WEATHER-ADJUSTED PERFORMANCE GUARANTEES

Matt Hollingsworth
Clean Power Research
Napa, CA 94559
matthol@cleanpower.com

Jeff Ressler
Clean Power Research
Napa, CA 94559
jressler@cleanpower.com

Richard Perez
ASRC, University at Albany
perez@asrc.cestm.albany.edu

ABSTRACT

Photovoltaic (PV) system value is based on the amount of energy that a PV system produces (kWh) and not simply its power rating (kW). As a result, there is a movement within the PV industry toward a greater concern about PV system performance as the PV market grows and matures.

Installers and insurers may offer performance guarantees to cater to increasing end-user sophistication. At the time of installation, the installer guarantees how much energy the PV system will produce in the future. Installers and insurers must select "worst case" estimates for solar resource when creating guarantees in order to protect them against the risk created by solar resource variability.

This paper investigates the approach of using a baseline dataset of monthly system production estimates coupled with a location-specific monthly solar resource index to enable installers to provide more accurate Weather-Adjusted Performance Guarantees for systems.

1. INTRODUCTION

PV system output varies based on the capabilities of the equipment and the on-site environmental factors. Of these factors, the most unpredictable variable affecting PV output over time is the quantity of solar radiation reaching the array. The Solar Information Resource Service (SIRS) of the State of New York [1] is illustrative of the oftentimes highly localized variability of solar irradiation from year to year.

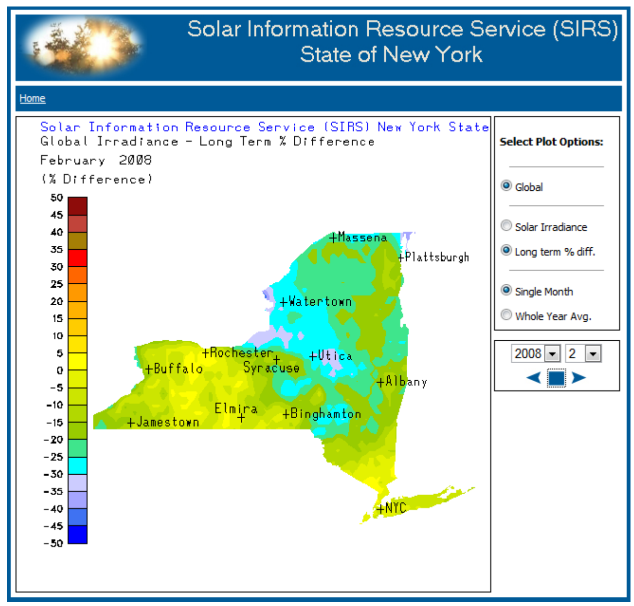

Fig. 1: SIRS New York irradiance variability map, Feb. 2008.

In this study, we consider how an initial set of baseline monthly energy production estimates can be adjusted via a published, location-specific monthly satellite-based performance index to estimate PV-generated energy. This baseline and index can then be used by installers to provide end users with a Weather-Adjusted Performance Guarantee. The Weather-Adjusted Performance Guarantee relies on the index to externalize the weather variability. More specifically,

Estimated energy production =
Reference Performance Guaranteed x Solar Resource Index

When calculated on a monthly basis, the monthly Solar Resource Index = Average Global Horizontal Irradiance (GHI) in the Actual Year and Month / Average GHI in the Reference Year and Month. Reference Performance Guaranteed = PV System Energy Production (kWh for the particular system) in the same corresponding Reference Year and Month.

2. SOLAR RESOURCE VARIABILITY

The figures and tables below illustrate a significant variation in the monthly solar resource over the period of multiple years. For example, consider the variation in global horizontal irradiance (GHI) for Albany, NY (lat=42.65, long=-73.75) and San Jose, CA (lat=37.35, long=-121.95) based on data from the SolarAnywhere® [2] satellite-based irradiance estimates for years 2003-2009. Tables 1 and 2 present the average hourly irradiance for each month and year; Figures 2 and 3 present the minimum, average, and maximum values; and Figures 4 and 5 illustrate the deviation from the 7-year average. The figures illustrate that the year–to-year deviation for a month is often in the range of +/- 20 percent and is sometimes as high as 40 percent. Such departures can have a significant impact on a system's financial return, particularly when using seasonal or real time tariffs.

TABLE 1: AVG. HOURLY GHI BY MONTH (W/m^2), ALBANY, NY

	2003	2004	2005	2006	2007	2008	2009
Jan	70	65	59	80	91	87	74
Feb	103	76	116	117	116	92	103
Mar	152	148	162	163	150	146	166
Apr	195	201	214	209	173	232	178
May	201	231	225	200	274	232	215
Jun	219	251	261	209	259	238	220
Jul	254	223	249	252	245	240	228
Aug	213	206	213	218	224	219	219
Sep	166	185	189	149	194	177	175
Oct	118	113	100	115	120	124	99
Nov	69	75	79	70	76	67	78
Dec	56	51	67	53	54	54	55

TABLE 2: AVG. HOURLY GHI BY MONTH (W/m^2), SAN JOSE, CA

	2003	2004	2005	2006	2007	2008	2009
Jan	101	90	77	98	118	80	107
Feb	136	68	118	141	118	140	121
Mar	212	216	179	159	220	216	201
Apr	222	270	257	196	258	279	260
May	294	309	265	311	313	308	293
Jun	333	342	314	317	340	338	311
Jul	322	329	327	330	325	323	323
Aug	290	291	292	286	300	297	292
Sep	235	242	242	241	227	240	240
Oct	191	165	177	168	171	175	171
Nov	110	115	117	111	122	111	126
Dec	76	93	76	90	90	90	84

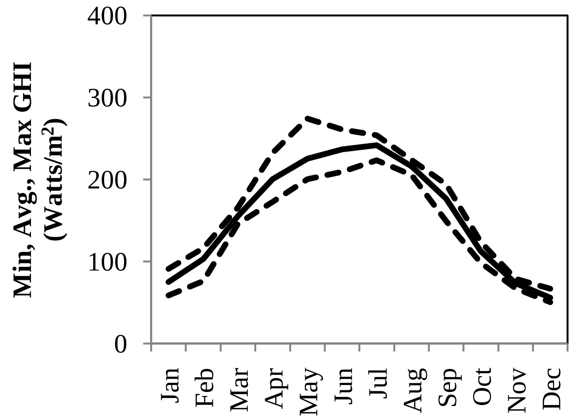

Fig 2: Avg. hourly GHI by month, Albany, NY, 2003-2009.

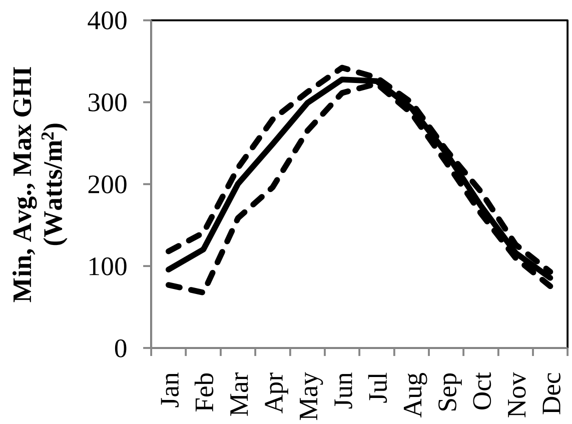

Fig 3: Avg. hourly GHI by month, San Jose, CA, 2003-2009.

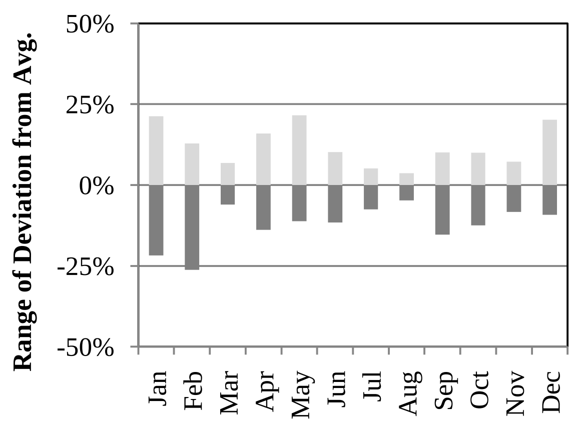

Fig. 4: Avg. hourly GHI variability by month, Albany, NY, 2003-2009.

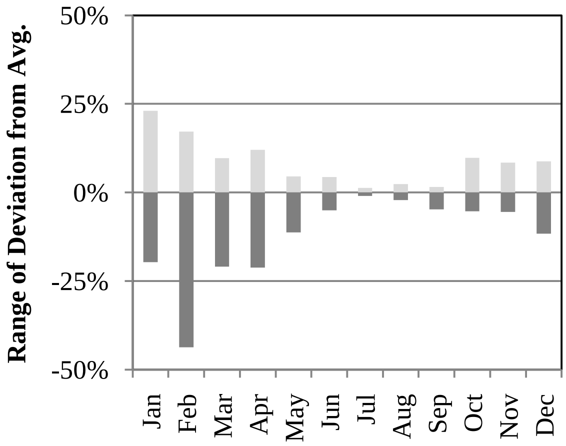

Fig. 5: Avg. hourly GHI variability by month, San Jose, NY, 2003-2009.

Installer-provided performance guarantees define the expected energy production level as well as the normal range of variance from the expected level. The Weather-Adjusted Performance Guarantee allows the normal variance supplied with the guarantee to be reduced by removing much of the production uncertainty related to solar resource variability.

Consider the following example. Suppose that the date is January 1, 2007, an end-user is purchasing a 50 kW_{DC} PV system in Albany, NY, and the baseline analysis year is 2006. Further suppose that the system is guaranteed to produce 7,500 kWh in June (reference year 2006). Now, move forward in time to June, 2007. As can be seen from Table 1, the Solar Resource Index is (259/209) = 124 percent and thus the estimated output is 9,300 kWh. The use of an index has removed 1,800 kWh of weather variability from the performance guarantee. Externalizing the weather variability helps installers guarantee equipment performance (which they can control) without concerns for weather related performance (which they cannot control). The installer and end user are better off because they can share a more narrowly defined performance expectation for a proposed system.

The remainder of this paper tests the validity of estimating system output in support of a Weather-Adjusted Performance Guarantee via system specific system baselines coupled with monthly solar resource indexes.

2. WEATHER BASELINE

The first step required when implementing the proposed Weather-Adjusted Performance Guarantee is to capture a year of baseline weather inputs for the location. In the study, monthly baseline averages were captured for GHI, direct normal irradiance (DNI), wind speed, and temperature. SolarAnywhere satellite-derived solar resource estimates were utilized to ensure a broad geographic coverage independent of the presence of a local ground station solar irradiance data source. Temperature and wind speed estimates derived from a METAR network were sourced from the SolarAnywhere service. The total monthly GHI values (in kWh/m^2) for each location are illustrated in Figure 6 below.

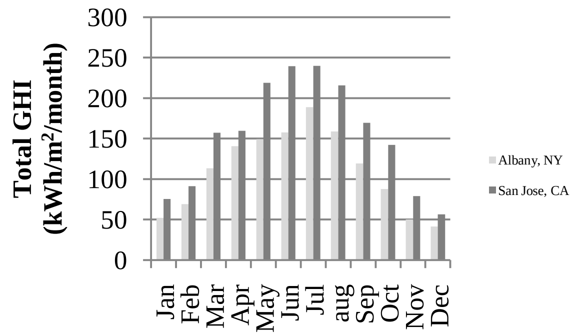

Fig. 6: SolarAnywhere total monthly estimated solar irradiance (kWh/m^2) for baseline year of 2003.

3. ENERGY PRODUCTION BASELINE

The next step when developing a monthly Weather-Adjusted Performance Guarantee is to generate estimates for the baseline system energy using the baseline weather estimates.

For illustration purposes, the simulated PV system consisted of twenty Sanyo Electric Model HIP-205NKHA5 modules with a 3.595 kW DC/3.955 kW CEC-AC/3.595 kW CSI-AC rating coupled with a SMA America Model SB6000U 240V 6.0 kW inverter. The panel geometry was specified with a 30 degree tilt facing South with no shading from surrounding obstructions.

Hourly system energy production estimates were generated using PVSimulator® [6] by inputting the hourly GHI, DNI, wind speed and temperature for each location along with the specified system configuration in the baseline year of 2003. The hourly results were then summed to generate monthly totals. Figure 7 presents the system energy production estimates for San Jose and Albany in 2003, the baseline year.

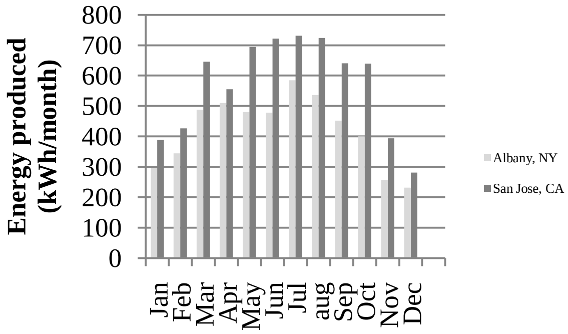

Fig. 7: SolarAnywhere estimated system energy (kWh) produced by month for baseline year 2003.

4. MONTHLY SOLAR RESOURCE INDEX

A Weather-Adjusted Performance Guarantee relies on a Solar Resource Index to adjust the initial monthly estimates for the solar resource variability in subsequent years. As stated above, the Solar Resource Index is the ratio of the current monthly estimated GHI to the baseline monthly GHI for the selected location. Weather-adjusted monthly system output is determined by multiplying the monthly system energy production for the baseline year by the Solar Resource Index. Figure 8 presents the monthly Solar Resource Index for San Jose across the years 2004-2009 using a baseline year of 2003.

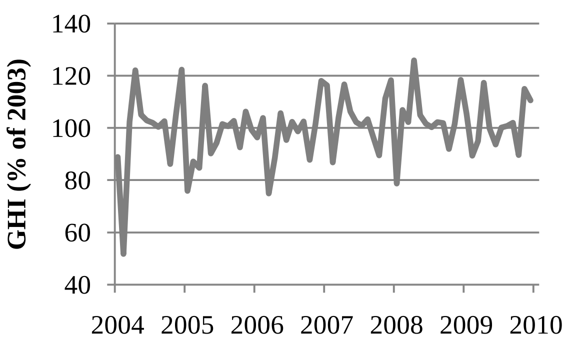

Fig. 8: Monthly Solar Resource Index, San Jose, CA.

DNI, wind speed, and temperature are not tracked as part of the monthly Solar Resource Index. This simplification assumes that GHI has the largest impact on PV system output variability and further assumes that the incorporation of more detailed weather factors during the monthly baseline adequately adjusts for average seasonal variation of DNI, wind and temperature. The impact of these assumptions on the accuracy of the index-based energy production estimate will be explored in the next section.

5. ACCURACY OF ENERGY PRODUCTION PREDICTIONS

The tracking accuracy of the Solar Resource Index with respect to PV simulations was conducted across 2004-2009. Figures 9 and 10 track how closely in percentage terms the Solar Resource Index predicted energy production compared with full PV simulations. Results suggest that most of the months were within a few percent of full PV simulations.

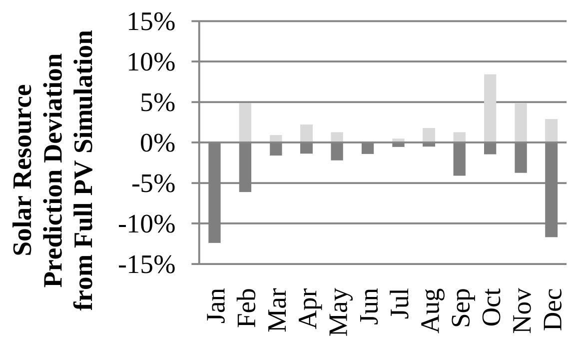

Fig. 9: Monthly energy prediction variation (%) vs. full simulation results for current month, Albany, NY.

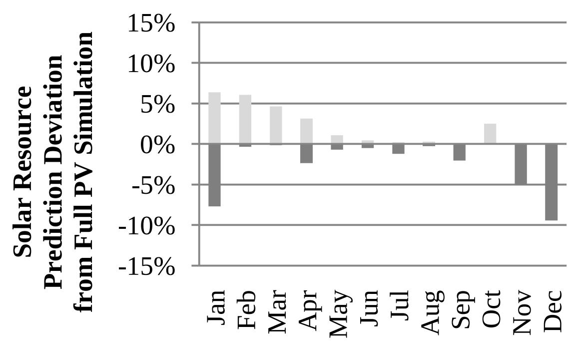

Fig. 10: Monthly energy prediction variation (%) vs. full simulation results for current month, San Jose, CA.

5. CONCLUSION

Installers and insurers are beginning to offer performance guarantees to cater to increasing end-user sophistication. At the time of installation, the installer guarantees how much energy the PV system will produce in the future. Installers and insurers must select "worst case" estimates for solar resource when creating guarantees in order to protect them against the risk created by solar resource variability. This paper investigated the approach of using a baseline dataset of monthly system production estimates coupled with a location-specific monthly Solar Resource Index to enable installers to provide more accurate Weather-Adjusted Performance Guarantees. Results suggest that the technique could allow insurers and installers to externalize a portion of the weather related variability to create a more precise Weather-Adjusted Performance Guarantee while at the same time opening up the possibility of increased financial returns.

6. ACKNOWLEDGMENTS

The authors would like to thank Dr. Tom Hoff from Clean Power Research for the initial vision of how a solar index could simplify solar energy production estimation as well as his support during the creation of this paper. We would also like to thank Andrew Parkins from Clean Power Research for providing the PV simulation results.

9. REFERENCES

1. Solar Information Resource Service (SIRS) of the State of New York, http://www.iedat.com/sirs-ny/databrowser.php, March 2010.
2. Clean Power Research SolarAnywhere, http://www.solaranywhere.com, March 2010.
3. Perez R., J. Schlemmer, D. Renne, S. Cowlin, R. George and B. Bandyopadhyay, (2009): Validation of the SUNY Satellite Model in a Meteosat Environment. Proc., ASES Annual Conference, Buffalo, New York.
4. Stein, J., Perez, R., Parkins, A, (2010): Validation of PV Performance Models Using Satellite-based Irradiance Measurements: A Case Study. Proc., ASES Annual Conference, Phoenix, Arizona.
5. Perez, R., Ineichen, P., Moore, K., Kmiecik, M., Chain, C., George, R., and Vignola, F.(2002), A New Operational Satellite-to-Irradiance Model, Solar Energy 73, 5, pp.307-317.
6. Ressler J. PV Output Validation with SolarAnywhere and PVSimulator, Napa, California: Clean Power Research, (2008). See also: http://www.californiasolarcenter.org/pdfs/forum/2008.2.8_SolarForum_JRessler-CPR_PVSimulatorOverview.pdf.