

Strategies And Techniques For Increasing Yield Of Thin-Film Solar

Alternative wiring techniques can reduce systems' energy loss, but connectors and junction boxes must be adjusted accordingly.

■ Aryn Strand

Thin-film modules create new possibilities to increase energy yield per rated kilowatt. These modules have unique characteristics, and system integration techniques that take advantage of these are starting to take form.

With the enormous supply of low-cost thin-film modules coming to market over the next few years, now is the time to learn techniques to effectively integrate these modules into solar power projects to provide the best energy yield. The results will be seen in the bottom line - cost per kilowatt hour.

To understand the potential for thin-film solar projects, it is important to look at the energy yields (kWh/kW) that are possible and some techniques to increase output to the highest possible level. There are many factors that affect the energy yield per rated kilowatt, making conventional benchmarks - such as cost per watt of a solar power system - obsolete.

The inherent yield advantage of thin-film modules is the first consideration to take into account when comparing thin-film and crystalline systems. Thin-film modules have temperature coefficients as low as half the value of crystalline's - depending on the technology - with cadmium telluride and amorphous silicon (a-Si) leading the pack.

Thin film also has improved energy capture in diffuse lighting. According to a study by Energy Photovoltaics and Kadam Consulting, an a-Si system can achieve 15% more energy output per rated kilowatt in hot climates and 12% more power output in cloudy climates. This difference is a significant result in terms of the potential return on investment (ROI) of a project.

In addition, thin-film systems are generally expected to have a lower total cost than crystalline silicon systems. However, even if the costs were equal, the extra energy yield from the thin-film system could provide the better ROI.

The wiring configuration can also have a great impact on system performance. Up to 15% of potential energy production from thin-film systems is wasted when repeating conventional wiring techniques. The good news is that there are several emerging alternatives to recoup these losses. But how does the installation configuration cause such a drastic energy loss in the first place?

PV modules create a voltage and a current. When modules are wired in a series, voltages are additive from module to module, with a single current flowing through all of them. This current is limited by the lowest-performing module in the series. In

other words, a single module will disproportionately reduce power output from an array when it is wired in a long series of strings.

System losses

The power-reduction issue is not unknown to the solar industry. It did not take long to discover that a shaded module can wipe out the power production of a string of modules, while creating a hot spot that can cause permanent damage. It also did not take long to incorporate bypass diodes into modules, which prevents damage during partial shading.

Unfortunately, bypass diodes are only a partial solution, with major limitations in preventing overall power losses from the array. The answer, then, is that a significant amount of potential energy production from an array can be lost the moment it is wired together using traditional series wiring.

On paper, system losses are often not anticipated to be so high, as it is extremely difficult to account for the multitude of variables that can cause power degradation and the extent of their impact. In the real world, thin-film modules with relatively loose manufacturing tolerances (typically +/-5%) have their own inherent mismatch that causes an initial drop in output.

Add partial shading from common rooftop obstructions or building congestion, uneven dust coverage, bird droppings and variable cloud coverage, and you can quickly approach

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the 15% mark, even without any extreme circumstances.

Although bypass diodes are still used today, there are more recent technologies attempting to tackle this issue. Companies such as Enphase, for instance, have created module-scale inverters that eliminate the interaction between different modules of an array by connecting each module directly to the grid. In addition, National Semiconductor is developing an electronic device that is attached to each module to decouple it from the rest of the array and minimize module-to-module dependencies.

There is also a third solution that is particularly viable for thin-film technologies because it does not require an additional cost to the system. Because the weakest-link effect only applies to modules wired in a series, one solution is to wire modules in parallel.

Parallel wiring

The higher voltage and lower current of thin-film modules open new possibilities for parallel wiring. No longer does a string of modules need to be defined as some number of modules connected together in series. Now, it is possible to create strings of parallel modules.

In fact, with thin film, it is possible to wire 100% of modules parallel - a concept known as massively parallel. Parallel wiring offers the same advantages as a module scale inverter, but it maintains the low costs associated with a higher-power inverter. When modules are wired in parallel, each module can operate at its own maximum potential, thus avoiding wasted potential energy production in the face of variable conditions typically experienced in PV systems.

Some unique wiring solutions are needed to take advantage of the massively parallel configuration, as are inverters that are matched to the voltages of thin-film modules.

To make this configuration feasible, wiring and connectors must follow a different convention than what is typically seen today. Bringing cables from every module to a combiner box would not be an acceptable solution.

Fortunately, there is a simple solution, and some module manufacturers are already starting to take action. If the standard two-wire junction boxes on the back of modules are replaced with four-wire junction boxes, massively parallel wiring can become the simplest and fastest installation technique.

The four-wire junction box can also provide new flexibility in how solar modules are arranged on a

roof. Mitsubishi Heavy Industries and Honda are both producing thin-film modules with the four-wire connector, and several other thin-film players are currently considering the option.

The final step is to find inverters with a DC input range that matches the voltage of thin-film modules, which means a low-voltage inverter is required. Low-voltage inverters for grid-tied PV systems are not common today, but as system integrators and customers of solar power systems gain familiarity with the advantages of massively parallel installations, there is expected to be a significant increase in demand for these products.

A University of Hong Kong study performed a head-to-head comparison of parallel vs. series wiring with thin-film modules. Fully aware of the module mismatch issues experienced with series wiring, the researchers sorted their modules based on flash test data. To mitigate the mismatch, they placed the highest performing modules in the series array. The lower-performing half of the modules were used for the parallel array.

Despite this disadvantage, the parallel array performed better than the series array, especially in the presence of partial shading. The study provided strong confirmation that energy yields can be improved. ☛