Bringing the factory floor to solar plant construction

Construction | Automated systems to speed up the construction of PV power plants have become a key tool in building bigger and cheaper projects. Sara Verbruggen looks at some of the state-of-art technologies helping the industry drive down system costs

Credit: Brittmore

As PV plants have grown in size and pressure to reduce the levelised cost of energy for solar power has increased, some companies have turned to automation and robotics for addressing various phases of developing and building ground-mounted PV plants.

Automating elements of construction and installation reduces labour costs, in the same way that greater automation in PV module production processes have helped to reduce manufacturing costs. Automation also speeds up overall PV project development. A project that can be built in 10 months instead of 12 costs less, not only because equipment and staff are on site for less time, but also because the PV plant can be commissioned earlier to start producing electricity and earning revenues sooner.

"Industrialising installation optimises the project's development and speeds it up, in the same way that greater automation in PV module production processes has helped to reduce manufacturing costs," says Hans Jürgen Sauter, chief sales officer at Krinner, a German company that has developed an automated ground-screw foundation process.

Robots

Another company that has developed some novel construction techniques is California-headquartered Brittmore. Established in 2010, the company's approach comprises three core elements that help to make PV construction more like a factory operation and less like a construction site.

These are an on-site panelisation process, dubbed SolStak, in which modules are assembled into panels on site or nearby. The technique is compatible with crystalline and thin-film modules, framed and frameless. The other element is a proprietary mounting system, SolWay, which is compatible with the third element – an automated installation process. Automated technologies are deployed to efficiently install panels, including shuttles that map installation positions, automated loaders that lift the panels on to the end of the array before shuttles deliver them into position.

Brittmore's robots are small and portable so that the installation is done from the centre of the PV array outwards, so no heavy equipment is required to move up and down aisles, which can create dust and mud and risks breakages as the panels are picked up and delivered to their destination in the array.

Automation is playing an increasingly prominent role in plant construction

Brittmore's typical customers are solar engineering, procurement and construction (EPC) firms. The company started out by supplying EPCs with a full turnkey service that covers racking, panel assembly and panel installation. More recently, however, Brittmore shifted its business from that of a turnkey structural balance-of-system installer, which was necessary to help the company develop the technology, according to co-founder, Bram Britcher.

"The focus is now on the endgame business model, which is to license the technology to EPCs. We have several companies in the US interested in licensing the technology for upcoming projects in both California and Tennessee," he says.

A core robotics element of the system is an automated large panel PV shuttle, which moves atop the rack carrying and positioning panels in each row of the array. The technology includes an auto-loader, which together with the PV shuttle can accomplish the installation of 40 or more panels an hour. For short rows the number is up to 60, while for rows longer than 200m, or on slopes, the rate is lower as the shuttle transit time increases.

The shuttle travels the length of the rack mapping all installation positions. No programing is required. Aisle breaks in an array can be bridged with temporary rails, extending the area that can be reached from a central material handling location. Heavy equipment traveling between array rows is not needed.

The PV shuttle functions autonomously. A central site manager can configure the shuttles, monitor them and start or shut them down remotely.

Brittmore's panelisation process means modules can be delivered to the site, or close by, and assembled, including fixing junction boxes, assembly panels, by framing the modules or working with frameless modules.

Modules are riveted to the rail instead of clamping, which eases cleaning on the front surface as no dirt is trapped at the clamp.

"The industry has found that panelisation really cannot be done remotely. The additional shipping cost of the large assemblies, which are also at a lower packaging density, is prohibitive," says Britcher.

The only effective means of panelisation is on site or nearby and various EPCs do mechanical panelisation. However, Brittmore is one of a few companies able to provide adhesive-based panelisation on site. The mobile adhesive technology was developed with a grant from the US Department of Energy.

The BoS cost reduction achievable with Brittmore's technology is around 15% in a licensing model, the company claims. Installation times are compressed, improving the economics further. Faster project completion means lower cost of capital and quicker energy revenue. The deployment cost is justified at 1.5MW or larger.

Britcher says: "Traditional BoS installation has come down in cost with incremental improvements to installation labour and high volume rack manufacturers lowering prices significantly. However, conventional racking is nearing design and manufacturing optimisation. Raw material cost is the limiting factor."

In high heat, labour costs greatly increase as workers require frequent breaks to prevent overheating, or work has to occur outside of daylight hours. Using Brittmore's panel installation process, 90% of the construction crew works comfortably under a shade structure outfitted with fans as they assemble the panels from modules and other components. Out in the field, robots are able to do the heavy lifting.

Well grounded

German company Krinner's automated ground screw process was instrumental in the rapid execution of the 300MW Cestas solar farm completed in late 2015, near Bordeaux in France. The plant, developed by Neoen, was Europe's largest solar farm when it came online. It was built in eight months, with each installation team completing 4MW a day.

To date nearly 3,000MW of PV plants have been built using Krinner's technology. In 2001 The company developed an alternative to concrete foundations, using ground screws and automated installation, adapting the technology for PV plant constructions six years later.

Six years before Cestas, in early 2009 Krinner completed a 54MW plant with QCells, now Hanwha Q CELLS close to its headquarters, to demonstrate how the ground screw technology, combined with automated screw positioning and installation, optimised the foundation construction phase of the PV plant development. When the 54MW plant was built, it had the distinction of being one of the largest PV plants in the world at the time.

Credit Neoen

Krinner's ground screw process helped it build France's 300MW Cestas project in just eight months

In less than a decade Krinner is still pushing the limits of PV plant development. The company is starting soon on a 1.2GW solar PV project in Abu Dhabi, in the United Arab Emirates, which will be one of the largest in the world, when built. The plant will cover an area of 7km by 2km. In total 700,000 screws will provide the foundations for the project. The phase of installing them will take around 20 weeks, requiring 30,000-35,000 screws to be installed a week.

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"A PV plant of this sort of scale needs automation. There really is no alternative," says Hans Jürgen Sauter, Krinner's chief sales officer.

As PV costs have fallen and new markets have opened up, many of these are in regions where radiation levels are high and so are the temperatures, and difficult terrain, such as rocky and very uneven ground, can be challenging for construction. Countries where plants have been built or are being constructed using Krinner's technology include South Africa, Chile, India and Bangladesh.

To construct the Abu Dhabi project the foundation work, racking and installation of panels will take place at night.

Of BoS costs, mounting is the biggest portion, and foundation or structural BoS costs tend to be about 10%. Krinner's approach speeds up the construction of foundations and the racking assembly designed around it. However, the company has also reduced the weight of its racking to squeeze further savings.

"We have optimised the processes of foundation construction, racking and module installation. We can compress the time required to construct PV plants and meet really challenging schedules," says Sauter.

Like Brittmore, Krinner has also turned its attention to developing a panelising process at the site. Tents are constructed at project sites where the panelising takes place and modules are rolled along to the exact position. Sauter sees this as the future.

Harsh environments

Alion Energy, based in California, focuses on PV projects being built in rocky or harsh environments as these tend to be areas with the maximum solar irradiation and therefore best LCoE, according to Mark Kingsley, the company's chief executive.

"We chase dust clouds, rocks and corrosive soils. The company focuses on PV In harsh environments as these remains the futures lowest cost areas to produce solar energy," says Kingsley.

Alion Energy developed the use of

slip-form concrete extrusion to create fully ballasted systems at low-cost and at scale. The approach avoids up to $0.04/W in drilling costs and also eliminates subsurface corrosion issues that are common where driven posts are used, the company claims.

"To speed up construction the rest of the PV industry benchmarked highway construction and adopted guardrail post driving as a methodology," says Kingsley. Alion Energy investigated how the concrete, slip-form extruded, curbs and gutters along the side of highways were built and adapted this technique for constructing extruded concrete rails to replace posts and metal racks for installing panels on.

The company has also developed what it claims to be a unique single-axis-tracker designed to reduce steel mass from 65 to 30 tonnes/MW. This has been achieved through an 'A' format, rather than a 'T' format frame that most trackers have.

The parts can be carried by two construction workers and avoid the use of heavy equipment on site. This, combined with savings on torque bolt connections due to greater use of factory pre-assembled components, speeds up installation. Construction times and costs are reduced significantly.

"We found that by reducing the mass of component parts and eliminating pre-drilling and torque connection, we were able to drive down costs in the harsh environments we target," says Kingsley.

However though Alion Energy used automated installation for a 4MW project in Lancaster, California, several years ago, since then the company has refocused on advanced mechanical design and automating operations and maintenance (O&M). Taken together these provide both short-term and long-term cost advantages, according to Kingsley.

"We found the demand for O&M robots vastly exceed that for automated installation. However, by improving designs our systems to be installed by robots, we also made them easier for non-skilled labour to assemble in harsh environments," Kingsley says.

Another company that has built its business model around enabling PV construction in difficult and challenging terrain is Florida-based TerraSmart. Challenging sites – ones that are rocky, dry, dusty, with challenging soils – tend to be cheaper, saving developers money.

Rather than pay for equipment to prepare the ground by removing or breaking up rocks, TerraSmart offers developers and their EPCs a ground-screw foundation system that overcomes these issues, in much the same way as Krinner has found large screws can be driven into the rockiest terrain to provide firm foundations on which to install racking and mounting, even on sloping and hilly areas.

TerraSmart has not only crunched down costs in its racking and foundations – reducing materials and weight and simplifying components – but has also invested in automating site surveys, which can take many days, even weeks, over large sites.

The company has developed its own drones to fly over sites record and take images to provide detailed topography data to reduce costs in the mapping stage. Recently the company launched an autonomous precision survey rover to ensure greater accuracy and also speed in the site surveying stage.

As PV plants have grown in size, the need for automating phases of the pre-commissioning stage has increased. The companies that are enabling faster, yet more accurate, PV plant construction have evolved business models that are about much more than hi-tech robots. They are attacking the opportunity to reduce LCoE from every angle, be it site selection, to surveying, to constructing the foundation, to how mounting structures can be simplified or made with less material.

Krinner's process

Before the installation of its screws, Krinner undertakes extensive preparation, which includes soil sampling and 3D modelling of the soil, down to 1.5m depths, as well as photographing the surface, using aerial drones. In the next phase, automated robotic vehicles drive over the site and map out where exactly each screw will be driven into the soil.

The automated robots can accomplish 4,000 survey points in a 24-hour period. The data that they record is processed on a cloud server, called the Krinner Cloud Cockpit. The cockpit provides an overview about every single step of the project. Screws are selected based on the condition of the soil at the site, or a particular part of the site. Even coatings are adapted depending on specific site conditions for maximum corrosion protection and to minimise maintenance costs.

Human operators traverse the site in vehicles that use GPS co-ordinates to precisely fix in the screws, based on the dimensions of the panels being used. Attachments such as hammers can be used to embed screws in even the rockiest ground. Where the ground is uneven the vehicles will automatically level so the screw is always installed vertically.

The racking has been designed to be quickly assembled by workers once the ground screws have gone in. The panels are lifted manually to be loaded between the two racks and are pushed along to the other, followed by more panels until the racking is full.

Krinner has produced about 100 vehicles that are used around the world. Thirty of these are the latest version which use x-y coordinates for accuracy down to a few millimetres when positioning the screws. About 20 of these will be deployed at the Abu Dhabi project.

Credit: Krinner

Krinner's ground screw robot is to be used on the giant 1.2GW Sweihan project in Abu Dhabi