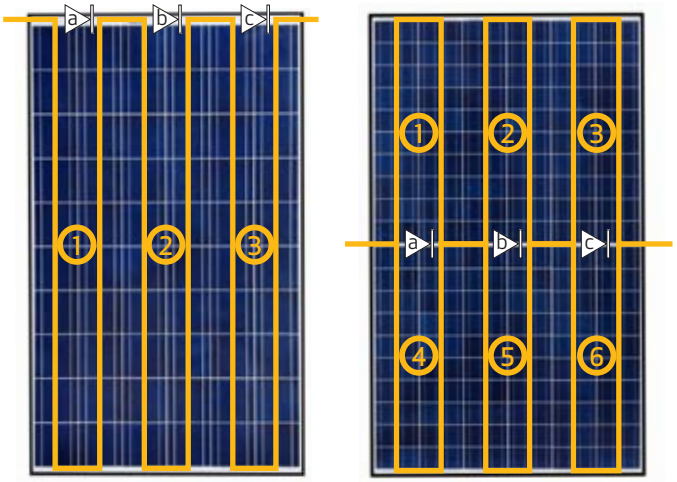
The REC TwinPeak Series:
Innovative module design gives improved yield performance in shaded conditions

The innovative design of REC TwinPeak Series solar modules offers customers a number of significant improvements over standard 60-cell panels. Through intelligent system layout, customers can benefit from increased energy yield, even when the installation is affected by shade at certain times of the day or year, enabling continued production in shaded conditions long after other modules have ceased generation.

The innovative design of the REC TwinPeak Series

One of the most striking features of the REC TwinPeak Series is its use of smaller cells. These are in fact, regular 156 mm (6 in) cells cut in half. The smaller size reduces internal resistance, increasing output, and has allowed REC to take a new approach with the layout, removing one cross connector, which enables greater inter-cell spacing and an increase in captured light. The removal of the cross connector is aided by a three-part junction box, placed in the middle of the rear of the module. The effect of this is to split the cell strings into two, i.e., six strings in total, controlled by three bypass diodes as shown below (fig.1). With this, the module takes on a different behavior pattern in shaded conditions which can help achieve an increase in overall energy yield.

Fig. 1: Standard and REC TwinPeak modules showing representative flow of current through cell strings (1, 2, 3, 4, 5, 6) and bypass diodes (a, b, c)



Standard Module
With three internal strings of cells

REC TwinPeak Module
With six internal strings of cells

The effect of shading on a solar module

Solar modules convert sunlight into energy, so any drop in irradiation, through shading, will reduce the amount of power produced. Depending on the cause, and its position relative to the installation, the loss may be only seasonal, or for a few hours each day, but spread across a module string or an array, the overall production level may drop considerably, reducing earnings and savings from the installation.

Cells in a module are connected in series, like links in a chain. Setting up the cells and modules in this way means that they all produce the same current under the same irradiance. Most cases of shading however, are not uniform across the module string, so if the current drops at one point, the whole chain is restricted and output is reduced. This creates a mismatch - a difference in the characteristics of an electrical system which reduces the electricity flow to the level determined by the lowest performer in the series – for example, if all modules in one string are working to produce a current of 8A and then a shaded module can no longer conduct these 8A, then the string will only be able to produce the current that the shaded module can conduct.

In order to manage such situations, solar modules use bypass diodes to divert current around cells unable to conduct in line with others. In standard modules, a bypass diode covers 20 cells out of 60, meaning that when activated, one third of the module is lost to production.

Testing the performance of a single REC TwinPeak Series

In order to assess the behavior of the new design in shaded conditions, tests were performed on the REC TwinPeak Series under different levels of shading to measure the effect on energy production. By taking the IV trace of the modules under the different amounts of shade coverage, the cell strings could be monitored and measured (fig. 2):

Fig. 2: How shading of strings affects a single standard and REC TwinPeak module

Shading	Standard module	REC TwinPeak module
2a: Zero shading	All diodes inactive	All diodes inactive
	Voltage (V) 100% Current (A) 100% Power (Wp) 100%	Voltage (V) 100% Current (A) 100% Power (Wp) 100%
2b: 1 string	SHADE Diode a active Diodes b & c inactive	SHADE Diode a is active, bypassing shaded string. Top string continues to generate energy.
	Voltage (V) 66% Current (A) 100% Power (Wp) 66%	Voltage (V) ~66%* Current (A) 100% Power (Wp) ~66%* * Diode will turn on to allow excess current through depending on MPP tracking.
2c: 2 strings	SHADE Diode a active Diodes b & c inactive	SHADE Diode a active Diodes b & c inactive
	Voltage (V) 66% Current (A) 100% Power (Wp) 66%	Voltage (V) 66% Current (A) 100% Power (Wp) 66%
2d: 2 strings	SHADE Diodes a & b active Diode c inactive	SHADE All diodes inactive
	Voltage (V) 33% Current (A) 100% Power (Wp) 33%	Voltage (V) 100% Current (A) 50% Power (Wp) 50%
2e: 3 strings	SHADE All diodes active	SHADE All diodes inactive
	Voltage (V) 0% Current (A) 0% Power (Wp) 0%	Voltage (V) 100% Current (A) 50% Power (Wp) 50%

Testing demonstrated that production stops across the length of a standard module as each bypass diode is activated, whereas the REC TwinPeak Series loses less surface area to shading compared to

a standard module. The way module power is affected by changes in voltage and current depends on the extent of shading, which in turn determines whether a bypass diode is activated or not.

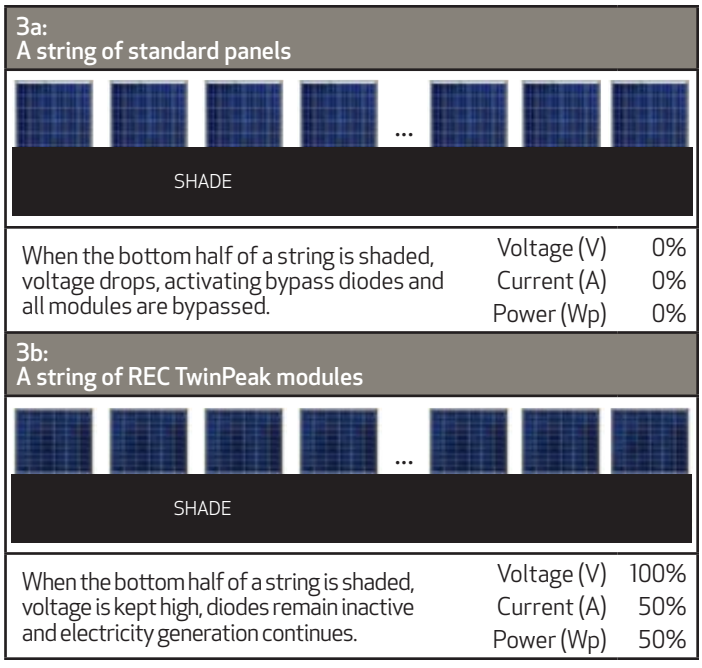
Where module level power electronics (MLPE) such as micro-inverters or optimizers are used on REC TwinPeak modules, this behavior pattern can offer a substantial advantage in electricity generation and overall energy yield. Due to the way the MLPE unit turns the modules into independent generators connected in parallel, the influence of mismatches can be negated and each module operates at its own MPP.

Testing the performance of an REC TwinPeak Series string

Most solar installations however, consist of more than one module and so it is the performance in shaded conditions of the entire string that is of more importance, i.e., how does the string react when mismatches are present. Testing across a string of modules showed that as per a single module, lower irradiance does not turn on the bypass diodes, meaning the currents from each cell string continue to be added together to give the module current. Depending however, on where the inverter tracks the MPP, the current may be brought down under certain conditions.

An open string with no shading will produce 100% voltage, 100% current and 100% power whether it is a standard module or an REC TwinPeak. Dependent on the optimum power point chosen by the inverter, and the point at which bypass diodes are activated, there may be a small benefit in yield with the choice of REC TwinPeak modules for when only a few modules are shaded, but usually, one or two shaded REC TwinPeak modules in a string will behave as a standard panel and be bypassed in favor of keeping current high. In general, if more than one module remains unshaded, the MPP operates at full Imp, and the shaded module is totally bypassed. If, however, shading is equal over half of an REC TwinPeak string, then the other section will continue to operate and the string will work at 50% Imp and 50% power, where a standard panel would normally stop working all together (fig. 3).

Fig. 3 Uniform shading in an string of standard modules can lose 100% of production, where a string of REC TwinPeak will continue generation in 50% of the string



This advantage is best seen in installations where inter-row shading can cause the system to stop generation (fig. 4). By splitting the REC TwinPeak into two sections, the string will continue to produce electricity in at least 50% of the panel until the other section is also shaded (fig. 3b) improving the overall energy yield.

Fig. 4: Inter-row shading in an array can lose production in a complete string with standard modules while still exposed to sunlight

The impact on installations

As the testing above demonstrates, customers can achieve a clear advantage from REC TwinPeak modules – with half of every panel continuing to contribute to electricity generation for a longer period, customers will see improved yield. Installation of the REC TwinPeak Series parallel to the shade will result in both of the twin sections of the module (top and bottom) being equally shaded and there will be no major benefit over a standard module (fig. 2c).

Of course, if the installation is designed so that no shade falls on the array, the owner will benefit even more from the other power technology enablers inherent in REC TwinPeak Series solar modules, increasing overall energy yield and profit.

How do I get the best performance of REC TwinPeak modules?

If shading of the installation is unavoidable and the path of any regular shade can be predicted before installation, e.g., by a building or other row of modules, it makes sense to install the modules so that only half of the REC TwinPeak module is shaded at any time. This can reduce the area of the module that is switched off by the bypass diodes and allow the opposite side of the module to continue producing energy, increasing output and earnings.

Conclusion

Use of the REC TwinPeak Series can offer a big advantage and improved performance in shaded conditions where the shading across a string is generally even, for example where caused through obstacles such as other rows or walls, as long as the modules are correctly positioned to the path of shading.

Aligned with other energy generation advancements in the REC TwinPeak Series, a significant increase in overall energy yield is achievable, making the new panel a better option for energy production in confined or limited spaces.

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REC is the largest European brand of solar panels, with more than 15 million high-quality panels produced at the end of 2014. With integrated manufacturing from polysilicon to wafers, cells, panels and turnkey solar solutions, REC strives to help meet the world's growing energy needs. In partnership with a sales channel of distributors, installers, and EPCs, REC panels are installed globally. Founded in 1996, REC is a Bluestar Elkem company with headquarters in Norway and operational headquarters in Singapore. REC's 1,800 employees worldwide generated revenues of USD 680 million in 2014.

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