A DEVELOPER'S GUIDE TO SOLAR

THE CASE FOR SITE-SPECIFIC OPTIMIZATION

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Optimization is a concept that has gained acceptance as a useful tool for getting the most out of a solar development. What does it really mean? What exactly should be optimized – and why?

As a baseline definition, optimization means defining the precise data set needed and applying the appropriate analysis and modeling to determine the project characteristics that will yield the right level of energy production for the cost of the investment.

Note, however, that optimization is not the same as maximization. As in modeling for the economics of any commodity, the goal in solar optimization is predictable production. It should neither over- nor underachieve the desired quantity of available energy – a tricky task given the multiple, variable factors at play.

OBSTACLES AND PAIN POINTS FOR DEVELOPERS

As a young industry – most utility scale solar plants in North America have been operating less than a decade – solar developers have less historic detail to draw on than other industries, yet face the same (if not greater) risks in calculating return on investment.

Independent engineers are a critical arm of a financier, yet typically their energy estimation analysis is minimal. Today, many of the most commonly used tools for solar project development still rely on generalized approaches and statistics and a bare minimum approach to estimation. A developer that knows where and how to push to gain true optimization can ensure more predictable outcomes and greatly improve project value.

BEYOND “BASIC” PROJECT DESIGN

True optimization, like the old saying about politics, must be local. In fact, without site-specific data – like weather input from on-site meteorological stations – a project cannot be said to be optimized at all. General data is simply a baseline, the minimum, yet often it is all or most of what informs the energy output model provided to a developer.

True optimization begins with local data and feeds more advanced -- and more localized -- modeling tools. All project valuation is based on complex financial models and client goals and here, too, the more micro-targeted and specific to the project site these can be, the more accurate they will be – and, the less uncertain they will be.

Below, we’ll examine the elements of developing a solar project, and outline how at each step of the project, optimization means going local and going beyond basic modeling to gain a better outcome. First, we’ll look at the energy estimate itself, then dig into factors that can reduce output, such as soiling, snow, AC/DC losses and more. Finally, we’ll address site design optimization.

ENERGY ESTIMATION 101 – AND BEYOND

Arguably the most important element in any solar development is a verifiable energy estimate that provides finance partners, owners and/or developers numbers they can count on.

Perhaps for this reason, one of the oldest and most widely utilized tools is energy estimation software, with PVSyst being the industry standard. Like any tool, from a hammer to a paintbrush, the results gained from it depend on the knowledge and skill of the one who wields it. PVSyst provides a basic approach to multiple elements. Below, we’ll look at three of them – the pan file, the Ond file, and met data – and see how optimization takes each one further.

The Pan File: How will solar panels perform over time? Basic approaches rely on default PVSyst data to represent the various characteristics that impact the way particular solar modules operate when exposed to sunlight. To gain a more accurate assessment, the optimized approach further examines the manufacturer data and may also include objective, third party data (such as the performance of a particular production module run in lab simulated sunlight conditions.) The latter is particularly important as each module is unique and the performance of one production line can be significantly different from the one used in the default models.

The Ond File: Inverters may respond differently under specific voltage conditions. While the basic approach uses PVSyst default data to model typical behavior, the optimized approach includes the inverter manufacturer's vetted Ond File for the actual inverter used, then goes a step further, modeling likely behavior specific to the voltage conditions of this use-case.

Meteorological Data: It's one thing to know, for example, the number and intensity of sunny days in Western Texas; it's another to have actual solar radiation data from the past ten months for the south side of a particular hillside on a specific acre. To gain a sense of anticipated sun in a region, the basic approach relies on (paid or free) publicly available "typical" meteorological year (TMY) data such as TMY2 and TMY3. While TMY data is one of the most critical aspects of a solar project, it is typically only available for major population centers and can provide only statistically average data.

The optimized approach starts first by using site-specific met files created with satellite data. Unlike the standard TMY files, these files use satellite imagery to correlate real ground measurements to the broader area offering far greater accuracy. Essentially, they look at the cloud cover over time and relate that to other areas with known weather values.

Truly honing in for a site specific data file involves placing meteorological stations on site and gathering site-specific data over time. Similar to how the satellite sets are created in the first place, using site specific data fine-tunes individual project characteristics, resulting in greater energy output model accuracy (and reduced risk and uncertainty) for the specific project in development.

OPTIMIZATION STARTS WITH THE SITE

Rules of thumb are a natural starting point for estimating the output of energy from a system, but for a developer's purposes, it's vital to gain the most accurate calculation for a given site. The site design can be fine-tuned in dozens of ways to obtain the optimal output for the investment.

Ground Coverage Ratio: One of the essential elements of site design is the question of how much land will be

required to site panels. Rule-of-thumb approaches to GCR assume the largest possible spacing required, while a site-specific plan takes into consideration the overall desired outcomes of the project. For example, there are hard costs like interconnection or site acquisition, that can't be avoided or changed but whose impact on return can be minimized. In some cases, by sacrificing a little power per module, the design could support a higher GCR (with more modules) and yield higher output values from the site and maximize the return on fixed costs.

Grading the Site: Every site requires some form of grading before construction. Yet simply grading a site uniformly is to miss opportunities for savings. Minimizing the area needed to be cut, cleared and grubbed can reduce the cost of construction. It also helps minimize the amount of reseeding required – an important factor, particularly in sensitive or challenging environments such as arid landscapes. A cost/benefit analysis can help identify areas -- such as those requiring extensive grading with little benefit -- that can be entirely avoided.

Foundation Design: Modules require a solid foundation, but it doesn't need to be limited to a uniform approach across an entire site. By scrutinizing and fine-tuning on-site testing, designers may be able to create a foundation plan for the racking system that can eliminate miles of costly steel without sacrificing safety, longevity or performance.

DC/AC Ratio: Developers can benefit from a basic understanding of the factors that determine the power profile of a site's DC/AC ratio, sometimes called the inverter load ratio (ILR). When the net module rated power feeding an inverter is greater than the inverter's rated power, some of the power output from the module will be lost or "clipped" since the inverter can't handle the full volume. Conventional wisdom holds that minimizing "clipping loss" is ideal, yet in practice, a higher DC/AC ratio can deliver better economic results for a particular site.

String Length: Determining string length and configuration is an important part of site design and varies based on whether or not the plant will be grid connected and many other factors. For example, longer strings mean less wire, more capitalization of racking and better long-term performance. The basic NEC method for calculating ideal string length uses the temperature coefficient and ASHRAE minimum temperature requirements, while an alternative approach, which can help optimize string configuration and length, involves using temperature and irradiance. This method can result in a boost of one to three more modules in a string.

AC Medium Voltage Collector System: The wires that bring power from the inverters to the substation make up this system, which can be one of the single highest costs on a project. A standard layout uses a radial design, yet other approaches, such as considering alternative placements of junction boxes and routing of conductors – could minimize cost and maximize performance.

ANTICIPATING THE EFFECT OF DIRT AND DEGRADATION

Soiling Impact: Just as a car parked outside accumulates pollen and dirt, PV modules accumulate a surface film from being out in the field. This film negatively impacts performance by blocking incoming light. This effect has been extensively researched and can be predicted based on site conditions such as local sources of soiling (soil type, nearby agriculture or industrial activities, etc.) as well as how often soiling is removed from the system from average weather conditions and module washings.

Reducing unnecessary cleaning saves money since it is an expensive undertaking to shut down and clean modules. Conversely, ensuring cleaning is done frequently enough, also supports the equation by enabling optimal module performance.

The basic approach to soiling calculation relies on standard, state or even nationwide assumptions. These may also be informed by multi-year data sets of rainfall to model natural soil removal. With these, O&M cleaning schedules can be refined to better match soiling needs and project goals. However, to fully optimize soiling estimates, experts go further. They leverage data from on-site weather stations equipped with tools to measure the soiling rates at particular plants, allowing for a detailed understanding of the local sources of soiling.

Snow Losses: In regions like Massachusetts, which have both high levels of solar adoption and regular snowy seasons, the impact of snow on solar availability is important to anticipate accurately. Snowfall often completely covers modules for extended periods of time and must be cleared safely. Even without precipitation, the cold conditions of climates where snow is common can further limit system performance. While standard assumptions can guide modeling of snow-based losses, it is vital to the optimized approach to not only leverage multi-year weather data but local data on conditions at the plant site, including monitoring the actual equipment used.

Transformer Characteristics: Two types of energy losses inevitably occur within every transformer. Losses incurred while electrical current flows in the coils (commonly called “load losses”) and losses incurred in the magnetic field alternating in the core (commonly called “no-load losses”) all affect the production of energy from a solar plant. Since different models and types of transformers have distinct operational and loss characteristics – and particular price

points associated with each – optimizing transformer performance again becomes a site/plant-specific task. In selecting the most appropriate transformer, standard assumptions need to be informed by a comprehensive analysis of a balance of factors, including costs, output, losses per equipment type, etc., based on the individual project.

DC/AC Line Losses: Similarly, line losses cannot be avoided, but an array of factors can play into the selection of the most effective materials for a particular plant. For example, while one size wire may be generally considered optimal for reducing line losses, an alternative size wire could be less expensive, more readily available or more efficient to install (or some combination of all of these factors) in a particular case. This can deliver savings that could offset standard assumptions for line loss best practices.

Horizon: Typical energy production calculations often don't emphasize the role of the horizon in losses, perhaps because during the key production period in the middle of the day, when the sun is high in the sky, little shade may be cast. Yet horizon plays a significant role in morning and evening production -- times when incremental production could contribute valuable resources. Getting the most output from site resources to deliver an accurate availability of energy is good business in any scenario, and planning to gain extended hours of productivity could also prove valuable in future rate or tariff scenarios incorporating off-peak production or when coupled with energy storage.

Degradation: As modules deteriorate over time, their power output declines. While standard calculations use a linear approach to calculating reduced output due to degradation, too often these may be more informed by other loss factors examined above, such as inverter clipping or line losses. An optimized approach to calculating output under module degradation includes both independent, lab-informed data on manufacturer's module degradation reports, calculations that take into account the site conditions, as well as the impact of clipping on an inverter's energy output.

PLANT-BASED OPTIMIZATION MAKES THE DIFFERENCE

In each of the above areas, we've seen how the basic approach can provide developers with a broad, introductory understanding of energy production, while the optimized approach can deliver significantly more accurate, in-design accuracy to meet the needs of actual, specific projects. Armed with this knowledge, developers who can verify that every aspect of their plant design has been determined by this more detailed cost/benefit analysis will have a clear advantage in developing projects that deliver optimal value -- and in winning PPAs against their less optimized competitors.

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