Quality and safety in photovoltaics: why it matters and how to measure it

According to the International Energy Agency (IEA) solar power is the least costly option for new electricity generation in most countries worldwide. However, the global economic crisis challenges government and private sector investment, putting pressure on operators of large-scale PV systems to reduce Capital Expenditure (CAPEX). One option is to use cheaper, low quality components, but won't this jeopardize the overall performance of the solar plant? And how can this be measured? In this roundtable interview, we put these questions to the experts at Stäubli Renewable Energy, a player in the industry for nearly 30 years.

PES: I am pleased to welcome Andrea Viaro, Global Head of large-scale PV systems, Dominic Buergi, Global Head of Renewable Energy Services and Guido Volberg, Senior Consultant for Product Regulatory Affairs.

Andrea, in your position you are in regular contact with large-scale PV system operators. Which key performance indicators (KPIs) are important in assessing the performance of a solar PV plant?

Andrea Viaro: Thank you for the opportunity to speak about this important topic of quality and performance in solar PV plants. Each solar power plant has an expected and forecasted performance yield, making economic KPIs crucial in decision making.

Solar power is at the forefront of efficient production costs. As of 2022, the global weighted average cost of electricity from solar photovoltaics fell to USD 0.045/kWh. That is more than 20% lower than the cheapest fossil fuel and it continues to decline as technology improves and costs reduce.

This is why, despite global economic challenges, solar energy remains at the forefront of energy generation. Solar plants are investment assets where the optimal balance between CAPEX and OPEX to optimized Levelized Cost of Energy (LCoE) plays a crucial role.

PES: Looking at the total cost of production of a solar plant Guido, as an expert in regulatory affairs, can you explain the importance of reliable and safe connectors in a PV system? And how can you measure safety and performance?


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Andrea Viaro

Global Head of large-scale PV systems

For the past 15 years, Andrea has been dedicated to advancing the transition toward sustainable energy generation. He has gained extensive experience in the photovoltaic industry, working internatonally with leading tier-one manufacturers and consultancy firms.

Andrea holds a master's degree in Materials Engineering from the University of Padova and possesses in-depth expertise in the PV market, technology and quality standards.

Committed to driving the solar industry forward, he actively participates in roundtable discussions and public events, sharing his knowledge to promote the safe and sustainable growth of the sector.

Guido Volberg

Senior Consultant for Product Regulatory Affairs

Guido Volberg has been in the photovoltaic industry for over 25 years.

After graduating in electrical and electronic engineering he started his career with the international standardization organization TÜV Rheinland in Cologne.

Through his work at TÜV Rheinland and his role as Head of the Global Competence Centers for PV modules and PV components, he has been an active member of various committees to define national and international standards that ensure safe PV installations and operations.

In recognition of his exceptional contributions to the development of IEC standards, he has been honored with the prestigious 'IEC 1906 Award.'

A proven expert in his field, he joined PV connector market leader Stäubli Electrical Connectors as Senior Consultant in Product Regulatory Affairs and is supporting the renewable energy business to improve safety in the PV industry.

Dominic Buergi

Global Head of Renewable Energy Services

Dominic has substantial professional experience in the industrial sector, focusing on advanced technical solutions. He has delivered strategic consultation and operational support to clients worldwide, demonstrating a proven ability to develop markets and establish solid, strategic customer relationships.

He holds a Bachelor of Science in Business Engineering from the University of Applied Sciences Northwestern Switzerland.

As a subject matter expert at Stäubli Renewable Energy, Dominic has been instrumental in managing and planning the development of the photovoltaic product portfolio, taking into account market trends and customer requirements.

He frequently shares his expertise with customers through training sessions. Dominic is an active participant in several international and national technical committees dedicated to promoting the safe and reliable use of photovoltaic connectors in a variety of contexts.

Guido Volberg: Thank you for inviting me to this roundtable. Official certification bodies independently test and measure components. There are established PV product standards such as IEC 62852:2014 + A1:2020, UL 62852 or UL6703 and installation standards IEC 62548 or IEC 60364-7-712.

These standards were designed for mating connectors within the same product family from a single manufacturer. They apply to the tested connection of a socket and plug within a product family, rather than to individual connector components.

Based on these existing standards, notified bodies and accredited certification institutes confirm the tested and certified safety and quality of a specific product series. This certification serves as a foundation for long-term reliable operation of a PV plant.

In practice, most issues in the field arise from low quality connectors, improper handling and assembly due to lack of knowledge, or cross-mating incompatible connectors.

AV: Exactly. High quality connectors are crucial for solar plant performance, return on investment and LCoE. You can measure that. Before a connector drops out, the contact resistance on the power-carrying parts increases and the performance decreases. The operator will need time to go onsite and detect why there is a power loss and where it occurred.

The faulty connection must be replaced. This is time-consuming and the operator faces unexpected costs on top of missing revenue due to reduced performance. There might even be legal costs when it comes to clarifying liability regarding severe hazards and performance losses.

PES: You mention that failure detection is time-consuming. Dominic, as Global Head of Renewable Energy Services Business, you have extensive knowledge of field data and operator needs. What can asset owners and operators do, to prevent such issues?

Dominic Buergi: Thank you. We need to understand the source of these issues to prevent them. Recent publications show that 74% of all problems occur in the DC

distribution of a PV system (see PV Health Report, Solargrade).

Within this DC distribution sub-system, 59% of all issues are related to field-made connectors and poor wire management.

The volume of wires and connectors in photovoltaic (PV) systems exceeds that of all other equipment. Consequently, these components are more likely to experience issues related to poor quality, potentially leading to a higher percentage of problems.

The Stäubli campaign, 'Small components. Big impact' highlighted significant insights regarding the role of small photovoltaic connectors and their impact on the reliable and safe operation of solar power plants.

PES: How can an EPC or assigned installation party choose the right connector? Andrea, can you tell us more?

AV: Utility scale solar plants cover vast areas and consist of hundreds of thousands of PV modules that need to be connected to the eBOS (electrical Balance of System). The eBOS components collect the outputs from all the solar panels and combine them to match the electrical input parameters of the inverter.

The key question is to identify the most appropriate DC wiring design solution that optimizes the combination of DC strings and the selection of the right products within this eBOS application.

The components of the eBOS application significantly influence the success or failure of a solar project. They can affect the initial costs (CAPEX) and installation efficiency during the conception and construction phases. Additionally, they can prevent maintenance issues in the operational phase, which, as we know, still occur too frequently. These issues can lead to higher operational costs (OPEX).

DB: When selecting the connectors, several critical factors must be considered. Firstly, the manufacturer's credibility and the quality of their products, determined by the materials used and proven through rigorous testing beyond industry standards, are essential. Additionally, proper handling of connectors during field assembly and their seamless integration into the end application are of paramount importance.

PES: And which technical aspects can be measured to ensure plant performance?

AV: PV connectors operate at significantly high current and voltage levels. The quality of the insulator body material, contact technology and contact resistance can be tested. By choosing a quality product from a bankable partner, one can have increased confidence that the housing will provide the required protection against fires, weather resistance, thermal endurance and tolerance to breaking and bending without jeopardizing the conductive properties of the connector over the lifetime of the PV project.

The long-term performance of electrical connectors and their contact elements is also determined by the stability of low electrical resistance over time and under aging. In product testing, climatic tests employing the principle of accelerated aging are an essential component of our internal tests and also product certification by independent bodies such as TÜV Rheinland or UL.

Quality is key to long-term operation, therefore Stäubli is testing its components beyond the norm

Certified installer having successfully passed the training for quality assembly

The international standards IEC 62852, UL62852 and UL 6703 apply to testing electrical PV connectors. If a connector undergoes these tests, the customer can be confident of acquiring a quality product.

PES: What happens if an installer or EPC chooses PV connectors, which are named MC4 compatible, but sourced from different manufacturers?

GV: Mating PV connectors from different manufacturers can create dangerous situations. Several critical factors must be considered, such as the functionality of the internal contact technology, the potential interactions between different plastic or metal alloy materials, many of which are not visible and the high power being transferred through the connectors.

The National Electrical Code (NEC) explicitly states: 'Where mating connectors are not of the identical type and brand, they shall be listed and identified for intermateability, as described in the manufacturer's instructions.' However, to date, no connector has been listed as intermateable with the Original Stäubli MC4.

PES. Does field data confirm these cross mating issues? Dominic, what is your experience?

DB: Field inspections confirm that in certain markets and application areas, the most common issues include cross mated connectors, improperly integrated connectors with excessively tight bend radii, or improperly torqued cap nuts, to name a few.

PES: Which services and new technologies help prevent such issues and ensure the safety and performance of a solar plant?

DB: The quality of connectors is critical for ensuring the safety and optimal return on investment of PV assets. However, having high-quality products alone is not sufficient to enhance safety. It is equally important to know how to assemble PV connectors and integrate these connections correctly into a PV system. At Stäubli, we are dedicated to sharing our expertise by offering training, installation and commissioning oversight services and adjacent offerings such as DC Health inspections.

Our Stäubli Customer Academy provides specialized courses designed to enhance the knowledge base of various stakeholders within the PV industry. These courses focus on PV connector configuration and assembly techniques and a comprehensive range of installation guidance, particularly regarding connector and wiring strategies. Additionally, we offer certification for installers who complete our training programs.

PES: In summary, high-quality connectors and proper installation prevent costly issues and improve ROI and LCoE, ensuring optimal solar plant performance. Certified components, tested by independent bodies like TÜV Rheinland or UL, alongside correct installation and field inspection services, can prevent costly issues and this ensures long-term and stable performance of a solar plant.

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