

Examining Solar Energy in Oklahoma



SIERRA CLUB OKLAHOMA CHAPTER

"To explore, enjoy and protect the wild places of the Earth; to practice and promote the responsible use of ecosystems and resources; to educate and enlist humanity to protect and restore the quality of the natural and human environment; and to use all lawful means to carry out these objectives." The Oklahoma Chapter of Sierra Club is dedicated to educating the public on a myriad of environmental issues related to improving the health, safety and well-being of all Oklahomans. We have funded the following document as part of a broad strategy to assure the State of Oklahoma firmly pursues a path towards a brighter future for our children by fully and firmly embracing clean energy.

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Examining Solar Energy in Oklahoma: A Study

Abstract

This report serves as an overview of solar energy in Oklahoma with identification of current U.S. market trends and future potential. States across the country with far less solar radiation than Oklahoma have vibrant and lucrative solar markets. The U.S. solar industry generated \$154 billion in economic activity in 2016, and is on a trajectory that will far exceed that figure in the coming years. Oklahoma, with the sixth best peak sun hours in the nation according to many reports, could and should have a substantial solar energy market.

The goal of this work product is to provide a better understanding of the possibilities solar energy can offer, and thus, convey the strong message needed to change public opinion and dispel myths about solar. The following quote provides a clear indication of the type of misconception that solar advocates often confront.

"One of the most persistent myths is that much of the United States suffers a climate too cloudy for solar to be effective. This is dispelled by the fact that Germany on average has about as much solar resource as Alaska, and far less than the US average, but leads the world in total solar capacity and "dominates the PV market" worldwide (NREL, 2011)."¹

While misconceptions about solar are common nationwide, Oklahoma is comprised of a citizenry that is devoutly loyal to the state's oil and gas industry, which makes embracing renewable energy - which some consider a threat - even more challenging. Unfortunately, renewable energy has been highly politicized in the state, so the false information that must be overcome is not insignificant. Optimistically, the factual data remains on the side of solar energy. Like the abundant wind resource in the state, solar can work in tandem with Oklahoma's natural gas resources to provide affordable, clean energy for generations to come.

Through four key sections, the study describes Oklahoma's erratic history with solar, highlights opportunities to develop the state's industry, illuminates the many ways solar promotes collaboration within and among the sectors, and finally, examines and compares the solar industries of states that are politically and geographically similar to Oklahoma, with states that have far fewer peak sun hours, in order to underscore Oklahoma's true potential. Indeed, when one examines the solar irradiance maps included with this report, anyone with knowledge of Oklahoma would say without hesitation, if those maps illustrated untouched oil and gas prospects, someone should aggressively pursue these energy assets and leverage them to benefit both individual citizens and the state's economy.

¹Stephan Wayne Schmidt, Integrating Solar Energy and Local Government Resilience Planning, June 2014. <https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=2294&context=theses>

Citizens of the states with robust solar industries are enjoying lucrative development opportunities, increased jobs, lower utility bills, and stronger, growing economies. This study aims to compile the relevant information, and present it in a straightforward way to promote and assist advocates and state leaders in successfully maximizing Oklahoma's solar potential.

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Oklahoma Solar Association

Formed in 2017, OSA's mission is to educate and advocate for policies that support renewable energy with a special focus on solar and its accompanying technologies. With collaborative assistance and support of members, OSA promotes and protects solar and storage investments and ideas in Oklahoma and beyond. OSA members believe solar energy holds the promise of maintaining Oklahoma's status as a world energy leader for generations to come.

September 1, 2018

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Executive Summary

The purpose of this study is to examine solar opportunities in the state of Oklahoma.² Solar energy is a sustainable and sound long term investment with growth of the U.S. industry predicted to reach \$422 billion by 2022.

There are four principal sections which include a brief *History* of solar energy, *Opportunities* for its further development, prospects for *Collaboration*, and a *Comparison* of other state's solar markets.

The history section describes the advent of solar as an energy source through present day. Oklahoma once had a burgeoning solar industry, but it dwindled for decades before resurfacing in the last several years.

The *Collaboration* section features the many ways states have leveraged solar energy to benefit all areas of society. From healthcare, education, and agriculture, to governments, the military, and the corporate sector, other states have shown how increasing solar energy provides unique educational opportunities, resiliency safeguards, lower utility bills, unique ways to lower greenhouse gas emissions and pollution levels, and programs that provide fair and equitable access to all citizens. Voluminous examples exist for Oklahoma to follow. The spirit of collaboration thrives in Oklahoma and with the addition of more solar energy opportunities, citizens across all 77 counties have a chance to benefit.

The state of Oklahoma shows great promise to support a viable solar industry as discussed in the *Opportunities* section. Oklahoma receives on average between 4.5 to 5.5 hours of peak sunlight daily, making it one of the top states for average peak sunlight hours.³ This gives the

²See attached images from National Renewable Energy Laboratory: Direct Normal Solar Resource of Oklahoma; Global Horizontal Solar Irradiance; Solar Power Rocks, Oklahoma Solar Report Card.

³Renogy, *Average Peak Sun Hours by State*, <https://www.renogy.com/template/files/AverageYPeakYSunYhoursYbyYState.pdf> (last visited Sep. 1, 2018).

State enormous potential for solar energy investment and production. Unfortunately, regulatory barriers and the lack of clear legislative support have hindered the growth of the solar industry in Oklahoma, causing the state to miss out on the economic benefits a strong solar industry has provided many other states. Despite its vast solar energy potential, Oklahoma ranks 42nd in the nation for installed solar energy production with a generating capacity of 45.91 MW.⁴ Until a June 2018 Oklahoma Attorney General Opinion, a major driver of residential solar systems, third party power purchase agreements (PPAs), were thought to be prohibited by state law.⁵ The lack of clear policy on PPAs coupled with the state's very limited net metering laws which do not require utilities to credit solar power producers for excess energy supplied to the grid resulted in the majority of the state's solar capacity being generated by utility scale facilities like OG&E's Mustang and Covington solar power plants.⁶ Notwithstanding the lack of supportive state solar policies, the solar industry has already invested over \$56 million dollars in the state, supporting 739 jobs through 33 solar companies. The recent AG opinion is a good step towards boosting the state's solar industry, specifically with distributed generation (small scale localized solar generation typically residential units). A robust solar industry will allow the State to diversify its energy portfolio and supply inexpensive clean energy to the Southwest Power Pool.⁷

The study concludes with the *Comparison* section which highlights the benefits of clear and supportive state policy. States like Georgia, Missouri, and Massachusetts are noteworthy examples. Georgia has become a leader in solar power by installing 1,552.98 MW, a figure more than thirty three times Oklahoma's current solar capacity.⁸ Georgia's \$2 billion solar industry is

⁴ Solar Energy Industries Association, *Oklahoma Solar*, <https://www.seia.org/state-solar-policy/oklahoma-solar> (last visited Sept. 1, 2018).

⁵ Office of Attorney General State of Oklahoma, *Attorney General Opinion 2018@5* (Jun. 26, 2018) [http://www.oag.ok.gov/Websites/oag/images/Documents/Opinions/AG/2018/AG%20Opinion%202018%5%20\(TY25\).pdf](http://www.oag.ok.gov/Websites/oag/images/Documents/Opinions/AG/2018/AG%20Opinion%202018%5%20(TY25).pdf).

⁶ Jack Money, NewsOK, *OG&E brings a second solar generating facility online* (Mar. 30, 2018, 5:00 AM), <https://newsok.com/article/5588946/ogeybringsYaYsecondYsolarYgeneratingYfacilityYonline>.

⁷ Solar Energy Industries Association, *Oklahoma Solar*, <https://www.seia.org/state-solar-policy/oklahoma-solar> (last visited Sept. 1, 2018).

⁸ Solar Energy Industries Association, *Georgia Solar*, <https://www.seia.org/state-solar-policy/georgia-solar> (last visited Sept. 1, 2018).

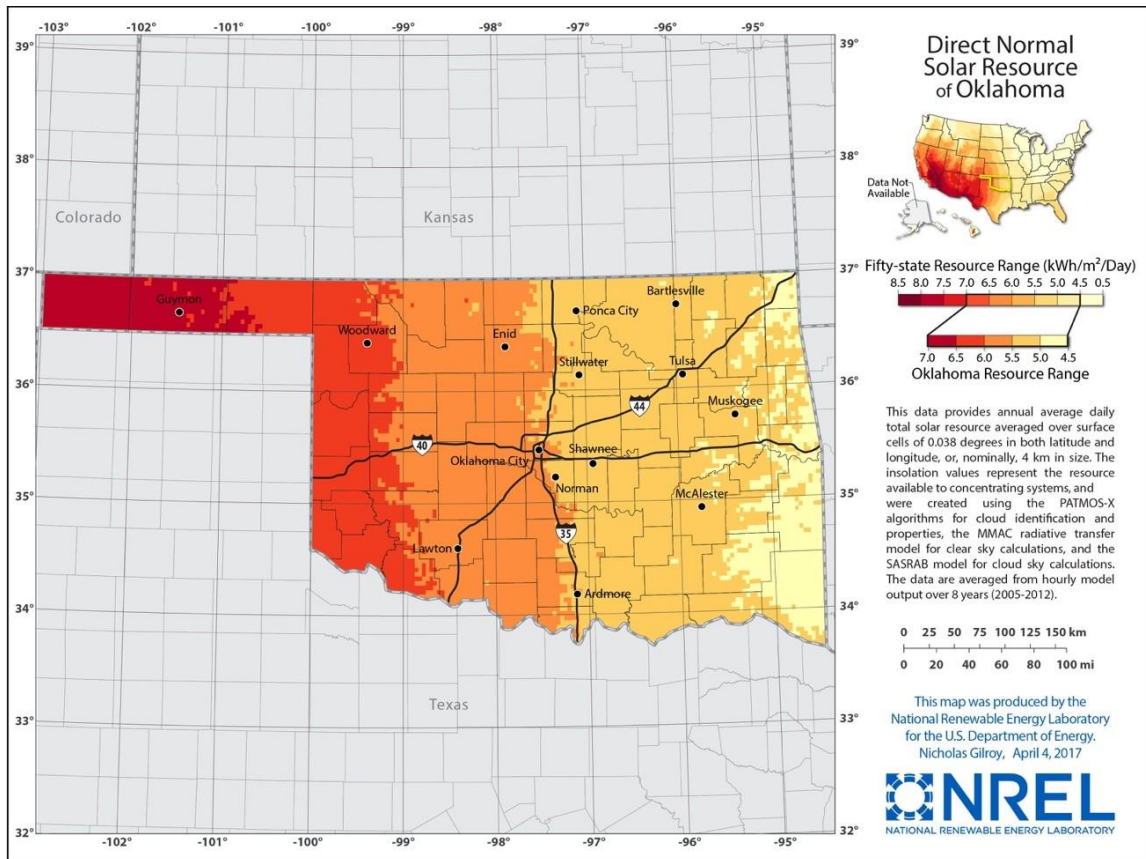
the result of a combination of generous net metering credits, a history of clean energy tax credits and codified permissibility of PPAs.⁹ PPAs in the state, allow consumers (typically residential consumers) to install solar systems at little to no cost, while reaping the benefits of reduced electricity bills. Oklahoma's neighbor, Missouri, has a \$500 million solar industry that has grown as the result of a Renewable Portfolio Standard law that requires 15% of the State's electricity production (with .3% from solar) come from renewable sources by 2021.¹⁰ To meet this RPS requirement several utilities offer rebates of up to \$5,000 for customers looking to install solar systems.¹¹ The state also offers a property tax exemption for solar installations. Massachusetts provides a great example of how a state with less average peak sunlight hours can grow a robust solar industry, through supportive state policies. Massachusetts' \$5.4 billion solar industry is the result of strong RPS laws, generous net metering credits, which can be carried forward on billing cycles, state tax credits, valuable solar energy certificates, property tax exemptions, and sales tax exemptions.¹² The state is also home to several community solar farms which allows groups of people to collectively benefit from net metering and lower electricity bills without needing to purchase and install their own individual systems. This makes solar power an option for customers who do not have the means to purchase or lease their own solar systems. Collectively, these states provide Oklahoma with a roadmap on how to grow solar power within the state.

⁹ SRG LLP, *A Win for Solar Energy in Georgia - SGR's Sustainability Practice Group Instrumental in Passage of HB 57* (May 12, 2015), <http://www.sgrlaw.com/pressreleases/sgrattorneyscelebrateenactmentofsolarenergyfreeYmarketYfinancingYactYofY2015/>.

¹⁰ Solar Power Rocks, *Missouri*, <https://solarpowerrocks.com/missouri/> (last visited Sept. 1, 2018).

¹¹ *Id.*

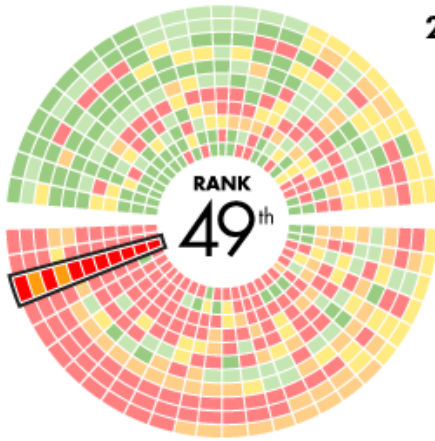
¹² Solar Power Rocks, *Massachusetts*, <https://solarpowerrocks.com/massachusetts/> (last visited Sept. 1, 2018).



Source: National Renewable Energy Laboratory

Oklahoma

2017 SOLAR REPORT CARD



Overall Grade: **F**

Policy

- D** RPS Law
- F** Solar Carve-Out
- D** Electricity Cost
- F** Net Metering
- F** Interconnection

Incentives

- F** Tax Credits
- F** Rebates
- F** Performance Payments
- F** Property Tax Exemption
- F** Sales Tax Exemption

5-kW Solar Payback Time: **16 Years**

Investment Return (IRR): **4.8%**

Source: Solar Power Rocks

EXAMINING SOLAR ENERGY IN OKLAHOMA: A STUDY

I. HISTORY OF SOLAR

Solar energy has had a multitude of uses in human history. During the Second Punic War in circa 212 B.C., Archimedes is rumored to have reflected the sun off a parabolic mirror to set enemy ships on fire.¹³ Much later, Albert Einstein won the Nobel Prize in Physics in 1921 for his 1904 work on the law of the photoelectric effect. But solar energy technology development actually began in earnest during the Industrial Revolution, long before Einstein's paper made the process more widely understood.¹⁴ Significant contributions to solar development that helped lead to Einstein's work came from French physicist Alexandre Edmund Becquerel, who is credited for first discovering the photovoltaic effect in 1839, and New York based inventor Charles Fritts, for installing the first rooftop solar array in 1883.¹⁵

By 1977 the U.S. Department of Energy launched the Solar Energy Research Institute, a federal facility dedicated to harnessing power from the sun. The agency would later become today's National Renewable Energy Laboratory (NREL). Enthusiasm for solar energy research, development, and deployment was at an all time high with President Jimmy Carter and his administration publicly and financially supporting it. The Energy Tax Act of 1978 (ETA) offered the commercial and residential versions of the investment tax credit (ITC) with up to \$2,500 to those who installed residential energy saving devices like wind and solar between 1977 and 1986. The residential ITC expired as planned in 1985, while the commercial ITC was continuously extended until it was made permanent in 1992. The effects of Carter's policies were noticed around the country, including in Oklahoma. A local paper back in 1985 highlighted

¹³ Zachary Shahan, *A Brief History of Everything Solar*, (Mar. 21, 2012), <https://cleantechnica.com/2012/03/21/history-of-solar/>. See also Joseph Calamia, *How Archimedes Burned Those Ships, Mirror or Steam Cannon*, (Jun. 28, 2010, 11:00 AM) <http://blogs.discovermagazine.com/discoblog/2010/06/28/how-archimedes-burned-those-roman-ships-mirror-or-steam-cannon/#.W3i8tZNKjq0>.

¹⁴ U.S. Department of Energy, Energy Efficiency and Renewable Energy, https://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf. (last visited August 9, 2018).

¹⁵ History of Solar Power, Matthew Sabas, Febr. 18, 2016. (last visited August 9, 2018). See also Nikki Chua, *Edmond Becquerel: The Man Behind Solar Panels*, (Jun. 16, 2016), <http://solenergy.com.ph/solar-panel-philippines-edmond-becquerel/>.

<https://instituteeforenergyresearch.org/analysis/history-of-solar-power/>, (last visited August 9, 2018).

Oklahoma’s “rapid increase” in the number of solar businesses in the state, specifically featuring those owned and managed by women.¹⁶ As a result, solar panels could be spotted on roofs in neighborhoods, and citizens joined together to promote an industry with much promise for the future. Oklahoma’s burgeoning solar industry was complete with its own local chapter of the national trade group Solar Energy Industries Association (SEIA), which was based in Norman and consisted of fifteen members in 1985. Unfortunately, that particular solar boom was short lived. Soon after President Ronald Reagan’s inauguration, the panels on the White House came down, followed slowly by panels across the country, and ultimately the policies that put them there were permitted to expire. Public enthusiasm for solar energy seemed to depart with President Carter amid waning worries about global energy supplies. An article in the *San Diego Union Tribune* lays out a timeline illustrating the connection between ownership and control of renewables by large oil companies and the decline in solar between the advent of the commercial industry in the late seventies and the plunge in the late nineties and early 2000s.¹⁷ The article’s author argues that solar progress was effectively prevented by oil companies that were heavily marketing oil while publicly denouncing solar energy’s ability to be a viable, affordable energy source.

Oklahoma leaders circled back to make renewables a priority again during Governor Brad Henry’s tenure, in an effort to assist the state in realizing NREL’s prediction that Oklahoma could be the second largest wind provider by 2030.¹⁸ In May of 2008, Governor Henry signed an Act that would allow utilities to recover investments made in wind transmission. Governor Henry also acknowledged the state’s desire to “harness every bit of capacity [it could] deliver to the nation’s grid”¹⁹, referring to Oklahoma’s membership in the Southwest Power Pool. Today, however, political party powers have shifted, and misunderstanding of the state’s production, consumption, and opportunities for energy exportation are widespread.

¹⁶ City Women’s Jewelry Design Business a Gem, M.J. Deventer, (Aug. 28, 1985), <https://newsok.com/article/2119428/cityYwomensYjewelryYdesignYbusinessYaYgem>.

¹⁷ Tracy Emblem, *How Big Oil Had Controlled the Solar Industry*, (Apr. 17, 2011), <http://www.sandiegouniontribune.com/sdutYhowYbigYoilYhadYcontrolledYtheYSolarYindustryY2011apr17Ystory.html>

¹⁸ Oklahoma became the nation’s second largest provider of wind by capacity in January 2018. https://www.ok.gov/portal/newsroom.php?news_id=418. <https://newsok.com/article/5581518/oklahomaYmovesYintoYno.Y2YspotYforYwindYpowerYcapacityYinYtheYNationYassociationYsays>.

¹⁹ *Id.*

Early in her tenure, Governor Mary Fallin introduced the “First Energy Plan.”²⁰ Energy from renewable sources was included, and an increase in solar energy development seemed compatible with the plan. However, this theoretical compatibility did not materialize into growth for the industry. In fact, the industry’s potential took a step backward with the enactment of S.B. 1456, a measure that allegedly aimed to protect Oklahoma utility ratepayers from bearing the burden of grid costs as more solar DG systems were added to homes. The argument was one sounding in fairness - solar customers would eventually have little to no electricity costs, while non solar customers would be paying for all infrastructure maintenance and upgrade costs. While a parity argument seems sound on its face, in reality, there were only 346 customers with DG systems out of the utility’s more than 843,000 total customers. S.B. 1456 was dubbed the “Sun Tax” and led to confusion as to actual costs and even one’s ability to install solar. While the bill did become law, to be implemented, the specifics of the tariff had to be approved by the Oklahoma Corporation Commission (OCC). To implement such a tariff, the OCC required the utility to show that non-rooftop solar customers were subsidizing those with rooftop solar, a proposition the utility could not prove with the data it put forth.²¹ S.B. 1456 is still law in Oklahoma, however no regulated utility has been permitted to implement a tariff under it because the data actually show that a rooftop solar customer exports more value to the grid and thus, the utility, than the utility’s cost to serve that customer, essentially proving that customers with solar subsidize their non-rooftop neighbors, rather than the other way around.

II. SOLAR OPPORTUNITY IN OKLAHOMA

The state of Oklahoma has enormous potential to be a leader in solar energy production. Global solar energy production is increasing exponentially, and it is expected to be a leading source of energy by 2050.²² With its improved technology, decreased cost, and near

²⁰ Oklahoma’s First Energy Plan. 2011.

<https://www.ok.gov/governor/documents/Governor%20Fallin's%20Energy%20Plan%20%20Jan%202012.pdf>.

²¹ Paul Monies, *Oklahoma Corporation Commission votes to turn down OG&E's rooftop solar tariff plan*, (Apr. 13, 2016, 12:00 AM), <https://newsok.com/article/5491298/oklahomaYcorporationYcommissionYvotesYtoYturnYdownYogesYrooftopYsolarYtariffYplan>.

²² International Energy Agency, *Technology Roadmap - Solar Photovoltaic Energy*, 2014 edition, page 5.

http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapSolarPhotovoltaicEnergy_2014edition.pdf (last visited Sept. 1, 2018).

global availability, solar energy is predicted to exceed wind generation worldwide within the next decade. In the first quarter 2018, the U.S. installed more solar energy than any other source of electricity.

Oklahoma currently ranks 6th in the nation for average peak sunlight hours, making it a prime location for solar energy production and investment.²³ Unfortunately, regulatory and legislative barriers, coupled with a lack of state incentives and supportive state policies has left Oklahoma behind most of the country. Despite its vast solar energy potential, Oklahoma only ranks 42nd in the nation in installed solar capacity.²⁴ An increase in solar energy investment would bring new businesses to the state, hundreds of jobs, and new technologies which will attract talented professionals, increase tax revenue, reduce energy bills, diversify the state's energy resources and economy, and benefit the environment. Oklahoma has long had an energy-driven economy; investment in solar would allow the state to remain competitive as this increasingly cheaper and cleaner form of energy becomes more widely adopted globally.

Solar Technology

Electricity is generated from sunlight in two main ways: through photovoltaics and concentrated solar power. Concentrated solar power (CSP), also known as solar heating, is the process of using direct sunlight to create high-temperature steam to drive a conventional steam turbine or other similar device which generates electricity.²⁵ Large concentrated solar power plants may use hundreds or thousands of mirrors called heliostats to focus sunlight onto a central power tower. The power tower is a water-filled boiler, which when heated by the concentrated beams of sunlight from the collective mirrors, creates the steam that flows to the steam turbines to generate electricity. The world's largest CSP installation, opened in 2014 in

²³ Nebraska Energy Office, *Comparison of Solar Power Potential by State*, <http://www.neo.ne.gov/statshtml/201.htm> (last updated Mar. 11, 2010).

²⁴ Solar Energy Industries Association, *Oklahoma Solar*, <https://www.seia.org/state/solar/policy/oklahoma/solar> (last visited Sept. 1, 2018).

²⁵ Solar Energy Industries Association, *Concentrating Solar Power*, <https://www.seia.org/initiatives/concentrating/solar/power> (last visited Sept. 1, 2018).

the Mojave Desert, is the Ivanpah Solar Electric Generating System, which generates 392 MW of electricity Y enough electricity to power 140,000 homes.²⁶

A much more common technology for converting sunlight into electricity is photovoltaics (PV). Photovoltaics concern the process of converting light into the flow of electrons through traditional solar panels. PV was first discovered over a hundred years ago in 1839, with the first solar panels capable of generating usable electricity in 1954.²⁷ Today, PV is a relatively common technology, powering devices as simple as a calculator and generating electricity for millions of homes worldwide. The Energy Education Team from the University of Calgary offers a helpful explanation for how PV systems work:

*The light from the Sun, made up of packets of energy called photons, falls onto a solar panel and creates an electric current through a process called the photovoltaic effect. Each panel produces a relatively small amount of energy, but can be linked together with other panels to produce higher amounts of energy as a solar array. The electricity produced from a solar panel (or array) is in the form of direct current (DC). Although many electronic devices use DC electricity, including your phone or laptop, they are designed to operate using the electrical utility grid which provides (and requires) alternating current (AC). Therefore, in order for the solar electricity to be useful it must first be converted from DC to AC using an inverter. This AC electricity from the inverter can then be used to power electronics locally, or be sent on to the electrical grid for use elsewhere.*²⁸

²⁶U.S. Department of Energy, *Ivanpah Project Summary*, <https://www.energy.gov/lpo/ivanpah> (last visited Sept. 1, 2018).

²⁷Solar Energy Industries Association, *Photovoltaic (Solar Electric)*, <https://www.seia.org/initiatives/photovoltaicYsolarYelectric> (last visited Sept. 1, 2018).

²⁸Univeristy of Calgary, *Photovoltaic System*, https://energyeducation.ca/encyclopedia/Photovoltaic_system (last visited Sept. 1, 2018).

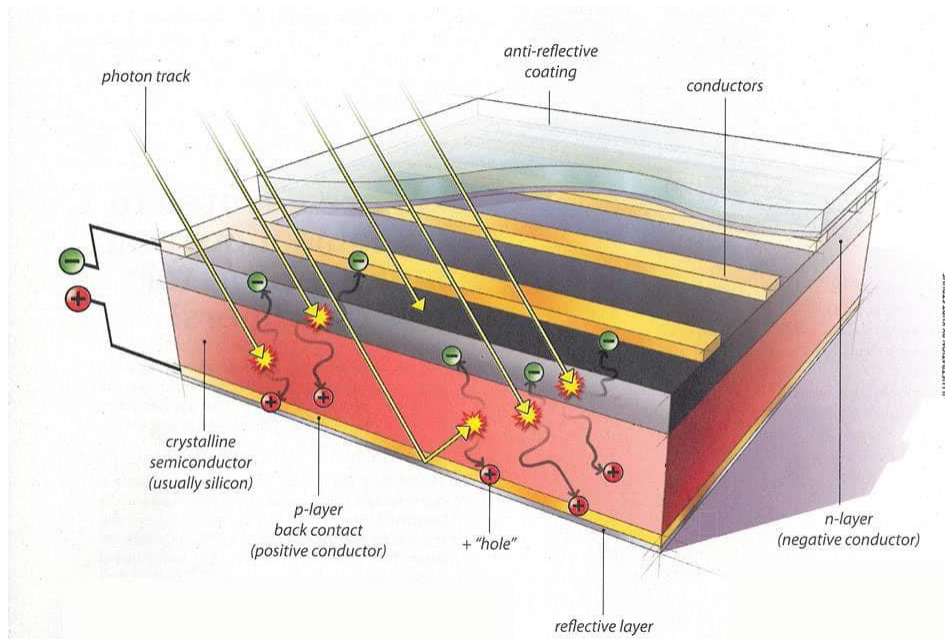


Diagram of a typical crystalline silicon solar cell. To make this type of cell, wafers of high-purity silicon are “doped” with various impurities and fused together. The resulting structure creates a pathway for electrical current within and between the solar cells.²⁹

In addition to the solar panels, a typical PV installation consists of several vital components collectively referred to as the “balance of system” or BOS.³⁰ These components include wiring, inverters, disconnects, combiners, circuit breakers, racking and tracking mounts, and electric meters. The solar panel itself is made up of solar cells made of semiconducting materials, such as silicone. These cells are incased in protective materials to shield them from environmental elements. The solar cells capture light and convert photons from the sun into electricity using the photovoltaic effect (see above diagram). The electricity created by the solar cells is direct current (DC) and an inverter is used to convert it to alternating current (AC) which is the type of current generated by power plants and used in homes throughout the U.S.³¹ Solar panels are mounted on “racks” (also referred to as racking) which can be affixed to rooftops or the ground. These racks position solar panels in a way that achieves the best sun exposure throughout the day for the region. Complex and more expensive racking systems “track” the

²⁹ <https://www.seia.org/initiatives/photovoltaicYsolarYelectric>

³⁰ Univeristy of Calgary, *Photovoltaic System*, https://energyeducation.ca/encyclopedia/Photovoltaic_system (last visited Sept. 1, 2018).

³¹ *Id.*

sun through motors and sensors to increase efficiency and electrical output. Circuit breakers provide protection against surges or increases in current. Electric meters are used to measure the amount of electricity being produced by the system and, if connected, fed into the utility electric grid. A bi-directional meter is used by the utility company to determine how much electricity the customer with the solar installation is using from the grid and how much the electricity the customer is providing to the grid. Typically, a utility company will credit the customer's account for the electricity they provide to the grid, reducing the customer's electric bill through a program called net-metering. Net-metering is discussed in more detail in subsequent sections.

Advances in solar technology

The first silicon solar panel capable of producing enough useable electricity to power everyday electrical equipment was created in 1954 and only achieved 4% efficiency. This efficiency percentage relates to the sunlight that shines on a solar cell that is converted into electricity. "Improving this conversion efficiency is a key goal of research and helps make PV technologies cost-competitive with conventional sources of energy."³² Since 1954, there have been significant advances in solar cell technology which have led to great improvements in conversion efficiency and reductions in solar cell cost. The 1980s saw efficiency for silicon solar cells rise to 20%, then 27.6% by 2018. The technology's theoretical maximum is 29% efficiency, however, other, more expensive materials are used to create solar cells such as semiconductors composed of indium, gallium, germanium, and phosphorus. These materials have allowed researchers to achieve 46% efficiency as of 2018.³³ Increases in efficiency, coupled with advances in manufacturing, have led to a more than 60% reduction in cost of PV systems over the past decade which has led to exponential growth in PV installations.³⁴ In 2008, electricity from solar panels cost \$8.82/watt. Today in the U.S., after deducting the thirty

³² National Renewable Energy Laboratory, *Best Research-Cell Efficiencies*

<https://www.nrel.gov/pv/assets/images/efficiencyYchartY20180716.jpg> (last visited Sept. 1, 2018).³³

National Renewable Energy Laboratory, *Best Research-Cell Efficiencies*

<https://www.nrel.gov/pv/assets/images/efficiencyYchartY20180716.jpg> (last visited Sept. 1, 2018).

³⁴ Solar Energy Industries Association, *Photovoltaic (Solar Electric)*, <https://www.seia.org/initiatives/photovoltaicY-solar-electric> (last visited Sept. 1, 2018).

percent federal tax incentive, that cost is down to \$3.14/watt.³⁵ This average cost has become competitive with standard electricity service. As traditional electricity generation continues to increase, renewables are proving to be winning the cost competition now more than any time in modern history.

Advances in solar cell technology have not been limited to just efficiency and manufacturing; companies are now aiming to make the technology more functional and aesthetically appealing to consumers. In October of 2016, Tesla corporation unveiled the Tesla Solar Roof with the aim of making solar panels more affordable and more visually appealing, by mimicking the look of traditional roof tiles and shingles. Tesla's Solar Roof costs \$21.85 per square foot, compared to traditional asphalt shingles which range in price from \$3 to \$5 per square foot.³⁶ While Tesla solar tiles cost more than traditional shingles, the savings consumers realize from purchasing less power from the grid (or in some cases, receiving credits for excess generation), brings the cost of the roof in line with that of traditional roofs. Additionally, Tesla has developed a lithium-ion battery known as the Powerwall which can store excess solar electricity that is produced during daylight hours to be used at night; enabling a home to be completely off-grid.³⁷

Distributed Generation vs. Utility Scale

Electricity made using solar energy is primarily distributed in two ways: distributed generation (DG) or utility scale generation. Distributed generation is the generation of electricity at or near where the electricity will be used.³⁸ This typically means the power is generated for single homes, businesses, schools, or a small grouping of structures at or very near the source. However, DG systems can also be connected to the electric utility grid to provide excess power to neighboring customers. Technologies that support DG include: solar panels, wind turbines, and fossil fuel generators. Large DG systems can be used commercially

³⁵ Sara Matasci, *Solar News, How Much Do Solar Panels Cost in the U.S. in 2018?* (Aug. 4, 2018), <https://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/>.

³⁶ Tesla, *Solar Roof*, <https://www.tesla.com/solarroof> (last visited Sept. 1, 2018).

³⁷ Tesla, *Powerwall*, <https://www.tesla.com/powerwall> (last visited Sept. 1, 2018).

³⁸ EPA, *Distributed Generation of Electricity and its Environmental Impacts*, <https://www.epa.gov/energy/distributed-generation-electricity-and-its-environmental-impacts> (last visited Sept. 1, 2018).

and include technologies such as combined heat and power systems, hydropower, biomass combustion, municipal waste incineration, fuel cells fired by natural gas or biomass, and large back-up generators. Use of DG systems in the United States has grown rapidly over the last decade with more than 12 million DG units in operation. DG units produce one sixth of the electricity generated by large centralized power plants.³⁹ The value of DG systems varies from state to state as these systems are regulated on local and state levels. As evidenced in the *Comparison* section of this study, states with favorable DG policies have seen the systems deployed in great numbers due to their ability to lower or eliminate utility costs. Proponents of DG view it as a way to increase generation capacity locally while reducing peak demand strain on the electrical grid as a whole. DG electricity is generated and consumed locally so it does not require the expansive transmission network necessitated by centralized power plants. The U.S. Energy Administration estimates that “electricity transmission and distribution losses average about 5% of the electricity that is transmitted and distributed annually in the United States.”⁴⁰ By producing electricity on site, DG consumers are collectively saving millions of dollars in lost electricity.

Utility-scale refers to large scale power generation, where a central power plant provides electricity to many distant consumers who are connected to it via the transmission lines of a power grid.⁴¹ Common types of utility-scale solar power plants include concentrated solar, large photovoltaic (PV) panel arrays, and concentrated photovoltaics. Compared to DG, utility-scale solar power plants are typically much larger in size, with generation capacities in the megawatt range, where the electricity produced is sold wholesale to utility companies. Power generated by utility-scale solar has a fixed price, making it an appealing source of electricity to utility companies during peak demand periods. North America’s peak demand periods take place in the afternoon during the summer months when air conditioning units and other electronics are

³⁹ *Id.*

⁴⁰ U.S. Energy Information Administration, *Frequently Asked Questions, How much electricity is lost in transmission and distribution in the United States?*, <https://www.eia.gov/tools/faqs/faq.php?id=105&t=3> (last visited Sept. 1, 2018).

⁴¹ EPA, *Centralized Generation of Electricity and its Impacts of the Environment*, <https://www.epa.gov/energy/centralized-generation-electricity-and-its-impacts-environment> (last visited Sept. 1, 2018).

running at both businesses and residences. Additional electricity is needed on the grid during these times, so utility companies burn more fossil fuels, which fluctuate in price based on demand. The higher the demand, the higher the price. Coincidentally, the afternoon is when solar panels have the greatest sun exposure, generating the most electricity at the same time the market price for electricity is at its highest. Robust utility-scale solar power plants help offset the use of fossil fuels, which have fluctuating prices, potentially lowering the rate the utilities charge the consumer.

There has been a lot of discussion among advocates of solar power about which form of generation, DG or utility-scale, will best aid in the continued expansion and adoption of solar power technologies. Utility-scale solar power is leading the way nationally with nearly 53 gigawatt hours of electricity produced, compared to only 24 gigawatt hours of solar DG electricity produced in 2017.⁴² One of the main drivers for wider adoption of utility-scale solar power generation is the Public Utilities Regulatory Policies Act (PURPA) of 1978. The act was passed by Congress with the aim of encouraging investment in alternative forms of energy and to increase competition among electric utilities and producers. To spark competition, the Act created Qualifying Facilities (QF) which are “Federal Energy Regulatory Commission approved electric generating facility(ies) that fall into one of two categories (1) Small power producers, which are generating facilities of 80 MW or less whose primary energy source is a renewable resource, biomass, waste, or geothermal; and (2) Cogeneration facilities, which sequentially produce electricity and another form of useful thermal energy.”⁴³ The act allows these facilities to connect to the grid and requires that the utility companies purchase the energy and capacity of these facilities at avoided cost. “Avoided cost is what it would have cost the utility to generate or contract for the energy and capacity in the absence of the qualifying facility.”⁴⁴ Due to recent reductions in the price for solar power, solar power can now be generated for less

⁴² U.S. Energy Information Administration, *Electric Power Monthly, Table 1.1.A. Net Generation from Renewable Sources: Total (All Sectors)* (Aug. 24, 2018),

https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_1_01_a.

⁴³ Solar Energy Industries Association, *PURPA 101*, <https://www.seia.org/sites/default/files/2018Y08/SEIAYPURPAY101YFactsheetY2018YAugust.pdf> (last visited Sept. 1, 2018).

⁴⁴ *Id.*

than a utility's avoided cost, making solar farms a better investment for developers. PURPA is therefore predicted to be a huge driver in utility-scale solar plants.⁴⁵

DG, on the other hand, is heavily dependent upon state policies. Net metering laws, power purchase agreements, Renewable Energy Portfolio laws with solar carve outs, tax incentives, rebates, and Solar Renewable energy certificates are all examples of state policies that reduce the cost of residential and commercial DG systems. These policies and their ramification on a state's solar industry are discussed in greater detail in the *Comparison* section.

Solar Industry and Solar Infrastructure: Global Overview

Nearly all nations have signed onto and support the Paris Climate Agreement which aims to keep any increase in global temperature this century below two degrees Celsius.⁴⁶ The scientific community has determined that a rise in global temperature above two degrees Celsius would increase heat waves, create larger rain storms, and cause dangerous rises in sea levels.⁴⁷ Despite the widespread support of the Agreement, the U.S. announced that it would pull out of the Paris agreement effective 2020.⁴⁸ Spurred by this desire to curb global warming, many nations have turned to renewable sources of energy to cut down on the release of greenhouse gasses into the atmosphere. Chief among these energy sources is Solar. Global solar power installations have been growing almost exponentially for the past decade as the cost for solar has decreased. In 2017 the global solar market grew by 29.3 percent, with the world adding 98.9 gigawatts of new solar power capacity for a total capacity of 405 GW as of the end of 2017.⁴⁹ China is the world's leading nation in solar power installations, having added 52.8 GW in 2017, or 53% of the global share. For comparison, the United States, in second place, added 10.6 GW of new solar in 2017. India came in third with 9.6 GW installed.⁵⁰

⁴⁵ Chris Warren, Green Tech Media, *Once an Obscure Law, PURPA Now Drives Utility-Scale Solar. Regulatory Conflict Quickly Followed* (Feb. 23, 2017), <https://www.greentechmedia.com/articles/read/purpa-causing-conflict-in-montana#gs.p89a0FI>.

⁴⁶ United Nations Framework Convention on Climate Change, *The Paris Agreement*, <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement> (last visited Sept. 1, 2018).

⁴⁷ Bob Silberg, NASA's JPL, *Why a half-degree temperature rise is a big deal* (Jun. 29, 2016), <https://climate.nasa.gov/news/2458/why-a-half-degree-temperature-rise-is-a-big-deal/>.

⁴⁸ <https://www.theatlantic.com/science/archive/2017/11/syria-joining-the-paris-agreement-now-what/545261/>

⁴⁹ Yale E360 Digest, *The World Added Nearly 30 Percent More Solar Energy Capacity in 2017* (Mar. 19, 2018) <https://e360.yale.edu/digest/the-world-added-nearly-30-percent-more-solar-energy-capacity-in-2017>.

⁵⁰ *Id.*

Solar Industry and Solar Infrastructure: National Overview and Growth

The solar power industry in the United States is a flourishing business made up of over 9,000 companies providing nearly more than 350,000 American jobs in 2016.⁵¹ In fact, more people in the United States work in solar energy than in coal, gas, and oil combined.⁵² Congress passed the Energy Policy Act in 2005 which created a 30% investment tax credit (ITC) on residential and commercial solar power systems. This investment tax credit has been extended to cover solar projects which will be completed by the end of 2023. This tax credit has been championed as one of the most important federal policies to promote the growth of the U.S. solar industry. In the last decade since the creation of the credit, solar has experienced “an annual average growth rate of 59%.”⁵³ The tax credit was a way to help offset the large financial cost of solar power installations when the technology was new and expensive - bringing stability and growth to the market. Since 2010, the cost to install solar in the United States has decreased by more than 70%. This reduction in cost coupled with the ITC has helped lead the industry to over 1.7 million solar installations in the U.S.⁵⁴ Today, the U.S. has 56 GW of total solar capacity, accounting for 2% of all electricity generated nationally. This is enough electricity to power 10.7 million homes. Growth has continued into 2018, with the U.S. market installing 2.5 GW of solar PV in the first quarter of 2018, 57% percent of which were from utility-scale PV systems. During this quarter, “55% of all new electric generating capacity brought online in the U.S. came from solar - the second consecutive quarter in which solar accounted for the largest share of new capacity additions.”⁵⁵ With solar accounting for at least 30% of all new electricity installed during the past three years, the U.S. is on track to double its PV capacity within the next five years.⁵⁶

⁵¹ Niall McCarthy, Forbes, *Solar Employs More People in U.S. Electricity Generation Than Oil, Coal, And Gas Combined* (Jan. 25, 2017, 8:30 am), <https://www.forbes.com/sites/niallmccarthy/2017/01/25/uYsolarYenergyYemploysYmoreYpeopleYthanYoilYcoalYandYgasYcombinedYinfographic/#1f8d3a6d2800>.

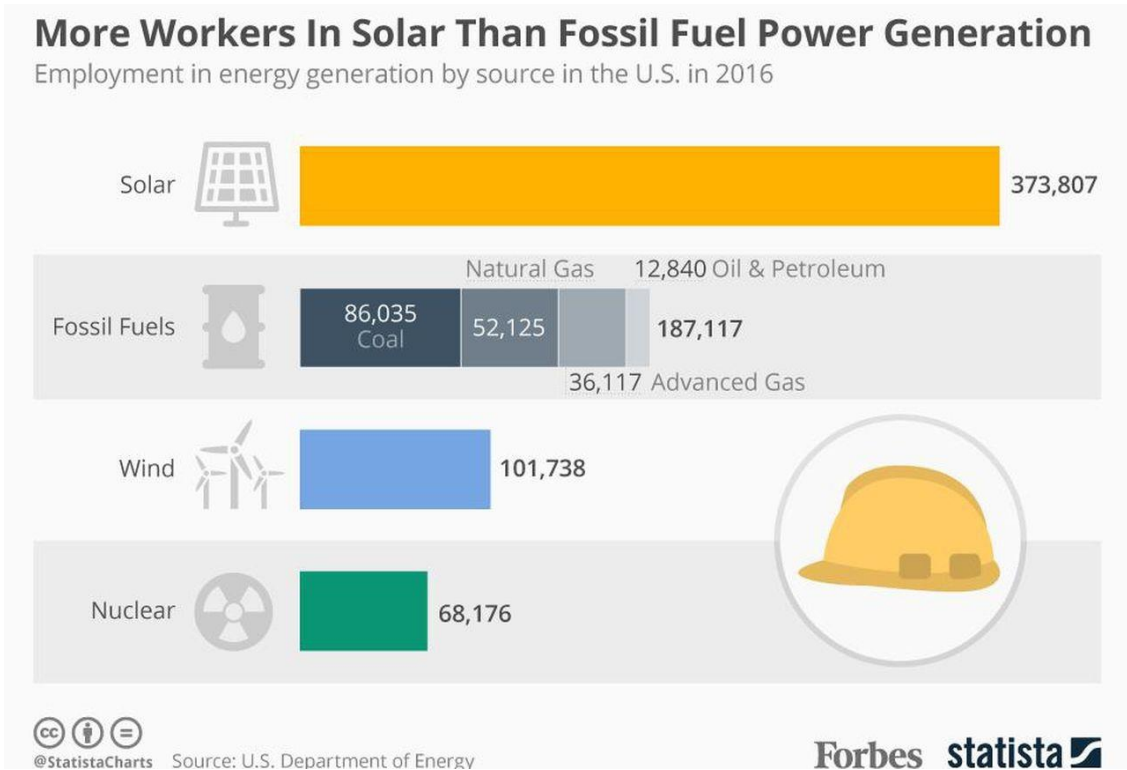
⁵² *Id.*

⁵³ Solar Energy Industries Association, *Solar Industry Research Data*, <https://www.seia.org/solarYindustryYresearchYdata> (last visited Sept. 1, 2018).

⁵⁴ *Id.*

⁵⁵ Solar Energy Industries Association, *Solar Market Insight Report 2018 Q2*, <https://www.seia.org/researchYresources/solarYmarketYinsightYreportY2018Yq2> (last visited Sept. 1, 2018).

⁵⁶ *Id.*



Source: Niall McCarthy, Forbes, Solar Employs More People in U.S. Electricity Generation Than Oil, Coal, And Gas Combined (Jan. 25, 2017, 8:30 am), <https://www.forbes.com/sites/niallmccarthy/2017/01/25/uYsolarYenergyYemploysYmoreYpeopleYthanYoilYcoalYandYgasYcombinedYinfographic/#1f8d3a6d2800>.

Solar Industry and Solar Infrastructure: Oklahoma Overview

Oklahoma has long had an energy driven economy. As recently as 2012, roughly one fourth of all jobs in the state had some connection, directly or indirectly, to the energy industry.⁵⁷ While the oil and gas industry has dominated the energy landscape for decades, wind power has recently become a tremendous source of energy and investment for the state. With 7,495 megawatts of installed wind power capacity at the end of 2017, Oklahoma became the second largest producer of wind power electricity in the country.⁵⁸ Building upon the success of the State’s embrace of renewable wind energy and in keeping with its established status as an energy state, Oklahoma has great potential to be a leader in solar power. Various studies have estimated that Oklahoma is ranked anywhere from 6th to 8th in the nation for average peak

⁵⁷ Joe Wertz, State Impact Oklahoma, *Oil, Gas and What a ‘Boom’ Mean to Bi-@Energy Oklahoma* (Jan. 19, 2012), <https://stateimpact.npr.org/oklahoma/2012/01/19/oilYgasYandYwhatYaYboomYmeansYtoYbigYenergyYoklahoma/>.

⁵⁸ Jack Money, NewsOK, *Oklahoma moves into No. 2 spot for wind power capacity in the nation, association says* (Jan. 31, 2018), <https://newsok.com/article/5581518/oklahomaYmovesYintoYno.Y2YspotYforYwindYpowerYcapacityYin-theYnationYassociationYsays>.

sunlight hours, giving the state great potential to harness energy from the sun.⁵⁹ While sun exposure in Oklahoma is some of the best in the nation, the state falls behind most of the country in installed solar capacity. Oklahoma currently has 45.91 MW of installed solar capacity, ranking it 42nd in the nation for installed capacity.⁶⁰ This places it behind states like Massachusetts (2,138 MW), Georgia (1,553 MW), and New Jersey (2,447 MW) who do not receive the same levels of sun exposure, ranking 18th, 10th, and 20th respectively in average peak sunlight hours.⁶¹ However, there was significant solar investment in Oklahoma during 2017, where Oklahoma ranked 30th in the nation for installed solar capacity for the year. Oklahoma installed 27.8 MW of solar energy in 2017, which is more than half of its total generating capacity of 45.9 MW.⁶² While the state lags behind most of the country in terms of its embrace of solar, over \$56 million has been invested in solar in the state, leading to 739 jobs, 33 solar companies in the state, and enough electricity to power 5,699 homes.⁶³ The state recently saw the completion of Oklahoma Gas and Electric's (OG&E) 10 MW solar power plant in Covington, OK,⁶⁴ following their 2 megawatt solar pilot program at their Mustang site. This Covington plant provides more than a fifth of Oklahoma's total solar power generating capacity. OG&E created a program to allow its customers to purchase the power generated by the facility at a fixed rate for the life of the plant. Oklahomans responded eagerly; the program was quickly oversubscribed, meaning more people were interested in paying extra for solar energy than the project could provide. This type of utility program affords consumers an opportunity to support and consume renewable solar energy without having solar panels installed on their property.⁶⁵

⁵⁹ Nebraska Energy Office, *Comparison of Solar Power Potential by State*, <http://www.neo.ne.gov/statshtml/201.htm> (last updated Mar. 11, 2010).

⁶⁰ Solar Energy Industries Association, *Oklahoma Solar*, <https://www.seia.org/state/solar/policy/oklahoma/solar> (last visited Sept. 1, 2018).

⁶¹ Nebraska Energy Office, *Comparison of Solar Power Potential by State*, <http://www.neo.ne.gov/statshtml/201.htm> (last updated Mar. 11, 2010).

⁶² Solar Energy Industries Association, *Oklahoma Solar*, <https://www.seia.org/state/solar/policy/oklahoma/solar> (last visited Sept. 1, 2018).

⁶³ *Id.*

⁶⁴ Jack Money, NewsOK, *OG&E brings a second solar generating facility online* (Mar. 30, 2018, 5:00 AM), <https://newsok.com/article/5588946/oge-brings-a-second-solar-generating-facility-online>.

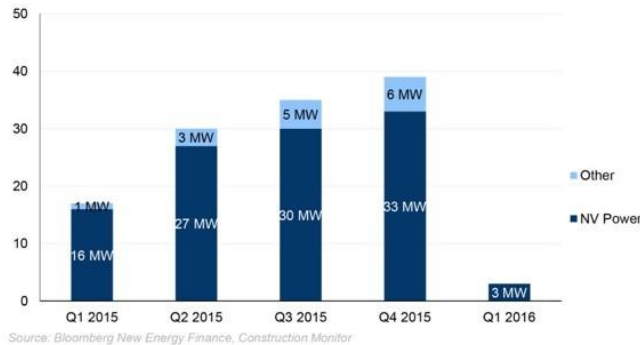
⁶⁵ OGE Energy Corp., *Solar Power*, <https://www.oge.com/wps/portal/oge/save-energy/SolarPower/> (last visited Sept. 1, 2018).

The solar industry has not been as successful in Oklahoma as it has been in other states due to a lack of supportive solar policies at the state level as well as lingering regulatory barriers. While Oklahoma law allows for net-metering, utilities are not required to purchase net monthly excess generation from customers who have DG solar systems. Net-metering is a billing program that allows a DG solar customer to receive a credit for electricity provided to the utility's grid when the customer is generating more electricity than he or she needs at that time. This credit can then be applied to the electricity that the customer purchases from the utility when the solar panels are not producing enough electricity to meet the customer's demand. Under Oklahoma's net metering policy, if the customer is producing more electricity than he or she is using in a given month, the excess electricity goes back to the utility's grid, with no compensation to the customer. Policies like Oklahoma's, severely limits the financial benefits a solar DG system could provide. Fair net-metering policies can lead to a thriving state solar industry. On the other hand, negative changes to existing net-metering policies can also damage a productive solar industry. One such idea introduced by utilities that has become a national trend is the theory of cost shifting. Utilities have indicated that when too many of their customers install solar, it causes a "cost shift" of grid maintenance and operating expenses, wherein the utility and non-solar customers are solely responsible for grid costs. Since a portion of grid maintenance is allocated to each customer's utility bill, utilities argue the cost-shift theory is especially true when its solar DG customers generate all of their own power, which results in a zero electric bill. These bad policies can and have caused marked declines in a state's solar industry. Nevada provides one such example, as noted in a piece by the Brookings Institution that emphasized how fair net-metering policies actually work to bolster solar development in a state.

Most glaringly, the local utility in Nevada successfully wielded the cost-shift theory last winter to get the Nevada Public Utilities Commission to drastically curtail the state's net-metering payments, prompting Solar City, Sunrun, and Vivint Solar—the state's three largest providers of rooftop panels—to leave the Nevada market entirely. The result: New residential solar installation permits plunged 92 percent in Nevada in the first quarter of 2016.⁶⁶

⁶⁶Mark Muro and Devashree Saha, *Rooftop Solar: Net metering is a net benefit*, (May 23, 2016) <https://www.brookings.edu/research/rooftopYsolarYnet-meteringYisYaYnetYbenefit/>.

Permits issued for Nevada residential PV by service territory
Q1 2015 - Q1 2016 (MW)



B Metropolitan Policy Program
at BROOKINGS

Source: Brookings Institute. Taken from Bloomberg New Energy Finance, Construction Monitor

In addition to its restrictive net-metering policy, Oklahoma has not had a clear policy for third-party solar power purchase agreements, until recently. A solar power purchase agreement (PPA) is a financial agreement where a third-party “developer arranges for the design, permitting, financing and installation of a solar energy system on a customer’s property at little to no cost.”⁶⁷ This third-party developer owns the solar system on the property and sells the customer the electricity that is produced from the solar panels at a rate lower than the utility retail rate. The developer then receives the credits that the solar system receives from the utility company when it provides excess electricity to the grid. Additionally, the developer receives available tax credits and incentives from the system. Customers benefit by paying a reduced rate for electricity while avoiding paying thousands of dollars to install a rooftop solar system. PPA’s can range from 10 to 25 years in duration, where at the end of the contract, the customer can either purchase the solar system themselves, extend the agreement, or have the developer remove the equipment.⁶⁸ On June 26, 2018 the Oklahoma Attorney General released an opinion addressing power purchase agreements and third-party ownership of DG sources. The opinion is below:

⁶⁷ Solar Energy Industries Association, *Solar Power Purchase Agreement*, <https://www.seia.org/research/resources/solar/power/purchase/agreements> (last visited Sept. 1, 2018).

⁶⁸ *Id.*

1. The permissibility of a third-party owned distributed generation source depends on whether the source is operating in unincorporated or incorporated areas of the State of Oklahoma:
 - a. If the distributed generation system is operated in an unincorporated area pursuant to a power purchase agreement, the third-party owner would be a “retail electric supplier” and prohibited by the Retail Electric Supplier Certified Territory Act from providing retail electric service in the certified territory of another retail electric supplier. See 17 O.S. 2011, § 152.25.
 - b. If the distributed generation system is operated in an unincorporated area pursuant to a lease agreement, the third-party owner would not be a “retail electric supplier” subject to the Retail Electric Supplier Certified Territory Act. See 17 O.S. 2011, § 152.25. However, the question of whether a specific contractual arrangement is a true lease will depend on the terms of the contract and is beyond the scope of this opinion.
 - c. A distributed generation system operated in an incorporated area pursuant to either a lease or a power purchase agreement is lawful, but a municipal franchise may be required if municipal streets or other public ways are used to operate or maintain the facilities. See *Okla. Gas & Elec. Co. v. Total Energy, Inc.*, 1972 OK 105, ¶ 33, 499 P.2d 917, 922.
2. A third-party owned distributed generation facility would be a small power producer or cogenerator within the meaning of OAC 165:40 so long as it is qualified under the Public Utility Regulatory Policies Act and is not more than 50 percent owned by an electric utility. See 16 U.S.C. § 796(17)(C), (18)(B); 18 C.F.R. Part 292; OAC 165:40-1-2.
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3. Under the Public Utility Regulatory Policies Act and rules promulgated by the Oklahoma Corporation Commission, electric utilities are required by the Federal Energy Regulatory Commission and the Oklahoma Corporation Commission to accept power from qualified small power producers and cogenerators, to the extent that they are qualified under the Public Utility Regulatory Policies Act and are not more than 50 percent owned by an electric utility. 16 U.S.C. § 824a-3, 796(17)(C), (18)(B); 18 C.F.R. Part 292; OAC 165:40-1-2.
4. If a third-party owned distributed generation system is a qualified small power production facility or cogeneration facility under the Public Utility Regulatory Policies Act, see 16 U.S.C. § 796(17)(C), (18)(B); 18 C.F.R. Part 292, the third-party owner would not be a “utility” under Oklahoma Corporation Commission rules. See OAC 165:35-291(a).⁶⁹

This is a potential significant victory for solar power in the state of Oklahoma. Prior to this opinion, it was widely believed that third-party ownership of solar DG systems was prohibited by Oklahoma’s Retail Electric Supplier Certified Territory Act and severely limited by Oklahoma Corporation Commission Rule 165:40Y5Y7(a) which states that for a producer of electricity that will be interconnected with the utility grid, that “producer will, except as otherwise noted, design, construct, install, own, operate, and maintain all equipment required to generate and

⁶⁹ Office of Attorney General State of Oklahoma, *Attorney General Opinion 2018-5* (Jun. 26, 2018) [http://www.oag.ok.gov/Websites/oag/images/Documents/Opinions/AG/2018/AG%20Opinion%202018Y5%20\(TY25\).pdf](http://www.oag.ok.gov/Websites/oag/images/Documents/Opinions/AG/2018/AG%20Opinion%202018Y5%20(TY25).pdf).

deliver energy and/or capacity.”⁷⁰ Since the customer (owner of the property with the solar system) did not own the solar equipment, he would not qualify as a producer able to connect to the grid. This clarification by the Attorney General is likely to lead to significant solar investment in the state.

Opportunities for Solar in the Southwest Power Pool

The Southwest Power Pool (SPP) is a Regional Transmission Organization (RTO) that lies within the Eastern Interconnection and serves fourteen states, including all of Oklahoma and Kansas, and portions of New Mexico, Texas, Arkansas, Louisiana, Missouri, Montana, North Dakota, South Dakota, Minnesota, Iowa, Wyoming, and Nebraska. As an RTO, the SPP monitors and coordinates the electric grid to ensure demand is being met and oversees the wholesale power market within its territory. Put simply, the SPP manages the energy market for the region with the goal of purchasing electricity from the least expensive source connected to the grid to meet demand. The largest component of total wholesale electricity costs are energy or fuel costs, which represented nearly 98 percent of SPP’s total costs in 2017.⁷¹ For example, in 2017 there was a 14% increase in the cost for natural gas which led to an overall 7% increase in wholesale electricity prices.⁷² Solar power within the SPP can play a vital role in helping to reduce fuel costs, thus lowering the wholesale market price of electricity within the RTO. Solar power has fixed costs throughout the life of the facility. Lazard, a prominent financial advisory and asset management firm, released a levelized cost of energy (LCOE) analysis for 2017 which found that the LCOE for utility-scale solar electricity fell from \$178/MWh in 2009 to \$50/MWh in 2017.⁷³ For comparison, the LCOE from Natural Gas power plants was \$60/MWh, and from coal plants \$102/MWh in 2017.⁷⁴ There are even examples of utility-scale solar projects that have entered bids as low as \$19.90/MWh for new solar.⁷⁵ The main takeaway is that solar has

⁷⁰ OAC 165:40Y5Y7(a).

⁷¹ Southwest Power Pool, *State of the Market*, page 2, https://www.spp.org/documents/57928/spp_mmu_asom_2017.pdf.

⁷² *Id.*

⁷³ Silvio Marcacci, Forbes, *Cheap Renewables Keep Pushing Fossil Fuels Further Away From Profitability- Despite Trump’s Efforts* (Jan. 23, 2018, 8:00 am) <https://www.forbes.com/sites/energyinnovation/2018/01/23/cheap-renewables-keep-pushing-fossil-fuels-further-away-from-profitability-despite-trumps-efforts/#2a96bc936ce9>.

⁷⁴ *Id.*

⁷⁵ Public Service Company of Colorado, *2017 All Source Solicitation 30-Day Report* (Dec. 28, 2017), <https://www.documentcloud.org/documents/4340162YXcelYSolicitationYReport.html>.

become a cheaper form of energy than coal and natural gas. Should Oklahoma take steps to realize its solar energy potential, there is great opportunity for investment in the state by solar producers and utility companies, especially considering Oklahoma's proximity to larger population centers with the SPP. New solar capacity within the state that is interconnected with SPP will be the cheaper alternative, and thus will have the most demand, compared to the fossil fuels in the SPP energy marketplace. This will provide a lucrative opportunity for developers and increase state tax revenue, all while reducing carbon emissions and benefiting the environment.

III. COLLABORATION

Solar energy has wide applicability and ample opportunities for growth as an industry. It can benefit virtually anyone who uses electricity and is already used to achieve a number of goals in both the private and public sectors. Solar energy reduces utility bills, enhances resiliency and emergency preparedness, increases students' interest and understanding of technology and STEM-related fields, decreases toxic and expensive environmental emissions, and provides endless opportunities for collaboration and cost savings among various industries.

Solar in Schools

There are many noteworthy examples of collaboration in the national solar industry that Oklahoma could follow to develop its own sustainable, productive state solar industry. Among them is the use of distributed solar PV installations on schools, which has been widely studied and duplicated and delivers an array of community benefits. Included with the installation of a PV system on a school, comes an informative science and technology curriculum that provides students of varying ages hands-on instruction on an innovative topic with relevance to fields other than solar. Students across the state could be acquiring a comprehensive understanding of solar energy beginning in elementary school. With a major shortage of candidates for STEM jobs in the state,⁷⁶ the knowledge base and workforce this kind of opportunity could develop is

⁷⁶ See C. Shay Braun, Point of View: *Greater STEM Funding Needed in Oklahoma*, (Apr. 13, 2018, 12:00 AM), <https://newsok.com/article/5590709/pointYofYviewYgreaterYstemYfundingYneededYinYoklahoma>. See also Brianna

extremely promising. Solar is a particularly unique opportunity for students to work with energy technology because of its practicality. Unlike wind turbines or oil rigs, which cannot be installed on the rooftop of a school.

By far the preeminent source for information for school solar projects is the Solar Energy Industries Administration's (SEIA) Solar in Schools report, which was last released in November 2017.⁷⁷ Included is an overview of relevant topics discussed in the report, however the authors recommend reading the full report for information that reaches beyond the scope of this study.

Schools across the country are going solar for many of the same reasons as government, businesses, and individuals. Solar energy provides schools a fixed price for their significant electricity needs and offers a sound financial investment, as technology costs have continuously declined. Student instruction on the school's PV system can be combined with innovative curricula and naturally spark student awareness of environmental concerns. When combined with the unique science, technology, and extra-curricular opportunities it brings the students, the reasons for adding solar PV systems to schools are compelling. Moreover, school officials can involve students, parents, and parent teacher organizations in meaningful experiences through efforts used to accomplish the projects. Interested students can participate in grant writing, establishing corporate partnerships, and grassroots advocacy and fundraising, which are all beneficial and transferable skills. In some cases, the students, themselves, initiate and fundraise for the projects.

In Oklahoma, the sixth-sunniest state by many reports, there are 180 school buildings in the Tulsa and Oklahoma City Public School systems alone, many of which are designed in the traditional flat-roof style, a structure conducive for solar PV. Despite this, Tulsa McLain High School is the only Oklahoma school known to have solar PV installed. Moreover, nearly 97 of those schools located in the Oklahoma City district begin classes August 1 each year, during one of the hottest periods of summer. Tulsa schools begin marginally later in August, yet with state

Bailey, *Help Wanted: Shortage of Skilled Workers in Oklahoma is Unsettling*, (Oct. 13, 2015, 7:00 AM), <https://newsok.com/article/5452738/help-wanted-shortage-of-skilled-workers-in-oklahoma-is-unsettling>.

⁷⁷ *Brighter Future: A Study on Solar in U.S. Schools*, <https://www.seia.org/research-resources/brighter-future-study-solar-us-schools>.

temperatures in the eighties and above late into September and beyond, utility costs are some of the largest line items in school budgets. One estimate from 2016 indicated Oklahoma City Public Schools could save \$525,000 in utility costs in one year if it went back to a traditional calendar that began the school year later in August.⁷⁸ These staggering budget figures illustrate how much Oklahoma schools could benefit from some of the long-term economical options solar energy can provide.

Schools across the nation have done more than merely add PV panels to roofs and nearby land. Some systems can provide shade for parking lots or buses, while other installations offer electric vehicle charging stations. The opportunities are abundant, and shade is a valuable commodity in Oklahoma for many months of the year. One such example for Oklahoma to explore is in St. Louis County, Missouri. The district there installed its solar PV system pursuant to a 20-year lease with no up-front expense. The school expects to save one million dollars over the course of the lease, which is contracted with a third-party owner, who remains responsible for operation and maintenance.

Oklahoma school leaders with interest in PV installations should solicit individual analysis, but encouragingly, the SEIA report found that up to 60% of all U.S. schools could benefit financially from adding solar.⁷⁹ The process begins with an interested student or school official and results in entire communities banding together to secure support and funding to achieve a shared mission.

On a practical level, there are also numerous opportunities for collaboration and funding sources for solar in schools. The Solar Foundation, SEIA's co-sponsor on the Solar in Schools Report, referenced herein, provides great resources to guide those interested in the process of school solar installations.⁸⁰ Another source for funding can be found in The Foundation for Environmental Education's (FEE) Solar Schools program.⁸¹ The Ohio-based 501(c)(3) partners with various investor-owned utilities and municipal power companies to

⁷⁸ Tim Willert, *Oklahoma City Public Schools Calendar is Under Review as Possible Money-Saving Measure*, (Nov. 18, 2016, 12:00 AM).

⁷⁹ *Brighter Future: A Study on Solar in U.S. Schools*, <https://www.seia.org/research/resources/brighterfutureystudy/solarus/schools>, page 9.

⁸⁰ The Solar Foundation, <https://www.thesolarfoundation.org/solar/schools/>.

⁸¹ The Foundation for Environmental Education, <http://solarschools.org/foundationforenvironmentaleducation/>.

develop educational programs, install solar PV systems on schools, and install solar thermal units on fire stations, YMCAs, and public housing. In addition to philanthropic corporations, nonprofit organizations, and foundations, there are federal and state grants to help schools go solar, all of which can be found for free in the public domain.

Government and the Department of Defense as Leaders

It is imperative for military bases across the country to have the tools needed to protect against and respond to various security threats. The military must have low-cost, reliable access to electricity at all times. Indeed, resiliency can be the sole reason for military leaders to install solar. The Department of Defense is the nation's largest energy consumer and has the largest deployment of renewables. Military leaders note that the choice is not a political one. In fact, the military's move toward renewables began under President George W. Bush.⁸² Because of this, the U.S. military has been utilizing solar energy as an effective resource to protect against potential power loss for many years. Some of the military's implementation of renewables has occurred to comply with federal law and regulations; however because of the cost savings, there are no apparent plans to end the practice.⁸³ In emergency situations, solar is superior to diesel-fueled generators due to its lower overall cost to operate and potential inability to deliver and store fuel during periods of conflict. A DG system with integrated battery storage specifically addresses concerns of grid failure or grid disruption in emergency situations. Furthermore, diesel generators are often used in combination with back up DG systems as a final failsafe. Whether in times of peace or military action, the solar DG systems provide a reliable and affordable form of energy.

Oklahoma's military bases have been considering their own resiliency efforts pursuant to federal law and Department of Defense requirements. With its excellent solar exposure, Oklahoma would do well to allow these large institutions the energy flexibility to strengthen and grow their operations in the state.

⁸² Timothy Gardner, *U.S. Military Marches Forward on Green Energy, Despite Trump*, (Mar. 1, 2017, 12:05 AM), <https://www.reuters.com/article/usYusaYmilitaryYgreenYenergyYinsight/uYSYmilitaryYmarchesYforwardYonYgreenYenergyYdespiteYtrumpYidUSKBN1683BL>.

⁸³ Elisa Wood, *U.S. Military Issues Solicitation for Microgrids with Energy Storage*, (Jan. 10, 2018), <https://microgridknowledge.com/microgridsYenergyYstorageYSolicitation/>.

State and Local Opportunities

State and local governments have benefited from solar installations on critical facilities in the same ways discussed for the military. One prime example in the local government sector is the Salt Lake City Public Safety building. The first net-zero energy public safety building in the U.S., the Utah facility houses police, fire, 911 services, and the city's primary data center.⁸⁴ Public buildings with emergency services must address resiliency issues and preparedness efforts to maintain community safety. In any state, natural disasters and cyberattacks are real considerations government entities must address and prevent, no matter their size or budget. There are various examples of items such as power generators, emergency signage, radio transmitters, and government building electricity, all powered by solar PV, having the ability to temporarily go on and off the grid during an emergency.⁸⁵

Oklahoma is no different from other states in that it faces challenges that solar energy installations could assist in solving. The state's severe weather and more recently, stronger earthquakes, pose actual and frequent vulnerabilities state leaders regularly face.

Healthcare Opportunities

Operators of healthcare facilities - both public and private - have turned to solar to ensure consistent power and lower energy costs. Healthcare facilities, like large-scale retail, are among the largest electricity consumers, both at the industrial level. If the U.S. healthcare industry were a separate country, it would rank as the seventh largest carbon emitter in the world.⁸⁶ But unlike retailers, medical facilities use power for life-sustaining measures, making the dependability of solar energy invaluable. Large healthcare systems have been moving away from fossil fuel energy sources as they consider the direct pollution caused, as well as pollution's negative effect on human health. Installation of solar systems provide both safety from grid interruptions and protection from fuel price surges.

⁸⁴Alex Wilson, *New Public Safety Building in Salt Lake City a Model of Resilience*, (Jun. 30, 2014), <https://www.resilientdesign.org/new-public-safety-building-in-salt-lake-city-a-model-of-resilience/>.

⁸⁵Stephan Wayne Schmidt, *Integrating Solar Energy and Local Government Planning*, (June 6, 2014), <https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=2294&context=theses>.

⁸⁶David Blumental, M.D. and Shanoor Seervai, *To Be High Performing, the U.S. Health System Will Need to Adapt to Climate Change*, (Apr. 18, 2018), https://www.commonwealthfund.org/blog/2018/be-high-performing-us-health-system-will-need-adapt-climate-change?redirect_source=/publications/blog/2018/apr/health-system-and-climate-change.

Along these lines, the industry has seen a shift toward power purchase agreements (PPAs) as opposed to buying energy from local utilities. One example of a leader in this arena is Partners HealthCare based in Boston, which developed and implemented an energy plan that included renewables back in 2010 as a result of fuel cost surges. John Messervy, Corporate Director of Design and Construction for Partners HealthCare explained that adding renewable sources was not cost-prohibitive as is commonly assumed. “Our unit cost of power is still significantly lower than the retail cost for (conventional) power,” Messervy said in 2014. “So there is a savings over conventional power purchases even though we are increasing our mix of renewables.”⁸⁷

Recently, Boston Medical Center (BMC) entered into a unique alliance with Massachusetts Institute of Technology (MIT) and Post Office Square to jointly purchase power from a North Carolina solar farm - the largest on the east coast with 500,000 solar panels on 1,200 acres.⁸⁸ The power purchase will offset approximately 40% of MIT’s electricity consumption and 100% of both Post Office Square and BMC’s. “This purchase is equivalent to 100 percent of BMC’s projected electric consumption, making us the greenest hospital in Boston and on pace to become the first carbon-neutral hospital in New England upon the completion of our campus redesign. This is the right thing to do for the quality of life and health of our patients and our planet”, said Robert Biggio, Vice President of Facilities and Support Services at BMC.⁸⁹

Also innovative in its use of renewable energy, the George Washington University Hospital provides a comprehensive example of sustainability efforts with its internal “Healthier, Happier” campaign. The campaign highlights the hospital’s current sustainability efforts while gathering support and ideas from its staff. The campaign’s collective focus is on using cleaner energy, safer chemicals, less waste, smarter purchasing, and healthier food.

⁸⁷ Lola Butcher, *Hospitals Shift from Fossil Fuel to Renewable Energy Sources*, (Nov. 8, 2014), <http://www.modernhealthcare.com/article/20141108/MAGAZINE/311089981>. See also, David L. Chandler, *MIT to Neutralize 17 Percent of Carbon Emissions Through Purchase of Solar Energy*, (Oct. 19, 2016), <http://news.mit.edu/2016/mitYneutralizeY17YpercentYcarbonYemissionsYthroughYpurchaseYsolarYenergyY1019>.

⁸⁸ Sun Energy 1, <https://www.sunenergy1.com/summitYfarms>. (Last visited Sep. 9, 2018).

⁸⁹ *Id.*

A separate, major issue the healthcare industry grapples with is providing healthcare in rural areas. The industry faces issues such as a lack of quality workforce, barriers to care such as distance, lack of transportation, excessive expense, and poor health literacy. Plus, rural areas tend to have a host of mental health and substance abuse concerns that still come with a stigma that prevents people from seeking care.⁹⁰ Although renewable energy cannot solve all of rural healthcare issues, deployment of solar DG systems can help free up financial resources by lowering facility's substantial utility costs and also providing a source of reliable electricity.

Untillable Farmland Opportunities and the USDA Conservation Reserve Program

Untillable farmland provides a practical resource for solar developers seeking land to install their projects, while royalties paid to farmers with land that can no longer be used for its intended purpose create a synergistic arrangement, mutually beneficial for both parties and the environment. Farmers in financial distress (or not) can sell a portion of their untillable land to a solar developer and earn more in royalty payments than the crops themselves ever yielded.⁹¹ Lease agreements between farmers and solar developers are long term, typically twenty to thirty years, and often pay more than traditional farming.⁹² The rural land is even more valuable when it is in close proximity to transmission lines.

Some rural and farm lands are less suitable for solar lease agreements, however, such as lands that are part of the United States Department of Agriculture's Conservation Reserve Program (CRP). CRP land is managed by the Farm Service Agency with technical support for soil and grass by the National Resource Conservation Service (NRCS). The CRP was created for highly erodible land to help dissuade farmers from planting environmentally damaging crops on their lands and instead, encourage them to plant sustainable varieties suitable for the area. The type of land the program accepts is considered excessively erodible, having an erodibility index of eight or more, which is soil that can easily be blown away or washed away.⁹³ Under CRP

⁹⁰ Rural Health Information Hub, <https://www.ruralhealthinfo.org/topics/healthcare> (last visited Aug. 23, 2018).

⁹¹ *Some farmers growing profit with new row crop: solar panels*, <https://nccleantech.ncsu.edu/somefarmersgrowingprofitwithnewrowcrop/solarpanels/> (last visited Aug. 31, 2018).

⁹² *Id.*

⁹³ United States Department of Agriculture, National Resource Conservation Service, *Highly Erodible Land Conservation Update*, (Jul. 7, 2017). [State_Technical_Committee_Mtg_June_17_Presentations_2.pdf](#).

agreements, producers⁹⁴ plant native grasses to nurture the soil back to health. Typical contracts last ten years. The program provides monthly rent payments to farmers willing to remove environmentally-sensitive land from agricultural production and adhere to these practices.⁹⁵

At first glance, it seems that solar installations could provide an opportunistic use of this type of land that otherwise cannot be utilized to grow crops. There are several concerns, however. With regard to CRP land and solar, if the land is enrolled in the program, solar installations will not conform to requirements, forcing the producer to wait until the CRP contract expires. Likewise, wind projects are impermissible uses of CRP land since any disruption of the soil is considered non-compliant. Nonetheless, some Oklahoma CRP lands contain oil well pads and wind turbines. In these cases, the producer determined that the terms of the oil and gas or renewable contract made it financially feasible to breach the CRP contract. In the event of breach, the government is required to complete a new assessment of the portion of land that is still considered CRP and not utilized by the energy technology. After the assessment, the producer must pay penalties for early removal of the land from the program, in addition to liquidated damages.⁹⁶ Notwithstanding these considerations, some producers decide to install a solar energy project on CRP land, because the economics simply make sense. As noted, solar leases pay more than traditional farming, so each situation requires a cost benefit analysis, but there are examples of renewable energy technology on CRP land in Oklahoma.

Native American Tribes

Some of Oklahoma's Native American Tribes have demonstrated leadership in solar technology deployment and a commitment to future growth in the area.⁹⁷ The Cherokee Nation joins the Delaware Nation of Anadarko as an example of a tribe leading the way with its

⁹⁴ A producer in this context could be the land owner or an operator of land.

⁹⁵ USDA Conservation Programs, <https://www.fsa.usda.gov/programsYandYservices/conservationYprograms/>, (last visited Sep. 1, 2018).

⁹⁶ Lisa Chavarria, *Solar Leases for Utility Scale Installations*, (Feb. 1, 2017), <http://sbaustinlaw.com/wpYcontent/uploads/2017/02/ChavarriaYSolarYLeasesYforYUtility-scaleYInstallationsY1.pdf>.

⁹⁷ Kelsey Misbrener, *Eight Native American Tribes Going Solar*, (Aug. 7, 2017), <https://www.solarpowerworldonline.com/2017/0>.

commitment to using clean energy and reducing its carbon footprint by investing in and installing solar energy.⁹⁸ The Delaware Nation which completed its solar project back in 2010, stood to save \$20,000 per year in utility costs while reducing consumption by 90,000 kWh.⁹⁹ Even though the project was completed eight years ago, the Tribe estimated it would recoup its costs in five to eight years. With a solar charging station placed into operation in November 2017 and more renewables and electric vehicle investments in planning phases, efforts by the Cherokee Nation provide an example to others in the state that solar can be a reliable, cost-effective source of power. With 39 tribes calling Oklahoma home, the potential for savings and economic development opportunities is abundant.

Corporate/Commercial

Corporate America has embraced renewables and has been moving toward solar power in a meaningful way for years. Especially in the case of the big box retailers, the decision to switch to renewables was financially driven. And yet, large-scale grocery and retail stores still hold enormous potential for solar growth.¹⁰⁰ Companies like Target and WalMart have taken turns leading the way in solar capacity installed, with Target most recently in the number one position with a clear lead.¹⁰¹ While environmental or reputational concerns may have been one consideration in developing massive amounts of solar capacity,¹⁰² it is unlikely corporate shareholders would support investments without the accompanying lower energy costs.¹⁰³ Wal

⁹⁸ Bill John Baker, *Cherokee Nation Takes the Lead in Embracing Green Energy Solutions*, (Dec. 12, 2017), <https://www.indianz.com/News/2017/12/12/billyjohnbakerYcherokeeYnationYtakesYth.asp>.

⁹⁹ *Oklahoma Tribe to Install Solar Roof*, (Mar. 22, 2010), Dept. of Energy, <https://www.energy.gov/articles/oklahomaYtribeYinstallYsolarYroof>.

¹⁰⁰ *Solar on Superstores 4 How the Roofs of Big Box Stores Can Help America Shift to Clean Energy*, (Febr. 16, 2016), <https://environmentamerica.org/reports/ame/solarYsuperstores>.

¹⁰¹ Anmar Frangoul, *Ten Massive Corporations Going Big on Solar Power*, (May 28, 2018), <https://www.cnbc.com/2018/05/28/10YmassiveYcorporationsYgoingYbigYonYsolarYpower.html>.

¹⁰² Jordan Weissmann, *Wal@Mart is Killing Corporate America in Solar Adoption*, (Oct. 21, 2014, 4:33 PM), http://www.slate.com/blogs/moneybox/2014/10/21/walmart_green_energy_it_can_produce_more_solar_power_than_35_states.html.

¹⁰³ David Ozment, *Walmart's Commitment to Solar*, (May 9, 2014), <https://blog.walmart.com/sustainability/20140509/walmartsYcommitmentYtoYsolar>. See also Diane Cardwell, *Chain Stores Said to Lead Firms in Use of Sun Power*, (Sep. 12, 2012), <https://www.nytimes.com/2012/09/12/business/energyYenvironment/chainYstoresYleadYfirmsYinYsolarYpowerYuseYstudyYfinds.html>.

Mart is one of many corporations that has pledged to operate with 100% renewable energy, while others have achieved the benchmark, such as Apple in April of 2018.

Large retailers are not the only corporate solar adopters. Banks and financial institutions are also leaders in solar deployment. Fifth Third Bank announced that it would achieve 100% renewable energy through a single power purchase agreement with project developer SunEnergy1. Kenny Habul, the CEO for SunEnergy1 said of the project:¹⁰⁴

SunEnergy1 pioneered the concept of corporate and institutional power purchase agreements for solar power. This is the first time that we have seen a corporation move to 100% clean power by purchasing all of the output from one project. When complete later this year, the Hertford County Aulander Holloman facility will be one of the largest solar projects in the US; it will provide an important economic investment in North Carolina; and it will lead to a meaningful and measurable difference in carbon emissions. The Earth is our vehicle through time so we congratulate Fifth Third for showing that companies can cut their emissions and improve the health of our environment today through solar power. We urge corporate America to stand up and join the 100% club.

The corporate sector is repeatedly listed as the top sector for solar potential. The Solar Energy Industries Association (SEIA) has resources dedicated to show the value of corporate solar adoption as well as programs, reports, and insights into how a business can do so successfully.

Higher Education

Institutes of higher education have benefited from renewables in a number of ways. From voluntarily purchasing clean energy through PPAs, to contracting to build facilities, to the very programs they offer to attract the brightest and most talented students, researchers, and leaders, higher education provides enormous potential for the solar energy industry.

Universities and colleges have been incorporating renewable energy and sustainability practices into their programs and business plans for years now and even have a nonprofit organization, the Association for the Advancement of Sustainability in Higher Education

¹⁰⁴ Eds. *Fifth Third Signs Power Purchase Agreement with 80MW Solar Project*, (Mar. 7, 2018), <https://www.powerYeng.com/articles/2018/03/fifthYthirdYsignsYpowerYpurchaseYagreementYwithY80YmwYsolarYproject.html>.

(AASHE), dedicated to facilitating and cultivating these efforts using a number of tools and resources. The largest fixed cost for colleges and universities are their campus facilities. With volatile energy prices, solar energy would offer a huge advantage for these institutions' budgets.

In Oklahoma, state universities are leading the way in unique partnerships. The University of Oklahoma (OU) has twenty different research centers and institutes related to renewable energy. The entities range from wind and solar to biofuels and policy. University faculty from OU have combined with colleagues at Oklahoma State University and the University of Tulsa to create the interdisciplinary, inter-university entity Oklahoma Photovoltaic Research Institute (OKPVRI).¹⁰⁵ This effort is the first of its kind in the nation where leaders from different universities in the fields of photovoltaics have come together to share research, resources, and ideas. OKPVRI holds an annual conference in Oklahoma each year, featuring national leaders in PV. The group's goal is to design, model, and fabricate cost-effective third generation solar cells as a cheaper alternative to current silicon-based cells. The research is cutting edge and is working to change solar PV technology as it is known today.

The work being done by universities across the state - both at individual campuses - and as a whole through OKPVRI, will continue to drive the solar industry forward in a positive way.

Equity in Renewable Energy

People of lower income households are disproportionately affected by rising energy costs. If they own homes, they can be less efficient due to unaffordable maintenance issues that cause already high utility bills to climb even higher. "Low income households spend about twice as much on energy, as a percentage of income, as the average household (U.S. EIA, 2013b)." ¹⁰⁶

¹⁰⁵ The Oklahoma Photovoltaic Research Institute, <https://okpvri.okstate.edu/aboutUs.html>, (last visited Aug 30, 2018).

¹⁰⁶ Environmental Protection Agency, Local Government Climate and Energy Strategy Series, *Energy Efficiency in Affordable Housing*, (2018), https://www.epa.gov/sites/production/files/2018/07/documents/final_affordablehousingguide_06262018_508.pdf. (last accessed Sep. 9, 2018).

Similar to other examples in this study, there are numerous resources to aid in providing equitable energy solutions to lower income communities and individuals. The Environmental Protection Agency (EPA) has a comprehensive guide for state and local governments to assist citizens in need with energy efficiency.¹⁰⁷ The EPA's Local Government Climate and Energy Series, the *Energy Efficiency in Affordable Housing* guide is extensive, publicly available, and was last updated in 2018. The purpose of the effort is to help local governments successfully reduce greenhouse gas emissions. The guide offers a global approach to energy efficiency for subsidized affordable housing, which it defines to include "both public housing, in which a government agency pays all or a portion of the occupants' monthly housing cost; and private housing, whose owners receive tax credits and other subsidies to set aside a percentage of their dwellings for low income households." This global approach contains concepts to improve efficiency in existing housing, approaches to maximize planning and design in affordable housing, examples of how to incorporate renewables (primarily solar) into efficiency plans, strategies to implement the plans, applicable financing programs, and a number of successful case studies.

Another guide, produced by the Clean Energy States Alliance and the U.S. Department of Energy's SunShot Program, provides information and resources to ensure DG technology is available to lower and moderate income citizens.¹⁰⁸ This guide is also focused on helping state and local governments succeed. The guide's co-producer, Clean Energy States Alliance, through its Sustainable Solar Education Project, also offers a host of resources such as webinars, an online course, a monthly newsletter, and in-person training.¹⁰⁹ With so many resources free and available to the public, there is no reason that citizens should be precluded from experiencing the many benefits of solar energy due to financial hardship.

Oklahoma is well-positioned to take advantage of the abundant opportunities for collaboration within the solar industry. Best practices can be developed and implemented from

¹⁰⁷ *Id.*

¹⁰⁸ Bentham Paulos, *Bringing the Benefits of Solar Energy to Low-Income Consumers A Guide for States & Municipalities*, May 2017, <https://www.cesa.org/assets/2017YFiles/BringingYtheYBenefitsYofYSolarYtoYLowYIncomeYConsumers.pdf>, (last visited Sep. 9, 2018).

¹⁰⁹ Clean Energy States Alliance, Sustainable Solar Education Project, <https://www.cesa.org/projects/sustainableYsolar>, (last visited Aug 31, 2018).

other states, with many excellent examples to replicate. Considering Oklahoma's needs, landscape, challenges, and opportunities, the state has great promise to continue as a national energy leader by adding solar energy to its portfolio. A strong solar industry bears jobs, cutting-edge technology, synergy among sectors, unique educational opportunities for students, and safe, reliable electricity for the whole state.

IV. COMPARISON

To realize the potential for Oklahoma's solar industry, one simply must look at states who have more robust, and favorable state policies and regulations toward solar energy. The following section will examine successful state solar industries in Georgia, Missouri and Massachusetts, focusing on their DG policies, jobs data and economic impact, recent projects, and state regulations regarding solar power.

Georgia

Georgia is ranked 10th in the nation for installed solar power capacity with 1,552.98 MW, enough to power 173,638 homes.¹¹⁰ Coincidentally, Georgia is also ranked 10th in the nation for average peak sunlight hours.¹¹¹ Compared to Oklahoma, Georgia has installed more than 33 times as much solar power capacity, creating a multibillion dollar industry within the state. Georgia is home to 45 solar system manufacturers, 100 installer and developer businesses, and 77 other solar related companies, supporting 4,310 jobs and investing over \$2 billion in the state. In 2016, the Butler Solar Project 103 was completed, which is a PV solar farm with the capacity to generate 103 MW of electricity - or more than double the entire installed capacity of Oklahoma. The average cost of electricity for residential customers in Georgia is \$.1226/kwh, which is slightly below the national average of \$.1302/kwh.¹¹² Georgia Power's Solar buyback program allows customers to sell their solar power to the grid at a rate of \$.17/kwh, more than

¹¹⁰ Solar Energy Industries Association, *Georgia Solar*, <https://www.seia.org/state/solar/policy/georgia/solar> (last visited Sept. 1, 2018).

¹¹¹ Nebraska Energy Office, *Comparison of Solar Power Potential by State*, <http://www.neo.ne.gov/statshtml/201.htm> (last updated Mar. 11, 2010).

¹¹² U.S. Energy Information Administration, *Table 5.6.A. Average Price of Electricity to Ultimate Customers by End Use Sector by State, June 2018 and 2017* (Aug. 24, 2018), https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.

\$.04 the retail rate. This program, along with other state policies discussed below, makes solar an attractive option for customers in Georgia.

Georgia, like Oklahoma does not currently have a renewable energy portfolio standard law (RPS). An RPS law is a mandate from the state government on utility companies requiring them to generate or purchase a certain percentage of renewable energy during a given period of time. If the utility does not meet this standard, the state assesses a fine. Utilities in states with strong RPS laws will often furnish customers incentives to produce renewable energy as the incentives are cheaper than fines imposed by the state.¹¹³ Therefore, states with strong RPS laws tend to have more robust solar power generation. Georgia allows for net-metering for solar systems up to 10kW, and its main utility, Georgia Power, will pay \$.17/kwh for power placed back on the grid. This makes solar power much cheaper than the retail rate for electricity in the state, making it a sound investment for many customers. Net-metering is limited to just 0.2% of the utilities' peak demand during the previous year, meaning that as solar becomes more and more popular within the state, customers may find themselves awaiting a space in the program, or alternatively, completely precluded from the benefits of net-metering.¹¹⁴

Georgia's solar power capacity has really exploded in the past 5 years, increasing from 116 MW in 2013 to over 1500 MW in 2017.¹¹⁵ From 2011 through 2014, the state had the Georgia Clean Energy Tax Credit which would give installers of solar power systems a 35% tax credit. The bill authorized \$15 million in new tax credits, which due to popularity was exhausted in three years, leaving the state without any tax incentives. Today, residents of Georgia, just like Oklahoma, only have the federal 30% ITC available to them. While the state tax incentive likely started the boom, the real growth came as a result of the Solar Power Free Market Financing Act of 2015. The Act "establishes that ... power purchase agreements (PPAs) are a lawful way to finance the construction and operation of a solar electric generation system. A solar company

¹¹³ *Id.*

¹¹⁴ DSIRE, *Net Metering, Georgia* (last updated Sept. 1, 2015),

<http://programs.dsireusa.org/system/program/detail/574>.

¹¹⁵ James Bruggers, Inside Climate News, *How Georgia Became a Top 10 Solar State, With Lawmakers Barely Lifting a Finger* (Jun. 14, 2018), <https://insideclimatenews.org/news/14062018/georgiaYsolarYpowerYrenewableYutilityYscaleYcleanYenergyYinvestmentsY2018Yelection>.

can finance the construction of solar panels for a home, business or institution in Georgia, including public schools, government buildings, colleges and universities, military bases, etc., and be repaid for the system through payment by the property owner for the electricity produced by the solar system.”¹¹⁶ This made Georgia the first state in the southeastern U.S. to approve PPAs from third parties, through law. PPAs remain the most attractive option available to residential consumers looking to invest in solar power. PPAs have little to no upfront cost to consumers, since the solar company or project financier pays for the installation and maintenance of the solar system on the consumer’s property. The consumer is simply buying the electricity provided by the system from the solar company, at a rate lower than the utility’s retail rate. This is made possible due to the PPAs’ long-term agreement, generally the same as the solar system - typically 20Y30 years. The project’s financier benefits from a stable and sound investment, while internal rates of return vary based on many factors, but 8Y12% is a common range. For the customer, the savings are immediate, and as retail rates increase, the rate for the power generated by the system stays the same. The consumer gets the benefit of reduced electricity bills, no maintenance or risk of system failure, and a reduced carbon footprint. While Georgia, may be missing RPS laws, tax incentives, and a robust net-metering policy, its codified authorization of third-party PPAs make it a solar friendly state.

Missouri

Oklahoma’s neighbor, Missouri is ranked 29th in the nation for installed solar power capacity with 167.61 MW, enough to power 18,118 homes.¹¹⁷ Missouri is ranked 14th in the nation for average peak sunlight hours, placing it behind Oklahoma.¹¹⁸ Compared to Oklahoma, Missouri has installed more than 3.5 times as much solar power capacity, creating a near \$500 million dollar industry within the state. Missouri is home to 22 solar system manufacturers, 54 installer

¹¹⁶SRG LLP, *A Win for Solar Energy in Georgia - SGR’s Sustainability Practice Group Instrumental in Passage of HB 57* (May 12, 2015), <http://www.sgrlaw.com/pressYreleases/sgrYattorneysYcelebrateYenactmentYofYsolarYenergyYfreeYmarketYfinancingYactYofY2015/>.

¹¹⁷Solar Energy Industries Association, *Missouri Solar*, <https://www.seia.org/stateYsolarYpolicy/missouriYsolar> (last visited Sept. 1, 2018).

¹¹⁸Nebraska Energy Office, *Comparison of Solar Power Potential by State*, <http://www.neo.ne.gov/statshtml/201.htm> (last updated Mar. 11, 2010).

and developer businesses, and 58 other solar related companies, supporting 2,609 jobs and investing over \$477 million in the state. In 2014, the O'Fallon Renewable Energy Center was completed, which is a PV solar farm with the capacity to generate 5.7 MW of electricity, enough to power 619 homes.¹¹⁹ The largest solar farm in Missouri began operations in Nixa, MO in 2017. It contains over 33,000 solar panels and generates 7.92 MW of electricity. The project is expected to save homeowners in the town of Nixa \$2.5 million in electricity bills over the next 25 years.¹²⁰ Missouri has recently seen an uptick in the average cost of electricity for residential customers, which is \$.1323/kw. This is slightly above the national average of \$.1302/kwh, making solar power an attractive option by increasing the return on investment over the life of the system.¹²¹

Unlike both Oklahoma and Georgia, Missouri has an RPS law which states that 15% of the state's electricity production must come from renewable energy sources by 2021. Additionally, of the power that is to come from renewable energy sources, the state has required that 2% must come from solar panels or 0.3% of statewide electricity production.¹²² Missouri's net-metering policy allows for much larger solar systems than Oklahoma and Georgia - up to 100kW and sets the aggregate cap of net-meter customers higher at 1% of the utility's single-hour peak load annually.¹²³ However, net excess electricity that is generated by the customer and provided to the grid is credited at an avoided cost of only \$.03/kWh, which is substantially lower than the retail rate of \$0.1323.¹²⁴ This is also a much lower credit than is found in Georgia (\$0.17/kWh) and Oklahoma (applicable retail rate at time of use). Additionally, Missouri does not have a clear policy regarding solar power purchase agreements. Where Missouri excels in solar versus Oklahoma is in state incentives and tax exemptions. Several

¹¹⁹ Solar Energy Industries Association, *Missouri Solar*, <https://www.seia.org/state/solar/policy/missouri/solar> (last visited Sept. 1, 2018).

¹²⁰ Wes Peery, OZARKS FIRST, *Largest Solar Farm in Missouri Dedicated near Nixa* (Nov. 15, 2017, 3:39 AM), <https://www.ozarksfirst.com/news/largest/solar/farm/in/missouri/dedicated/near/nixa/857538706>.

¹²¹ U.S. Energy Information Administration, *Table 5.6.A. Average Price of Electricity to Ultimate Customers by End Use Sector by State, June 2018 and 2017* (Aug. 24, 2018), https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.

¹²² Solar Power Rocks, *Missouri*, <https://solarpowerrocks.com/missouri/> (last visited Sept. 1, 2018).

¹²³ National Renewable Energy Laboratory, *Solar Research, Missouri*, <https://www.nrel.gov/solar/rps/mo.html> (last visited Sept. 1, 2018).

¹²⁴ Solar Power Rocks, *Missouri*, <https://solarpowerrocks.com/missouri/> (last visited Sept. 1, 2018).

utilities within the state, in order to satisfy the RPS law, offer rebates of up to \$5,000 for solar installations.¹²⁵ Lastly, the state offers a property tax exemption for solar installations. Solar power systems add considerable value to a home, since they dramatically reduce the home's need to purchase electricity from utilities, saving homeowners thousands of dollars over the life of the system. In an effort to promote solar within the state, Missouri exempts the increased value of solar systems from a homeowner's property taxes.¹²⁶

Massachusetts

While Massachusetts is tied for 18th in the nation for average peak sunlight hours, it ranks 6th in the nation for installed solar capacity, making the state a prime example of how state policies, not sunlight, determine the success of a state's solar power industry.¹²⁷ Leadership within Massachusetts' state government has created a robust solar power industry with 2137.81 MW of installed capacity, or enough to power 354,256 homes. In fact, 8.56% of the State's electricity comes from solar. The solar industry has brought over \$5.4 billion in investments to the state and created 11,530 jobs. The state is home to 85 solar manufacturers, 207 solar installer and developer companies, and 202 related businesses.¹²⁸ With residential rates at \$0.2111/kWh, electricity in Massachusetts is the fourth most expensive in the country, well above the national average of \$0.1302/kWh.¹²⁹ Therefore, by switching to solar, residents have the potential, and greater incentive, for substantial savings, especially because regular retail rates continually increase. In fact, the return on investment (ROI) for power purchase agreements, solar loans, and buying the equipment outright ranges from \$5,400 to \$17,000, with solar loans having the largest ROI.¹³⁰

¹²⁵ *Id.*

¹²⁶ *Id.*

¹²⁷ See Solar Energy Industries Association, *Massachusetts Solar*, <https://www.seia.org/state/solar/policy/massachusetts/solar> (last visited Sept. 1, 2018). See also Nebraska Energy Office, *Comparison of Solar Power Potential by State*, <http://www.neo.ne.gov/stats/html/201.htm> (last updated Mar. 11, 2010).

¹²⁸ Solar Energy Industries Association, *Massachusetts Solar*, <https://www.seia.org/state/solar/policy/massachusetts/solar> (last visited Sept. 1, 2018).

¹²⁹ U.S. Energy Information Administration, *Table 5.6.A. Average Price of Electricity to Ultimate Customers by End Use Sector by State, June 2018 and 2017* (Aug. 24, 2018), https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.

¹³⁰ Solar Power Rocks, *Massachusetts*, <https://solarpowerrocks.com/massachusetts/> (last visited Sept. 1, 2018).

Solar has been quite successful in Massachusetts due to the state’s commitment to renewable energy and its passage of the Green Communities Act of 2008. While the purpose of the act is to make the state more energy efficient and promote clean renewable energy across all sectors, as it relates to solar power, the act specifically allows for third party power purchase agreements, sets a state renewable portfolio standard, creates a solar carve out, and establishes provisions for net-metering.¹³¹ Massachusetts’ RPS first required that 10% of all utility and retail suppliers produced electricity be from renewable energy sources. This requirement has since been updated to 15% by 2020. For each year after 2020, there must be a 1% increase in renewable energy production.¹³² The legislature mandated that 400 MW of this renewable energy come from solar by 2017, which the state met. The target has since been revised to 1600 MW by 2020.¹³³ The state requires investor-owned utilities to offer net metering for up to 7% of the utility’s peak load for private customers and up to 8% for government entities. Typical residential systems of 10kW or less are exempt from this cap.¹³⁴ The state also allows for neighborhood net metering for groups of 10 or more neighboring residential customers who wish to operate their own solar power system collectively. Net-metering customers receive credits for excess electricity that is generated by their system and provided to the grid. These “credits are calculated based on the excess kWh produced” and are typically slightly less than the utility’s full retail rate. There is no limit as to how long credits can be carried forward on billing cycles, allowing a customer to continue to benefit from very efficient systems during sunny summer months through winter months.¹³⁵ It should be noted that solar PV systems work during the less sunny months, and even produce some energy during times of shade.

Solar power within the state has also benefited from Massachusetts’ generous tax credits, solar renewable energy certificates, property tax exemptions, and sales tax exemptions.

¹³¹ Environment Northeast, *Massachusetts 2008 Energy Bill* (Jun. 25, 2008), https://acadiacenter.org/wp-content/uploads/2014/10/ENE_MA_2008_Energy_Act_Summary_062508.pdf.

¹³² National Renewable Energy Laboratory, *Solar Research, Massachusetts*, <https://www.nrel.gov/solar/rps/ma.html> (last visited Sept. 1, 2018).

¹³³ Solar Power Rocks, *Massachusetts*, <https://solarpowerrocks.com/massachusetts/> (last visited Sept. 1, 2018).

¹³⁴ DSIRE, *Net Metering, Massachusetts* (last updated Sept. 29, 2016)

<http://programs.dsireusa.org/system/program/detail/281>.

¹³⁵ *Id.*

In addition to the 30% federal tax credit, residents who install a rooftop solar system receive a 15% tax credit off the net cost (cost of system minus federal 30% credit) of the system, up to \$1,000.¹³⁶ Considering almost all residential systems cost several thousand dollars, most people who take advantage of this credit receive the full \$1,000 against their personal tax liability. A major policy difference between Massachusetts and the states previously discussed, is Massachusetts' solar incentive funding mechanism is called a "solar renewable energy certificate" or SREC. A SREC is a certificate which signifies that a producer has generated 1 MWh of renewable energy. Owners of a typical residential solar system will earn approximately six SRECs per year. Due to Massachusetts' RPS, utility companies seek to purchase SRECs from producers since ownership of a certificate is the equivalent of the utility producing the renewable energy itself.¹³⁷ SRECs cost less than the fines (\$350 in 2016) the state imposes on utilities that do not produce enough solar energy to meet the requirement. The current market price for a SREC is \$285, meaning a typical residential solar producer could make an additional \$1,700 per year.¹³⁸ This lucrative incentive program has been a major reason for the wide adoption of solar power in Massachusetts. Lastly, Massachusetts also has property tax exemptions and sales taxes exemptions for solar power installations.

Massachusetts is home to the nation's largest community solar farm: NRG Energy's Spencer Community Solar Farm located in Spencer, Massachusetts. This 20.1 MW farm covers over 200 acres and consists of more than 61,000 solar panels, powering more than 1,500 homes.¹³⁹ A community solar farm allows a group of people within a community to collectively benefit from the credits the solar farm produces through net metering. This allows people of all income levels to buy into the solar farm at a fixed month price, with no money down. These community solar farms reduce energy bills by 5-15%, all without requiring individuals to purchase, install, and maintain a more costly individual solar system, such as rooftop, which is

¹³⁶ Solar Power Rocks, *Massachusetts*, <https://solarpowerrocks.com/massachusetts/> (last visited Sept. 1, 2018).

¹³⁷ *Id.*

¹³⁸ SREC Trade, *Markets, Massachusetts*, https://www.srectrade.com/srec_markets/massachusetts.php (last visited Sept. 1, 2018).

¹³⁹ NRG Energy, *Massachusetts Community Solar Farm Projects* (Apr. 25, 2017), <https://www.nrgcommunitysolar.com/blog/understandingYcommunityYsolar/massachusettsYcommunityYsolarYprojects/>.

still cost prohibitive for many. Community solar projects are a renewable energy solution for people who want to be environmentally friendly, but who do not have the means to purchase or lease solar systems.

Through a robust set of pro solar state policies, Massachusetts has become a leader in creating an environment for the solar energy industry to thrive. Massachusetts' net metering, renewable portfolio standard laws, Solar Renewable Energy Certificates, and tax incentives make it an example for other states looking to realize solar power potential. These programs continue to be so successful and are projected to add an additional 1.7 GW of solar capacity to the state over the next 5 years.¹⁴⁰ If adopted in a state like Oklahoma, with much greater sun exposure, these policies would lead to billions of dollars of investment and bring new jobs and businesses to the state, all while helping Oklahoma citizens reduce their carbon footprint.

¹⁴⁰ *Id.*