CONVINCING PERFORMANCE

SolarEdge makes a positive impression in tests conducted by PHOTON Lab

The power optimizers made by SolarEdge are – if the figure of speech is at all appropriate – among the classics in this still-young market segment. And they are also among the few power optimizers available in mass production. According to information provided by the company, more than half a million units will be dispatched by SolarEdge this year. Solon SE and Ritek Corp. are among the module manufacturers that sell products with integrated SolarEdge electronics, and an agreement has been signed with a manufacturer of junction boxes, Molex Inc. Only Tigo Energy Inc. can boast a comparable position in the market. Numerous other companies – including giants like the second-largest manufacturer of inverters, Power-One Inc. – have also announced forthcoming power optimizers, but will only be able to launch them on the market in a few months' time, at the earliest (see box, p. 42). The PowerBox from SolarEdge is, therefore, the only new device of this type currently available, and as a result, it has landed on the test bench at PHOTON Laboratory.

The system makes a good overall impression. The conversion efficiency has improved over the previous model. The lab measured an average of 98.5 percent; the previous version managed

THE SECOND GENERATION OF POWER BOXES MADE BY SOLAREDGE HAS LANDED ON THE TEST BENCH. IN SHADE SIMULATIONS CONDUCTED BY PHOTON LAB, THE SYSTEM PRODUCED ADDITIONAL YIELD IN ALL SCENARIOS – EVEN WHEN NO SHADOWS WERE CAST. CONVERSION EFFICIENCY INCREASED BY NEARLY 1 PERCENTAGE POINT OVER THAT OF THE PREVIOUS MODEL. FUNCTIONS SUCH AS MODULE MONITORING AND AUTOMATIC MODULE DISCONNECT INCREASE THE TECHNICAL SAFETY AND ECONOMIC STABILITY OF THE INSTALLATION.

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When the SolarEdge system is used, each module must be equipped with a power optimizer of its own. PHOTON Laboratory tested the boxes as add-on devices; the electronics, however, are also available for installation in junction boxes.

97.8 percent. Values over 99 percent were observed in numerous measuring situations. And in all test situations, the device did, in fact, coax more energy out of the lab's test system in the solar simulator. The PowerBox really does justice to the name »power optimizer.«

The black units, which have shrunk in size by a good third compared to their predecessors, are easy to install without problems arising, and they did not cause any trouble during operation either. The online portal, to which the key performance figures for each individual module are sent, also makes a sound impression. Installation of the boxes, which at the moment are predominantly being sold as add-on devices for any kind of module, are straightforward – as was the case for the earlier model. The optimizers are simply hooked up to the modules using a two-pole connector, assuming the function of the junction box, and are connected in series. In the future, this step will become increasingly superfluous, as next year SolarEdge starts selling 40 percent of its systems for module factory integration. Currently, only 5 percent of the systems are »embedded,« according to Amit Rosner, marketing manager at the company. In contrast to power optimizers made by some other manufacturers, for SolarEdge devices, each module in a solar generator must be equipped with a box of its own. Because the system also features module-level power monitoring and integrated safety functions, in addition to power optimization, it should, for logical reasons, be operated with special inverters made by SolarEdge – or together with an interface box. When used with inverters made by other companies, the interface box provides those communication functions that are otherwise integrated into the SolarEdge inverter. Both versions functioned flawlessly in PHOTON Lab's test.

A third operating mode, in which the power optimization, but not the additional functions, is operational – a mode that requires neither an interface box nor a SolarEdge inverter – was not tested by the lab.

Four test installations

The system was tested in four configurations, each of which was compared with a reference configuration that was not equipped with power optimizers. Fourteen 180 W modules – model TSM 180 DC01, made by Trina Solar Ltd. – were used in a test installation in the solar simulator at PHOTON Lab. Halogen floodlights generated a reproducible light field in the chamber, with 1,100 W per m^2 of output at the module plane.

Configuration one: one string with 14 modules, connected to an SE 3300 inverter made by SolarEdge.

Configuration two: one string with 14 modules connected to an AT 2700 inverter made by Sunways AG, as well as the SolarEdge interface box (which performs the communication functions otherwise integrated into the SE3300).

Configuration three: two strings with seven modules each, connected to an SE 3300 inverter.

Configuration four: two strings with seven modules each, connected to an AT 2700 inverter, as well as the SolarEdge interface box.

Reference configuration one: one string with 14 modules connected to an AT 2700 inverter, without PowerBox optimizers.

Reference configuration two: two strings with seven modules each, connected to an AT 2700 inverter without PowerBox optimizers.

SolarEdge does not actually design its units for configurations three and four, and it stipulates at least eight modules per string. However, 16 modules will not fit into PHOTON Lab's solar simulator, which is why the lab decided to chance it with 14 modules. The test did not, however, reveal any issues due to the non-standard scaling; obviously SolarEdge has played it safe in this regard.

The yields attained from the four test systems were measured under a variety of shading situations, and each was compared with the reference installations – those that were not equipped with PowerBoxes. PHOTON Lab tested each of the shading situations listed below.

Horizontal shading: A finely woven metal screen used to reduce irradiation down to around 40 percent was employed in this case. Initially, the metal screen covers the bottom third of the lower seven modules in the solar simulator – thereby generating an effect similar to horizontal shading from a neighboring building, for example. The screen is moved downward at a speed of 4.3 mm per minute, so that the shading ends after 2.6 hours. The movement is a linear one.

Shading by a simulated dormer: In this case, an opaque metal surface is used that has been cut into a shape similar to that of the shade cast by a dormer window. The screen is around 2.4 m high,

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This interface box can be looped in between the supply cables for the strings and the inverter, allowing the system's monitoring functions to work with inverters that are not made by SolarEdge. If anything, this configuration had a positive effect during the lab's tests.

and 1 m wide. Its rectangular shape is tapered on the upper half on one side. The surface area produces partial shading on up to four modules. Because it is made of a solid material, it creates a very dark shadow. The screen is placed on runners, allowing it to be pulled into the generator area in increments of 1 cm using a roller conveyor, at a speed of 8.6 mm per minute. After around 2 hours, the movement is stopped and the rear edge of the simulated dormer has reached the front edge of the first module. The movement is a linear one.

Shading by a simulated pole: This shading area produces a similar partial shadow over up to six modules. The pole has a cross section of 5 by 5 cm^2 and a height of 240 cm. At the beginning of the test, it is placed in front of the modules at an angle of 45°. It is then raised to a vertical position using a cable winch over a period of 3 hours. This movement is nonlinear.

Reduced irradiance: A final measurement was made at reduced irradiance. This was done by cutting the irradiance from the entire solar simulator to around 830 W per m^2 with the aid of metal meshing.

The individual test results

First of all: PHOTON Lab's test in the solar simulator reconfirms that a clever choice of string lengths and a module arrangement that has been adapted to surroundings can significantly minimize the impact of shading. In a number of cases, utilizing power optimizers will not result in any great gains. This is particularly true for horizontal shading: it reduces the yield by up to a third when long strings are used. If two short strings are used instead, the loss only amounts to a few percent – provided that one string is installed above the other string, as is the case in the lab's solar simulator. However, an excessive loss of yield did not occur in the other shading scenarios either. System operators should therefore carefully investigate whether the use of power optimizers makes sense before installing them.

Two short strings: An increase in yield was detected in the simulator when the modules were not shaded, but were equipped with PowerBoxes: the modules tested generated around 1.5 percent more energy. This is a surprising start, considering that the efficiency of the boxes is less than 100 percent, a lower yield might have been expected. This result could be produced by the solar simulator: its field of light is not completely homogenous, and consequently the modules in it produce differing outputs. A similar effect also occurs when modules are mismatched. The effect, which is not especially large when an installer uses new, sorted modules, can increase over time, depending on the quality of the modules.

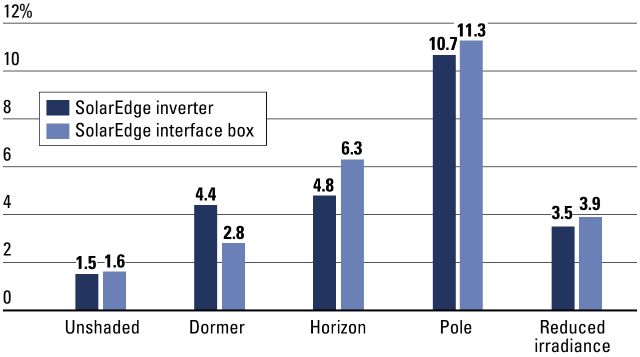
Simulating the shade cast by a dormer produced a similarly modest gain in efficiency of 2.83 percent (with the interface box) and 4.41 percent (using a SolarEdge inverter). Since the dormer was simulated using an opaque screen, the proportion of diffuse irradiation on the shaded modules is quite small. This means that the gains achieved by using PowerBoxes are not very large.

The simulation of elevating the horizon produced an extra yield of up to 6.3 percent. Interestingly, the system configuration with SolarEdge inverters performed considerably more poorly than the one that used an interface box and a Sunways inverter.

The largest gain occurred by simulating the shadow cast by a pole. The optimizers were able, in this scenario, to generate an additional yield of more than 10 percent; in comparison to the other shading scenarios, this is an impressive amount. The reason for the gains is undoubtedly the length of the screen representing the pole: in contrast to the other test screens, it predominantly cast its shadow onto the modules in both strings. The differences in the yields gained in the various test configurations using the pole simulation are correspondingly small compared to one another. Operators of installations struggling with shadows like these can therefore profit considerably from installing PowerBoxes.

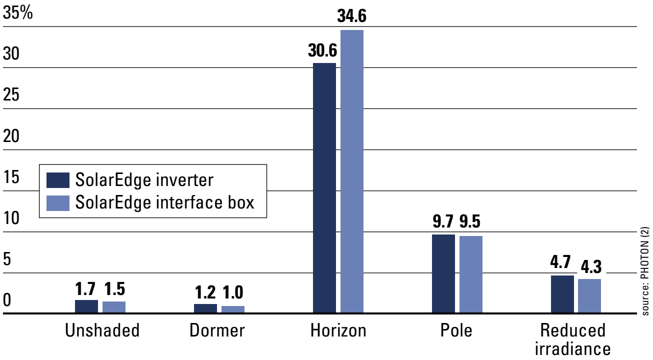
The devices functioned flawlessly during the simulation of reduced irradiance, producing a yield gain that suggests the metal screen did not produce an entirely homogenous irradiance reduction over the entire area. Ultimately, this test is a variation on the inhomogeneity of irradiance in the nonshaded case outlined above.

Additional yield produced by SolarEdge PowerBoxes – two parallel strings of seven modules each



The additional yields produced by installing PowerBoxes with systems that have comparatively short strings are rather modest. But performance is greatly improved by the devices when a system is shaded by a pole.

Additional yield produced by SolarEdge PowerBoxes – one string of 14 modules



When optimizing a long string, the differences in the results produced by varying shade conditions stand out. The gains are particularly large when there is horizon shading.

One long string: In principle, consistent gains in yield can also be produced with the PowerBoxes when long strings are used. The ability to compensate for mismatched modules, inhomogeneous and reduced irradiance, is similarly good in this scenario as it was with a configuration of two short strings. The additional yields generated when testing the simulated dormer shading are, by contrast, almost negligibly small – presumably because the bypass diodes in the shaded module interconnect and therefore keep the loss of current in the overall system to a minimum.

The results produced during horizontal shading are impressive. The yield increased by almost a third in comparison with the reference measurements made without PowerBoxes. When simulating the shadow cast by a pole, the higher yield had a similar magnitude to the one gained when testing the two short strings connected in parallel.

This series of measurements also revealed tangible differences between the system configurations using the SolarEdge inverter and the Sunways model. They are, however, consistently small and could, in part, be due to the measuring tolerance of plus or minus 3 percent.

Efficiency: The conversion efficiency of the latest power optimizer made by SolarEdge has increased to an average of 98.5 percent. PHOTON Lab measured a range between 97.94 and 99.06 percent. This considerable fluctuation in efficiency has to do with a changed operating strategy of the system: the previous generation only optimized the power harvest from the modules. The current generation also factors fluctuations in the conversion efficiency of the SolarEdge inverter into the equation. Under certain circumstances, a few thousandths of a percentage point of efficiency are relinquished when optimizing power at module level if this allows the string voltage to be raised into a range at which the inverter operates particularly efficiently. In this case, the manufacturer speaks of »global optimization.« One consequence of this strategy is that the SolarEdge inverter no longer operates using a fixed input voltage, but rather with a variable one, just like its conventional equivalents. It still does not, on the other hand, feature a maximum power point (MPP) tracker, so that the layout of the device generally remains a comparatively basic one, which is also reflected in the price. Using last year's measured value of 97.5 percent for the conversion efficiency of the SE3300 inverter, this now results in a maximum conversion efficiency of 96 to 96.6 percent for the SolarEdge system.

Additional functions

Besides increased yield, the SolarEdge power optimizer has a number of additional features that make it interesting for both installers and system operators. Given the debate about the fire safety of photovoltaic (PV) systems, the »normally off« function may be the most important such feature. This ensures that the modules do not emit any electricity when the inverter is inactive – for example, due to firefighters switching off the house service connection. The same applies in the event that the strings are disconnected. This function is available in all three operating modes – using the PowerBoxes with SolarEdge's own inverter, with the interface box, and with another type of inverter. The solar system then poses no risk during fire-fighting activities.

However, the devices employ a modified normally off function. Each module that has been disconnected produces voltage amounting to exactly 1 V, providing there is a minimum of light available. If the installer connects 15 modules in a row, for example, then a voltage of 15 V can be measured between the two poles of a string – providing certainty that the string has been correctly configured.

The monitoring of the individual modules represents another feature. The boxes continually send power and voltage data to the SolarEdge inverter, or to the interface box, by power-line communication. These devices transmit the data to the SolarEdge portal using a standard Internet connection. The layout of the solar power array can be seen at the portal, which allows the power data from each individual module to be depicted graphically. Energy, output, currents and energy from a string or several boxes can be displayed. The system also creates reports, when required, and can issue alarm messages. This makes it easy to detect faulty modules – a task that can otherwise require a great deal of effort. This also makes asserting any warranty claims more straightforward.

In light of the features designed to increase convenience for the system operator and the installer, it is remarkable that connecting the inverter is quite impractical. This is done using an Ethernet network connector that is attached on the inside of the inverter, which makes good sense given its protection type, NEMA 3R. To ensure that the construction remains impermeable, the grid cable must be guided through a screw-on cable gland, but the connector does not fit through. The installer therefore can't avoid mounting the connector on the cable in the field – either on the inverter or the Internet router. This is an activity that is prone to errors and requires special tools.

Once this hurdle has been overcome, then the inverter and the interface box will find the Internet portal without further ado. At most, a network firewall may still have to be configured for the system.

Summary

When it comes to the features, everything is just right with SolarEdge's PowerBox: the power optimization functions under all conditions, the monitoring provides investment security for the system operator and allows the installer to offer specially tailored service contracts. Its fireproofing provides a feeling of safety. When it comes to the purchase price for integrated systems, SolarEdge is currently aiming for 10¢ per W for the coming year. As the layout of SolarEdge's own inverter is more basic than its equivalents that use MPP trackers, additional savings can be made here. At SolarEdge, there are plans underway to manufacture 500 MW of power optimization systems in 2012, says Rosner. The company is currently negotiating with four of the five large Chinese module producers for the supply of devices integrated directly into junction boxes. However, Rosner is not expecting that the module suppliers intend to add a large sum to the purchase price of the electronics. »It allows them to create a unique selling point for their products,« he says. Should power optimizers manage to penetrate the mass market this way, then they ultimately only have to prove one thing: that their electronics actually do last as long as modules.

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