Solar Energy

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KEY POINTS

- California reached a milestone of ONE MILLION installed solar systems in 2019 and accounts for nearly half of all solar installations in the U.S.
- Fresno has the third-highest number of homes in California with rooftop solar panels.
- A solar panels/lithium-ion batteries complex— to be located in Kern County was recently approved by the Los Angeles Department of Water and Power. The project would meet 6% to 7% of L.A.'s annual electricity needs.
- California has the largest number of commercial solar customers in the U.S. The low cost of reliable solar energy storage systems (batteries) in the long-term will secure a more flexible and adjustable energy supply and has the potential to mitigate high peak-time demand charges.

Overview

The Golden State could also be referred to as the "Solar State," as it accounts for 47% of all solar installations in the U.S. Our abundant sunshine, high utility rates, and availability of land create an ideal environment for investments in solar. In addition, our state government's commitment to renewable energy has created a favorable legislative environment. In February 2005, California Governor Arnold Schwarzenegger introduced the California Million Solar Roofs bills (SB 1 and SB 1017). The two bills together were intended to create a ten-year incentive program to help Californians install one million solar systems throughout the state by 2018[1]. In September of 2018, then California Governor Jerry Brown signed Assembly Bill 100, which established a goal to have 60% of the state's energy derived from clean energy by 2030, and 100% by 2045.

Photovoltaic (PV) systems convert sunlight directly to electricity by means of PV cells made of semiconductor materials. California reached the milestone of ONE MILLION installed solar PV systems in 2019, one year later than the goal set by Governor Schwarzenegger. Numerous for-profit companies and nonprofit organizations like Grid Alternatives contributed to achieving this milestone[2]. According to a report

by the Solar Energy Industries Association, as of June 2019, 18.74% of the state's electricity came from solar, a significantly higher percentage than the national average of 2.5%[3]. It is clear that California is on track to meet its ambitious renewable energy targets, with solar power playing an ever more important role in California's energy future.

A solar power system represents a significant cost savings for its owner. If one assumes that a typical residential solar system can offset a $300 monthly energy bill, that solar system represents an after-tax savings of $3,600 per year. If that savings is applied across one million solar systems, it equals $3.6 billion in potential energy savings every year. Even more significant, the value of these savings increases over time as the value of a kilowatt rises every year with utility rates.

Solar Trends in California and the Valley

California continues its commitment to renewable energy through the new home solar mandate. Starting in 2020, all new homes in California are required to have solar power installed. The amount of solar required is determined by the square footage of the home and the climate zone in which the home is located. A typical new home will have 8-10 solar panels, which will not completely offset a home's energy consumption, but will allow the homeowner to benefit from reduced reliance on the utility for their energy needs[4].

Of note, Fresno has the third-highest number of homes in California with rooftop solar panels. The total electrical output capacity of Fresno's residential solar panel systems amounted to almost 148,700 kilowatts of direct current (DC) power[5]. In the four counties around Fresno (Fresno, Kings, Tulare, and Madera Counties), there were 1,000 solar permits issued per month in 2019.

The Central Valley has also proven an excellent location for large-scale solar facilities due to the relatively low cost of real estate, abundant open land, and mild climate. Large-scale plants often employ concentrating solar power (CSP) systems to concentrate the sun's energy using various forms of reflective or converging devices such as troughs, lenses, or mirror panels that produce heat, which is then used to generate electricity. Key requirements for CSPs include contiguous parcels of land with limited cloud cover and areas of high solar radiation (as measured by the sun's intensity). According to the National Renewable Energy Laboratory (NREL), the U.S. Southwest, including Central California, meets these requirements particularly well. Table 1 provides a list of large (100 megawatt AC capacity or more) solar power generating facilities located in the Central Valley[6,7].

FRESNO HAS THE THIRD-HIGHEST NUMBER OF HOMES IN CALIFORNIA WITH ROOFTOP SOLAR PANELS.

Table 1
Large Solar Facilities in the Central Valley with 100MW AC Capacity or More

Station	Location	Capacity (MWAC)
Great Valley Solar Farm	Fresno County	200
Tranquility Solar Project	Fresno County	200
Astoria Solar Project	Kern County	175
Beacon Solar Project	Kern County	162
Catalina Solar Project	Kern County	143
Garland Solar Facility	Kern County	200
Solar Star	Kern County	579
Springbok Solar Farm	Kern County	260
Henrietta Solar Project	Kings County	105
Mustang Solar Project	Kings County	100
Quinto Solar Project	Merced County	110
Data Source: U.S. Energy Administration		

Solar Energy

In addition to established solar plants, new solar projects are planned for the Central Valley. In November 2019, the Los Angeles City Council unanimously approved purchasing power from the Eland Solar and Storage Center. "Located on 2,650 acres in Kern County, the project will include two large-scale solar facilities that will capture 400 megawatts (MW) of solar energy and store up to 1,200 megawatt-hours (MWh) of energy. The site will hold enough energy to power 283,330 homes across Los Angeles." The facility is estimated to be the largest solar energy and storage facility in the United States[8,9].

In Merced County, the Wright Solar Facility, with a 200 MW capacity, came online November 30, 2019 to provide energy to San Mateo. "This project will add hundreds of construction jobs in the community, bring in millions of dollars of new tax revenues and will greatly enhance the effort to make our state and region more environmentally sustainable," according to a County official.

According to the Solar Jobs Census of 2018, there were 242,000 jobs in the solar industry in the U.S. (including installation, manufacturing, trade & distribution, and operations & maintenance). California employed about 77,000 of the total, or close to one-third of U.S. solar jobs. While counties like Santa Clara and San Francisco employ roughly 10,000 solar workers each, the six-county area that makes up the Central Valley had just over 2,000 jobs total. Table 2 indicates the distribution of solar jobs by county[10].

Factors Affecting the Solar Industry

The demand for solar installations is impacted by the cost of the technology, the availability of tax credits from both state and federal authorities, the capacity and compatibility of energy storage devices, the useful life cycle and recyclability of solar panels, and environmental factors like the recent weather and fire conditions that have created grid shut downs. The costs associated with prices of modules, inverters, other hardware balance-of-system components (BOS), and all the soft costs have been reduced by more than half over the last eight years as shown in Figure 1[11]. In addition, the cost to install solar has decreased 70% over the last decade. An average-sized residential system has dropped from a pre-incentive price of $40,000 in 2010 to roughly $18,000 today[12].

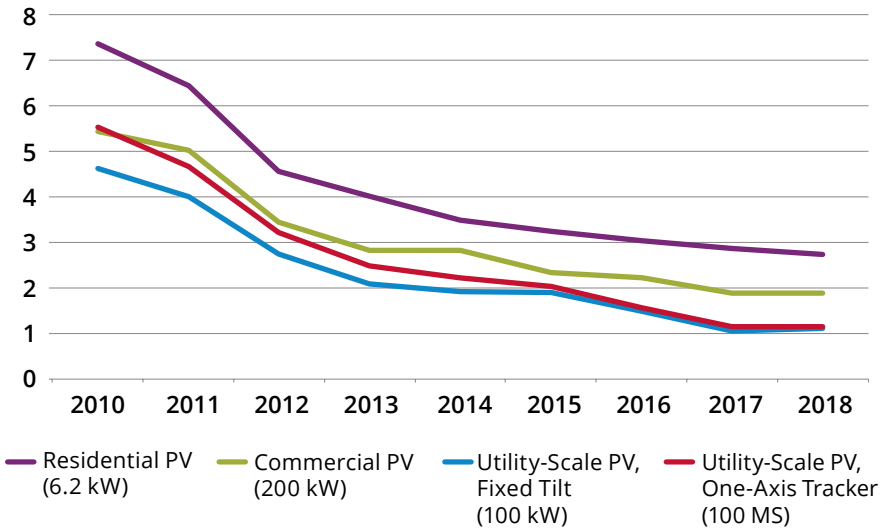
Tariffs on solar panels imported from China impose stress on solar energy installation. According to a report published by Solar Energy Industries Association (SEIA)[13], the

Table 2
Solar Jobs in Central Valley Counties

County	Solar Jobs
Kern	895
Fresno	862
Tulare	223
Kings	38
Madera	29
Merced	26
Total	2073

Data Source: The Solar Foundation, Solar Jobs Census, 2018

Figure 1
Cost by Year for Types of PV Solar Systems • 2018 $ per Watt DC



Data Source: PV System Cost Benchmark Summary (inflation adjusted) by National Renewable Energy Laboratory, 2010–2018[12]

four-year tariff program that began in early 2018 could potentially reduce installations by 10.5 gigawatts (equal to 1.8 million homes) between 2018 and 2021. The White House (Trump administration) has argued that more solar manufacturing jobs could be created in the U.S. by resisting China's heavily subsidized solar industry. However, the reality is most panels installed in the U.S. are made in China (China PV manufacturers hold over 50% global market share), and solar panel price increases significantly discourage people to buy and install.

Government Incentives and Subsidies:

The Solar Investment Tax Credit (ITC) has been one of the most important federal programs to support the growth of solar energy in the U.S. The tax credit provides a federal income tax credit equal to 30% of the cost of a solar project for both residential and commercial projects. Originally created in 2005, the program phases out over a three-year period starting in 2020. The tax credit in 2020 is 26%, drops to 22% in 2021, and drops further to 10% in 2022[14]. In 2023, residential solar projects will receive no tax credit, while commercial solar projects will continue to qualify for a 10% income tax credit.

Figure 2 provides information about the installation types and overall growth in installations in California for the past decade[15]. Most segments of the solar industry have experienced tremendous growth year-over-year. The number of utility-scale solar projects fluctuates year to year due to the time required to develop these projects and the timing of their coming online for service. Residential and non-residential (commercial) solar projects have seen consistent annual growth over the past ten years. In 2016 there was a spike in solar projects due to the anticipated expiration of the solar investment tax credit (ITC) at the end of that year. Even though the ITC was extended six more years in December 2015, many solar projects had been planned for completion prior to the ITC expiration. This spike in 2016 led to a reduced number of solar projects being completed in 2017. The year 2018 saw a return to the annual growth rates of previous years.

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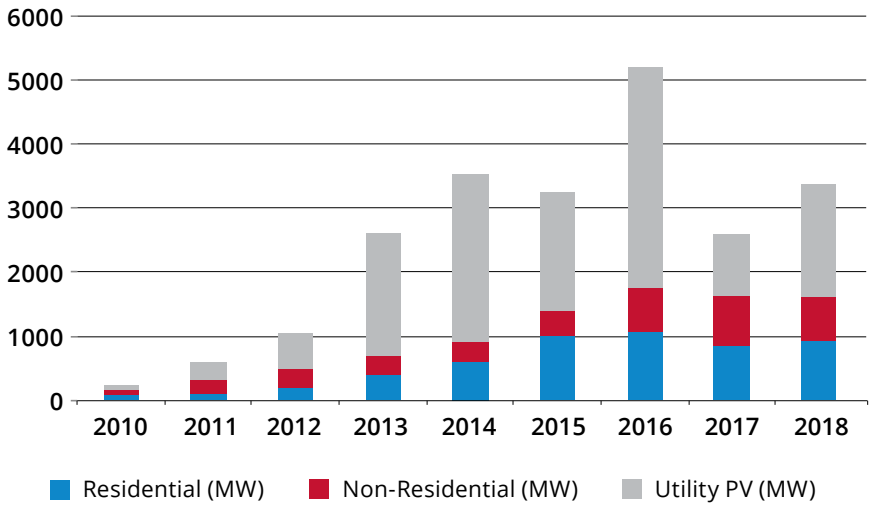
In addition, the Self-Generation Incentive Program (SGIP), a rebate program offered by the State of California for approved renewable technologies is commonly applied to batteries that are used for solar energy storage. The value of the incentive can range from $0.50 to $0.25 per watt-hour, which translates into a savings of

Figure 2
Number of New Solar Installations by Year and Type (in Megawatt Capacity)



Data Source: California annual solar installation capacity of photovoltaic (PV) systems, 2010 to 2018[15]

$1,250 to $2,500 on a 5kW battery[16]. With a battery energy storage system, California homeowners can not only store excess solar electricity and decrease energy bills, but also secure energy for unexpected extreme situations.

Environmental Factors (Weather and Wildfires):

The recently implemented Public Safety Power Shutoffs (PSPS), which occur during high winds and high fire danger events, have drawn attention to the benefits of energy independence. During certain weather conditions, the utilities turn off power to affected regions to reduce the risk of fires. Even if power is only turned off for 24 hours, it can take days for the utility to inspect transmission lines after the weather conditions have passed. Most solar systems are designed with a safety feature to shut down when the electric grid is turned off to prevent the solar system from pushing power into the grid when the utility requires the grid to be completely disabled. It comes as a surprise to some solar consumers that their solar system will not provide backup power during a power outage.

One of the solutions to this problem is a backup battery system. When a solar system is designed with a battery component, the solar system detects when the power from the grid is disabled and switches to an "islanding mode." This allows the solar system to operate independently of the grid, providing power for the home or business to consume during the day, and providing backup power via the battery's storage capacity in the evening.

Solar Energy Storage:

Currently, there are two different types of battery storage systems in California applications: grid-tied systems and off-grid (or independent) systems. The challenges faced by grid-tied systems are their complex design and installation, while their benefit is a small size and a balance of excess energy demand such as unexpected changes from equipment overloads or storms, different daily patterns of human activities, etc. Since the power supply and demand in the electricity grid must be equal at any given moment, the grid-tied systems can smooth out the supply and ensure it matches the demand. The off-grid systems typically work with renewable energy systems, e.g., solar panels, and are installed in areas that have a high chance of disconnection from the grid to protect devices against shortfalls of power through their rapid response and quickly discharging power to the electricity grid. Their batteries are therefore larger in size and are more costly to install, particularly due to their high initial cost. In comparison, normal energy backup systems (gas or diesel generators) tend to take a much longer time to respond to the disconnection. In addition, off-grid battery systems can offer a nearly endless service life, a clean, quiet and adjustable energy supply, and the integration capacity to future home upgrades (e.g., smart home) and a future smart grid. In the long term, they have no additional fuel cost and very few maintenance or service costs.

It is estimated that just over 25% of U.S. commercial customers have the option to subscribe to a utility payment structure that includes a "demand charge" (a charge for electricity used at the operation's peak level of demand). Demand charges allow the utility to distribute more of the costs of building and maintaining system capacity to those who contribute most to the need for increased capacity. Such charges may exceed $15 per kilowatt. California has the most commercial electricity consumers (over 1 million)[17]. Given this potential for high demand charges, many commercial customers in California and elsewhere are considering installation of battery systems and other storage devices.

Solar Long-Term Maintenance and End-of-Life Disposal:

The deployment of solar photovoltaic (PV) in the US accounted for over 50 million solar modules in 2018 and is estimated to double by 2022[18]. By 2050, the US is expected to have 7.5 million tons of PV waste with the potential to recover enough raw materials to produce 2 billion new panels[19]. Although the installed solar panels can usually last for 10~20 years, the predictable waste volume of solar urges people to establish a long-term maintenance and waste-management & disposal strategy.

Solar power installation in California is becoming more economical and affordable, a factor allowing the state to stay on track to meet future ambitious renewable energy goals.

Early failures and end of life projects will create an economic opportunity and an environmental need to recycle PV modules. Currently, the PV module recyclers do not have the required volume to run the recycling factories to the sufficient capacity to make the process economical. At the same time, there is no system and funding in place to relocate the PV modules from the rooftops to the recycling factories. The Solar Energy Industries Association (SEIA) has written a white paper stating the need for a system and currently only the state of Washington has such a system[20].

Recycling of PV modules and batteries has the potential to become a valuable secondary resource for critical materials: for example, it has been argued that high-cobalt-content modules and batteries should be recycled immediately to bolster cobalt supplies[21]. Numerous recycling methods, such as thermal and chemical methods currently attract increasing research efforts and are under fast development. These methods can be adapted to the PV modules, home energy storage systems and even car batteries. With around 12,000 MW solar and over 700 MWh of batteries installed in 2018 in California, recycling is becoming a game changer in the solar industry and supply chain.

Conclusion

Solar power installation in California is becoming more economical and affordable, a factor allowing the state to stay on track to meet future ambitious renewable energy goals. As an excellent location with abundant sunshine and availability of land, the Central Valley has built over 2,200 MW AC capacity solar-power generating facilities and created over 2,000 solar jobs. Although recent tariffs on Chinese imports may impose stress on solar power system deployment, the long-term cost reduction and low maintenance requirements will lead to the continued overall growth of solar installations in California. Solar power generation with a battery energy storage system has the great potential to mitigate the risks associated with maintaining a continuous power supply during extreme conditions and can optimize the demand-production balance for the electric power grid.

Endnotes

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