

Best Practices for Solar Assessment

Developing a solar project requires a large upfront investment. A standard development roadmap conserves time and money and ensures that the most promising projects are constructed. Each stage of development asks different questions about the solar resource and each stage requires varying degrees of information and investment of financial resources.

Rely on Solar Assessment Experts

Vaisala 3TIER Services team has experience performing solar assessment on all 6 continents and in very challenging climates, such as India, where monsoon activity dramatically impacts solar resources. In addition, the team has helped the world's largest solar developers secure over \$5.5 billion in project financing at locations around the globe, including the 392MW Ivanpah CSP facility and a majority of the shortlisted project application submitted for the Australian Solar Flagships program.

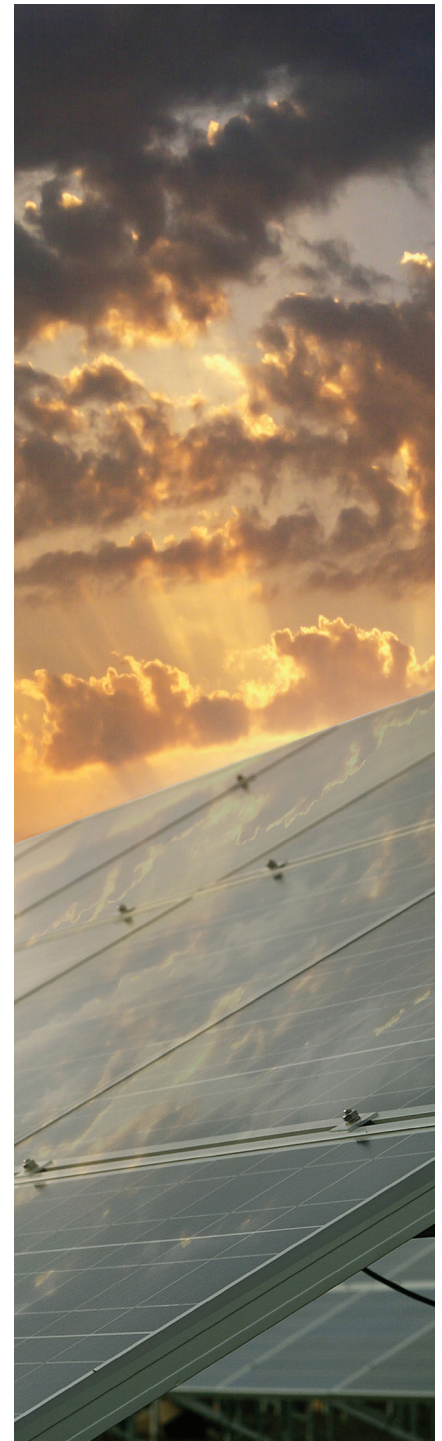
Through partnerships with numerous private and public agencies, such as NREL, the Clinton Foundation, and the Asian Development Bank, Vaisala has provided a better understanding of the challenges of solar energy development and established best practices for solar assessment. These recommendations help make new solar projects more commercially successful and ultimately promote the continued adoption of solar energy.

Solar Development Roadmap

Prospecting and Planning

The first step in building any solar resource project is identifying the regions most suitable for development. The price of energy, access to transmission, and environmental siting issues should all be taken into consideration, but the most essential variable is the availability of the solar resource – the fuel of the project.

At this early stage, average annual and monthly irradiance values can be used to assess the feasibility of a site and to select the appropriate solar technology to be installed. Basic solar annual and monthly averages can be found via online solar maps and in the form of GIS (Geographic Information System) layers. TMY (Typical Meteorological Year) datasets are also a good estimate of average seasonal variability and typical conditions at a site. These tools allow developers to quickly target the best locations for further investigation and identify red flags early in the process.



Design and Due Diligence

Once a promising site is identified, a more in-depth analysis is required to design the project, secure funding, and better quantify the long-term availability of the solar resource. While TMY datasets are often used for this purpose due to software compatibility, they are not appropriate because they offer no indication of year-to-year variability and actually exclude non-typical low solar years, which are critical in determining project viability and financial risk.

From year-to-year there are always good and bad solar years due to climate cycles, particularly with direct normal irradiance (DNI). These include monsoons, volcanic eruptions, climate change, changes in the release of natural aerosols and pollution, and climate indexes such as ENSO (El Niño, Southern Oscillation).¹ This is true even in areas known to have strong solar resources, where solar projects are actively developed, such as the southwest US, north and south Africa, India, and Australia. Recognizing this variability and building it into financial modeling before making any significant investments or breaking ground is key to the commercial success of a project.

As shown in Figure 1, for global horizontal irradiance (GHI) it may only take 2-3 years of measurements to be within +/-5% of the long-term mean, but it takes much longer for DNI – up to 15 years.¹ Thus, measurement periods of 1 year are not sufficient for a resource assessment, especially for DNI.

Hourly time series covering a period of years provide a more complete record for calculating accurate estimates of solar resource variability and 1-year P90 exceedance values, which are required by many financial and rating institutions.² A 1-year P90 value indicates the production value that the annual solar resource will exceed 90% of the time. A 1-year P90 value (as opposed to a 10-year P90 value) is

typically mandatory because most solar projects have a lending structure that requires them to service debt one to four times a year, not one to four times every 10 years. If power production decreases significantly in a given year due to solar variability, debt on the project is at risk of defaulting – which is precisely what financiers are trying to avoid. Alternatively, if plant production is much higher than expected over the course of the project's lifetime or even multiple years it may mean that the project developer was too conservative in estimating performance and accepted financing terms that were not as favorable as they could have been. The amount of lost revenue in this scenario depends on many factors, but can be as high as US\$500,000 to US\$1M each year. The only way to determine 1-year P90 values acceptable to funding institutions and protective of developers' investments is with long-term continuous data at the proposed site.

If collected properly, surface observations can provide very accurate measurements of solar radiation at high temporal resolution, but few developers want to wait the 10+ years required to develop a 1-year P90 value. Satellite derived irradiance values can accurately provide a long-term, hourly time series of data without the expense and wait.

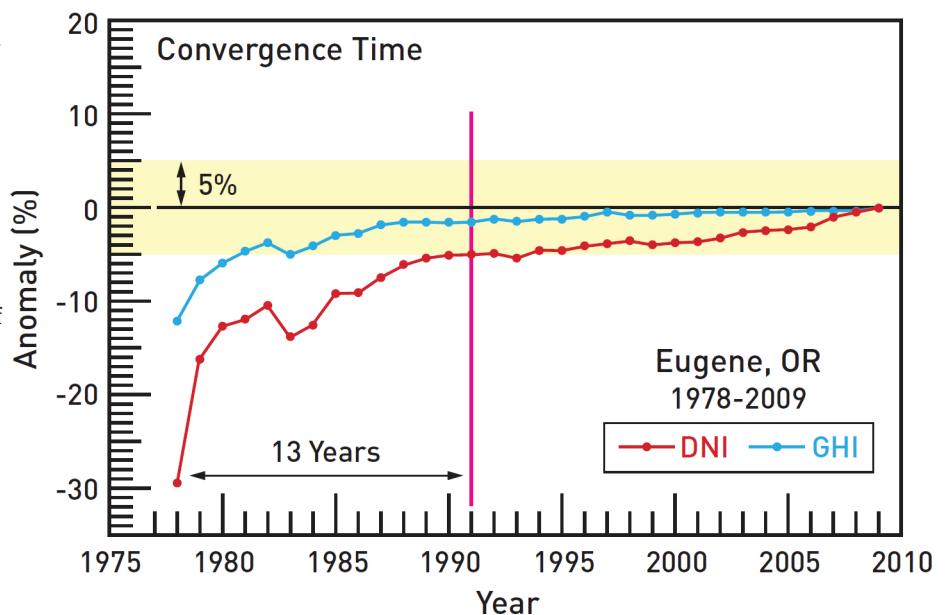


Figure 1.
A graph showing convergence rates for DNI and GHI at site in Eugene, Oregon, USA from 1978-2009.¹

However, satellite data cannot always capture the micro-scale features that affect a site. Therefore a combination of short-term ground measurements and long-term satellite derived irradiance values is ideal for assessing variability and project risk. One method of combining short-term ground measurements with longer-term satellite data is a technique known as model output statistics (or MOS).

The MOS algorithm by Vaisala 3TIER Services can significantly reduce error and bias by statistically correcting our long-term, satellite derived irradiance values to the environmental context of a particular site based on available surface observations.

MOS is a multi-variate linear regression analysis between a prescribed set of predictors and the surface observational data. The primary result from the MOS algorithm is a multi-linear regression equation that is designed to remove bias and adjust the variance of the raw satellite-derived data as compared to the surface observational data. Vaisala's MOS process is further illustrated in the Figure 2.

Case Studies

The Vaisala 3TIER Services team has provided MOS-corrected satellite data for assessing numerous projects. An example of the effectiveness of this technique is shown in Figure 3 at a site near Desert Rock, Nevada (36.63N, 116.02W) where long-term GHI measurements are publicly available.

Over a 10 year period, ground observations show annual GHI variations generally less than 5% from the mean, with one anomalous year of low GHI in 2002 where GHI was about 6% less than the long-term mean. The satellite derived solar dataset captures this interannual variability with an annual correlation coefficient of 0.97 and an overall mean bias error of 2.5%.

A MOS-corrected time series was derived using 1 year of ground observations from Desert Rock from 2008 and satellite record at the site. The MOS-corrected time series retained the high correlations with the observed data (annual correlation coefficient of 0.97) and also reduced bias from 2.5% to less than 0.5%. This MOS-corrected time series provides a long-term perspective using short-term observations and can be used as a way to calculate 1-year P90 exceedance values.

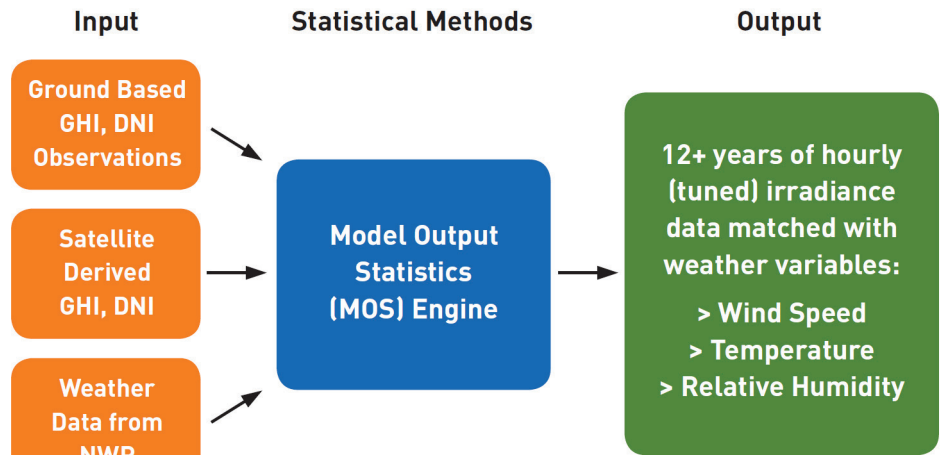


Figure 2.
A flow chart of MOS technique by Vaisala 3TIER Services.

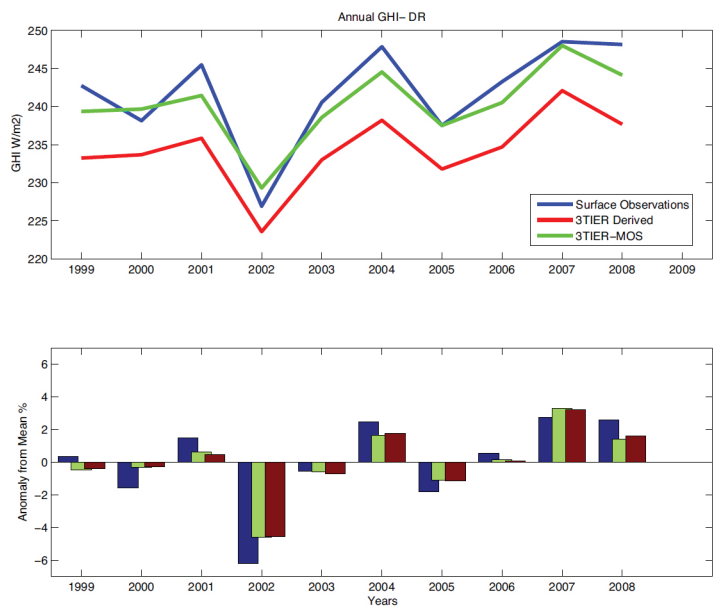


Figure 3.
Annual observed, Vaisala 3TIER Services derived, and Vaisala 3TIER MOS GHI values for a 10-year period (1999-2008) at Desert Rock, Nevada., USA

Conclusion

The development of solar projects has expanded significantly and appears to have a promising future. However, even the best locations are not immune to normal year-to-year variations in solar irradiance, which have a corresponding impact on power production and the ability of the project to service its debt. Therefore, TMY datasets should only be used at the prospecting stage or with low cost residential installations.

While on-site observations capture the localized nuances of solar irradiance at a particular location, they do not provide the long-term perspective required for project funding and must be well maintained to be trusted. Satellite derived solar datasets, on the other hand, accurately capture year-to-year fluctuations, but do not always capture micro-scale effects. A solar resource assessment, combining both on-site observations and long-term satellite derived data, helps extend measurement records and gain long-term context. This method greatly reduces uncertainty, and provides the “bankable” production estimates required to secure financing. Widespread adoption of this practice will ensure that only profitable solar projects are constructed and secure the future success of the solar energy industry.

References

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- 2 Venkataraman, S., D'Olier-Lees, T. “Key Credit Factors.” Standard and Poor’s Solar Credit Weekly 29.42 (2009), 29-30, 49-50. E-article.

