Bifacial solar advances with the times—and the sun

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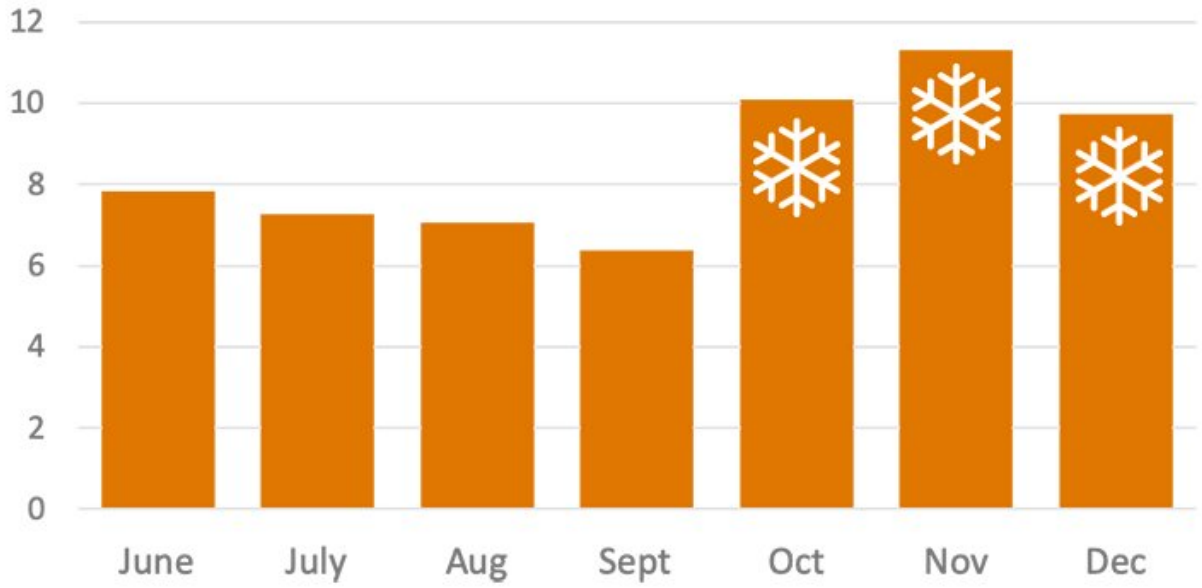

Improved gains due to partial snow cover in October, November, and December. Credit: National Renewable Energy Laboratory

Traditional solar modules convert light to electricity using photovoltaic (PV) cells on the top side of the panels. Now, National Renewable Energy Laboratory (NREL) researchers are shining a light on what lies beneath.

In May 2019, a team at NREL kicked off a three-year study to evaluate

bifacial modules that collect light on both sides of a panel while also following the sun throughout the day. The key benefit of bifacial panels is obtaining more power production without expanding system footprints or reconfiguring the panels too much.

Early results show a significant boost from the bifacial panels. Data from June through November 2019 revealed up to a 9% gain in energy production using bifacial panels compared with their one-sided cousins.

"The cells themselves are pretty much the same price," Chris Deline, NREL researcher and principal investigator on the study said. "You're going to a slightly more expensive package. You have to do something different on the backside—either glass or clear, transparent plastic. On the whole, it's going to be less than 10% more cost."

To determine how much more power such panels can produce, the team needed data, so they are gathering it. Some of their data is already publicly available—an industry first for a study of this scale. NREL researchers anticipate new data will remove barriers to advancing the cutting-edge technology by providing information and best practices that increase installation efficiency, reduce costs, and improve durability. So far, the results have not disappointed.

"Everybody is really excited because the results are returning in line with expectations," Deline said. "Compared with initial simulations, we're actually getting more energy out than what was modeled."

Electricity from the Ground Up

During the current study, the team plans to evaluate the benefits of different ground covers beneath the solar panels. Since the bifacial PV energy gain relies on reflected light, the more the ground can reflect, the more powerful the panels.

"We look at ways of enhancing the ground albedo [the proportion of the incident light or radiation that is reflected by a surface, typically that of a planet or moon] through different treatment options like natural vegetation, crushed rock, and weed barriers," Deline said. "Some of that is already happening in industry, but this will be the first multiyear study with open data."

In the study's first year, Deline's team is testing natural ground cover. They will follow by adding crushed rock in the second year, and Deline said they are considering rolling out some kind of white fabric for a third comparison.

"We're seeing that as the grass turns brown, it gets more reflective," Deline said. "And snow cover is great."

With snow on the ground, when average albedo is several times more reflective than grass, all tested panels hit their highest recorded gains.

Solar and Storage—Better Together

Credit: National Renewable Energy Laboratory

The team at NREL's Golden, Colorado, research site is working with commercial partners including Prism Solar, Sunpreme, and Lumos Solar—a supplier based in the nearby town of Nederland, Colorado—along with major international manufacturers. Leveraging relationships with a total of six companies, the lab will benchmark and compare mono- and bifacial panels from the same brands across multiple years.

The study's 10-row PV array follows the sun using NEXTracker's single-axis tracker technology, increasing the amount of direct sunlight that can be captured for energy. The higher energy production from each module means installations require less supporting hardware per megawatt, lowering what is known as the balance of system costs.

"By boosting output, these modules can also reduce the total number of panels required, which makes for more efficient use of inverters, racking, tracker systems, interconnects, and other hardware," Deline said.

Deline and his team also paired the PV array with two Avalon Battery vanadium redox flow batteries. The batteries store energy generated during the day and make it available for use during higher evening demand.

That storage, along with the solar tracking technology, helps to level the system output. It relieves the steep, mid-day production peaks bookended by lower morning and afternoon generation that is commonly associated with traditional, stationary solar.

"We're running an energy arbitrage scenario with the batteries that discharges in the afternoon and evening with roughly four hours of continued power from solar generation," Deline said. "Otherwise, bifacial gain is clipped at the peak but low elsewhere—so this provides

more stable and consistent generation."

The study also supports material durability research in partnership with other research organizations through the Department of Energy's (DOE's) Durable Module Materials Consortium (DuraMAT).

"We're looking at module reliability on single-axis trackers, and specifically whether modules damaged during shipment, resulting in cracked cells, are still usable or deteriorate further when installed on single-axis trackers," Deline said.

High-Performance Computing for the Win

With state-of-the-art computational modeling and predictive simulation capabilities, NREL's high-performance computing (HPC) resources reduce the risks and uncertainty that often limit progress on new and innovative technologies.

"We've drawn on the Eagle high-performance computer a lot recently," Deline said. "We're completing one-year performance simulations that would take four or five days on a laptop—in less than a minute on Eagle."

As a result, the team can maximize output for different configuration scenarios, including racking height, spacing, and even material choices such as black or reflective support framing. The simulations are open source, meaning others can use and build upon the datasets for future analyses.

"Our simulations start at the panel and fly photons back to where they intercept the sky dome—it's backwards ray-tracing and evaluates irradiance at the modules," Deline said. "All sorts of geometries are possible."

That means complicated topography and structures including car ports, pergola canopies, and varying rack systems can be evaluated prior to construction. The simulations can also layer additional scenarios such as vehicles parked beneath solar modules used at car ports.

Setting the Standard for Business Investment and Safety

When PV developers are designing a new system, they know that a 300-watt monofacial module will, not surprisingly, provide half the power of a 600-watt module. Businesses can rely on such straightforward assumptions thanks to testing and certification standards.

"But we don't have that yet for bifacial modules," Deline said. "So when you add backside sensitivity, industry is asking for the methodology needed to label a module to reflect the added value in a consistent way. Without it, buyers won't know the cost per watt."

Financial contracts for PV systems are based on how much power is generated, so installers and utilities need a clear understanding of how much power is produced to fairly monetize the extra production of bifacial technology. Deline's team is creating capacity tests that determine the new output and will help update standards accordingly.

"All of this requires a new ecosystem of standards, performance modeling tools, and best practices for instrumentation," he adds.

Safety standards are another important outcome of NREL's research. Installers need to know how electrical current will increase when installing a bifacial rather than monofacial module. Conductors, such as cables and fuses, need to be sized appropriately. Here again, precise standards and calculations are needed for efficient and safe installation.

Investing in the Future of Energy

As a national laboratory with strong ties to industry, NREL is uniquely positioned to deliver the data, analysis, standards, and best practices these technologies require.

"By publishing on this, solar installers are going to see better terms on financing," Deline said. "Utilities are going to bring more consistent, renewable, and affordable energy into their generation mix."

Provided by National Renewable Energy Laboratory