Research Challenges in PV Reliability

Reliable solar PV power plants will deliver the expected performance throughout their entire service life. They will experience very limited component degradation, failures or system down-time. Improving reliability means derisking electricity production and return on investment of PV systems.

1. Why do we need ongoing research?

In the coming decades, installed PV capacity in the EU is expected to rise from today's 150 GW to the TW scale. Deployment of PV assets requires a significant financial commitment in the range of hundreds of billions euros from utilities, electricity prosumers, energy communities and governments. Levelized cost of electricity (LCOE) not only depends on investments (CAPEX), it also includes operation and maintenance (O&M) costs, and needs the utilization rate (production in kWh/year) as input, which in turn is impacted by service life, PV plant availability and annual degradation rates of the installed PV equipment.

PV technology has been undergoing highly dynamic innovation processes for LCOE reduction, which are expected to continue over the next decades. Although historic PV module designs have demonstrated service life potentials beyond 35 years, the sector has learned that every innovation step generates unforeseen reliability risks, not detected by state-of-the-art testing and certification procedures.

2. Research topics

Type testing standards like IEC 61215 and IEC 61730 are based on experience from former or incumbent technologies. Reliability Research is required for their adaptation to novel and future technologies, including heterojunction, passivated contacts or dual junction cell devices, as well as multi-wire and shingle interconnection technologies. Furthermore, novel applications in the context of PV integration come along with specific stress effects.

Accelerated degradation tests on component level need to walk hand-in-hand with performance assessment under relevant climatic conditions, and system level testing including increasingly harsh environments. A holistic approach needs to address not only the PV module, but also the other balance of system (BOS) components that affect PV plant performance and safety.

Research challenges associated to PV plant design include the need to create digital twins of PV plants which can be then transferred to the O&M phase, the introduction of disruptive engineering concepts based on LCOE optimized design, and the reduction of uncertainties related to yield assessments especially in novel PV module technologies. Reliability Research should be aimed at digitalization of the entire O&M ecosystem, optimizing field operations for lowering OPEX and improving remote failure detection for increasing energy yield