

2020 Solar Generation Index

*Quantitative Insights from
Leading Asset Owners*



kWh analytics

Opening Remarks

Every asset class is governed by market cycles and modeling assumptions, which naturally swing between optimism and conservatism. As solar continues its ascension, the optimism that naturally emerges from market growth can inadvertently undermine the long-term stability of the industry as a whole.

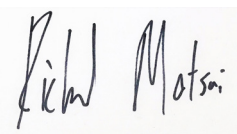
Fortunately, our industry has matured tremendously in a few short years. Our asset class has now generated a decade of actual data that can be harnessed to guide sustainable growth. This data affirms an array of positive attributes of the asset class, but it also reveals that we have collectively turned a blind eye to realities of solar asset performance.

Under the leadership provided by our industry's largest asset owners, kWh Analytics has been given the opportunity to publish the world's most comprehensive analysis of real-world project performance (30% of the U.S. market) to review how we as an industry are performing against the yield expectations we have set for ourselves and for our investors.

The data speaks for itself: if you blindly trust a production estimate, on average, you are likely overestimating a site's production. With the data and support of 10 of the 15 largest asset owners, we are publishing this inaugural report to provide our industry with an opportunity for introspection.

Although underperformance impacts multiple stakeholders, the long-term equity investors are the most exposed to inaccurate energy forecasts. Change won't happen on its own. It is up to us as an industry to collectively allow hard data to overcome opinions, however well-intended. We look forward to the shared work of improving our solar industry and accelerating the clean energy transition.

Regards,



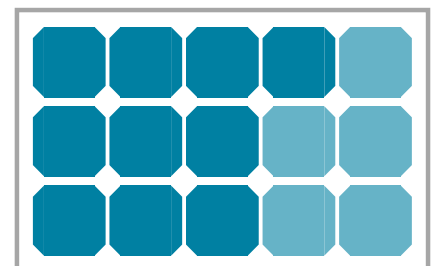
Richard Matsui
CEO of kWh Analytics



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10 of the 15 largest Asset Owners



Data represents 67% of the largest asset owners

Executive Summary

kWh Analytics, as the leading solar risk management company, collaborated with 10 of the 15 largest asset owners to generate the largest industry-wide energy validation study. The aim was to quantify the magnitude of the industry's accuracy – or inaccuracy – embedded in a solar project's base case ("P50") production estimate.

The results of the analysis show that solar projects in 2016-2019 underperformed their third-party P50 estimates (target production) on average by 6.3% on a weather-adjusted basis, with a quarter of the projects missing their production targets by over 10% even after weather-adjustment.

While the industry uses the same software tools and engineering firms to generate production estimates, the lack of accepted standards means that production forecasts can vary dramatically depending on who is running the model. Until now, data has been unavailable to validate those production forecasts with real-world operating data at scale. This research highlights the need to bring this real-world data into the project evaluation process to meet investment return expectations.



Solar projects in 2016-2019 underperformed their target production on average by 6.3%

Introduction

Reliable solar production forecasts have been a key cornerstone to the financeability, and therefore growth, of the sector since its inception. As a market that grows at a rapid clip of 20% year-over-year, solar capacity is widely expected to expand significantly. Solar now comprises the largest base of newly installed generating capacity and the United States is expected to double its installed solar capacity over the next five years.¹

The solar industry has continued to attract new forms of capital to meet the voracious capital needs of building out a new energy paradigm. Solar developers, the industry's "front line workers" in the creation of new solar projects, have laboriously and over time attracted long-term equity capital for these projects from a variety of sources, ranging from the public markets to private infrastructure funds. Our industry's continued success is predicated upon its ability to reliably deliver the results promised to its investors.

But with growth comes growing pains, and the industry has slowly come to terms with the fact that, on the whole, solar projects are underperforming relative to their production forecasts and risk falling short of their return expectations. What started as the concerns of a few asset managers has evolved to be the topic du jour at conferences and in the boardroom. However, these conversations to-date have largely been based on anecdotal evidence from single projects or portfolios.



Introduction (*continued*)

This industry-wide study confirms the anecdotes. In collaboration with 10 of 15 largest asset owners, kWh Analytics analyzed >30% of the industry's utility-scale and C&I projects and found an average 6.3% over-estimation in production, even after adjusting for weather, relative to the official P50 estimate.

Leading asset owners in the solar industry are sharing data to quantify this issue and make analysis available to the industry so that the industry may collectively make changes that enable long-term, sustainable capital deployment into the solar market. Return profiles that can be accurately forecasted underpin the industry and need to be addressed to grow as a sustainable asset class.

How Did We Get Here?

Predicting energy yields for generation sites did not begin with solar: other generating assets like natural gas and wind also rely on modeling by engineering firms to assess energy yield potential. As a result, when lenders began diligencing solar projects, they borrowed the same playbook to model their exposure and return expectations off of predicted production estimates.

In the early 2000s, when solar was still a young and untested asset class, the initial estimates used were conservative and projects typically out-performed expectations. ² With the rapid pace of market development, new technologies, more complicated site designs, and a more competitive landscape, production estimation became more complex. Further, the importance of the P50 in solar financings introduced intense pressure from the competitive market to what was heretofore a purely technical discussion. Forecasting shifted from overly-conservative to overly-optimistic.

Production estimates play a significant role in the market valuation of a project, as they are a key input into the financial models of the solar project's economics. Stakeholders are often financially motivated to increase production estimates, as it is directly correlated to the amount of capital that can be raised. While this trend is not driven by nefarious intentions, the data is irrefutable: as an industry our production forecasting has trended aggressively relative to actual, in-field performance.

The "P50" estimate is a statistical measure that indicates the base case, predicted energy yield. This is a challenging number to derive, based on a number of site-specific assumptions. Solar is not alone with these challenges, either: the National Renewable Energy Lab led recent research in the wind industry with similar conclusions, even though that industry identified the problem a decade prior. ³

In 2020, kWh Analytics collaborated with 10 of the 15 largest asset owners to conduct the industry's largest energy validation study and quantify the magnitude of the industry's inaccuracy when relying on P50 estimates. By analyzing the historic performance of distributed generation and utility-scale solar projects with >1 MW DC capacity, we highlight how the industry is actually performing.

Industry Assessment Results

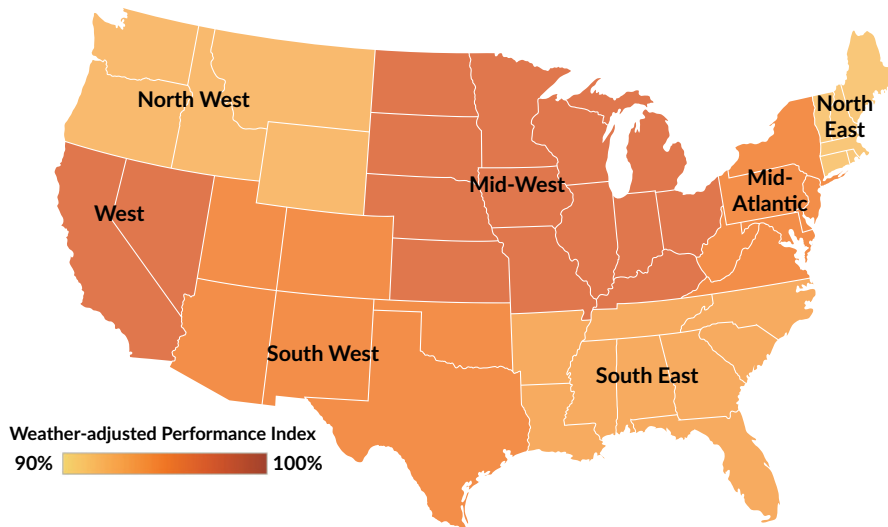


Figure 1: Weather-adjusted Performance Index by Region (2016-2019)

This analysis of >30% of the industry’s non-residential projects in the U.S. compared actual production against original P50 estimates for operating years between 2016 and 2019 and found that projects on average underperformed by 6.3%, even after adjusting for weather.

The performance results against P50 estimates fall on a distribution and vary by region, but highlights a troubling reality: we, as an industry, are relying on inaccurate and unreliable production estimates.

It’s Time for a Course Correction

With over \$4 trillion more solar investment forecasted by 2050, the solar industry has an opportunity to address this issue in its infancy.⁴ The course correction has already begun. The industry’s largest asset owners are collaborating to quantify potential biases and using data to drive accuracy and transparency in future solar financings. As an industry, we can leverage our collective knowledge and expertise, develop data feedback loops, and improve the way we model and assess solar risk. While developers may be concerned about the near-term impact on solar asset valuations resulting from adjusted P50 estimates, we believe that this course correction will enable our industry to continue the structural trend of lower-cost capital entering into the industry. This ultimately has a positive impact on solar asset valuations.

Our Approach and Systems Analyzed

This was a coordinated initiative with 10 of the 15 largest asset owners in the U.S. Combining the contributed data and kWh Analytics' HelioStats database, this analysis encompassed over 30% of the industry's non-residential solar projects across more than 30 different asset owners. Projects analyzed were larger than 1MW in DC capacity. The analysis compared historical generation between 2016 and 2019, relative to the P50 expectations from as-built designs. P50 expectations were degraded annually based on the annual degradation factor assumed by the asset owner. The results do not incorporate system losses due to utility curtailment.

With over \$4 trillion more investment forecasted for solar by 2050 to support the clean energy transition, we have the opportunity to address this issue now.

In order to factor for localized and temporal weather factors, kWh Analytics leveraged Clean Power Research's SolarAnywhere® weather database to assess weather anomalies against long-term historic averages. SolarAnywhere is trusted for its bankability and long-term, consistent accuracy.⁵

Endnotes

¹ [SEIA](#), "Solar Market Insight Report 2019 Year in Review"

² Jigar Shah, September 15, 2020, [Greentech Media](#): "#Solar100's Jigar Shah and Van Skilling on the Evolution of Solar Asset Class"

³ [National Renewable Energy Laboratory](#), Wind Plant Performance Prediction (WP3) Benchmark

⁴ [Bloomberg New Energy Finance](#), June 18, 2019, "Solar, Wind, Batteries To Attract \$10 Trillion to 2050, But Curbing Emissions Long-Term Will Require Other Technologies Too"

⁵ Clean Power Research's [SolarAnywhere](#)®