BURNS McDONNELL

WHITE PAPER / **BEST PRACTICES FOR SOLAR OPERATIONS AND MAINTENANCE**

MAKING SOLAR PV PLANTS SHINE WITH BETTER PLANNING

BY Matt Brinkman

Opportunities for utility-scale solar photovoltaic (PV) plants in Mexico are growing as a result of the 2013 Energy Reforms, which opened the market to private investment and set aggressive renewable energy goals. Developers can enhance the life and profitability of PV projects by following best practices for selecting key equipment and developing effective operations and maintenance agreements.

DESIGN FOR PERFORMANCE

To enable sustained, long-term performance of a utility-scale solar photovoltaic (PV) facility, developers must consider the operations and maintenance (O&M) of their plant at the earliest stages of project planning. This begins with some basic design decisions.

SITE SELECTION CONSIDERATIONS

Site characteristics, particularly the characteristics of adjacent land uses, can have a significant impact on overall performance of the PV plant. For example, if a potential project site is adjacent to a large agricultural or farming operation, dust generated from those operations could soil the solar modules and affect energy production.

It is not just a matter of considering the characteristics of a site and adjacent lands as they are in the present; developers must consider how these lands will look in 30 years, the average life span of a solar PV plant. This is particularly important if adjacent lands have trees and other foliage that could grow to obstruct sunlight. If the rights to trim and maintain vegetation surrounding your facility have not been secured, such growth could dramatically impact annual energy production.

What lies beneath the surface also can affect plant performance and design. For one development project, we assessed two sites that were similar in terms of economic capacity. However, one of the sites was home to burrowing animals, whose presence could have created issues with direct-buried conduit or direct-buried cables that are typical for utility-scale plants. This was a contributing factor for selecting the other site.

In addition to the physical characteristics of a site, developers also must consider location based on the cost to interconnect with the transmission system. For every project and/or site location in Mexico, the developer must submit an interconnection study request to CENACE, or the National Center for Energy Control. CENACE is the public body responsible for operating and controlling the national transmission grid and the general distribution grid. The purpose of interconnection study requests is to identify potential system impacts at the point of interconnect. CENACE studies provide developers with a list of potential impacts and associated upgrades they must include in their project to mitigate those impacts prior to moving on to the next study level.

THE SHEEP SOLUTION

Solar PV plant owners across Europe have been using sheep for many years for natural vegetation control. The use of sheep is catching on in North America, too. A 500-MW solar PV facility in California, one of the largest facilities of its kind in the world, uses sheep to manage vegetation across the 3,200-acre site. According to experts, sheep are generally self-sufficient so long as the area is fenced. They are preferred over other small grazing farm animals, such as goats, because they will not to climb on the PV modules or damage them by chewing through wires.

PLANT DESIGN AND LAYOUT

Numerous factors related to the long-term O&M of a solar PV plant must be considered when designing the facility. Row spacing is highly dependent upon factors such as vegetation control, cleaning, erosion control and road access. Spacing also is influenced by the technology selected for the project.

Ground cover is necessary on many projects. Protection against erosion on-site is critical for maintaining all-weather roads to enable maintenance and emergency vehicles to access all areas as needed. Options for ground cover can vary as widely as the sites. Crushed rock is a potentially low-maintenance option, but it can be cost-prohibitive and create extra dust and soiling issues for the PV modules. Native plants and vegetation provide a cost-effective option for ground cover, but they must be maintained. Lack of vegetation control can result in growth underneath and around the panels that could limit performance and damage modules.

CHOOSING PV PLANT COMPONENTS

Plant O&M costs are directly affected by the quality and durability of key components. Inverters are the most important components in relation to plant operations, reliability, maintenance costs and overall performance. Plant owners should select inverters that their O&M team or contractor knows how to work with and that have a solid performance record. Owners should thoroughly investigate inverter warranty provisions to fully understand what is covered.

Another key consideration for inverter selection is the proximity of the manufacturer or the manufacturer's service technicians to the project site. The number of technicians a manufacturer has in North America, and their proximity to your site, can make a big difference in your plant's downtime.

Different tracking systems come with different O&M requirements. A fixed track system, for example, requires virtually no O&M. However, the annual energy yield for such systems is typically lower than that of a single-axis tracking system, which has marginally higher O&M costs and maintenance requirements. The tracking system selected will factor into the overall site design and how it will be maintained once in operation. Configurations for sites that require mowing for vegetation management, for example, call for different considerations, such as cable management and the width between panel sections.

PV modules typically do not require extensive maintenance other than the occasional washing (a site-specific variable), checking of connections and conducting of thermography on a periodic basis. Key considerations for module maintenance involve the type of soil on a site. For example, if a site is in a windy area and has a clay-based soil, then more washing will be needed. However, if the site is located on sandy soil that will blow off in the wind, rain may provide sufficient washing. The frequency of cleaning PV modules also may be influenced by how the solar power is used. Some facilities may schedule PV washing to get greater output on a seasonal basis during high-value peak times. If regular washing is required, the availability of water resources will be an important consideration.

DEVELOPING O&M AGREEMENTS

There are essentially two types of cost models for developing O&M agreements with third parties, based on the risk profile and type of company that owns the facility. For example, a regulated utility in the United States typically values cost certainty, or a fixed-cost contract, over cost savings because of its need to recover fixed costs within the rate base. Developers and independent power producers, on the other hand, typically want to pay for value extracted from the project and generally prefer contracts with fixed scheduled maintenance costs and variable costs for unscheduled maintenance.

Regardless of the cost model, an O&M agreement should clearly define who is responsible for what, such as warranty administration. The engineering, procurement and construction (EPC) contractor typically manages the warranties on engineered equipment in the first year or two of a project. However, various engineered equipment have varying warranty lengths:

- PV module warranties typically extend for 20-25 years.
- Racking structure warranties typically extend for 20 years.
- Inverters typically have 5- to 10-year warranties.

The challenge with O&M agreements is that there are no established industry standards. Each O&M provider may have a standard agreement, but owners should carefully scrutinize any such document. Agreements should clearly define the scope of services, including warranty administration and troubleshooting, rather than just repair. The agreements should clearly define frequency of module cleaning and vegetation management, as well as diagnostic functions (e.g., infrared scans and I-V curve tracing), and determine if those costs represent fixed or variable costs.

Owners also should address spares and plant improvements within the O&M agreement to reduce potential change orders and better manage costs. For example, if an inverter in an older facility is outdated and no longer available in production, then a different type of inverter must be installed that might require minor modifications. Specific processes must be in place to manage plant improvements in an efficient and cost-effective manner.

EVALUATING PERFORMANCE GUARANTEES

There are numerous types of guarantees that owners should consider to gain assurance for their plant's performance. Energy or capacity guarantees provide owners with assurances that the project will generate an agreed-upon quantity of megawatts on an annual basis. An EPC contractor, or a vertically integrated company that provides EPC and O&M for the plant, typically will agree to a capacity guarantee. It is unlikely that a third-party O&M provider would agree to a capacity guarantee.

Another option is an availability guarantee that ensures the system will be online for a minimum number of hours per day and a defined number of days per week. Failure to meet these guarantees would typically result in liquidated damages. This method essentially guarantees owners revenue without directly relating it to energy or capacity.

Owners could ask their O&M provider for a responsiveness guarantee. This requires the provider to be on-site and addressing plant issues within a defined time frame. There can be significant cost differentiation between the different levels and types of performance guarantees. Owners should determine what is best for their organization based on how the plant is used. For example, if owners have a power purchase agreement that includes substantial liquidated damages related to energy, an energy or capacity guarantee may be more ideal. If it is a smaller system, serving a single end user, such as an industrial complex, a responsiveness guarantee could be sufficient.

Owners also should carefully consider what is included within their performance guarantees, such as downtime. If there is a warranty issue on an inverter that is not within the control of the O&M provider, could the O&M provider exclude the downtime from that inverter under the performance guarantee? There are many ways to address this and other questions regarding how liquidated damages are applied. Fundamentally, it is essential for O&M agreements and performance guarantees to clearly define what is and is not covered.

MAINTAINING YOUR INVESTMENT

Solar PV plant developers can sustain profitable performance for the lifetime of their facility through comprehensive O&M plans that take form during the site selection, technology selection and design phases of the project. By designing a facility with maintenance in mind, the developer can reduce costly issues and maintain performance and cost certainty.

The long-term O&M agreement between plant owners and third parties can be just as important as the design. Unlike traditional power generation, solar PV O&M agreements are not yet standardized across the industry. Protecting your investment and the return on investment requires careful consideration and detailed specifications that fit your preferred cost model. Such agreements should clearly define scope, parties responsible, and required levels of responsiveness and/or performance, with defined damages for failure to meet performance requirements.

Unlike in other types of power generation projects, numerous decisions must be made early in the development of solar PV plants that will affect long-term operations and costs. By involving highly experienced O&M providers early, key questions regarding module placement, technology, vegetation and erosion control can be addressed before costly challenges arise, and thus contribute to the long-term profitability of your PV plant.

BIOGRAPHY

MATT BRINKMAN is solar business unit manager and regional energy practice manager in Phoenix for Burns & McDonnell. In that capacity, he is responsible for business development, resource allocation and business planning related to utility-scale solar projects. He manages a multidisciplinary group of engineers and designers specializing in capital and O&M projects at existing power plants and utility-scale solar plants. Matt's team has worked on some of the largest and most lauded solar projects in the nation, including serving as the owner's engineer on the largest solar thermal plant in the world (Ivanpah, 392 MW) and the largest solar PV project in the United States (Solar Star, 580 MW). He was appointed by Arizona Gov. Janet Brewer to serve on the governor's Solar Energy

ABOUT BURNS & McDONNELL

Burns & McDonnell is a family of companies bringing together an unmatched team of engineers, construction professionals, architects, planners, technologists and scientists to design and build our critical infrastructure. With an integrated construction and design mindset, we offer full-service capabilities with offices, globally. Founded in 1898, Burns & McDonnell is a 100% employee-owned company and proud to be on *Fortune*'s list of 100 Best Companies to Work For. For more information, visit **burnsmcd.com**.

08272-BPS-0820