High voltage, low costs

System architecture | As the solar industry continues to squeeze out cost reductions, 1,500V architecture is tipped to make its mark in 2017. John Parnell looks at the potential pitfalls and likely winners as utility-scale plants dial up the voltage

Credit Sungrow

1500V PV power plants, such as Sungrow's 50MW project in Datung, China, are expected to become a more common sight as the industry shifts to the higher voltage

The cost per kilowatt hour of solar projects will continue to fall. Take a look at the value of some power purchase agreements signed of late. NV Energy will be paying just US$0.0387/kWh for power from First Solar's Playa Solar 2 plant. If power purchase prices are going to keep falling, the industry is going to need to keep finding savings.

This is not news to project designers and engineers. But if solar does not continue to remain competitive on price, it doesn't have a future.

This task is not solely the responsibility of the module manufacturers. As the biggest cost component of any project, modules get the lion's share of attention when it comes to reducing that crucial per-kWh figure.

Walking the halls of any of the major trade shows in 2015 and 2016, bifacial modules, PERC, energy storage and ever-simplified trackers were competing for attention. A growing number of vendors were also displaying 1,500V products.

With certification arranged by Trina Solar, SMA, Canadian Solar and many others, the starting gun on the 1,500V transition has been fired. Analysts firm GTM expects "wide-scale adoption" in 2017. The rest of the industry seems to agree.

Not tech tokenism

Gabe Cantor is director of plant architecture and plant technology at developer and EPC firm Strata Solar. "When you are talking about transitions from one technology to another, that's what I live day in and day out," says Cantor.

"We have several tens of megawatts under construction with 1,500V equipment; this is happening, it is not just vendors shouting loudly about it at SPI [Solar Power International]."

Cantor isn't quite convinced that 1,500V will become the dominant architecture in 2017 but acknowledges that it will certainly be far more than a token part of the market. "It's going to be a substantial portion," he says. "A lot of our projects are actually constrained by what has already been submitted in our interconnection requests to utilities. In some cases it doesn't make sense to re-study those with a new inverter. In a lot of cases the study process with the utility can take 18 months or even two years. So it really depends but I think some projects are more flexible than others."

That will apply across the US and in other markets where network operators are involved in the process. Projects in the pipeline not marked down for 1,500V will likely remain that way. As they are joined by fresh 1,500V-based proposals the outlook for future project development will most certainly evolve into one dominated by the new architecture. The speed of the switch to 1,500V requires numerous pieces of the puzzle to be in place and is constrained in a way that shifting to new module technologies, for example, would not be.

Cantor oversaw the company's switch up from 600V to 1,000V and is confident that lessons learned during that process should make things smoother this time around. "There are some lessons we learned there and some mistakes that we made that we are trying not to repeat this time around. The main difficulty with the transition to 1,000V was not really technical, it was more regulatory.

"A lot of our projects are inspected by local inspectors who like to see UL or other nationally recognised testing laboratories' kite marks on all of the equipment and at the time that 1,000V inverters first came out, the modules still had to catch up on the listing aspect.

"This time around, our first 1,500V projects are larger than we were doing for the last transition and they are what we would consider to be 'behind the fence' [utility owned and operated], so the local inspector element is not an issue."

One surprise element that impacted Strata during the 600V to 1,000V changeover was the field tools its installers use. That is likely to be the same again with the 1,000 to 1,500V transition, although, as before, the impact of that will be tempered to a degree by the fact that much of the componentry will remain the same.

"In the last transition we had to retool to make sure we had the right multimeters and tools for measuring the string current and open circuit voltages. A lot of our equipment at that time was rated to 600V and we needed to buy that equipment for 1,000V. Things like that aren't completely obvious when you're first looking at the project; you have to get into the nuts and bolts of it to find all of those issues and shake them out," says Cantor.

"The combiner boxes and connectors and cabling are all basically going to stay the same. It's not any substantial change. We're going to be building plants with basically the same methods and materials as before. The cabling that we use currently is rated to 2,000V so this isn't an issue either," he adds.

Inverters

One obvious component that has to change in the 1,000 to 1,5000V transition is the inverter. The main area of debate here is the appropriateness of string inverters versus central inverters for 1,500V projects.

"We advocate the logic of varied designing for various conditions," says Dr. David Zhao, senior vice president and president of the PV production

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division at Chinese inverter manufacturer, Sungrow. "Generally speaking, for solar power plants on flat ground, central inverters are the best choice for 1,500V system designers. One obvious reason is that such a plant requires fewer central inverters than string inverters and thus maintains a reasonable number of command and control interfaces.

"When it comes to an irregular terrain where structure shades or inconsistent array directions may lead to loss of power production, string inverters with more MPPTs become a more reasonable choice," explains Zhou.

Strata's Cantor agrees and points out that in some instances, making the jump to 1,500V might not even be the best decision. "If you have an array and a piece of land that is big enough for one and half arrays with one inverter size and one that is big enough for two arrays with a smaller inverter size, you will be better off with the smaller inverter," he offers as an example.

But where the choice of 1500V makes sense, Cantor believes that string inverters will certainly have their place, as long as the right considerations are given to how the system is configured.

"With a 1,000V string inverter we have 480V output and that combination of voltages pushes you to move your inverter into the field because you get fewer losses on the 480V output than on the string," he explains. "But with 1,500V string inverters, they tend to have a 600V output so it's a lot lower proportionately to the string input voltage. That pushes you, at least if you're analysing it on cabling, it pushes you to centralise those string inverters and cluster them near your medium voltage transformer, so effectively you'd be building a plant that looked like it was using central inverters but it's just got a number of independent string inverters that are co-located."

A big advantage Cantor sees to string over central inverters is in the relative ease with which they can be replaced in the event of failure. One of the larger risks with central inverters is the risk of an inverter manufacturer not being there in 10 years to support the product. "We have seen it with Satcon, Advanced Energy, and central inverters tend to be very specific in terms of the output voltage they require for the transformer and the general arrangement of where the cabling goes in," he says. "Replacing a central inverter with a compatible unit from another manufacturer is usually an impossibility so going to string inverters I think de-risks the project in the long term and can have an availability effect as well."

This is similar to the way Sungrow sees string inverters being utilised for 1,500V projects. Zhao refers to it as a "virtual central inverter", a concept that makes use of the company's 125kW 1,500V string inverters.

"[It] combines the flexibility of string inverters and the cost effectiveness and command and control advantages of a central inverter. This virtual central inverter concept is adaptable to irregular terrain so it works perfectly for system designers who are in great need of flexibility. We believe, as the cost reduces and the capacity increases, our virtual central inverter concept will catch on quickly."

Lior Handelsman, co-founder of inverter manufacturer SolarEdge, and the company's head of product strategy, believes that the shift to 1,500V will help central inverters remain competitive. "1,500V as a concept was born and defined for reducing balance of system (BOS) costs. I agree that in a central inverter architecture you can reduce a lot of BOS by going into 1,500V because you have a lot of strings. Every string has a go and a return cable and combiner boxes with longer and longer cables. With 1,500V you reduce the cost of cabling and BOS by around 50%. The benefits with string inverters are lessened by [the additional] combiner boxes and better for the DC cabling but

The 1,500V club

PV Tech has been reporting on the release of 1,500V modules since 2013 when Suntech showed off a frameless module at SPI that year. At this stage German system integrator Belectric had already connected the world's first 1,500V system. It used central inverters from GE for the installation. Since those early years a great deal more suppliers have joined the fray. Below are some of the products launched by leading suppliers to service the growing 1,500V market.

Hanwha Q CELLS, Q.PLUS L-G4.2
The panel is specifically optimised for large-scale deployment with power classes of up to 340 Watts and is UL and IEC 1,500V certified. The utility-scale module incorporates Hanwha Q CELLS' proprietary Q.ANTUM technology based on the rear side passivation of solar cells and utilises additional features to optimise the efficiency and performance of the PV cells to reduce the LCOE for the US market. It was launched in June 2016.

Canadian Solar, Diamond CS6X-P-FG
The 72-cell, 1,500V PV module with heat-strengthened double-glass configuration for commercial and utility-scale applications was designed for high-voltage systems of up to 1,500V. By replacing the traditional polymer backsheet with heat-strengthened glass, the Diamond module is claimed to have a lower annual power degradation rate than a traditional module and offer better protection against the elements, making it more reliable and durable during its lifetime. The company claimed the module had a first year annual degradation of 2.5%, each subsequent year 0.5% and an 85.5% power output at year 25 and 83% power output at year 30. It was released in the last quarter of 2015.

ABB, PVS980
The high power outdoor central inverter has DC input voltage of up to 1,500V and a high power rating of up to 2000kVA. One of the key features trailed by the company is its self-contained cooling system. Based on development from the ABB ACS800-38 low-harmonic drive's innovative cooling system, the PVS980 uses phase transition and thermosiphon technology to avoid external air entering the critical compartments of the inverter. The inverter can operate from below freezing to extreme heat in 100% humidity without jeopardising functionality. The high DC input voltage, high efficiency, proven components, compact and modular design and a host of life cycle services that also includes the standard grid support features of PVS series inverters such as active and reactive power control including night-time reactive power support. It was launched in late 2015.

Schneider Electric, Conext SmartGen
Conext SmartGen is an intelligent, cloud-connected 1,500V utility-scale power conversion system, according to Schneider. It has a suite of supporting software solutions called the 'Power EcoSystem', including the cloud-based monitoring and control solution 'Conext Advisor 2'. The Conext SmartGen is the new approach for large-scale renewable power installations. It provides greater efficiency in power generation which Schneider says results in lower short-term and long-term costs, and a far longer service life. The integrated solution features built-in sensors and intelligence for connectivity to the entire plant, and optional monitoring and control using Schneider Electric's SCADA system, Conext Advisor 2. The system is claimed to lower capital expenditure due to its 1,500V DC configuration resulting in the need for fewer inverter stations, less equipment and less wiring. It was launched in October 2016.

overall there is value for string inverters as well," he says.

"I think central inverters are becoming less competitive with string inverters for many other reasons. 1,500V will help them keep up but for systems that are not very, very big, in my view, string inverters will win."

Modules and markets

In a period of module overcapacity, fretting about the availability of modules may seem like a strange thing to do, but one question that has been raised in connection to the transition to 1,500V is whether there will be sufficient modules on the market to meet demand. Cantor is sanguine on this, pointing out maintaining close links with modules suppliers should ensure developers and EPC firms are left short.

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A more specific cause for optimism is that whereas, as Cantor highlighted, in the shift from 600V to 1,000V the listing of 1,000V modules lagged behind the introduction of 1,000V inverters, UL already has a number of major manufacturers listed as holding certification for 1,500V modules including First Solar, LG, Jinko and Trina, suggesting the industry is better prepared this time around to make the leap up in voltage

Sungrow's Zhou expects 1,500V to have a 20% market share in the utility sector in 2017.

"In terms of specific markets, 1,500V projects will first thrive in North America in 2017 and then Asia will overtake the Americas in 1,500V shipments sometime between 2017 and 2018. EMEA will also follow this trend but at a much slower pace," adds Zhou.

SolarEdge's Handelsman envisages the shift hitting the US first. "One of the markets that will benefit from this is the US market because the electrical code requirements in the US create more cost into the system design. You need more fusing and more combiner boxes than in other markets. If you have more than two strings in parallel you need combiner boxes and fuses that you don't need in some markets. So the more strings you have the more cost you have. Longer strings have a greater impact on reducing cost in the US than anywhere else," says Handelsman.

An added factor skewing early development of 1,500V systems towards markets like the US is the cost of labour. Reducing BOS requirements naturally means a proportional reduction in labour. Markets with a high cost of labour such as Japan and the US will benefit even more from making the switch.

Switching to 1,500V is not a trend for the sake of the industry offering something new so people upgrade. It's not the latest iteration of a smartphone with a marginally better camera and ever so slightly different shape. Handelsman offers a reminder of the real drive behind the transition and need for all sections of the solar value chain to embrace it.

"The only way solar energy can push through is if we continually shave inefficiencies and cost out of it," he says. "1,000V architecture is creating more cost, more combiner boxes, more strings, more return cable. We need to streamline design, we need to streamline installation, we need to shave cost out." ■