Real world performance exceeds expectations

REC is committed to providing high-performance solar energy solutions and long term value for solar system owners. Being certain of performance in the field is critical for system owners to realize returns on project investments. REC outperforms PVsyst predictions to provide value beyond expectations.

Planning a solar installation

Most solar modules are sold by watt class, also referred to as the module's "nameplate" rating , which states the nominal power rating of a module as tested under prescribed factory conditions. However, test conditions rarely reflect the real world. The actual output of an installed solar module is far more involved than STC conditions as it depends upon local weather, system design characteristics and many other factors. Far more significant to the photovoltaic systems's value than the "nameplate" wattage is the reliability of energy production, as the energy volume produced over the plant's lifetime is a critical input for determining revenue stream and project returns. It is of vital importance for predicted values to be closely matched to actual performance.

When it comes to predicting the yield of a PV plant, there are a number of simulation methods that can be utilized. PVsyst is one of the most well-known software programs recognized by project developers and financial institutions worldwide for producing reliable yield profiles given the right input data. To demonstrate the accuracy of PVsyst in projecting yield performance, we have compared predicted figures to those actually generated on our rooftop systems at our integrated wafer, cell and module manufacturing facility in Tuas, Singapore. Results show that actual yields can be in excess of five percent above PVsyst predictions. This is in-line with findings from REC installations in Europe, where performance ratios are 1.8 - 8.0 percent above projections[1].

Background

At REC's integrated manufacturing facility in Singapore, a 300 kW array comprised of REC225 AE modules was been installed on the wafer plant rooftop. Installed in January 2010, the array is tilted at an angle of 10° to the horizontal and is split between north and south facing roofs. 151 kW of the array is accurately monitored by Solar Energy Research Institute of Singapore (SERIS). The monitored array is divided into sections ranging from 24.3 - 36.5 kW each and the monitoring system records irradiance at the module plane, cell temperature and inverter AC output at one minute intervals.

The complete system installed at REC's integrated manufactuing facility in Tuas, Singapore.

1 *European assessed sites include Luxel, France (4 sites); Bero II, Italy (5 sites); Bero III, Italy (10 sites) and Ikea Freiburg, Germany.*

The full year's data for 2011 was provided by SERIS, which enabled the investigation to determine the actual performance against that predicted by PVsyst. Due to a disruption in the data recording, the months of June and July were not appropriate for assessment and hence were excluded from the analysis. Two sections of the array were affected by extreme soiling contamination (from a waste stream now removed from the plant) and therefore have been removed from the analysis.

The PVsyst simulation

Care was taken when conducting the simulation to minimize assumptions fed into the model so as to provide an accurate prediction over the year. Since recorded irradiation and module temperature were used, this is considered a 'weather normalized' prediction, where discrepancies between assumed and actual weather conditions are avoided.

Input variable	Value	Source
System location	Tuas, Singapore	REC Integrated Facility
Irradiation data	Global at tilt	As recorded by SERIS at 1 min. intervals
Module temperature	Reference modules	As recorded by SERIS
Modules	103.275 kW	REC225 AE
Inverter	96 kW	SMA 10000TL (3) & 11000TL (6)
Module efficiency loss	0.7%	Reflective of 1 year's degradation
DC losses	1.0%	Design assumption
Module mismatch loss	0.3%	Simulated by REC
Soiling loss	2%	Assumption
Reflection profile	REC AR coating	As generated by SERIS

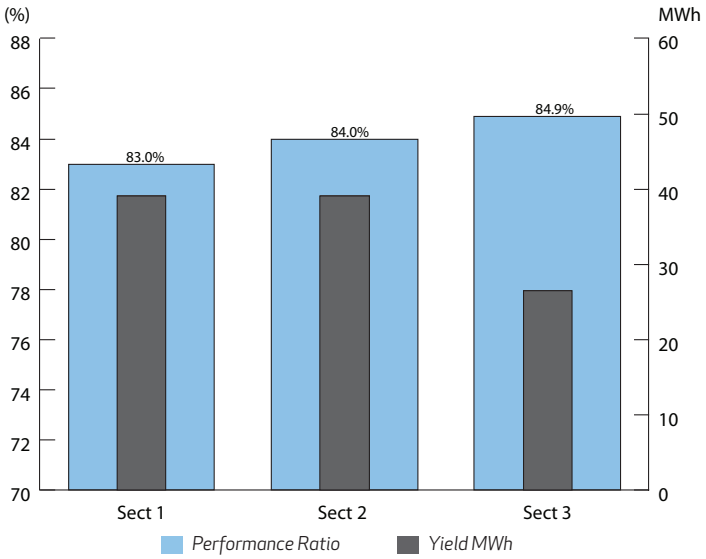
Key inputs used in the PVsyst simulation

Measured system performance

Performance ratio (PR) is one of the most important measures for comparing system performances from one location to another, independent of irradiance. It is defined as the ratio of actual measured output over a given period of time divided by the nominal power (nameplate rating) during that time. All three sections studied had high performance ratios of 83 percent or above (as shown in the graph overleaf).

The high PR of REC modules is a pattern replicated in the 2011 Photon Laboratory Field Performance Test of 45 different modules from 37 separate leading manufacturers. Based in Germany, and therefore in a temperate climate, REC modules had the highest PR relative to the competition of 90.8 percent and produced six percent more power than the test average. This is attributed to REC's anti-reflection coating and excellent low-light performance.

Measured system performance in 2011 (excludes June & July)

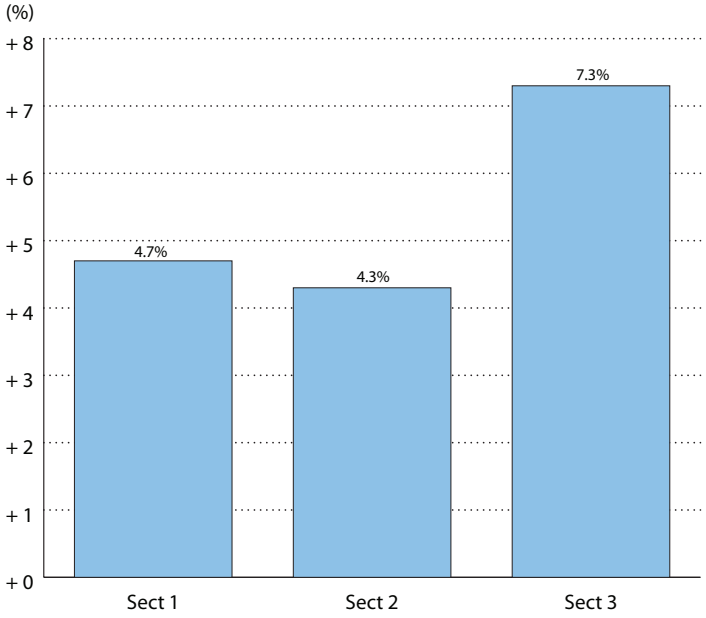


System performance for 2011 excludes June and July due to disruptions in data recording

Performance compared to PVsyst prediction

All three sections produced significantly more energy than the volume predicted using PVsyst. The arrays outperformed the simulations by 4.3 - 7.3 percent – an average over-performance of 5.4 percent. This trend is consistent with data measured in REC installations around the world and observed by independent test institutes, internal projects and satisfied system owners.

Energy yield compared to PVsyst prediction in 2011 (excludes June & July)



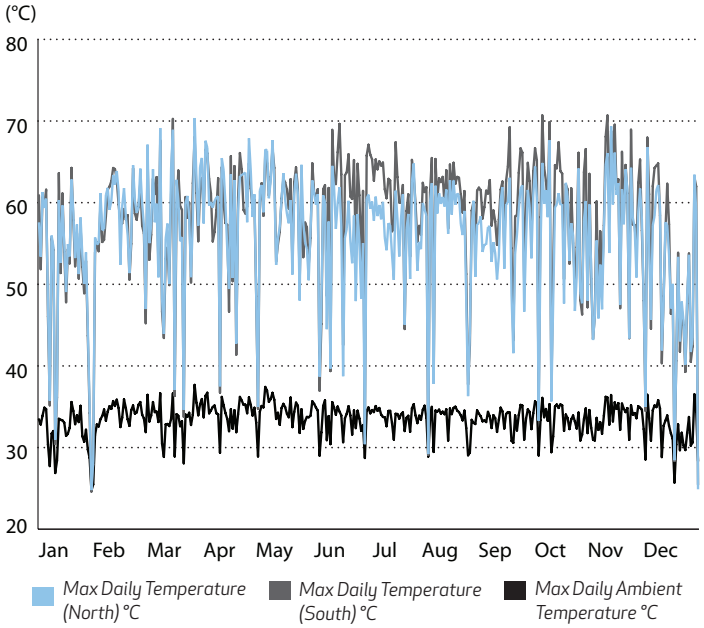
Energy yield averages 4.8% higher than those simulated in PVsyst

System level performance ratios of 83 percent and above are impressive considering the tropical climate in Singapore. Throughout the duration of the test, the average ambient temperature was 28.6°C, with an average maximum temperature of 33.5°C. As a result, module temperatures frequently exceed 60°C and were at times as high as 70°C. As is typical in tropical areas, Singapore is not only hot, but also humid. Levels of humidity in Singapore reach on average 76 percent[2] throughout the year which provides a challenging environment for solar modules. The site's yield complements REC's first place ranking at the Photon test site demonstrating high performance ratios in tropical as well as temperate conditions.

Section	PVsyst Simulated PR	Actual PR	Difference
1	79.1%	83.0%	+ 3.9%
2	80.6%	84.0%	+ 3.4%
3	79.0%	84.9%	+ 5.9%

Performance ratios in Singapore significantly exceed those predicted

Maximum 2011 daily temperatures in Singapore



Daily maximum module & ambient temperatures recorded on-site

Conclusion

For the three array sections totalling 102 kW on the roof of the REC integrated manufacturing facility, performance ratios of between 83.0 - 84.9 percent were recorded.

The purpose of this analysis was to determine real-world performance of REC modules against that predicted by PVsyst. Through this exercise it can be concluded that systems built with REC modules can significantly outperform software simulations and given the right input assumptions and grid availability, can even be in excess of seven percent above simulated predictions.

System designers are increasingly selecting photovoltaic modules based upon yield rather than nameplate watt class. Superior design and manufacturing are at the core of REC's high-yield performance and reliability. Due to inherent technological advantages, REC modules provide yield advantages not only beyond market competitors but above PVsyst predictions. These strong results in a hot and humid environment complement those seen in Europe to demonstrate REC's superior energy performance in all conditions.

2 *BBC Weather: http://www.bbc.co.uk/weather*

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REC is a leading vertically integrated solar energy company. REC produces polysilicon, wafers, cells and modules for the solar industry, and silicon materials for the electronics industry. REC also engages in project development in selected PV segments. Founded in Norway in 1996, REC employs around 3,200 people globally with revenues of more than NOK 13 billion in 2011, approximately EUR 1.7 billion and USD 2.4 billion. Please visit www.recgroup.com to learn more about REC.

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