angles including tax, legal, permitting, and technical limitations. As such, the issues of transmission, PURPA, generation taxes, net metering laws and BLM permitting requirements must be considered when developing a solar project in Wyoming.

Transmission

Though many issues come up while planning a utility-scale solar farm in Wyoming, perhaps the most important issue is that of transmission capacity. Figure 9 shows a map of Wyoming along with transmission lines and electricity generating facilities (Stafford 2012). For many years now, Wyoming has been operating at maximum transmission capacity. This means that any additional significant power generation resource would necessitate the development of new transmission lines for exporting Wyoming's electricity outside the state (Stafford 2012).

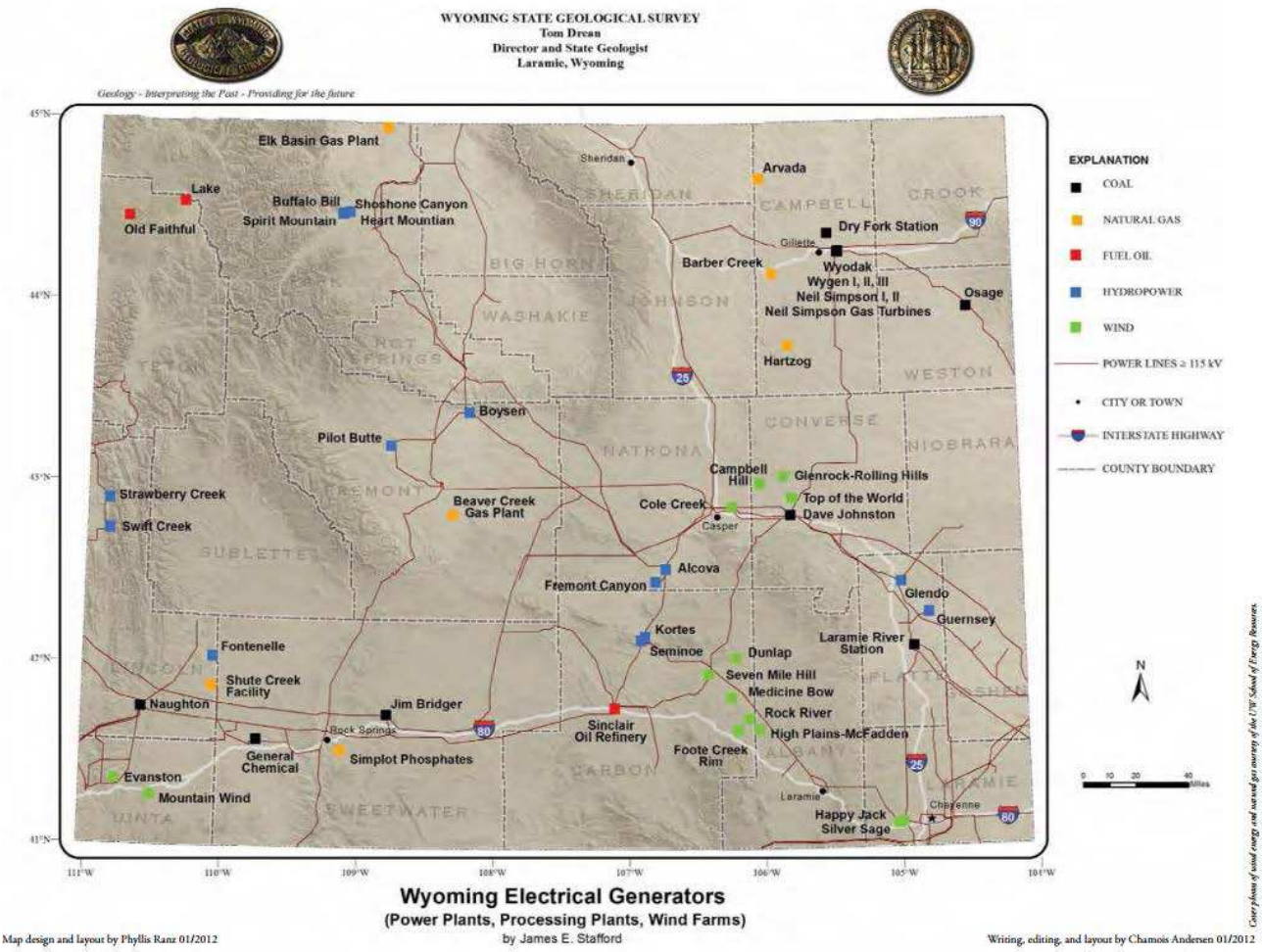

Figure 9 shows Wyoming transmission lines and electricity generating facilities (Stafford 2012).

The Western Electricity Coordinating Council (WECC) defines two exporting "paths" that lead out of Wyoming, path 19 and path 36. One measure of congestion on a WECC path is the U75 metric, which measures the percent of time the flow on a transmission path is above 75% of the path's operating limit or operating transfer capability (OTC) (Western Electricity Coordinating Council 2016). Figure 10 shows a graph of actual electricity flow for path 19-Bridger West for 2010. Though the U75 in 2010 for path 19 was 66.4%, the graph clearly shows that while not constantly at maximum capacity, the actual flow of electricity reached the path's OTC on several occasions (Western Electricity Coordinating Council 2013). This effectively has the effect of "maxing" out the transmission line.

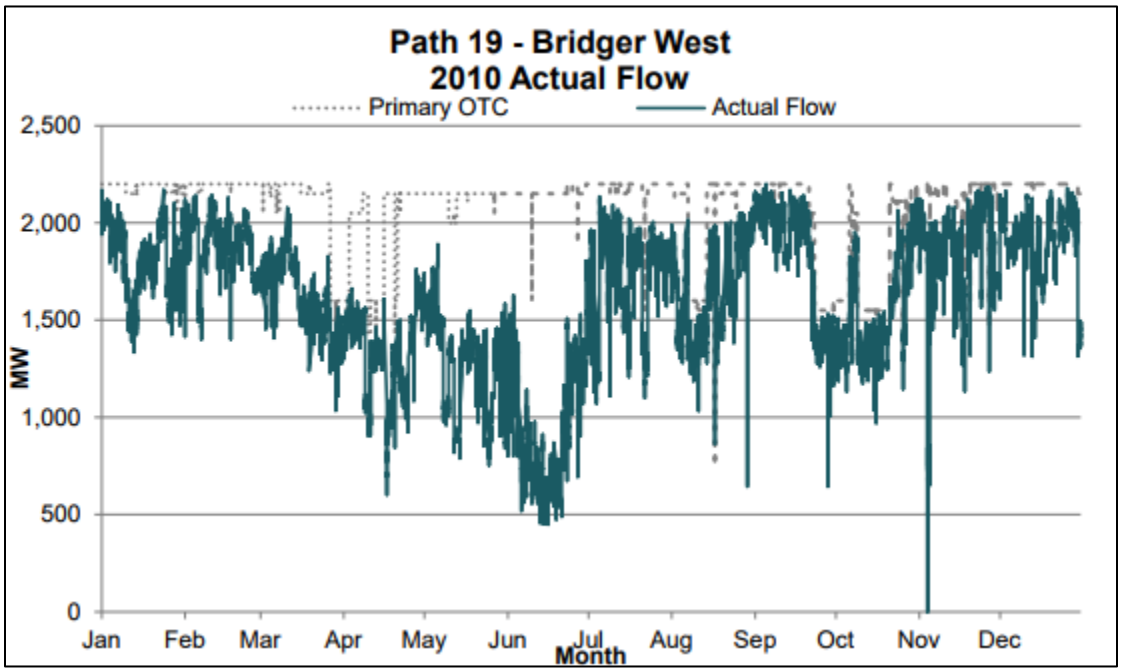

Figure 10 details electricity flow for "path 19-Bridger West" for 2010 (Western Electricity Coordinating Council 2013).

Therefore, before any significant new electricity generating facilities can be built in Wyoming, one of two things must first happen: existing power generating resources need to be retired, or new transmission lines must be created. When a small PURPA QF is proposed, the electric utilities compensate for the addition of the new electricity by decreasing their own output. This ensures the transmission lines do not get overloaded. However, when a large project, such as the 3,000MW Chokecherry and Sierra Madre Wind Energy Project, is proposed in southwest Wyoming, new transmission becomes a requirement. As such, Transwest Express is developing a 730 mile, 3,000 MW transmission line to deliver the Chokecherry and Sierra Madre Wind Energy to Las Vegas, Southern California and Phoenix (Transwest Express 2017).

PURPA limitations

Because of Wyoming's transmission line limitations, any new utility-scale solar projects in the state will be limited by the 80MW PURPA regulation. PURPA essentially guarantees the QF will be allotted transmission capacity on existing lines. It is not difficult to envision a situation where enough individual 80MW QFs are developed to cause significant problems for the utilities. The total power generated in

the state is limited by the existing transmission capacity, so for every QF added, the electricity generated by the electric utility's power plants must be decreased.

Generation tax

Wyoming has a reputation of not being friendly to renewable energies. One source of this is the fact that Wyoming does not have a renewable portfolio standard (RPS), as detailed in the Wyoming-based incentives section. Another example is the fact Wyoming is the only state to impose a generation tax on wind energy. The state levies a generation tax of $1/MWh for wind electricity and legislators have considered bills that would have increased the tax to $3 or $5 per megawatt hour (Deaton 2017). Though there is currently no generation tax on solar power, developers are worried that the state legislators will eventually tax solar similarly to wind. In fact, last legislative session, a proposed bill called the "Electricity Production Standard" would have limited electricity generation from a list of 6 approved sources including oil, natural gas, nuclear, hydropower and coal. Because wind and solar were left off the approved list, they would have been subject to a generation tax penalty of up to $10/MWh (Pentland 2017). This bill was ultimately killed and never stood a chance of making it out of committee. However, some argue that the entire purpose of proposing the bill was to send a message to renewable energy developers: "You are not welcome here." Supporters of the bill reason that renewable energy sources receive federal tax breaks that traditional energy sources, such as coal, do not benefit from. Additionally, unlike solar power utilities, non-renewable resources such as coal are charged a severance tax for the fuel they take out of the ground. As a result, proponents of the bill insist solar and wind projects have an unfair advantage over traditional sources, and that imposing generation taxes on renewable energies serve as a method of leveling the playing field. Increased taxes affects the bottom-line for investors in solar projects. Much of the funding for utility-scale solar projects comes from banks and Wall Street. When these investors see Wyoming attempt to pass a renewable energy generation tax, it signals to them that investing here is riskier than investing in neighboring states.

Net Metering and Virtual Net Metering

Net metering and virtual net metering issues do not affect utility-scale solar projects. Instead, these restrictions apply to customers that would like to offset some or all of their electricity burden by installing their own distributed energy resources (DERs) or by buying-in to a mid-scale community solar project. Net metering is a billing mechanism that credits homeowners who have installed solar panels at their homes for the electricity they add to the grid. As an example, "if a residential customer has a PV system on the home's rooftop, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backward to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Customers are only billed for their 'net' energy use" (Solar Energy Industries Association 2017). As mentioned in the Jackson Community Solar section, Wyoming Statute 37-16-101 states that to be considered a "Net Metering System" the facility must have "a generating capacity of not more than twenty-five (25) kilowatts" (Wyoming State Statute). The US average for those with installed solar panels at their homes is a 5 kW system (Matasci 2017). Therefore, the Wyoming statue limiting net metered DERs does not affect many individual homeowners trying to alleviate their electricity consumption from the grid. However, this potentially affects most community solar or mid-scale solar projects that seek to power a significant (>25 kW) commercial or residential operation using net metered DERs.

Permitting Requirements

Regulation, permitting and "jumping through hoops" complaints are heard from any developer who has ever tried to lease BLM land for the purpose of an energy project. Among other requirements, the BLM requires the completion of an overall environmental assessment (EA) document before any construction can begin. The EA is a lengthy document that can take months or even years to complete. It can include such topics as proposed action and alternatives, cultural resources, Native American concerns, historic trails, paleontological resources, grazing allotments, range management, soil analysis, vegetation, water resources, wildlife and fisheries resources, special status species, environmental consequences, and cumulative impacts (Bureau of Land Management 2017). Once the EA is completed, the BLM will make a decision as to whether or not the proposed energy project will have significant impacts on the environment. If approved, a right-of-way (ROW) grant would be issued allowing the company to "construct, operate, maintain, and decommission the Project" (The Bureau of Land Management 2017). None of these BLM reports need to be created if a project were to be situated on 100% private land.

Other than the BLM impediments, Wyoming Game and Fish have their own regulations. The Wyoming Game and Fish Department is particularly concerned about sage-grouse habitats and crucial winter range for various species. The Game and Fish has been known to require up to two years of wildlife monitoring before construction can begin on top of ongoing monitoring once the project is operational.

Historically, Wyoming has been a mineral-rich state. Therefore, laws and regulations are written in such a way that mineral rights take precedence over surface rights. Therefore, if an underground resource is found to be located under a previously existing solar facility, the mineral rights owner would legally be able to displace the solar farm. While this may seem like an unlikely scenario, it is one more concern that solar developers share when proposing a project.

Economic Impact for Wyoming

If a utility-scale solar farm were to be built in Wyoming, how much revenue would the state see and what economic impact would it have on the local economy? An economic Excel model was created and highlights from the model are detailed below. The three solar farm sizes explored for tax revenue and job generation are:

- 100 MW (A/C) solar utility farm;
- 500 MW (A/C) solar utility farm (size of a typical coal power plant); and
- One TW (1,000 MW) (A/C) solar utility farm.

Inputs and Assumptions

- All cases are assumed to be located in Sweetwater County, WY. The data is taken from the National Solar Radiation Database (NSRDB). The station ID is 24027, the city is Rock Springs, the elevation is 2056m, the global horizon irradiance (GHI) is 4.66 kWh/m^2/day, the average temperature is 5.9°C (42.62°F), and the maximum snow depth is 20cm (National Solar Radiation Database).
- The cost benchmark for fixed-tilt utility-scale solar systems is based on the Q1 2017 NREL PV cost of $1.34/W AC (Fu, et al. 2017).
- O&M expenses are $15.4/kW/year (Fu, et al. 2017).

- Assume a year-one capacity factor of 18.5%, with an annual degradation of 0.75% (Fu, et al. 2017).
- Insurance costs $7,092/MW/year based on NREL's System Advisor Model (SAM) (NREL 2010).
- Assume an inflation rate of 2.5%.
- PPA agreement price levels were varied between 3.0 ¢/kWh (avoided costs), 6 ¢/kWh, 8 ¢/kWh and 11 ¢/kWh with a 3.75% price escalation per year (Rocky Mountain Power 2015).
- Assume a project life of 30 years for income generation.
- Assume a land lease cost of $299/acre and an average of 7 acres/MW (Bureau of Land Management 2016).
- Assume no solar generation tax for the life of the project.
- Assume a 4% state wide sales tax, and an additional 2% local sales tax, for a total of 6% sales tax.
- Hard costs are assumed to be 59% of total installed costs (Fu, et al. 2017).
- Depreciation is calculated as straight line for a 20-year life, assuming no salvage value (Scherden 2017).
- Property tax for all commercial and industrial properties in Wyoming (which would include solar), is assessed at 11.5%. The average county mill levy in Wyoming is 68 mills, or 6.8%. Therefore the effective tax rate is 11.5% * 6.8% = 0.782% of the total value of the property. There are two main approaches to valuing a public utility in Wyoming: the Cost Method and the Income Approach method.
    - The Cost Method: During the first few years of a new public utility project in Wyoming, the cost method is used over the income method. This is because the operation has not yet shown an income pattern which the appraiser can use to predict a future income. Therefore, the actual "book value" of the solar farm is used for the first 3 years of the solar facility's life. Depreciation of assets must be accounted for in order to determine the book value for that particular year. For example, if the installed cost of a solar project is $10 million, then the property tax using the cost method is equal to $10 million * 0.782% = $78,200 (Scherden 2017).
    - Income Approach Method: This method is used in conjunction with the Cost method after the first three years of the project. The appraiser predicts an estimated future net operating income (NOI) of the solar facility. Net operating income equals (gross revenue from electricity sales) - (O&M costs) – (land leasing costs) - (insurance costs) – (property tax). That amount is then divided by an 8% capitalization rate to yield an overall value for the farm (McKinley 2014). As an example, if the appraiser estimates a solar farm will generate $1 million of NOI next year, that amount is divided by a 8% capital rate to come up with overall value: $1 million /8% = an overall value of $12.5 million. The property tax would then be calculated by: $12.5 million * 0.782% = $97,750 (Scherden 2017).
    - For the cases in this economic study, after year three, a weighted average of the cost (75%) and income approach (25%) method is used for determining the overall value of the solar farm.

Results

Tax Revenue from Solar Facility

The direct revenue that Wyoming receives from the development of a utility-scale solar facility comes from sales and property tax. Sales tax is independent of the PPA price of electricity. However, property tax, when calculated using the income approach method (after year 3), is heavily dependent on the PPA price. Therefore, each utility size scenario (100 MW, 500 MW and 1 TW) was analyzed at four PPA costs: 3 ¢/kWh (avoided cost), 6 ¢/kWh, 8 ¢/kWh and 11 ¢/kWh. Figure 11 shows a summary table of the revenue Wyoming could expect from each scenario while figure 12 shows the sales tax received per project.

Plant Size	**100 MW**				**500 MW**				**1 TW**			
Total Installed Cost (millions $)	**$134**				**$670**				**$1,340**			
PPA Price (¢/kWh)	**3**	**6**	**8**	**11**	**3**	**6**	**8**	**11**	**3**	**6**	**8**	**11**
Total Revenue for Wyoming over 30 years (million $)	$21.9	$26.6	$29.9	$34.9	$109.5	$132.8	$149.4	$174.4	$218.9	$265.6	$298.8	$348.8
NPV of 30 year revenue (million $)	$11.3	$12.5	$13.3	$14.6	$ 56.6	$ 62.3	$ 66.6	$ 73.1	$113.2	$124.5	$133.2	$146.3

Figure 11 summarizes the tax revenues and NPV of those incomes from various solar projects and PPA prices (see excel document).

Plant Size	**100 MW**	**500 MW**	**1 TW**
Total Installed Cost (millions $)	**$134**	**$670**	**$1,340**
Sales Tax Received	**$4.74**	**$23.72**	**$47.44**

Figure 12 details the sales tax Wyoming can expect from the construction of utility-scale solar farms (see excel document).

100 MW Solar Project

The total installed cost for a 100 MW solar farm would be $134 million. At a 6% sales tax, Wyoming would receive over $4.7 million from the construction of the project alone. Over a 30-year period, depending on a PPA price between 3 ¢/kWh and 11 ¢/kWh, Wyoming can expect to receive between $21.89 and $34.88 million, equivalent to an NPV (at an 8% discount rate) between $11.32 and $14.63 million.

500 MW Solar Project

A 500 MW solar farm is estimated to cost $670 million. At a Wyoming assumed sales tax of 6%, the state would receive over $23.7 million from the construction of the solar farm. Depending on PPA price, Wyoming can expect to receive between $109.46 and $174.38 million over a 30-year period, equivalent to an 8% NPV of $56.61 to $73.13 million.

One TW Solar Project

The cost to install a one TW solar farm would be $1,340 million. Wyoming would receive over $47 million in sales tax revenue from the construction of the project alone. Over a 30-year period, depending

on PPA price, Wyoming can expect to receive between $218.93 and $348.77 million, equivalent to an 8% NPV between $113.22 and $146.26 million.

Job Generation

Construction times for solar farms vary according to many factors, including plant size. A three-year construction period for solar farms with a capacity larger than 500 MW is used as a rule of thumb. For projects smaller than 500 MW, the construction time drops to between 2.5 years.

Construction Phase

An average of 2.3 full-time equivalent (FTE) construction job years are created per MW of solar installed (Philips 2014). A 100 MW plant that takes 2.5 years to build will create 230 FTE job years, equivalent to 92 full-time jobs during the construction period. Similarly, a 500 MW plant that takes 3 years to construct will yield 1,150 FTE job years, equivalent to 383 full-time jobs for the construction period of the farm. Finally, a one TW solar plant would take 3 years to construct and could generate 2,300 FTE job years, equal to 767 full-time positions needed per year during the construction phase of the solar facility.

In Wyoming, a full-time construction worker's average yearly wage is $48,908 (Wyoming Department of Workforce Services 2017). Therefore, a 100 MW solar farm would pay out over $11.2 million in wages over the construction period, a 500 MW facility would pay over $56.2 million in construction wages, and a one TW farm would pay nearly $112.5 million in wages over the construction period. The Wyoming Department of Workforce Services estimates that the average Wyoming full-time employee household pays $1,542 in state and local taxes each year in the form of fines and fees, motor vehicle licenses, property tax, sales tax and other tax (Manning 2017). Consequently, construction workers for a 100 MW, 500 MW and 1 TW solar farm would pay state and local taxes of $0.35 million, $ 1.77 million and $3.55 million, respectively. Figure 13 summarizes the job creation, wage income and local taxes paid for the construction phase of solar facilities.

	Construction Phase		
Plant Size	100 MW	500 MW	1 TW
Construction Time (years)	2.5	3.0	3.0
FTE Construction Job Years	230	1,150	2,300
Full-time Construction Jobs	92	383	767
Yearly Average Wage	$ 48,908	$ 48,908	$ 48,908
Total Wages	$ 11,248,840	$56,244,200	$ 112,488,400
State & Local Tax paid per Worker	$ 1,542	$ 1,542	$ 1,542
Total State & Local Tax paid	$ 354,614	$ 1,773,300	$ 3,546,600

Figure 13 summarizes the job creation, wage payments and state and local tax contributions of utility-scale solar farms during the construction phase.

Operations & Maintenance Phase

Though the typical solar facility has an operational life of 25-30 years, for this study we assume every plant has a life of 30 years. On average, one full-time worker is needed for operations and maintenance

(O&M) per 31.1 MW of solar capacity. This means that for a 100 MW plant, 3 to 4 full-time workers will be needed for the 30-year life of the project, equal to about 96 FTE job years. Likewise, for a 500 MW facility, 16 to 17 full-time jobs will be created for 30 years, equivalent to 482 FTE job years. Lastly, for a one TW solar farm, 32 to 33 full-time jobs will be created for the 30-year life of the facility, equal to about 965 FTE job years.

The average yearly salary for a solar O&M employee is $69,250 (Philips 2014). Thus, over the 30-year life of the solar facilities, a 100 MW, 500 MW and 1 TW solar power plant would pay their O&M employees $6.68 million, $33.4 million and $66.8 million, respectively. As mentioned earlier, an average Wyoming household pays $1,542 per year in various state and local taxes. This translates to $0.15 million, $0.74 million and $1.49 million paid in taxes to Wyoming over a 30-year period for a 100 MW, 500 MW and 1 TW solar facility, respectively. Figure 14 summarizes the job creation, wage income and local taxes paid for the O&M phase of solar facilities.

	O&M Phase		
Plant Size	**100 MW**	**500 MW**	**1 TW**
Operation Life	**30**	**30**	**30**
FTE O&M Job Years	**96**	**482**	**965**
Full-time O&M Jobs	**3.2**	**16.1**	**32.2**
Yearly Average Wage	**$ 69,250**	**$ 69,250**	**$ 69,250**
Total Wages	**$ 6,680,064**	**$33,400,322**	**$ 66,800,643**
State & Local Tax paid per Worker	**$ 1,542**	**$ 1,542**	**$ 1,542**
Total State & Local Tax paid	**$ 148,727**	**$ 743,730**	**$ 1,487,460**

Figure 14 summarizes the job creation, wage payments and state and local tax contributions of utility-scale solar farms during the O&M phase.

Economic Summary

The building of solar farms will generate revenue for the state of Wyoming in three direct ways: sales tax, property tax, and local taxes paid by employees. A 100 MW solar facility will pay between $21.9 and $34.9 million in sales and property tax, depending on PPA price. Additionally, this facility has the potential to generate 326 full-time equivalent (FTE) job-years, paying over $17.9 million in wages to employees over the 30-year life of the facility. In turn, these employees and their households will contribute over $0.5 million in state and local taxes.

A 500 MW solar facility will pay between $109.5 and $174.4 million in sales and property tax, dependent upon PPA price. Furthermore, this solar utility will create 1,632 full-time equivalent (FTE) job-years, paying its employees over $89.6 million in wages over the 30-year life of the project. These solar employees and their households will then contribute over $2.5 million in state and local taxes.

A one TW solar utility will pay between $218.9 and $348.8 million in sales and property tax, based on PPA price. Moreover, a solar facility of this size will create 3,265 full-time equivalent (FTE) job-years, paying its employees over $179.2 million in wages over the 30-year life of the project. These solar employees and their households will then contribute over $5.0 million in state and local taxes.

Wyoming's Consensus Revenue Estimating Group's (CREG) latest revenue forecast for the state for 2017 is $2,837.4 million (Consensus Revenue Estimating Group 2017). Over the 30-year life of the project, a 100 MW solar plant can contribute between 0.8% and 1.2% of one year's worth of tax revenue for Wyoming, depending on PPA price. Similarly, a 500 MW solar plant would contribute between 3.9% and 6.2% of one year's worth of tax revenue for the state, depending on PPA price. Finally, a one TW utility solar plant would generate between 7.9% and 12.5% of one year's worth of tax revenue for Wyoming, depending on PPA price.

Putting job creation and tax revenue potential aside, it is important to note that the latest ITC subsidized, utility-scale levelized cost of electricity for solar power is between 3.6 - 4.9 ¢/kWh (Lazard 2016). Therefore, unless a solar developer can negotiate a PPA for more than their levelized cost of electricity, the project will not be economical for profit-seeking investors. The levelized costs do not include the significant added cost of building new transmission lines.

Conclusion

Though Wyoming has a solar resource that rivals solar producing states as well as a low average temperature that increases the efficiency of photovoltaic cells, Wyoming does not have a single utility-scale solar facility within its borders. While there are at least three companies trying to develop solar resources in the state, only the non-utility-scale Jackson Community Solar project is poised to begin construction anytime soon. Lack of utility-scale solar projects in Wyoming can be boiled down to four main issues:

1. Lack of transmission;
2. No Wyoming solar incentives;
3. BLM permitting requirements; and
4. An unfavorable legislative attitude towards solar.

The greatest single impediment to Wyoming building a utility solar facility, or any additional electrical utility-scale generating facility, is the lack of transmission. Because Wyoming only consumes 1/3 of the electricity it produces, the majority of Wyoming's electricity is sold and exported. Therefore, the limiting factor comes down to a lack of transmission. Building additional transmission lines increases the cost of any electricity-generating project and are therefore difficult to finance. The fact that Wyoming does not have a RPS forcing local utilities to include solar as part of their portfolio, explains why coal and natural gas continue to dominate the state's generating landscape. It is important to point out that while many states have a state income tax, Wyoming does not, which offers an implicit financial advantage to companies choosing to locate within the state's boundaries. Another issue is the complicated regulated process of permitting that comes with trying to develop a solar project on federally managed BLM land. The final issue, and arguably the least impactful, is the commonly held view that Wyoming laws and elected officials sometimes obstruct, and are generally unaccommodating to, the solar industry. This can be seen by proposed (and failed) solar and wind generation tax laws. While a small (<80MW) utility-scale solar facility can get its electricity accepted to existing transmission lines under PURPA laws, these projects would likely be uneconomical. This is mainly because under PURPA, utilities are only obligated to purchase power from a qualifying facility at their "avoided costs", which are lower than the levelized cost of electricity for the average utility-scale solar project.

A utility-scale solar farm would generate millions of dollars of tax revenue for the state and create some long-term full-time jobs. However, until additional transmission lines are built to increase Wyoming's exporting capacity, it is unrealistic to expect any large electrical utility project to locate itself in the state.

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