CFC ISSUE BRIEF

Understanding Utility-Scale Solar

National Rural Utilities
Cooperative Finance Corporation

Introduction

Solar energy is the fastest-growing energy resource on the U.S. grid. Driven by lower prices, technology improvements, and state and federal incentives, solar is playing a key role in bringing clean energy onto the grid. Over the last decade, solar energy capacity has grown by 24%, on average, each year. With the passage of the Inflation Reduction Act (IRA), electric cooperatives now have more incentives to invest in solar.

Solar is an intermittent resource, but it is clean and cheap. Solar energy is being deployed at different scales, both behind the meter and on the grid. Grid-scale solar is becoming more common, with growth outpacing behind-the-meter resources, such as rooftop solar. Utility-scale solar is the largest application, followed by community solar and rooftop solar. Utility-scale solar feeds the electric grid, while community solar allows for shared access to solar power, and rooftop solar directly serves individual homes. Community solar is a large, central power plant within a geographic area whose benefits flow to multiple consumers—such as homeowners, businesses, nonprofits and other groups. Utility-scale solar provides fixed-price electricity, especially during peak demand periods, which can be cheaper than fuel-based generation.

According to the U.S. Energy Information Administration (EIA), nearly 6% of U.S. electricity comes from utility-scale solar energy, and nearly 60% of new planned generating capacity for 2024 is expected to come from solar energy. The energy sector will potentially undergo a transformation with the IRA. The IRA includes a vast range of tax credits and other incentives—such as grants—to promote, among other things, clean energy projects. Prior to the IRA, generation and transmission cooperatives were not able to directly benefit from the tax incentives offered to solar developers unless they were taxable. The "direct pay" incentives allow electric cooperatives to take advantage of the tax credits available through cash payments in the form of a tax refund.

The "direct pay" incentives that are a part of these programs allow cooperatives to earn both production tax credits and investment tax credits and other incentives that could lower the costs of ownership of utility-scale solar. For a deep dive into the IRA incentives for cooperatives, read the CFC and NRCO report, "Inflation Reduction Act Opportunities and Considerations."

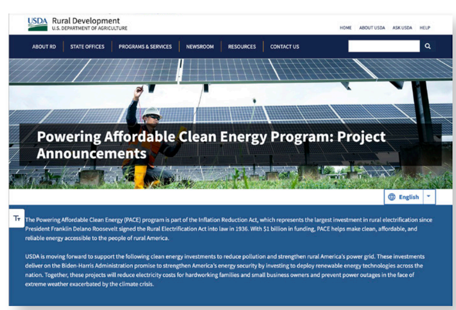
Solar energy contributes about 3,937 MW of capacity to electric cooperatives, which is about 5.4% of the generation mix, according to the EIA. While it is still a small part of the overall energy mix, the share of solar in the renewable energy mix has been increasing over the past five years.

This issue brief is intended to serve as a guide to electric cooperatives that want to gain a deeper understanding of utility-scale solar, with a focus on solar technology, current market trends, the economics that are driving supply and demand, and the future outlook for the industry.

The IRA includes two key programs that incentivize the shift to clean energy, including utility-scale solar for electric cooperatives.

- The Powering Affordable Clean Energy (PACE) program is aimed at increasing clean energy and making it more affordable for rural consumers through partially forgivable loans for utility-scale clean energy projects, such as wind, solar, hydropower, biomass, geothermal and energy storage with renewable energy. The PACE program has a total of $1 billion in funding and up to $100 million for loan applicants.

- The Empowering Rural America (New ERA) program has a $9.7 billion budget exclusively for electric cooperatives to ensure resiliency, reliability and affordability of rural electric systems that achieve the greatest reductions in CO2, methane and nitrous oxide emissions. Among the activities supported under the New ERA program are the purchase of renewable energy and zero-emission systems through both ownership and power purchase agreements.



Background

What is Utility-scale Solar?

There are varying definitions on the threshold of capacity that makes a solar project "utility scale." These definitions have shifted over time with the rise of more efficient solar panels. Given the smaller size of electric cooperatives, utility-scale projects usually range from capacities of 1 MW into the hundreds of MWs.

The technologies deployed most frequently are concentrating solar thermal power (CSP) plants and solar photovoltaic (PV) plants. CSP plants are less common today, as solar PV has benefited from advancements that have increased capacity and lowered costs. Solar PV projects are usually ground mounted, as opposed to roof mounted, which is common among residential and commercial solar users..

Key PV Technologies

There are two types of technologies that are commonly deployed in solar farms: fixed-tilt PV and tracking PV. The orientation and tilt of the PV panels relative to the sun determines the amount of electricity the panel generates.

Fixed-tilt PV

As the name suggests, the fixed-tilt PV system has stationary mounting. The solar PV system is mounted on the ground at an optimum tilt to absorb the most sunlight. It is usually adopted in geographies that are more challenging, such as slopes and rolling terrains. These are cost effective to install and can result in substantial cost savings as fewer posts are needed, assembly and installation time is short, and maintenance costs are lower. In general, fixed-tilt systems are more durable and can withstand harsh weather.

Table 1: Fixed-tilt PV, Tracking PV

	Fixed-tilt PV	Tracking PV
Installed MW	11,437	50,013
Average Installed Costs (2022 $/W)	$1.2	$1.4
Capacity Factor (%)	25%	29%

Note: Values denote W and MW of AC electricity.

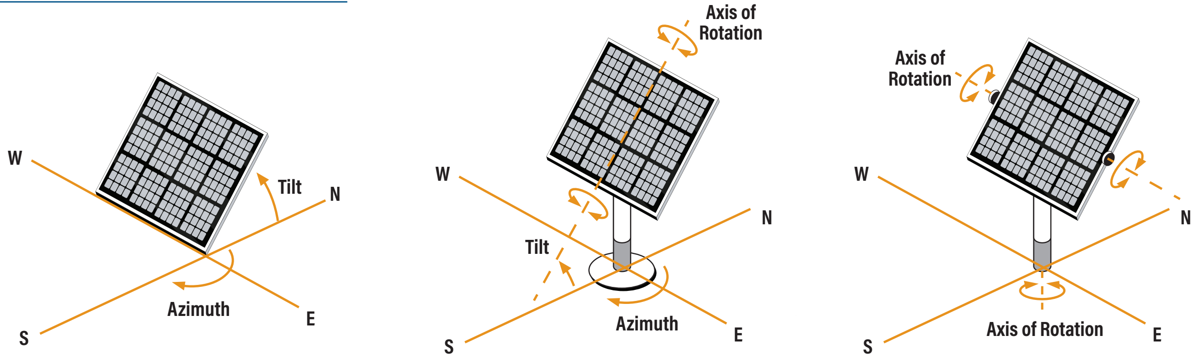
Tracking PV

Solar PV tracking systems optimize the path of the sun throughout the day using sun-tracking technology, i.e., the panels move through the day to follow the movement of the sun. This rotates the panels along a single axis or dual axis, capturing more radiation. Tracking PV generates more electricity than fixed-tilt PV systems. This technology is well suited for locations with high solar potential. Tracking PV systems have a growing share of the utility solar market because of these advantages and falling costs.

The installed or nameplate capacity reflects the total or maximum electricity that a system is able to produce and is usually determined by the manufacturer, or in the case of solar, the number and capacity of the modules installed. The capacity factor measures the energy output over a period of time to the maximum energy output over the same period. In other words, it measures how often the system or plant is running at maximum power.

For solar PV systems, the capacity factor is relatively low, averaging between 25% to 30% (Table 1), but it depends on the region of the country. Furthermore, fixed-tilt PV systems with a lower capacity factor generate less energy than tracking systems. As a comparison, the average capacity

Solar Fixed-tilt and Tracking PV Systems



PV array facing south at fixed tilt.

One-axis tracking PV array with axis oriented south.

Two-axis tracking PV array.

factor of a battery storage system is 16%, onshore wind is 33%, a combined-cycle gas plant is 57% and nuclear is 92%. Solar energy in these systems is generated only during daylight hours, and the energy output varies based on the weather conditions. Solar is unable to meet the generation needs in the evenings during the peak demand hours. In poor weather conditions—when it is cloudy, raining or snowing—solar doesn't generate to its maximum potential. Therefore, the energy available from solar is much lower than the reported installed capacity. For grid reliability, solar needs to be coupled with other generation resources providing firm capacity.

Bifacial and Monofacial Solar Panels

Traditional solar panels are monofacial: They absorb light from the sun from one side of the solar panel. Bifacial solar panels are able to absorb light from both sides of the panel. They absorb light directly from the sun from one side as well as light that is reflected off the ground and other surfaces from the other side of the panel. This feature makes bifacial panels more efficient, yielding an estimated 11%–27% more energy.

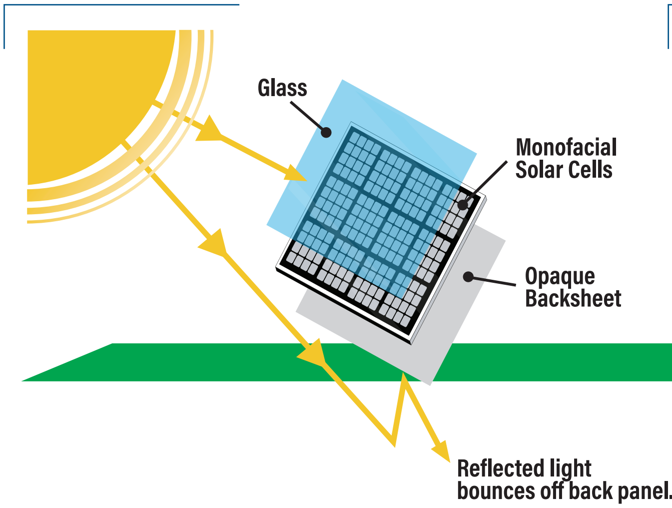
The most common and effective application is in ground-mounted solar PV systems, particularly tracking PV systems. However, these systems cost more than the traditional monofacial panels, up to $0.10 per watt (Energy Sage). Bifacial panels had tariffs levied on them from 2018 to 2022, but are now exempt. The price of these panels is expected to fall and become less expensive to procure in the future (Energy Sage).

Solar PV Plus Battery Storage

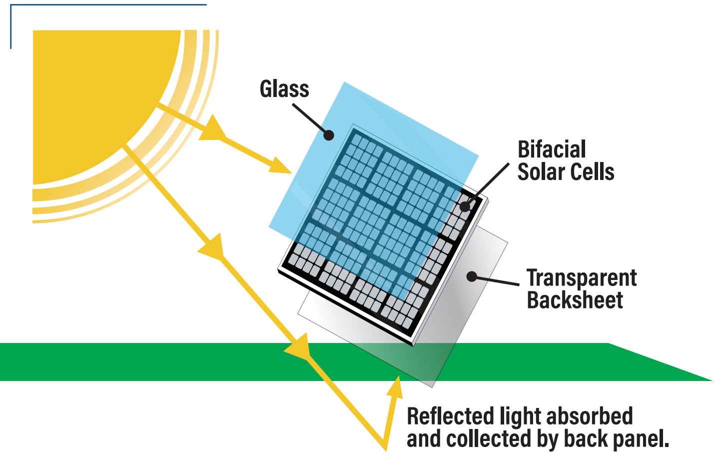
In recent years, solar PV has often been combined with battery storage to form hybrid systems that make electricity available during the evening hours when the sun isn't shining. These systems also help reduce the amount of electricity consumed during peak hours and increase the value of the utility plant by decreasing intermittent electricity supply from solar generation.

Economies of scale and technology improvements have led to decreasing costs and larger capacity of battery storage technology. There is an uptick of new projects as well as retrofitting of existing projects to include battery storage with solar. According to LBNL, battery storage was stable in 2022, when 35 plants built storage as a retrofit or as a new greenfield plant coupled with solar PV. A total of 7.1 GW_{AC} of PV and 3.9 GW of battery storage achieved commercial operation, largely in California and Texas as well as in Massachusetts in 2023.

Monofacial Solar Panels



Bifacial Solar Panels



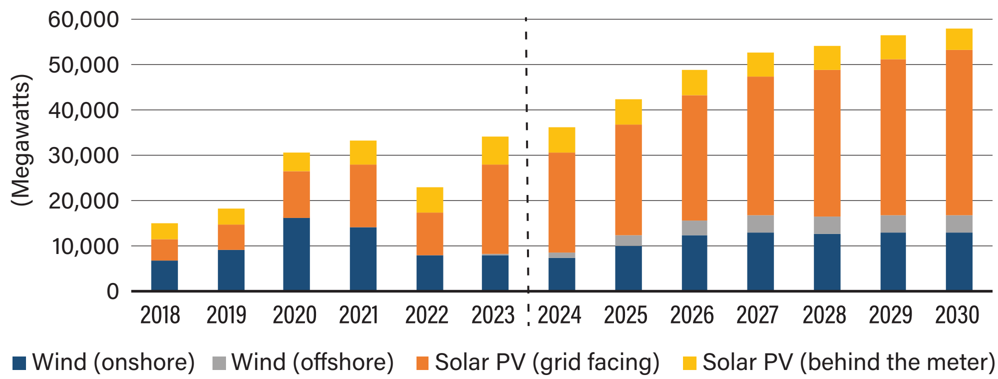
Overview of the Industry

The solar energy sector has seen rapid growth and momentum over the past 10 years and has the potential to get a boost from the IRA. Over the last five years (since 2022), 180 GW of new supply was added to the U.S. power sector, of which over 50 GW came from solar PV generation (S&P). Solar PV accounted for about 53% of all new capacity additions to the grid in 2023 (Wood Mackenzie) (Figure 1). The installed capacity of utility-scale solar grew by 77% in 2023 (Wood Mackenzie) and a total of 22.5 GW of utility-scale solar PV was interconnected.

Since 2015, fixed-tilt systems have become a smaller overall share of installed systems as the technology, though less expensive, is not as efficient as tracking systems (LBNL). Meanwhile, single-axis tracking systems make up the majority of the new capacity additions and installations in the industry. Overall, tracking systems have the majority of the market share for utility-scale solar. The annual capacity additions for utility-scale solar show that over the last five years, the share of fixed-tilt PV has remained relatively stable at under 2 GW_{AC}. However, the vast majority of new additions have been tracking systems, with an estimated 94% of new PV projects using tracking technology.

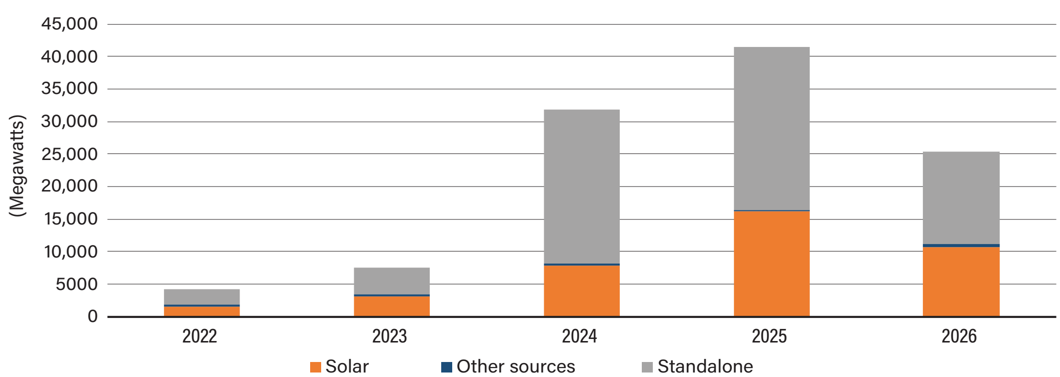
Battery storage continues to be deployed along with solar to address issues of reliability from the intermittent electricity supply. California added the most storage capacity with roughly 960 MW, followed by Texas (LBNL). There is about 85 GW of utility-scale energy storage that is planned to enter commercial operation between 2023 and 2025 (S&P). The forecasts for battery storage growth also show an increase over the next decade. Battery storage is growing both as a standalone resource on the grid and when it is co-located with solar power (Figure 2).

Figure 1: U.S. Renewable Capacity Additions



Source: IHS North American Power Market Outlook, IHS Markit.

Figure 2: Energy Storage Co-located, Standalone Systems



Source: Standalone and Co-located Energy Storage Projects, Energy Storage Capacity by In-service Date (MW), S&P Capital IQ.

Economics Shaping the Utility-Scale Solar Sector

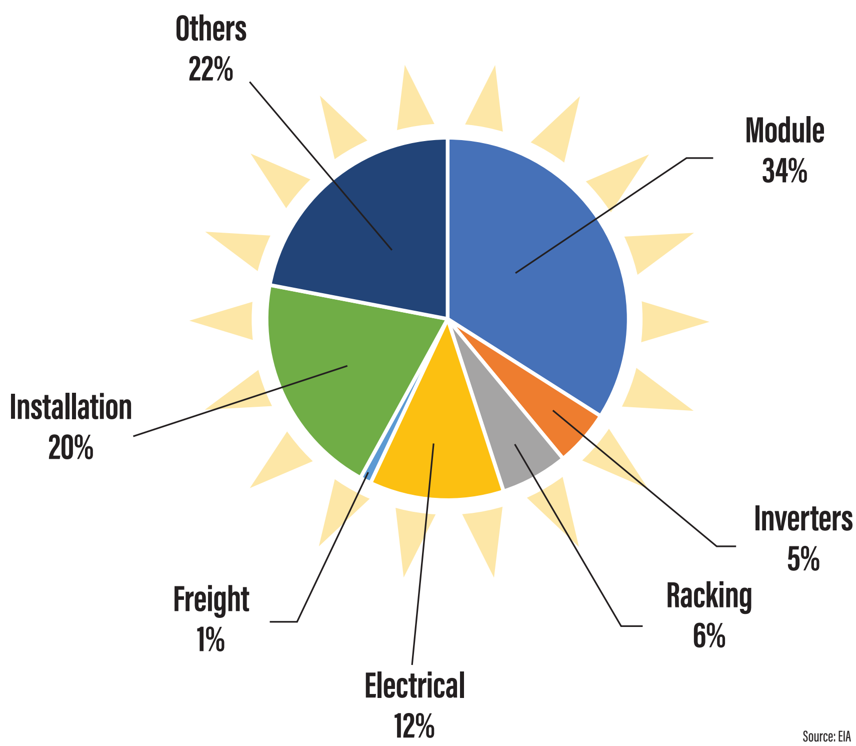
The costs of solar have declined drastically over the last decade. With IRA incentives, many cooperatives will find it economically advantageous to build, own or lease solar energy. The price declines are generally attributed to a fall in the costs of modules, stemming from a fall in the prices of raw materials and an increase in the efficiency of the module technology. Modules usually account for 34% of the installation costs (Figure 3). Other factors that have led to declines in prices are a fall in installation costs and higher levels of incentives and subsidies, which lower overall costs. Some of the "soft costs," the costs related to permitting, licensing and overheads—like the marketing, sales and administrative costs—have been slow to change.

The installed costs of solar PV have fallen by 78% since 2010 (LBNL). Correspondingly, the prices for the different types of PV systems have also fallen. While tracking technology for PV systems is more expensive than fixed-tilt systems, the price differential has narrowed over time. Tracking systems have a higher upfront cost, but they deliver electricity with more efficient technology.

The levelized cost of energy (LCOE) represents the average revenue per unit of electricity generated that would be required to recover the costs of building and operating a generating plant during an assumed financial life and duty cycle. LCOE is a metric that combines the primary technology costs and the performance parameters of capital expenditures, operations expenditures and capacity factors. It is generally used to determine the price of a power purchase agreement (PPA).

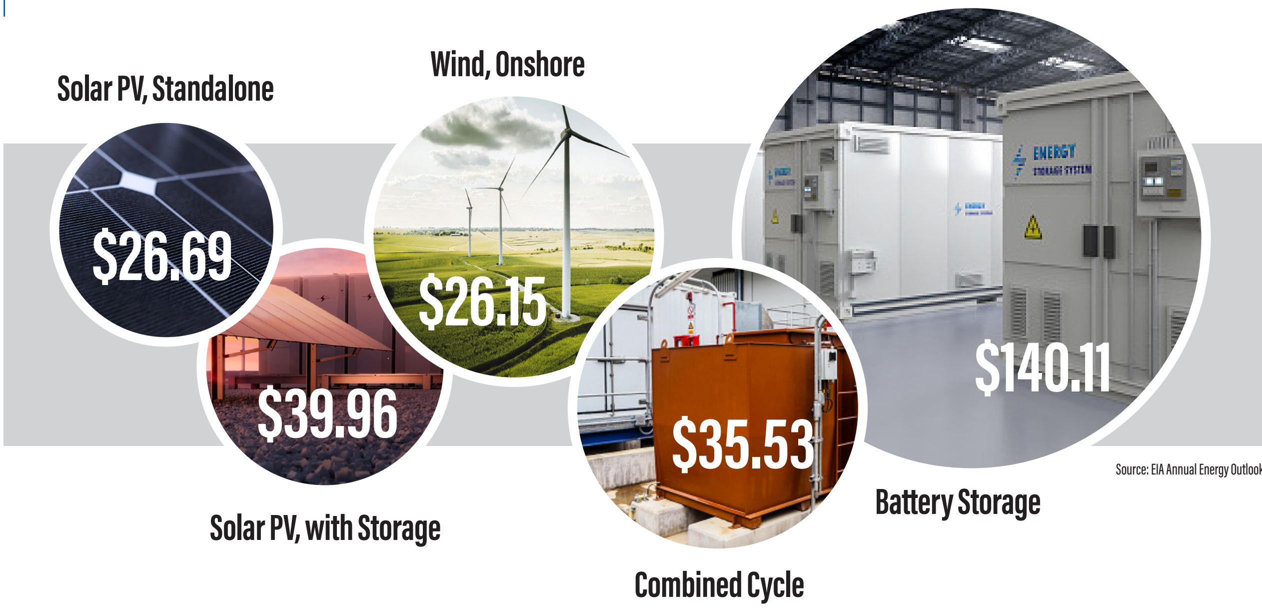
In 2024, the LCOE for utility-scale solar PV was \$26/MWh, which is 84% less than in 2010 (without the investment tax credit) (Table 2). The levelized PPA prices follow the same trajectory as the LCOE but are lower owing to the investment tax credits that account for about 30% of the capital costs (LBNL). For electric cooperatives, purchasing renewable energy through a PPA is the most common approach to shift their electric mix.

Figure 3: Share of Installed Costs of Solar Panels



Source: EIA

Table 2: Levelized Cost of Energy for New Generation Resource Plant Types Entering Service in 2024 (in USD/MWh)



Source: EIA Annual Energy Outlook.

Notes: Tax credits include the ITC or PTC available for some technologies, including solar and wind. The solar technology is assumed to be single-axis tracking PV. For the solar with storage, the single-axis system is coupled with a four-hour battery storage system. The values are expressed in 2024 dollars per MWh.

The U.S. solar industry is heavily reliant on imports across the supply chain, which has led to several challenges relating to the availability and prices of solar PV. In cell and module manufacturing, polysilicon is the primary material, which is melted to produce ingots that are then sliced into thin silicon wafers. China has about 72% of the global polysilicon production capacity, more than 96% of the ingot production capacity and produces about 97% of the world's silicon wafers (DOE Supply Chain Deep Dive Assessment). In 2023, the U.S. imported roughly 54 GW of panels, an increase of 82% from 2022 (S&P). The U.S. imports 78% of cells and modules, mostly from countries in Southeast Asia, including Malaysia, Thailand, Vietnam, Cambodia and South Korea (NREL). The remaining 22% comes from India, China, North America, the rest of Asia and the world.

The IRA included significant incentives for use of American-made components for energy projects. Guidance addressing waivers for materials that cannot satisfy demand with domestic supplies has not yet been an issue. There is added political tension to divest from China's prevalence in critical industries. With China producing nearly all of certain components, this application of waivers will significantly impact the growth of new solar generation.

Over the past couple of years, manufacturers from Cambodia, Malaysia, Thailand and Vietnam have come under scrutiny by the U.S. Department of Commerce (DOC) for side-stepping tariffs. These are anti-dumping and countervailing duties imposed on certain Chinese-made products in 2012 by the Obama administration. The manufacturers under question will face the same duties imposed on Chinese-made products. The duties were levied as Chinese products were heavily subsidized by their government. In October 2024 (with additional updates in November), the DOC released the preliminary determinations for the countervailing cases. The DOC assigned rates that range from 3% to 23% for the four countries. In late November 2024, the DOC also released preliminary determinations for the anti-dumping cases with tariff rates ranging from 18% to 271% for these countries.

In addition, the Uyghur Forced Labor Prevention Act (UFLPA) was signed into law by President Biden in December 2021 in an effort to tackle imports made by forced labor in the Xinjiang Uyghur Autonomous Region of China. One of the high-risk priority sectors identified by the U.S. Customs and Border Protection (CBP) was polysilicon, a raw material for solar panels. The law went into effect on June 2022 and the U.S. CBP detained about 4,650 shipments at U.S. ports, affecting the renewable energy industry. Other critical infrastructure, such as transformers, are also facing shortages due to a lack of domestic supply, with long lead times and price increases. The recent bottlenecks in the supply chain and imports, coupled with rising interest rates and inflation, have impacted the solar energy industry.

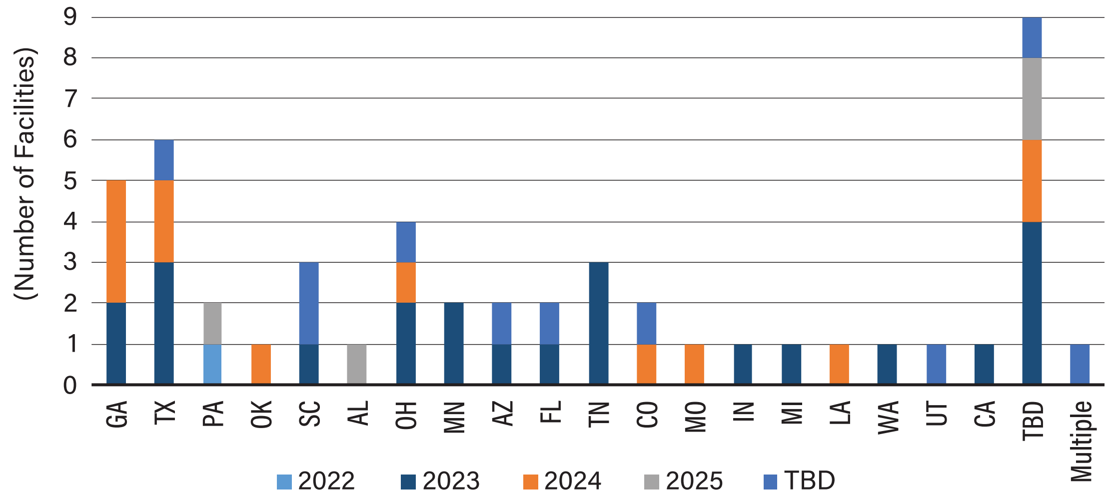
Outlook for the Industry

The current U.S. manufacturing capability is limited for different components along the solar supply chain. It has capacity to produce metallurgical-grade silicon, polysilicon, steel, aluminum resins, racking and mountings. However, it lacks substantial capacity for producing solar ingots, wafers, cells and solar specialty glass, and has limited capacity to produce modules, trackers and inverters, according to the Solar Energy Industry Association (SEIA). The specific report is listed in the references at the end of this document. Since the passage of the IRA and its incentives for manufacturing, there have been about 110 GW of manufacturing capacity announced across the supply chain, including PV modules, c-Si cell, wafers, trackers, etc. (Figure 4). The onshoring of solar manufacturing could provide a diverse set of options for buyers, secure U.S. energy needs with local supply and reduce risks associated with supply chain bottlenecks in different countries. However, it will take time for these manufacturing facilities to become operational.

The U.S. solar industry is forecasted to increase rapidly in the future (Figure 5). With the existing pace of progress in the solar industry, coupled with policy incentives, analysts forecast a 15% annual growth rate on average in installed capacity (Wood Mackenzie). By 2050, it is estimated that solar will account for about 30% of the U.S. generation mix (S&P).

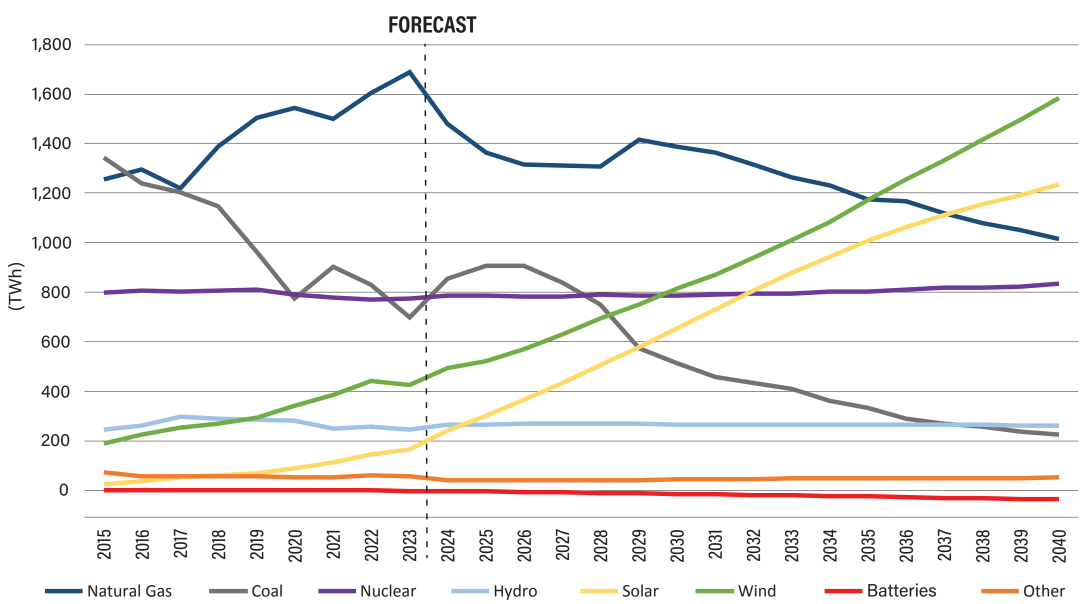
While growth is forecasted, one of the key obstacles the sector needs to overcome is the interconnection queue. The interconnection queue is the list of projects waiting to be evaluated by electric transmission system operators before the project is connected to the grid. This bottleneck has resulted in over 2,600 GW of generation capacity in the queue in early 2024, of which about 95% is renewables and storage (LBNL). About 1,086 GW of solar energy is in the queue, accounting for the largest share of generation capacity. With the IRA incentives, more renewable energy will likely be added to the queue, and the pace of evaluation will need to keep up.

Figure 4: Announced U.S. Solar Manufacturing Facilities



Source: American Clean Power Association: Clean Energy Investing in America Report.

Figure 5: U.S. Generation by Fuel Source



Source: IHS North American Power Markets Outlook.

▶ CFC CASE STUDY

Deseret Power Electric Cooperative

Utah's Deseret Power Electric Cooperative (Deseret) has triumphed over supply challenges and taken advantage of federal tax credits to flip the switch on its first solar array, Bonanza Solar 1, which sits next to its key generating station, the Bonanza coal-fired power plant. The new renewable energy plant went operational in 2023 and provides its distribution cooperative members with cheaper energy during the summer months.

In 2022, Deseret began developing a 15 MW DC solar project on the site of its Bonanza Power Plant with financing from CFC. For the project, Deseret invested in single-axis trackers that move with the path of the sun. The advantage of trackers is that they capture more solar radiation for a longer duration of the day. The capacity factor is about 35% in the summer and reduces during the winter to about 5%. The project generates roughly 27,000 MWh of electricity annually, which is less than 1% of Deseret's total generation capacity. The solar project covers 70 acres of land, and the equipment is designed to last at least 20 years.

Benefits

The cooperative's decision to invest in solar stemmed from a desire to diversify its resource capacity, taking an "all-of-the-above" approach to the generation mix. With drought conditions affecting the generation available from hydropower, the solar project offered Deseret the opportunity to offset the higher costs of electricity, especially during the summer months, while complementing the G&T's existing supply of affordable power. During the summer, the solar project provides energy to Deseret during daylight hours at costs well below typical summertime market prices. In addition, investing in solar is perceived positively by the various stakeholders, from the consumer-members who want cleaner sources of energy to financial institutions and insurance companies that prefer a more diversified portfolio, which reduces risk.

Financing

Deseret received $15 million in long-term financing from CFC for the solar project. As Deseret is a nonprofit, taxable corporation under the state laws of Utah, it was able to leverage the federal government's 30% investment tax credit (ITC) for installing solar. The cooperative's management received support from Deseret's board of directors and also involved the general managers of its distribution cooperative member-owners during the initial decision-making process. Deseret's distribution cooperative members are bound by an all-requirements contract. The ITC made the project viable, as well as affordable for the consumer-members. The solar investments did not lead to rate increases, as the ITC and the value of the energy generated largely offset the project costs. For nontaxable cooperatives, direct pay introduced under the IRA or PPAs with taxable entities are alternatives to receiving the ITCs.

Challenges

Deseret experienced challenges in supply chain disruptions and time lags during construction. The procurement process, and associated delays, pushed the timeline and completion date back several times, as trackers, switches, breakers and panels experienced delivery delays. Eventually, Deseret located used transformers so that it did not have to wait two years for new transformers.

Background

Utah-based Deseret is a regional generation and transmission cooperative that provides wholesale electric service to its five member systems: Bridger Valley Electric, Dixie Power, Garkane Energy, Moon Lake Electric and Mt. Wheeler Power. Its member distribution cooperatives are based across Utah, Arizona, Colorado, Nevada and Wyoming. Deseret's members are primarily agricultural and energy-related customers and national parks.

As a vertically integrated power producer, Deseret owns and operates the primary assets and services it provides to members. Deseret owns over 200 miles of transmission lines and has approximately 900 MW of generation. The G&T's primary generating resource is the Bonanza Power Plant, a 458 MW coal-fired plant located near Vernal, Utah. The remaining power comes from a combination of coal- and gas-fired thermal resources, solar, hydropower and market purchases. Deseret sells the surplus power it generates to municipalities and western energy markets.

"Deseret invested in solar to diversify our portfolio. We believe that an 'all-of-the-above approach' best serves our members with reliable and effective sources of energy."

Greg Humphreys
Vice President and CFO, Deseret


Bonanza Solar 1, located on the site of Bonanza Coal Power Plant.

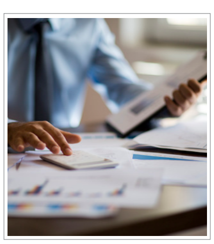
Key Considerations for Investing in Utility-scale Solar

Deseret Chief Operating Officer Eric Olsen recommends the following operational considerations for other cooperatives considering solar installations:

Hire contractors that are trusted and experienced. Having open lines of communication with the contractor will be helpful at every stage in the process.

Since the procurement process may result in long lead times on certain products, cooperatives should consider including a sufficient buffer, as it will help mitigate delays and resulting cost increases.

Be prepared for long interconnection queue wait times. Consider undertaking the application for an interconnection in parallel to the planning phase to cut down on the wait time.



Budgeting for a planned investment should take into account that the Federal Energy Regulatory Commission has directed the North American Electric Reliability Corporation to develop standards for inverter-based resources, which may affect the project costs for cooperatives once they are implemented.

Be aware of the natural landscape and how it may affect the project. Wildlife and vegetation management are important once the solar arrays are installed for fire suppression and protection. In Utah, the area experienced unseasonal rainfall, which led to the rapid growth of thistle tumbleweed. Additionally, rodents and small animals could cause damage and destruction to the panels and wires.

Deseret Chief Financial Officer Greg Humphreys offered the following advice on tax credits:

If a cooperative is trying to access tax credits, the management team should do its research on what credits are available and accessible to them and the mechanics of how they are applied or received. In addition, there are different kinds of incentives and bonuses that can be added on to receive a higher tax credit. Deseret found it beneficial to use a tax consultant specifically for this project.

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