EU PVSEC 2025
42nd European Photovoltaic Solar Energy Conference and Exhibition

EU PVSEC 2025
PANEL DISCUSSION

Session BO.13:
Bankability and Reliability in PV

Key Take-aways

1. Introduction

The panel focuses on the bankability and reliability of new solar photovoltaic (PV) cell and module technologies, which are still the single most expensive item when analyzing the cost structure of solar PV projects. Furthermore, solar modules are where most technological changes in the PV industry are presently occurring.

2. Global Solar Market

The post-pandemic **global solar market** is characterized by 4 **macro-trends**:

- An **exponential growth** with historically average compound annual growth rates (CAGR) of 30-40% and a peak year-on-year variation of +88 %/y in 2023 over 2022 ([8]).
  The global PV market in 2025 is expected to reach ~660 GWp/y (estimate) of new additions, while totaling a cumulative installed capacity of: ~2.9 TWp (estimate).

- Global solar PV **manufacturing capacity** has moved from Europe, Japan and the US to China over the last 15 years. Today, China's share in all the steps of solar PV module manufacturing (i.e. polysilicon, ingots, wafers, cells and modules) exceeds 80%.

- Very sharp decline of PV **module prices** (-30 to -45% in 2023, continued in 2024, -5 to 10% in 2025), due to manufacturing overcapacity in China, meaning that companies need to drastically constrain costs to remain competitive. Mainstream PV modules sell at ~0.1 €/Wp on the European spot market. Some investigations indicate that these prices are 40-50% lower than so called Minimum Sustainable Prices (MSP) for the manufacturing value chain. In 25 years, the cost of PV modules has declined by -98%.

- A **revolution in solar PV** cell and module **technology**, with several novel cell and module designs (and materials) entering the market.

3. Technological Evolution vs. Revolution

With respect to the last point, we emphasize that between 1990 to 2019 (~30 years) technology has undergone a linear **evolution**, with a **turning point** around 2019 when suddenly multiple changes (often combined in the same module design) have started tumultuously entering the market. The main driver for this sometime **disruptive technological revolution** is related to multiple factors, including the constant push to reduce costs, a pressure to differentiate products in a market that still perceives solar panels as a commodity, specific industry trends (e.g. the adoption of bifacial solar cells and modules), which are accompanied by several requirements in terms of design and material selection.

The main changes in module manufacturing are recalled here:

- **Cells**: the transition from p-type to n-type-based wafers and cells (with the introduction of high-efficiency crystalline silicon solar cells), and in particular from PERC (Passivate Emitter Rear Cell) solar cells to Topcon (Tunnel Oxide Passivated Contact), SHJ (Silicon Hetero-Junction) and BC (Back Contact) solar cells. The use of much thinner wafers and bifacial cells.

- **Module structure**: the transition from glass/foil structures to glass/glass structure using thinner glasses and heat-strengthened glass in place of tempered glass. Or thinner tempered glasses with lower tempering properties.

- **Interconnects**: the transitions from few ribbons towards multiple wires, foil-embedded wires, or zero bus-bars (0 BB).

- **New encapsulants and polymeric materials**: an increased adoption of polyolefins or EPE (EVA/polyolefin/EVA) to replace EVA (Ethylene Vinyl Acetate) as the dominant encapsulant materials. New materials used as backsheets (BS, including transparent BS) in module/foil structures.

- **Power/size**: in the same time frame, the average size of the modules has been growing – particularly for the utility-scale market segment – from ~1.6 to ~3 m2. In parallel for the same market segment, the average module power has increased from 350-400 Wp to over 600 Wp.

4. Main Panel Take-aways

4.1 Increased Risk

The panel experts agree that that novel PV modules technologies - with the present market dynamics previously recalled - are associated to a **higher industry risk**, even if this risk is frequently not perceived yet by downstream players in the value chain such as EPC, project developers, plant owners or financial institutions. In the **buyer's perspective** price and availability in fact still seem to count more than reliability or perceived quality. PV modules in fact are still perceived by many as a commodity.

The higher risk associated with the **reliability and durability** of the latest generation of solar modules is due to a combination of factors:

- **Innovation cycles** of module manufactures and time to market of novel products are too fast and have been reduced to 6-12 months.

- The adoption of **simultaneous module design changes** (or the adoption of new materials), reducing the capacity to foresee failure modes or complex interactions of different components or materials.

- A **lack of field track record and data** to support the reliability and durability of the recently installed technologies.

- The observed **extension of performance warranties** to 30 (or 30+) years, not supported by increased requirements in **testing and certification prerequisites**, increased modelling capabilities nor field experience. Application and climate-specific testing of modules are also largely missing.

- Only very recently have **major weaknesses** and design limitations – behind anecdotal evidence – started to be reported in the literature and partly understood. This has reached a point where some of these changes (and particularly their combinations and interdependencies) are starting to be questioned. A typical example of multiple changes into a single module design is the simultaneous adoption of thinner and larger solar cells in larger glass/glass module manufactured with thinner un-tempered glass covers, which may lead to spontaneous glass or cell cracking. Analogously, larger than usual degradation by exposure to UV have been reported for high-efficiency solar cell (Topcon and SHJ).

- Finally, manufacturer understandably use multiple suppliers of single materials or components. However, the **regular change of suppliers or BOM** (Bill-of-Material) in the same module design rises concerns about the reproducibility of field performances (and indoor reliability testing) for PV modules of the same type manufactured in different batches or at different times.

In short, a wide consensus exists among the panelist that this **very rapid technological transition** – accompanied by the previously recalled market dynamics – may endanger the well-earned reputation of solar PV gained over more than 3 decades of experience. A large effort is therefore required to the solar PV industry to address these main challenges.

4.2 The Way Out (proposed solutions)

The last part of the panel has been dedicated to proposing mitigation strategies or solutions to the perceived higher industry risk, which we recall briefly here:

- ✓ **Testing**: IEC (International Electro-technical Committee) testing has done historically a great job in providing a minimum quality threshold to the industry. However, several limitations to IEC testing exist, such as the inability to identify specific failure modes in new classes of materials, solar cells and designs. Further, application and climate specific stresses need to be considered. Extended testing sequences or the adoption of novel combined, or sequential stress sequences are needed. Due to the high risks imposed by material changes, we need to carry our reliability testing of PV modules rather than performance testing.

- ✓ **Modelling**: Improved modelling of degradation rates (and service lifetime) should go hand in hand with testing, as we cannot wait 30 years to receive field feedback for a specific module design.

- ✓ **Increase quality in production**: Consistency in manufacturing is critical. Changes to BOM should be minimized and assessed carefully, as the impact of single changes on long-term performances is largely unknown. This should be enforced through factory and batch inspections and a larger transparency from module manufacturers.

- ✓ **Transparency**: Together with increased communication between different players through all the value chains are needed to allow implementation of the appropriate feedback loops. Transparency requirements should consider these different aspects: the precise BOMs used in module manufacturing; public-facing reliability test and results (e.g. of IEC61215/61730); knowledge sharing on failure modes to improve feedback loops, etc.

- ✓ **Delivery inspections**: Careful and precise acceptance inspection of containers and batches at plant level must be improved and become common practice.

Contributors:
Alessandro Virtuani, CSEM, Switzerland
Ulrike Jahn, Fraunhofer CSP, Germany
Ronald Sastrawan, Munich Re, Green Tech Solutions, Hong Kong
Ralph Gottschalg, Fraunhofer CSP, Germany
Giorgio Bardizza, TÜV Rheinland, Germany
Ruben Martínez, Banco Sabadell, Spain
Julien Dupuis, EDF, France

Robert P. Kenny, European Commission JRC, Italy
Jon de Gregorio, WIP Renewable Energies, Germany
Utku Ege Birgi, WIP Renewable Energies, Germany