

Title: Standards for performance measurements of emerging photovoltaic technologies

Abstract

The rapid growth of emerging PV technologies such as organic PV and perovskites has led the growth of the niche market of semi-transparent PV devices, both for indoor and outdoor applications. There is currently a lack of harmonised protocols for performance testing of emerging PV technologies when devices are metastable, which limits market penetration, impartial evaluation between test laboratories and faster commercialisation of such technologies. Therefore, new standards on indoor PV applications and semi-transparent PV devices need to be expanded, to underpin these new markets. Proposals addressing this SRT should contribute to deliver new protocols and standards for performance testing of emerging photovoltaic (PV) devices and evaluate recent standards such as IEC TS 60904-1-2:2019 on emerging PV applications.

Keywords

Photovoltaics (PV), Standards, Energy, Performance measurements, Efficiency.

Background to the Metrological Challenges

A major barrier towards commercialisation and market growth for emerging PV technologies is the lack of appropriate testing standards. Perovskite-based PV devices and some similar emerging PV technologies possess the characteristic feature of metastability – depending on illumination or bias conditions, their generated photocurrent can take a significant amount of time to stabilise. Metastable PV devices are slow to respond to voltage bias settings, making current-voltage (I-V) measurements challenging. These aspects had in the past led to the publication of the technical report IEC TR 63228:2019, which summarised general perspectives and considerations for I-V testing of metastable PV devices. Nevertheless, there are still no harmonised protocols for preconditioning, I-V testing and power rating for metastable PV devices, and each test lab currently uses their own protocols for such measurements. This creates significant inconsistencies in power and efficiency measurements between labs, which was also confirmed as a major outcome in the intercomparison measurements of the recent EMPIR project 19ENG01 Metro-PV. In consequence this remains a significant barrier for commercialisation of PV technologies that exhibit a metastable behaviour. Hence, being able to measure these electrical characteristics through a harmonised protocol is a critical step for such PV products to reach the market and this will significantly contribute to the scale-up of manufacturing of net zero technologies in the EU.

One major barrier until recently was the lack of any testing standards for indoor PV devices, this hampered market growth and efforts of indoor PV integration to support Internet of Things (IoT) and remote sensing devices. The recent IEC TS 62607-7-2:2023 provided the first international technical specification for performance testing of PV devices under indoor light. Through this IEC document, the Indoor Standard Testing Conditions (ISTC) were defined regarding irradiance levels, spectral profile of light source and temperature. In the recent project 19ENG01 Metro-PV significant differences above 20% were observed in the intercomparison measurements of indoor PV device electrical parameter testing. As a conclusion it was shown that significant challenges to ensure traceability and harmonisation still remain for indoor PV testing. There are currently no requirements or guidelines for reference cell calibration for such measurements, while international intercomparison activities are required towards improvements in future revisions or expansions of IEC TS 62607-7-2:2023.

Semi-transparent PV products are critical for applications like agricultural PV (Agri-PV) or building-integrated PV (BiPV) schemes. Nevertheless, testing standards or guidelines for power rating of such products are still lacking, and it is unclear if bifacial PV testing standards can be used, such as IEC TS 60904-1-2:2019. This has resulted in ambiguity for power rating testing and labelling of such products in the market, and whether they should be tested as monofacial or bifacial PV products. Such ambiguity limits market penetration, as well as reliable PV system design and yield forecasting of semi-transparent PV systems (e.g. in Agri-PV or BiPV applications). Therefore, there is the need to define specifications for indoor PV reference devices that add necessary details beyond the current IEC TS 62607-7-2:2023, specifically the requirements for indoor reference device calibration and the need to investigate stability of reference devices during long duration measurements (typical for metastable device testing) both under indoor and outdoor standard testing conditions.

In the case of metastable PV device testing, measurements (power rating or I-V testing) can last several orders of magnitude longer than with conventional PV technologies, which creates new challenges for traceable and accurate irradiance monitoring during measurements. Stability of reference cells along those timescales needs to be validated, to maintain traceability of measurements. In the case of indoor PV device testing, there are currently no guidelines for calibration requirements of reference devices, or relevant protocols or procedures. This is a significant challenge for implementing IEC TS 62607-7-2:2023, especially for laboratories that do not have the capability for in-house calibration of an indoor reference cell to target indoor conditions. New guidelines and technical specifications for indoor PV testing reference cell calibration will allow the development of commercial reference cells, which currently do not exist, limiting the expansion of the indoor PV market as a whole. Such progress will underpin this growing market and ensure traceability of indoor PV measurements.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The proposal shall focus on metrology research necessary to support standardisation in emerging photovoltaic technologies.

The specific objectives are:

1. To define guidelines for current-voltage testing and power rating of metastable PV devices. In addition, to revise IEC TR 63228:2019 and/or formulate a new draft Technical Specification to be brought for discussion to TC82 (WG2 and/or WG8) related to the above protocols.
2. To evaluate the current IEC technical specifications for PV device performance testing under indoor conditions (IEC TS 62607-7-2:2023) via international intercomparison activities. This includes potential expansions, such as indoor reference cell calibration guidelines.
3. To define requirements for performance measurements for semi-transparent PV devices, and/or to link them with bifacial PV device testing standards (IEC TS 60904-1-2:2019). In addition to provide a standardisation route to include semi-transparent devices in the IEC technical specifications (TC 82 and TC 113), both under indoor and outdoor standard testing conditions.
4. To define specifications for indoor PV reference devices that add necessary details beyond the current IEC TS 62607-7-2:2023, specifically the requirements for indoor reference device calibration. In addition, investigating the stability of reference devices during long duration measurements (typical for metastable device testing) both under indoor and outdoor standard testing conditions.
5. To contribute to a revision of standards IEC TR 63228:2019, IEC TS 60904-1-2:2019 or IEC TS 62607-7-2:2023, by providing the data, methods, guidelines and recommendations, which are necessary for the standardisation of emerging PV technologies. Outputs should be in a form that can be incorporated into the standards at the earliest opportunity and communicated through a variety of media to the standards community and to end users.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support

explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMRP and EMPIR projects ENG55 PhotoClass, 16ENG02 PV-Enerate, and 19ENG01 Metro-PV and how their proposal will build on those.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.0 M€ and has defined an upper limit of 1.3 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the 'end user' community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the "end user" community (e.g. letters of support) is also encouraged.

You should detail how your proposal's results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Facilitate improved industrial capability, or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the Photovoltaic sector.

You should detail other impacts of your proposed JRP as specified in the document "Guide 4: Writing Joint Research Projects (JRPs)"

You should also detail how your approach to realising the objectives will further the aim of the Metrology Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Timescale

The project should be of up to 3 years duration.