Ensuring Success In Global Utility Solar PV Projects

A GTM Research Whitepaper

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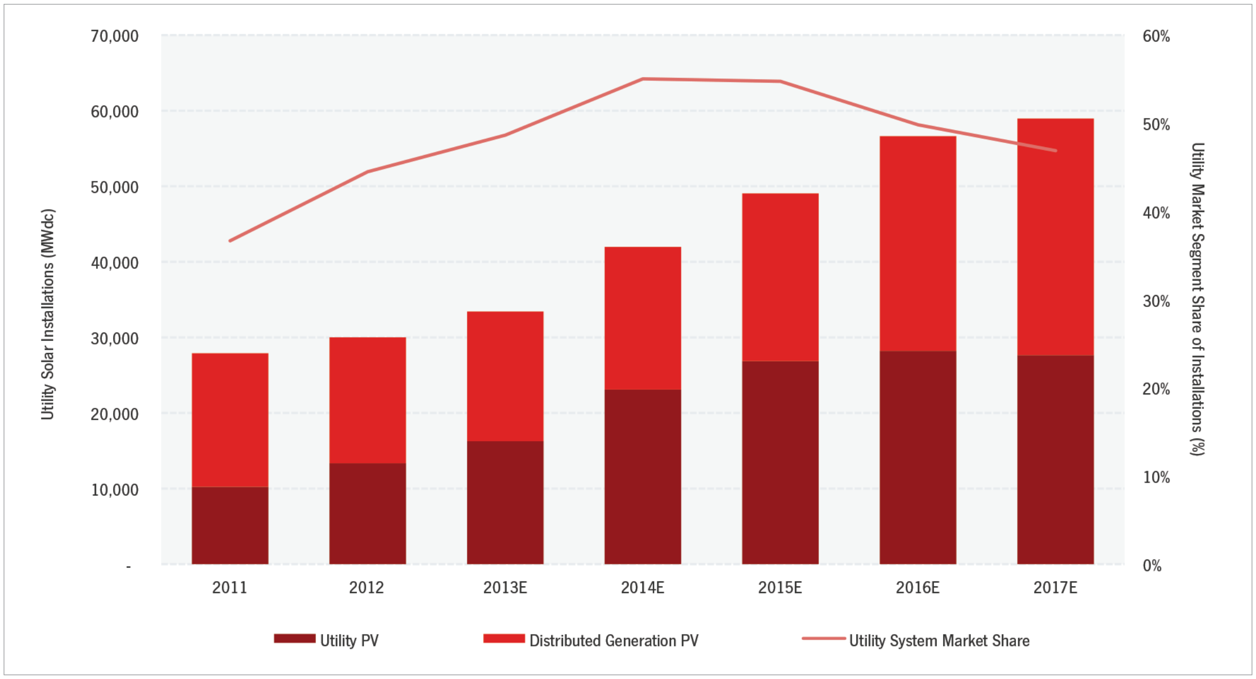
PART 1

Introduction

The global solar photovoltaic market saw modest growth in 2013, with over 33 gigawatts (GW) of installations during the year, up from 30 GW in 2012.[1] Underneath top-line growth, however, were significant shifts in regional and market segment share. While residential and commercial markets accounted for as much as 63% of the market in 2011, these segments' collective share decreased to 51% in 2013 and is expected to drop again in 2014 to just 45%. As major markets like the U.S., China and Japan continue to ramp up installations and new markets like India, South Africa, Chile and others emerge, the promise of utility solar continues to be a bright spot of the industry. Globally, over 122 GW of utility-scale solar are forecast to be installed in total from 2013 through 2017.

Figure 1-1: Global Installations by Market Segment and Utility Share of Total, 2011-2017E



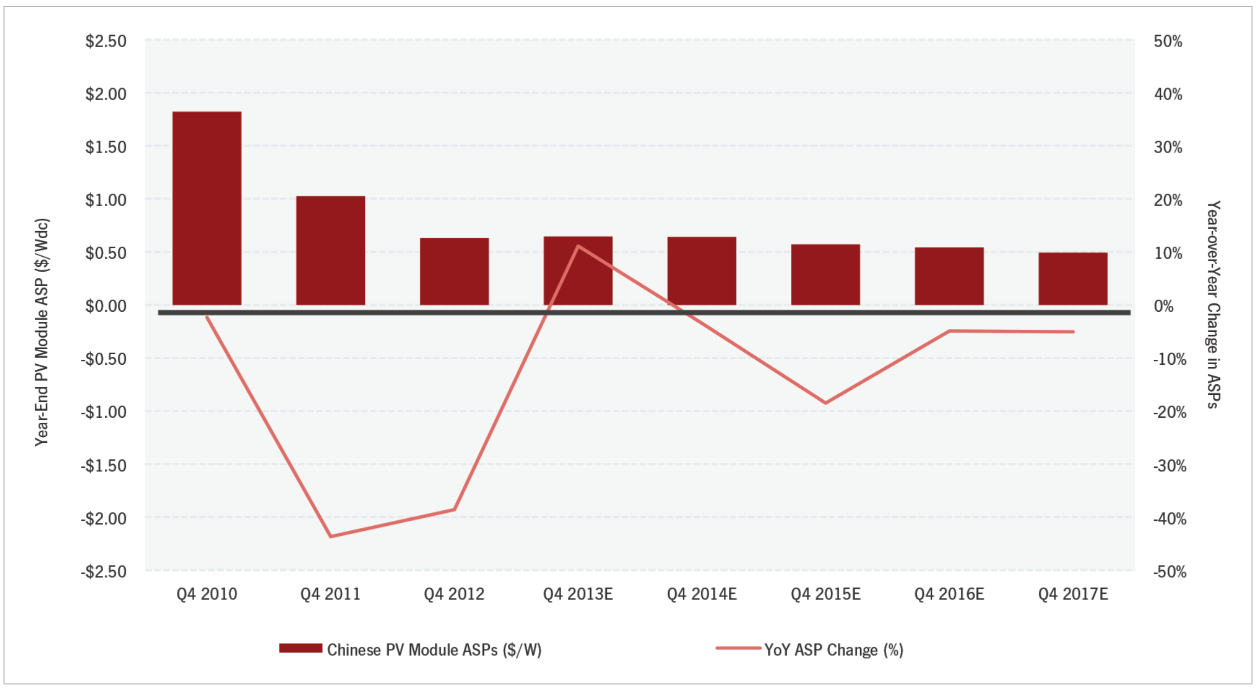
Source: GTM Research

1 GTM Research

The growth in utility-scale solar installations is coming at a time when the industry is facing significant challenges. Utility markets in countries such as the U.S., Canada (Ontario), China, India, and the U.K. still benefit from relatively strong (but rapidly shrinking) government support. However, major European markets have cut back or removed government support for utility solar. Recent stabilization in PV module pricing has further threatened utility project economics. In markets such as Spain, Italy, Chile and certain regions in India, developers are looking to develop unsubsidized or very lightly subsidized projects to directly compete with traditional generating sources. Upfront cost reductions are an important step toward a post-subsidy market reality, but the industry must place equal focus on equipment reliability, company bankability, system interconnection, and system-level performance in order to ensure long-term profitability and growth.

Module cost reductions and incentive programs have driven the industry's growth over the last five years, with average selling prices for crystalline silicon (c-Si) PV modules decreasing by nearly 70% between 2009 and 2013.[2] However, as Figure 1.2 demonstrates, module price reductions are forecast to slow significantly between 2013 and 2017, especially as module manufacturers seek a return to profitability. Therefore, emphasis will be placed on driving down total lifetime costs through reductions in commodity use in balance-of-systems[3] (BOS) components and increasing reliability and bankability through new and innovative solutions beyond the module.

Figure 1-2: Crystalline Silicon Module Average Selling Price Reductions, 2010-2017E



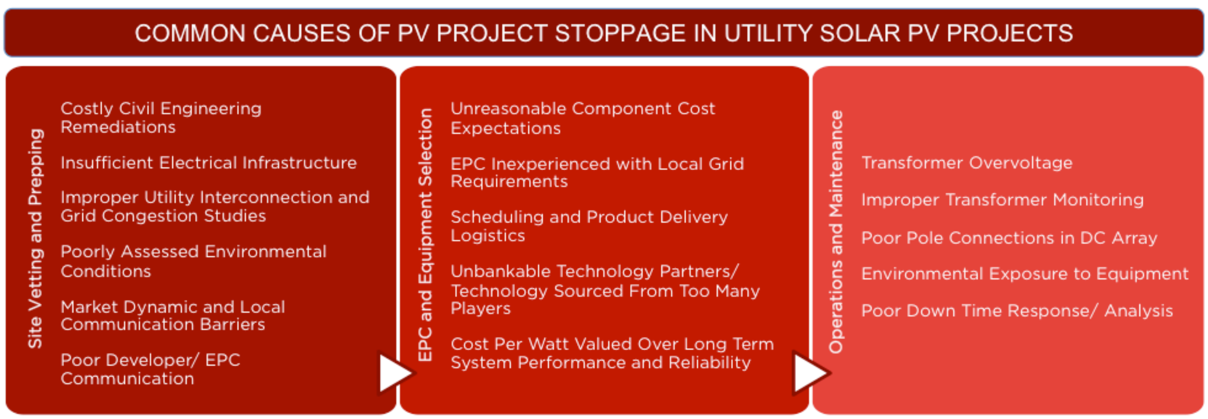
Source: GTM Research Global PV Competitive Intelligence Tracker

2 GTM Research Global PV Competitive Intelligence Tracker

3 "Balance of system" is defined as all equipment in a PV plant other than the solar module itself. This can include racking structures, inverters, wiring, transformers, monitoring equipment and other hardware, and indirect cost components

The first signs of unsubsidized solar demonstrate how far the solar industry has come from its humble beginnings; however, the process of installing solar is still fraught with obstacles and challenges. With thousands of individual policies directly related to solar, and countless more that affect solar installations, even seemingly unified standards can vary on a country-by-country, state-by-state and utility-by-utility basis. New standards and maturing practices reduce some of the complexity, but the intricacies of ever-changing policies, new technologies, new financial instruments, and reinvigorated emphasis on BOS necessitate an experienced partner to enable specific projects to succeed. This white paper will explore what it means to have bankable BOS by diving into common BOS obstacles in utility solar projects and highlighting how these challenges are mitigated or sidestepped by market leaders.

Figure 1-3: Common Causes of Project System Delays and Stoppages



Source: GTM Research

PART 2

Proper Site Vetting and Preparation

2.1 Integrated Engineering Assessments

Siting feasibility issues cause many potential solar projects to be abandoned before they ever break ground. Not surprisingly, identifying a large area suitable for solar is the first requirement for many developers. Without a sizeable site, the project may not be able to achieve the necessary scale to ensure financial viability, even with generous solar incentives. However, a suitable area is more than just an open, unobstructed ground space; proper civil, environmental, and electrical infrastructure must exist as well.

Even relatively simple ground-mounted systems may face multiple challenges. For example, soil composition will determine the size and type of an array's anchoring structure. In other locations, like reclaimed brownfields or landfills, penetration of any kind may be prohibited. If the area is not relatively flat, it may need to be re-graded to accommodate ground-mount racking structures. Distance to the nearest connection point can also be an issue, as long wire runs, especially if trenched below ground, can tack on significant additional costs. In the current tight margin environment, developers must correctly estimate and optimize system design and site work in order to avoid costly overruns while maintaining a competitive bid.

Most sites require an array of engineering expertise, including civil, structural, electrical, and mechanical. In order to ensure optimal system design and site preparation, the various project engineers and/or technical consultants must communicate fluidly. EPCs or developers often subcontract different aspects of the project engineering, which can lead to patchwork system design and project delays. Fully integrated EPCs offer a full suite of engineering capabilities and manage utility interconnection study capabilities in-house. This ensures communication between project engineers and product suppliers, whether internal or external, for optimal project execution.

2.2 Managing System Interconnection Requirements

The electrical buildout of the PV system is often a challenge as well. Regional and local electrical codes differ significantly, and codes can also be subject to inspector interpretation. PV plants have undergone significant delays simply because local inspectors were not consulted and engaged during the product selection and project design processes. Working with a global technology provider with a global footprint and local experience better ensures that the products selected will match local expectations. Furthermore, larger providers can also draw experience for other localities that can help solve local permitting issues that may emerge.

Similarly, utility interconnection can be a significant barrier to completion. Even in locations with relatively low levels of solar penetration, large-scale intermittent generation can have disproportionate effects on local distribution, requiring further study. The outcomes to the usually mandatory interconnection studies can be unpredictable, especially given the exponential growth rate of PV deployment in major solar markets. The cost of the studies and upgrades to the utility infrastructure will almost always be borne by the project and can significantly impact its financial outlook. Furthermore, because the implications of high penetration of intermittent PV generation are not yet well understood, utilities may limit the size of PV plants or require developers to pay for costly upgrades. In Japan, the Hokkaido Electric Company has limited large-scale PV interconnection to 400 MW for the island, out of nearly 2 GW of announced projects and interconnection applications. Similarly, feeders throughout southern New Jersey have been closed to megawatt-scale systems due to already high levels of penetration.

In other regions, utilities have imposed onerous connection standards that may also require energy storage capabilities. For example, the Puerto Rico Electric Power Authority requires PV output to fluctuate by no more than 10% from minute to minute, essentially mandating storage. The economics and engineering of energy storage are significantly different than those of solar PV and often require specific technology, EPC and developer expertise.

Developers and EPCs are quick to point out that there is no “typical” or “perfect” site. Each prospective site has nuances that require specific engineering solutions. Even so, many of these siting challenges can be mitigated or avoided in advance—vendors with larger product portfolios can ensure that these challenges can be mitigated with the most cost-effective solution.

Grid connection requirements and market dynamics vary widely from site to site. Partners with a global footprint and experience can mitigate the risk of code noncompliance and project delays by bringing valuable experience gained from operating in other sectors. Some firms have diversified from thermal or other power sectors into the PV sector and can bring to bear their experience developing traditional power projects in their work in emerging solar markets. As demand for utility-scale solar continues to diffuse beyond incumbent markets, working with balance-of-systems providers that can operate and execute efficiently in mature and emerging markets alike will become increasingly important.

PART 3

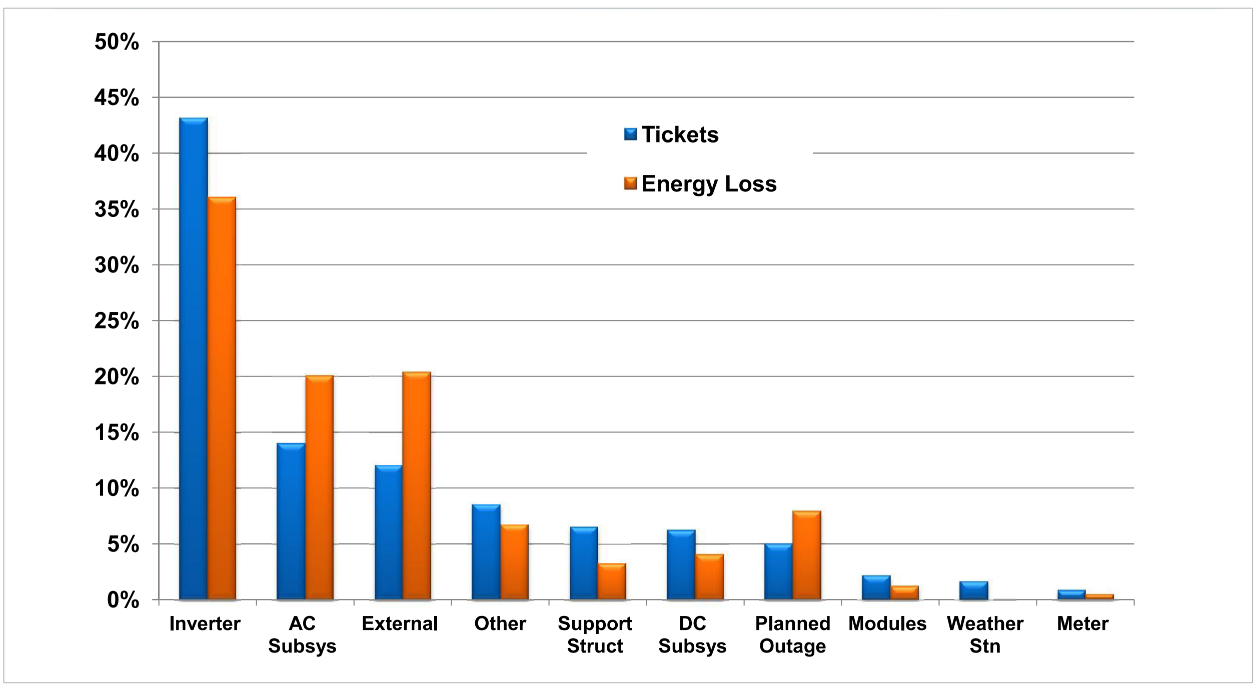
Keys to Equipment and Technology Partner Selection

3.1 Product and Component Reliability

Continued pricing pressure on all parts of the PV supply chain has caused many industry incumbents to worry about the long-term performance and reliability of PV components. While concerns over module reliability have been afforded the most attention, BOS components such as inverters and racking also merit scrutiny. Long-term asset owners should properly vet all components installed in a PV system. While first- or third-party engineering and testing studies may not be feasible for small, distributed systems, the scale of utility systems will often justify the cost of more rigorous assessment.

Even before any testing transpires, overall product and project reliability can be assessed through understanding the design philosophy of the vendor. The PV inverter is a good example to consider when discussing product reliability, especially since inverters have a reputation for posing the greatest risk in terms of component failure. In fact, a 2012 IEEE presentation by a project developer showed that 43% of its fleet-wide system alerts stemmed from issues manifesting at the PV inverter. An experienced vendor can rely on field data to inform product design and therefore is better equipped to assess and respond to general reliability issues and specific project requirements.

Figure 3-1: Source of System Tickets and Energy Loss by System Component



Source: SunEdison

One of the most significant stressors on PV systems as a whole, especially the PV inverter, is thermal stress. During the day, an outdoor inverter can experience temperatures above 40°C, with some regions of emerging solar markets like Chile and India often reaching temperatures beyond 50°C. Coupled with internal heat generated by component inefficiency, the inside of an inverter can reach startlingly high temperatures. Product designers mitigate this issue in two ways: proper thermal management (cooling) and overdesign of the thermal capability of components. However, both of these design characteristics need to be balanced with market pricing concerns in order to deliver a competitive product. As a result, specific attention is paid to designing out or using higher-tolerance versions of the most common sources of critical failure, including the IGBTs, electrolytic capacitors and solder joints.

Furthermore, stakeholders must understand the ultimate use conditions of various components and how their equipment selection fits with expected site conditions. For example, systems installed in extreme desert conditions must be able to handle large temperature swings and to resist particle ingress. Other environmental concerns include corrosivity, wind, snow, and seismic conditions. As a result, a product's track record within a certain environment is as important a metric as overall track record.

More recently, products have shifted toward modular architectures in order to assist with both monitoring and ease of maintenance. For example, a developer may choose an inverter design that incorporates many smaller modular units instead of a single inversion block. These modular power blocks can cycle load to reduce inverter wear and, in the case of failure, can be worked on and replaced with minimal impact on the overall system output. This approach is spreading to other parts of the system, where vendors are also exploring modular and distributed racking and BOS components.

Figure 3-2: Central Inverter Comprising Modular Units

Source: Power-One, GTM Research

3.2 Techno-Economic Analysis

Even after proper siting, interconnection review, and reliable equipment selection, solar projects are not risk-free; equity investors' expected returns reflect the real chance of project failure. Customers should consider that solar is unique compared to the many other classes of capital equipment procurement and that the relative newness of solar results in less precedence and accumulated experience. As such, more due diligence and openness may be required to ensure project success. Working with a partner that has seen many projects through to completion and can respond to various demands from both offtakers and operators is essential to ensuring projects move forward.

A successful project balances sometimes competing interests and priorities on the parts of all parties involved. For example, build-and-sell developers have an incentive to minimize upfront costs, whereas offtakers naturally want high reliability and consistent output. An integrated vendor supplier with project construction experience can assist, not only by outlining the cost-benefit of various equipment packages, but also by highlighting hidden or second-order cost effects stemming from equipment selection. Furthermore, a vendor with an extensive and diversified portfolio of products has less incentive to push solutions in a single direction in order to make a sale.

> *A build-then-sell mentality can often lead to a focus on lowering upfront capital costs when sourcing equipment. For example, when assessing whether to specify indoor versus outdoor switchgear at the substation level, technical and economic aspects must be analyzed by an experienced technical adviser. Although capital costs for exposed outdoor equipment may be as much as 10% lower than for an indoor solution, indoor equipment is typically more protected and reliable. Larger plants utilizing more collector circuits may actually benefit more from the added reliability and economies of scale from the use of indoor components than the initial component discount of outdoor equipment. An ideal project partner will be able to maximize project economics and technical viability simultaneously.*

3.3 Safeguards for Ensuring Project Completion and Maximized Returns

The request for proposal (RFP) process continues to be a popular method of procuring solar, especially as more public entities begin to recognize the benefits of solar energy. The goals of the RFP process should be clear: finding a qualified contractor (in the case of cash purchase) or solar PPA provider at the lowest cost with minimal time investment from the end user. However, the nascence of the solar industry and recent flood of new entrants mean that some end users may be disappointed with the results due to provider inexperience.

Construction timelines are often contingent on BOS delivery timelines, due to the fact that transformers and electrical switchgear are custom-designed for specific sites. Competitive bidding can drive overly aggressive pricing and project timeline expectations to the point that they threaten project viability. RFP processes should require safeguards to ensure that the project is completed in a reasonable and timely manner. Such safeguards can include higher bid deposits, criteria for previous experience (including a track record for similarly sized projects and technology), and financing and reference contacts.

Furthermore, penalties for incomplete systems can be implemented to ensure developers do not walk away from partially completed installations. The delays that these requirements cause in the bidding process will pay for themselves by reducing risk.

Even with these safeguards in place, underperforming projects are all too common. Many services exist to maximize the returns of existing systems to owner/operators. When properly monitored, PV systems produce massive amounts of data that must be analyzed to yield useful insights. Techno-economic analysis can be performed on this data to provide solutions for increasing the output of operating systems.

Working with a technical consultant that understands the technical and economic aspects of operating systems is important. Small portions of an operating fleet of systems may underperform, and often the signals indicating this are lost in a mountain of data. In other cases, simple equipment upgrades or adjustments can increase the performance of already high-performing systems. Project experience and techno-economic consulting can maximize the returns of operating systems.

3.4 Bankability

If any word has dominated the PV lexicon, it's "bankability." For banks and investors, the importance of bankability exceeds the promise of incremental improvements in project performance or returns. The concept of bankability applies to every project partner from the developer to the product suppliers to the end customer; to offer a simple definition, it is the assurance that each entity and component will perform as promised and be around for the project lifetime to honor all applicable contracts and warranties. While every entity has different criteria for bankability, they essentially boil down to evaluating two major components: technical risk and company/execution risk.

Figure 3-3: PV Bankability Components and Criteria

PV BANKABILITY RISKS AND CONCERNS	
CATEGORY	COMPONENTS AND CONCERNS
Technology Risk	Third-Party Verification of Performance
	Long-Term Reliability and Field Experience
	Substitutability
Company/Execution Risk	Balance Sheet/Company Longevity
	Long-Term Product Support
	Track Record of Operation

Source: GTM Research

Experience-in-field and strong finances to back up potential warranty issues are the key factors for bankability and ultimately for securing financing for utility projects. Relatively untested technologies from new companies are often considered too new and risky for many financial investors and creditors to back. Working with diversified and entrenched players can mitigate this risk. Furthermore, estimated component and system production from utilized components must be verified by independent third-party engineering firms, using robust simulation models. This vetting adds cost and may affect output assumptions, potentially impacting resulting EPC and PPA rates.

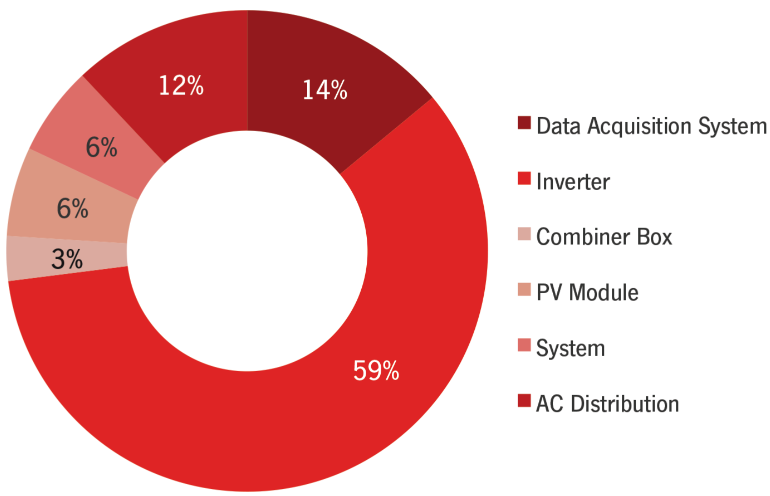
PART 4

Optimizing Operations and Maintenance

4.1 Minimizing Component Failures

Identifying experienced partner firms, seeking financing, and building the commercial solar installation is only the beginning of the project. Even with bankable components, the system can run into trouble after construction. Testing and commissioning the newly installed system is critical in order to work out initial problems. Simple problems like loose fasteners or wiring can cause significant lost electricity production, especially over a 20- to 25-year period. Improper installation can cause ground faults, safety hazards, and in a worst-case scenario, even fires. Loose connection points on the direct current (DC) side of the PV system[4] are some of the most common technical failures in operating PV systems. Problems such as these are caused by mistakes during the installation process that can easily be overlooked in large installations.

Figure 4-1: Unscheduled Maintenance Costs by Component for 5 MW System



Source: Sandia National Laboratories, based on data from TEP Springerville 5 MW PV system

System failures can be the result of improper design. PV systems require the proper integration of many components and parts, and inexperienced system designers can be tempted to push system designs beyond their technical limits. For example, overvoltage on transformers is one of the most common causes of substation failures. System designers typically attempt to push systems to 10% overvoltage, though most transformers are certified to 5% overvoltage. Rather than redesigning the system, transformers are typically adapted or oversized to accommodate the 10% overvoltage requirements. This practice can lead to oversized or underperforming transformers. Even the most reliable inverter will be rendered useless

4 The DC side of the system is defined as the equipment on the module side of the system before the inverter.

by improperly designed or installed medium-voltage switchgear. As such, it's important that the EPC or equipment vendor understands how various components of the system will interact with each other, especially with electrical BOS and SCADA systems.

4.2 Monitoring and Maintenance

Even after successful commissioning and project turn-on, the PV system must be properly maintained to ensure long-term, trouble-free operation. Regular maintenance includes but is not limited to monitoring system performance with SCADA systems, maintaining the electrical and mechanical connections, and cleaning the modules. Preventive maintenance ensures the system is operating at maximum capacity and meets manufacturer-required milestones to maintain their standard warranties. Because each system is different (as are customers' needs), operations and maintenance contracts vary greatly from project to project, but typically cost between $0.01-$0.03/W annually (~$10,000 to ~$30,000 for every MW). This cost must be built into the financial model to ensure that the system is properly maintained.

End users must ensure that the parties involved are not only interested in maximizing the long-term performance of the PV project, but will also be around for the life of the project. Proper and active operation and maintenance can mean the difference between a system being a financial burden or a success. The nascent solar O&M industry is populated by many inexperienced entrepreneurs with minimal PV knowledge, scant insurance coverage, and unrealistic pricing structures, all of which may potentially lead to operational headaches.

Figure 4-2: Simple Calculation of the Cost of PV System Downtime

COST OF SYSTEM DOWNTIME	
Solar Resource (kWh/kW/yr.)	1250
PPA Rate ($/kWh)	$0.10
DOWNTIME (HRS.)	COST PER AFFECTED MW ($)
24 (One Day)	$342
48 (Two Days)	$685
72 (Weekend / Three Days)	$1,027
168 (One Week)	$2,397
672 (One Month)	$9,589

Source: GTM Research

*Does not include seasonal generation differences or penalties for PPA non-compliance

Quality system operation extends beyond regular system inspection. Developers should note that system reliability is different than system availability. Just because the system is outputting kilowatt-hours does not mean that there is not lost output. For example, underperforming system components and sections are notoriously difficult to identify, especially without the proper monitoring equipment. Too often, PV systems are installed without granular monitoring components because of the additional upfront costs. But these apparent savings can lead to lost energy production and ultimately to lost production and revenues. Active monitoring needs to be more than visually appealing graphs and charts. For example, the O&M party should know whether lower-than-expected system output is the result of local weather conditions or component issues, and, if the latter case applies, what the best strategy for addressing the failure may be. System monitoring should provide granular feedback that allows a system operator to intelligently manage and maintain the PV system. A quality O&M provider must be responsible for:

- Continuous and intelligent system monitoring
- 24/7 troubleshooting and alert servicing, including events outside of warranty coverage
- Quick warranty turnaround
- Discretion in balancing active preventative maintenance (i.e., cleaning) with realistic O&M budget constraints
- On-time, transparent and understandable billing for the PPA and for unscheduled maintenance
- Proper insurance coverage

The importance of proper and preventative PV systems O&M cannot be stressed enough. Quality components and a system that performs well on day one will not matter if consistent downtime eats away at system production over the 25-year lifetime.

PART 5

Summary

As the global solar industry continues to grow, utility solar developers and end users must assess and adapt to the rapidly changing landscape of solar technology and project development. With more mainstream organizations taking an interest in solar, developers and EPCs must learn to adopt streamlined best practices to lower the cost and complexity of solar energy installations. In addition, developers and vendors alike must continue educating the industry, prospective customers, and investors on the realities of project development, as well as solutions for preventing project failures. While the perils facing project development are many, in this paper we focused on early technical siting issues, equipment selection and long-term maintenance.

Early technical and siting obstacles include poor communication between the various project engineers, costly electrical infrastructure upgrades, and, ultimately, issues with utility interconnection. These challenges are difficult to predict and navigate without the guidance of a detailed site assessment and a participant intimately familiar with solar project development. Leveraging an experienced partner that is familiar with a variety of local regulations and market nuances can greatly increase the chance of a project surviving the technical feasibility phase.

Once the project passes the initial technical feasibility stage, proper equipment selection will ensure that the project reaches completion. Developers and end users must balance completion goals with suitable timelines for custom equipment delivery in order to ensure that projects are not subjected to rushed, potentially substandard execution. Furthermore, developers and end users should balance the initial cost of procurement with the implied long-term reliability and performance of the solar asset. As the solar industry is still nascent in comparison to many other equipment and energy industries, special attention should be paid to technology vendors' reliability and bankability—especially for solar equipment beyond the module.

Even after the system is successfully built, the project is not complete. Proper operations and maintenance can maximize system output and cost savings for the customer. The PV developer must possess the same long-term viability as the customer, as system warranties are worthless if the PV developer is not around to service the installation over the contracted lifetime.

The potential for failure in utility solar projects should not be taken lightly. Many barriers to solar adoption still exist, especially for new customers. However, with a knowledgeable solar partner, many avenues of failure can be avoided. The challenges of securing financing and policy/market instability will continue to haunt utility solar projects in the near term, but with the experience of developers with strong track records, individual prospective customers can greatly increase the likelihood of a successful solar project.

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