Ready for take-off

Commissioning | Commissioning should be as integral to the installation of a PV plant as a pre-flight checklist is to an aeroplane journey. Sara Verbruggen reports on the latest tools and technologies being deployed to ensure a smooth commissioning process and a project that operates safely and optimally

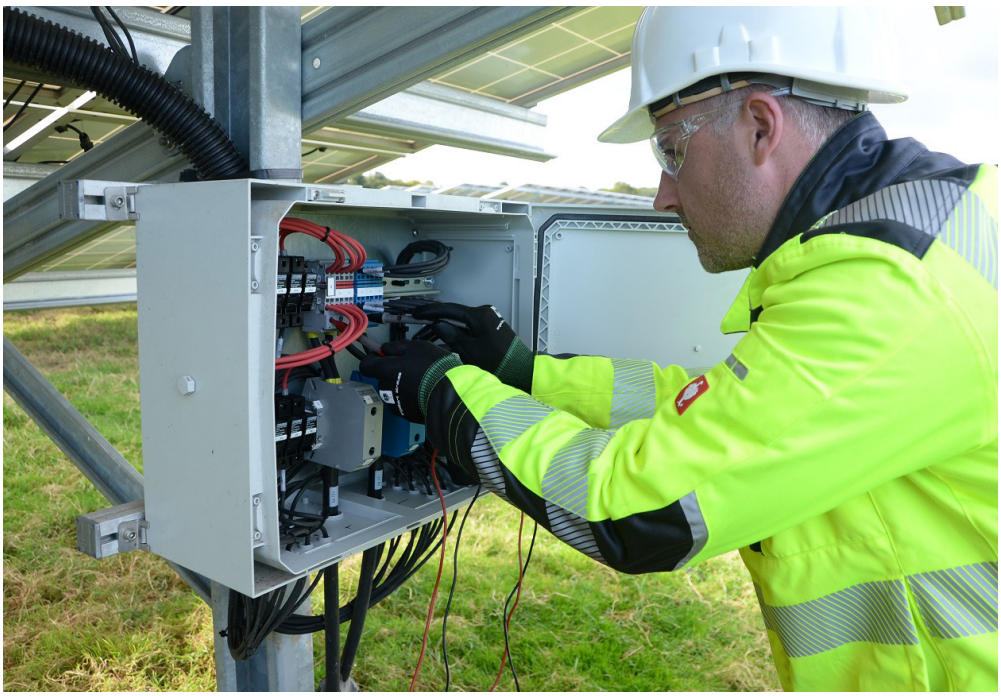
Commissioning is the process of assuring that all systems and components of a PV plant are designed, installed, tested, operated, and maintained according to the operational requirements of the project's owner or final client. In the utility-scale PV industry, where the entity that developed, or built, the plant, is unlikely to be the plant's owner, or sole owner, throughout its operational life, or where there are different investors – lenders as well as equity shareholders – commissioning procedures are important to ensure the asset performs reliably and safely while output is optimised.

Done thoroughly and properly commissioning helps improve safety of the plant and quality control, as well as ensure the asset meets relevant grid compliance codes and standards, and will perform as expected. The tests that are performed in some of the commissioning procedures can also provide a benchmark against which periodic inspections and routine maintenance activities are carried out during the PV plant's entire operational lifetime.

DNV GL senior engineer Ralf Meyerhof says: "Commissioning ensures that the PV plant investors' expectations are achieved. From an investor's perspective a successful PV asset is designed, constructed and operated to achieve optimal output, maximising revenues. Projects, therefore, have financial and economic considerations where the operational strategy is looking to maximise revenues and financial performance. Commissioning, prior to connecting to the grid, identifies any issues or problems that need to be rectified and also ensures the plant will operate safely."

According to PV plant commissioning practitioners and specialists, such as Enertis, DNV GL and Alectris, commissioning is also key phase from a contractual point of view, whereby the title of the project transfers from the contractor to the owner, documented in the form of a provisional acceptance certificate (PAC).

The PAC is critical for the warranty period, which is typically two years, according to DNV GL solar section head Ruben Ron. "Once the PAC is obtained the engineering, procurement and construction (EPC) provider is responsible for fixing any faults etc that occur within the warranty period."



Credit BayWa r.e.

Commissioning is vital in ensuring a PV power plant operates as expected over its lifetime

"If commissioning steps are missed, the risk is that you don't pick up module cracking, damaged cables for example," says Ron.

Commissioning concept

While commissioning can seem like an exhaustive process of checks, done properly it becomes a key procedure throughout the plant's installation, from the moment that components are delivered to site.

Meyerhof uses the analogy of a tree to explain how the commissioning process should ideally be conducted: the strings are leaves, inverters are branches and the substation is the trunk. You commission from the leaves to the trunk. You don't just commission the substation at the end. The correct approach to commissioning occurs subsection by subsection, to ensure that all components are working properly.

"When we talk about subsections we mean strings, which comprise about 25-30 modules. In strings for example you are testing for voltage and current."

Commissioning procedures have become common practice since the early years of Germany's solar market, Meyerhof explains. "When average system sizes were in the kilowatts, then megawatts, then multi-megawatts and eventually up to plants with capacities of 100MW or more, that we see today....the practice is fundamentally the same in that you start by commissioning from the smallest subsystems until the largest," he says.

How commissioning can influence long-term financial performance

Performance ratio (PR) is the ratio of measured output to expected output for a given reporting period based on the PV plant's name-plate rating.

To objectively measure the plant's PR it is important to have a suitable procedure in place from the contract phase and to demonstrate the plant has been commissioned and has reached a state of operation

in which all equipment is functioning normally, explains Enertis owner's engineer manager Jose Merlo.

He says: "Once this has happened, the main thing is to ensure that the equipment from which the inputs for the PR calculation are collected are working normally, for example, the plant meter or the meteorological stations. These are sensitive pieces of equipment so must be cleaned and handled with care.

"This project performance check is important in order provide the first benchmark to the owner that the plant is operating in conditions consistent with the design and financial considerations that were originally specified."

Cold commissioning and hot commissioning steps

PV plant commissioning occurs in two main phases: cold commissioning and hot commissioning. The latter occurs when the plant is temporarily grid connected, to enable critical checks of how the plant and specific components within it perform when energised, as the PV plant is an electrical asset.

Cold commissioning

In cold commissioning, also referred to as mechanical completion, the aim is to carry out all the necessary tests on all the plant's systems. These include the medium voltage cabling, the alternating current and direct current low voltage cabling, and junction and combiner boxes, in order to ensure that the subsequent commissioning phase can be carried out safely.

According to Alectris' Roberto Vallavanti: "Once the civil and electrical works are done and all equipment is delivered and installed, the cold commissioning is carried out.

"This includes testing each single component and the check list is usually detailed, referring to every component that is not energised. For example, checking modules, tightening cable connections, as well as checking for any breakages during the installation, checking the mounting system, which can include ensuring bolts and screws are sealed. Then there are string boxes, checking things like the section switch is open, that the fuses are in place, with no damage. Then the inverter, including checks to see if the station has sustained any damage, and isolation tests for all AC and DC sections."

Additionally, cold commissioning should also extend to checking any communications infrastructure, as well as fencing around the PV plant, roads, lighting systems, surveillance systems, safety signage, to ensuring all components and equipment are correctly labelled, as well as all documentation, drawings and designs are in order.

Credit: SMA Solar

The temporary energisation of inverters is among the stages involved in 'hot' commissioning

In short, everything that is related to installation and civil works has to be checked during cold commissioning. The output of all these checks and measurements is called mechanical completion. Mechanical completion provides an assurance that the plant is built to the design and the expectations of the owner/investor.

Hot commissioning

In hot commissioning, once the PV plant is energised, specific tests are carried out in order to verify that the plant is fully operational and compliant within the design parameters for which it was conceived, according to Vallavanti.

In the case of hot commissioning, the main objective is to check and certify that once all the plant's systems are energised, they work as expected, both in terms of performance and also functionality.

"The start-up of the plant, as the final phase of the project, must have been preceded by an exhaustive control of the construction of the plant. This control must have verified all the construction sub-processes, with special emphasis on the quality control of the plant, which is closely related to the commissioning itself," he says.

"As one example, during start-up it is very common to make random checks on the tightening torque of the tracker, which in turn should have been controlled during the construction phase of the plant according to the quality procedures," says Vallavanti.

"Mainly, it comprises the temporary energising of the inverter prior to its configuration. You would carry out a test of the safety switch, the auxiliary power supply, emergency buttons, as well as check capacitors, polarity of the connection, as well as whether the cabling from site is properly sealed, which may require using a thermal camera to check for a hotspot, which if not addressed could eventually heat up and burn. You are also testing the system operates at the grid's voltage," he says.

Checks to the inverter within hot commissioning are typically carried out by technicians employed by the inverter manufacturer onsite. "During energisation, you should also ensure the monitoring system is properly set up and check the availability of equipment and that everything meets what is set out in the supplier's, or manufacturer's documentation," Vallavanti says.

The hot commissioning phase is key because it is the only time, prior to fully energising the plant for operation, in which faults or failures can be detected that could be due to intrinsic defects in the equipment itself, such as internally damaged modules, or burned out fuses, or due to a failure in construction, such as overstretched DC cabling.

"At the end of the commissioning, a takeover 'punch list' is also good practice. This is where every single finding is listed,

detailing the corrective action that needs to be taken and the timeframe in which it needs to be taken by," Vallavanti says.

Provisional acceptance certificate signing and handover

Then, the PAC is signed. Usually the PV plant's financial investors, such as banks, require this certificate as it provides a date from when the warranty begins and the point at which the PV plant becomes 'bankable'. In other words, it ensures the construction has been done according to best practice and that the plant is expected to generate according to its design specification.

According to Vallavanti, "From that moment the company that is operating and maintaining the PV plant becomes responsible for the maintenance of the plant. It underpins the operations and maintenance (O&M) agreement and provides the basis of a warranty for the investor. After about two years from the plant's commercial operation date the warranty finishes and a final acceptance certificate (FAC) is then provided if the performance guarantee is in line with the expectations signed in the PAC."

Commissioning in practice

Supervisory control and data acquisition (SCADA) monitoring systems at PV plants can help ensure commissioning is done more efficiently, as some checks can be carried out remotely via the SCADA system. Otherwise tools and instruments in the field are used to take measurements, of power curves, for example and test different components.

"During commissioning the various measurements taken that detail radiation levels, temperature, weather and other parameters can be used as a benchmark for any future measurements taken during the plant's operation," says Meyerhof.

When the modules are installed insulation resistance tests are carried out to check, for example, whether there is adequate insulation between the module and the frame. "Also, you would run module thermal inspections using electroluminescent (EL) testing, to detect cracking that is invisible to the naked eye. It is possible to test groups of modules with EL tests, as opposed to single ones. These days you tend to test two, three, four strings, rather than individual modules, which saves time," he adds.

Sample testing is also used. "There are different approaches such as sample testing, which is more common as PV plants have increased in size. You wouldn't 100% EL test a 500MW PV plant but you might sample test 5% of modules," says Meyerhof.

Mechanical tests such as cable inspections are important because if a damaged cable is missed this will impact the operational lifetime of the plant. Meyerhof says: "Finding out any faults or problems as you go along is the only way, otherwise they won't be detected if you just commission only when the plant is built. If you address these issues then the asset has a better chance of operating for 20, 30 even 40 years."

Usually equipment and tools for administering tests and checks of utility-scale PV plants, including any tests for commissioning, include electrical power testers, insulation resistance testers, digital mustimeters, PV characterisation testers, I-V curve tracers, irradiance meters, infrared (IR) cameras and IR thermometers, digital cameras, portable computing devices, as well as power tools.

Merlo observes that the trends in the PV industry to optimise cost as much as possible have also influenced commissioning, but points out there are some testing processes that are difficult to optimise with regard to time and cost, such as testing the insulation of plant cabling or testing the operation of trackers.

"However, there has been a tendency to develop new commissioning procedures or technologies that allow certain testing to be carried out at much lower costs," he adds. "A good example of this would be thermographic camera inspection with drones."

Commission costs tend to be included in the construction cost and the cost of performing tests is very low, says Meyerhof. "In terms of time, commissioning can be a month or two months of technicians on site depending on the size of the PV project."

Traditionally the plant's engineering, procurement and construction (EPC) service contractor will do the commissioning. While having a third-party technical adviser to support or oversee commissioning is not mandatory, it is becoming more common, as the industry places more emphasis on PV plant bankability, in a post-subsidy market. Such providers, which support owners and investors, have expert knowledge and know what issues to look for during the commissioning of each subsection.

Merlo says: "Steps during both cold and hot commissioning are critical and additional resources for a project can be quite useful during these phases.

"It should also be noted that if a proper control of the project has been maintained throughout engineering and construction then commissioning is typically less chaotic or burdensome. During commissioning the total transfer of the asset is approaching. It is very important, both for the contractor to demonstrate compliance, but also for the owner to be able to acknowledge compliance. Specific additional resources from both parties related to performing or witnessing tests, confirming as-built documentation, O&M manuals, and so on can be quite valuable."

Conclusion

"Probably one of the biggest influencing factors on commissioning has been ongoing advances in wireless and other communication technologies, which has helped simplify commissioning in relation to certain equipment, such as trackers and combiner boxes, for instance," says Merlo.

He adds: "From Enertis' point of view, proper control through engineering and construction is the easiest way to facilitate a smooth and incident-free commissioning phase. In Enertis' experience during checks in commissioning you often see examples of trackers or mounting structures that have been inadequately assembled and issues with electrical connections."

While IEC standards provide clear guidance in terms of commissioning and are very comprehensive, Vallavanti says Alectris has been involved in efforts towards further standardisation of commissioning. The aim is to help make the process more transparent to benefit all entities involved in a PV plant, including investors, EPCs and asset managers/O&M service providers.

"Documentation, ideally in a digital format, is an integral part of the commissioning phase as well as a monitoring and asset management platform, which sits on top of the SCADA system, and acts as a repository for all documentation whilst also managing all operations of the plant and consolidating all technical, operational and financial data into a single place," he says.

Meyerhof thinks fundamentally, commissioning also needs to be considered in the context of the PV project's earliest stages, such as design and procurement. "The quality of modules, inverters, cables and other components, and the quality of the design all have an impact on whether you have a plant capable of optimal output.

"For example, define in your purchase contract that modules for your project should have zero cracking, then when you test those modules for cracks you have a contract to fall back on to ensure your project will be highest quality." ■