



HOW TO OPTIMIZE SOLAR BOS

for value and efficiency

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There's, perhaps, never been a better time to invest in solar energy. The sector is booming, fueled by tax incentives, advanced technology, and significantly lower prices. In fact, the cost to install solar has dropped by more than 70% over the last decade.

According to the Solar Energy Industries Association (SEIA)*, an average-sized residential system has decreased from \$40,000 in 2010 to about \$20,000 (or less) today, while utility-scale costs range from \$16 to \$35/MWh — making it competitive with all other forms of power generation.

Despite it being a pandemic year, America hit 10 GW of utility-scale solar commercial operation in 2020, with little sign of slowing down.

"The technology for solar modules has improved drastically and the demand in the marketplace has become much stronger," explains Dan Jungels, Business Development – Alternative Energy Strategy Leader, with Panduit. Panduit is a top U.S. provider of balance-of-system (BOS) components for the solar industry. "In the early days of solar installations, it was likely only done for environmental reasons. There were little, if any, cost benefits. But that's changed significantly, especially in the last

few years."today, solar developers can expect higher capacity factors with lower capital costs, including reduced maintenance and operating expenses and increased project lifespans. This has led to improved financing terms and better returns on investment, thanks to a lower levelized cost of solar-derived electricity.

"The effectiveness and the efficiency of the solar modules have come a long way. And by nature, the prices have dropped, as well," says Jungels.

However, the photovoltaic modules or panels are just part of a complete solar system. They're responsible for absorbing sunlight and turning it into DC power or voltage. For that electricity to be consumable, additional components are required to convert it to usable AC power. This is where the BOS components provide an important role.

What does the balance-of-systems include?

Most often, BOS refers to all of the components of a PV system other than the solar modules and their racking or tracking system.

"The definition of what consists of the balance-of-systems is somewhat debatable in the industry. It does not include the modules but, for us, we also exclude major equipment such as the inverters and medium-voltage transformers." Jungels says those are expensive, large equipment purchases that deal with the electricity management of the panels, which makes them unique.

"The balance-of-systems are all of the other devices that move the DC energy produced by the panels to the inverter to the power storage substation, which can then be used by the grid. We typically refer to these components as the management or cable-management solutions," he says.

These products include the cables, wires, clips, switches, connectors, tubing, and all of the devices that convert the DC to AC power, ensuring the electricity ultimately gets to the power station and the grid. This typically also includes enclosures, such as the combiner boxes that protect electrical connectors, and the software that integrates the components and monitors the entire solar project.

What's interesting is how BOS affects the project costs. They're typically the most costly part of a solar system.

"As module prices have come down, a project's expense has leaned more heavily toward components that support the panels — which is the balance-of-systems," says Jungels.

Whereas once the solar modules and racking system could measure closely in cost to the BOS, this is no longer the case now that the module costs are dropping so rapidly.

"Imagine two products are \$1 each and, together, they form a system that costs \$2. Then, over time, the first product drops in price and now only costs half of what it used to. That's great news," he says. "The entire system is now only \$1.50. But what makes up that \$1.50 has shifted and weighs far more heavily on the second product...and, in this case, that's what happened with the BOS."

There are valid reasons why the balance-of-system costs have not followed the lead of solar modules in terms of price decreases. For one, there's only so much technological advancement available to cables and wires.

"These items are commodity-driven and dependent on the materials used," he shares. "BOS components rely on plastics or resins, and copper or steel, which are at the mercy of inflation and the market. It's difficult to keep those costs flat and there's not a lot of technological improvements that drive those prices down."

Certainly, good manufacturers will find a way to offer cost-effective products. But it's also important to keep in mind that you get what you pay for. And the components that support electricity and the conversion of DC to AC power are simply not worth compromising in terms of quality.

"Supply chain issues can also cause price increases, as we've seen in this last year," he adds. "Nevertheless, most manufacturers do seek opportunities for savings that they can pass onto their customers. But for balance-of-system components, this requires a broader approach and one that focuses on the functionality of the products."

Where are the opportunities for cost savings?

If it's not possible to decrease the material or manufacturing costs of a product, there are sometimes other ways to increase value.

"Product availability and quality are two key differentiators to project managers and EPC contractors in the industry," says Jungels. And this is particularly true when supply chains are delayed. "However, improvements and cost-savings can also be met through product efficiencies."

Imagine a 2,000+acre or more utility-scale solar site. The sheer number of BOS components requiring installation is typically anything but efficient. Such projects rely on thousands of cable ties and clips alone, which require manpower and time.



Panduit offers a complete selection of cable-tie styles, sizes, and materials to meet customer needs.



Panduit BlackFin™ Installation Tools lead the industry in safety and reliability.

"Products that offer installations efficiencies, and fewer or more proficient tools, can save tremendous labor costs – and ergonomics. Repeatedly installing ties by hand on one site, let alone on several solar sites, can lead to overuse issues," he says. "So, simplifying BOS-related installation can save on the overall project costs."

As most utility-scale solar sites are located in remote areas, finding and maintaining labor are critical to project timelines and budgets. Depending on the project, dozens to hundreds of workers are required for these manual-labor jobs, which vary in length and location. Reliability is also important. Wires and cable ties must be installed correctly to maximize operation and minimize maintenance calls.



Panduit provides the most preferred hand-operated tools in the industry, which can be used for production, maintenance, or construction applications.

"Tools that can simplify and speed these manual installation tasks are critical," says Jungels. "So, for example, we offer a cable-tie tool that works in one motion. Where with conventional cable ties, one would have to run, sink, pull, and tighten the tie down and then clip the end, Panduit's installation tool can go down a line of wire, installing these ties with little motion. Plus, users need not carry around cutters or anything like that."





New edge-clip, cable-tie mounts from Panduit help secure wire and cable bundles with versatile mounting edges.

Edge clips are another example of a product that's speeding and simplifying wire installations at solar sites. "They're ideal for securing PV cable bundles and keeping them organized and cleanly mounted – without additional tools," he explains. "Every solar module requires a few of them, so to be able to do those without extra tools or equipment saves time and improves efficiencies."



Another way developers are optimizing projects is by first testing the components through a mock-up scenario. It's called a "golden row," which is a test scenario where each part of a solar system – including the modules and the BOS components, from the cable and wire to the combiner boxes – is set up in a minor experiment to see how it operates together.

"It's a great way to pilot the components during the design stage," says Jungels. "I mean, you likely wouldn't buy a car without a test-drive or to see how it handles, to learn where the different knobs, controls, and cup holders are at, and so on....and this is similar. It's even possible to test for the ergonomics and installation rates of different BOS components before assembling the entire project."

As each solar system is customized differently, the golden row test helps ensure the functionality of the project as a whole before it's fully installed. It can also be inspected to ensure industry best practices and standards are supported throughout the site.

"The golden row provides an overview, allowing for last-minute changes. And, most importantly, it helps avoid potentially costly mistakes being repeated thousands of times during installation," he says.



Stainless Steel Trefoil Cable Cleats offer protection against extreme environments and short-circuit current faults.

How to ensure product reliability?

When choosing balance-of-system components, it's important to consider wire and cable-management solutions that are versatile, reliable, universal, and efficient.

"Consider products that are lightweight and easy to install, requiring few tools to save on labor and installation costs," says Jungels. "But it's also important to pick what's going to last to save on maintenance costs."

This means assessing the environment that a project must operate in successfully and for as long as possible without unscheduled O&M issues. This is where product quality comes in.

"Cheaper nylon or plastic components are typically susceptible to UV damage. A lot of sunlight can make these materials brittle," Jungels says. "It's also important to use protective casing for wiring and cable ties that hold up in harsh conditions and aren't easily subjected to wear and tear, or rodents chewing through it."

Taking the time to choose wisely during the design stage of a project can equate to greater savings in the long term. BOS components should be UV- or harsh-environment-rated and insulated against weather and animals.

"Ultimately, you're dealing with electricity for these projects, which is not something you want to mess with. So, if you're buying lower-grade materials or metals that are mixed or not up to UL standards, that's an operational risk. It could result in a minor maintenance issue or something larger and catastrophic...and is it worth it?"



Jungels says it's important to balance the risk and reward when making these choices. Similar factors must be considered when choosing the suppliers for a project.

"There's always going to be several sources supporting a solar project," he says. "You just can't get everything, from the panels to the enclosures, in one place. But bear in mind, a greater number of suppliers equates to more complexity. There's a greater chance of timeline, pricing, and transport issues. At Panduit, we think it's extremely important to eliminate such complexities for balance-of-system components."

Panduit's portfolio currently offers about 75% of the build material required for the balance-of-system products. This includes expert consultations to maximize solar project efficiencies and decrease the total cost of ownership.

"We typically group this into four main categories that ensure safe and reliable balance-of-systems. This includes to bundle, connect, protect, and identify."

The Panduit solutions that cover more ground:

- **BUNDLE:** Cable-management solutions that reduce installation time and improve the operating life of wire and cables in harsh environments – while keeping them secure yet easy to access for maintenance calls.
- **CONNECT:** Designed to meet all applicable standards, such as UL and IEEE standards, and are tested to perform for 20 years in outdoor environments. Grounding connectors must ensure the system remains safe and is not susceptible to short circuits or fires.
- **PROTECT:** Technology that reduces risk and increases safety at solar sites.
- **IDENTIFY:** Labels and ID solutions that hold up in harsh environments.



Panduit compression connectors provide permanent terminations for a variety of industrial cabling applications, with best-in-class installation tools.

"When we consider a connection from point A to point B, we're thinking about safety and reliability," share Jungels. "This includes the grounding connectors and power connectors. We're also thinking about the cable management and secure bundling options, which are easy to access yet not susceptible to damage."

He adds that identification is also extremely important. "We offer UV-rated labels for the different applications, as well as mobile printers and programs to help with their identification process." These include pre-printed and print-on-demand labeling options that allow NEC compliance solutions.



A comprehensive offering of innovative printing systems, labels, and labeling software are available to properly identify electrical and network infrastructure.



The VeriSafe™ Absence of Voltage Tester minimizes risks by verifying the absence of voltage before equipment is accessed, making it easier for qualified electrical workers to ensure an electrically safe environment in a fraction of the time compared to hand-held portable test instruments.

Protection is a must for safe and reliable project operation. "One of our safety-related products is the VeriSafe Absence of Voltage Tester, which is a product put into converters, such as substation power boxes. It determines the absence of voltage with just a push of a button," he explains.

In summary, when choosing quality balance-of-system components, look for products that are:

- Tested to perform in harsh environments, ensuring UV protection
- Meet all applicable standards, such as UL and IEEE
- Install simply and reliably, with little complexity and few tools
- Modular, offering versatility and scalability
- Designed for longevity and reduced maintenance
- Compatible – that ground, bundle, connect, and protect efficiently and effectively together
- Labeled correctly – an important safety feature

"There's a lot going on in a solar system, so it's extremely important to source supplies that can offer peace of mind, experience, and proven products," says Jungels. "It's also worth partnering with a company that is interested in truly learning about your project and how to best optimize it right from the start."

To learn more about what the industry's current thoughts and ideas are on BOS, Panduit launched a recent survey, "Recommendations and challenges regarding balance-of-system components."

* seia.org/solar-industry-research-data

ABOUT PANDUIT...

Over the last decade, Panduit has partnered with EPCs and solar installers on PV installations totaling more than 5 GW of capacity. The company offers solar-specific, end-to-end solutions designed to reduce complexity and labor, thereby lowering total installed costs.

The company offers a combination of engineering and manufacturing expertise with a full portfolio of products, covering up to 75% of a typical PV installation electrical BOS.

Heilind Electronics is currently Panduit's largest electronics distributor, and one of its oldest, maintaining the world's largest inventory of Panduit products.



ABOUT HEILIND ELECTRONICS...

Heilind Electronics is a global distributor for interconnect, electromechanical, and sensor products. As the industry's preeminent distributor, the company stocks the largest inventory of connector products in North America.

Heilind offers products in over 25 component categories including wire and cable, connectors, switches, circuit protection products, terminal blocks, insulation and identification products, and much more.

