Potential European Partnership on Metrology
Call 2021 – Green Deal and Normative

Selected Research Topic number: **SRT-v15**
Version: 1.1

Important information about these documents

This call is being held ahead of any agreement from the Commission that the relevant funding will be available. At present the relevant legislation is still under discussion in both Council and Parliament, and there is no certainty on the detailed arrangements for funding selected projects. The funding of any selected project, and the terms and conditions of participation in the projects, are dependent on completion of the legislative process and the subsequent contractual processes between the European Commission and EURAMET. Proposers submit to this call at their own risk.

Background

Last year, EURAMET submitted a draft proposal to the EC for a further research programme to be established under article 185 of the Treaty on the Functioning of the European Union (TFEU) to follow on from EMRP and EMPIR. This was published by the EC at https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/european-partnerships-horizon-europe/candidates-digital-industry-and-space_en

The initiative would be called the European Partnership on Metrology and would aim to create, by 2030, a sustainable and effective system for metrology at European level that ensures Europe has a world-class metrology system that:

- Provides metrology solutions, fundamental metrological reference data and methods, offering fit-for-purpose solutions supporting and stimulating European innovation and responding to societal challenges.
- Supports and enables effective design and implementation of regulation and standards that underpin public policies that address societal challenges.

The Commission commissioned an impact assessment into this proposal and 11 others in similar priority areas, and, based on those findings, published their own proposal for the Partnership, their response to the impact assessment and a draft of the Decision on 23rd February 2021. See:

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:89:FIN

https://ec.europa.eu/commission/presscorner/detail/en/ip_21_702

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0035&qid=1614677899327

That draft Decision is currently under discussion in the European Council and the European Parliament.

Under the assumption that the Council and Parliament pass the basic act which would form the legal basis for this research programme, and that the participating countries named in the Draft Decision submit the required commitment letters, EURAMET is publishing these potential Selected Research Topics and draft guidance notes. These documents are not approved by the Commission nor will they lead to a binding decision by EURAMET e.V. for any further negotiation or funding. All published guides and templates are subject to amendment by the EC and EURAMET e.V. as further information becomes known.

Title: Metrology for performance assessment and monitoring of photovoltaic systems

Abstract

Photovoltaics (PV) is one of the cheapest forms of electricity generation in many countries and the sector will grow rapidly in the next decades, as solar PV is expected to be the main energy source of the future. However, and despite the growth, performance assessment and forecasting uncertainties lead to significant financial risks for companies and investors. While important steps have been taken in previous years to reduce measurement uncertainties for PV modules and irradiance sensors, metrology and standards at the system level are falling behind progress in the technology. Proposals addressing this SRT should therefore contribute towards an improved ability to assess and predict the performance of PV systems, in order to support the growth in PV deployment.

Keywords

Photovoltaics, renewable energy, PV systems, PV modules, bifacial systems, device characterisation

Background to the Metrological Challenges

All strategies aiming to avoid drastic climate change involve the emergence of PV as the dominant power source. This has been recognised by the International Energy Agency (IEA), which forecasts that PV will be the main electricity capacity installed in Europe by 2025. To meet the legally binding Paris Agreement commitments, EU nations must rapidly increase PV capacity to six times the current levels by 2030. Globally, installed PV capacity is expected reach eighteen times the current levels by 2050.

Despite metrology progress at the cell and module level, critical challenges remain at the system level that must be addressed to exploit the full potential of the latest PV technologies. Problems arise when measured PV system performance does not meet expectations because of (i) unrealistic expectations due to unquantified uncertainty or poor modelling, (ii) unsuitable measurement of rear-side irradiance in the case of bifacial systems, (iii) differences between field and laboratory behaviour of devices and measurements, and (iv) faulty components or premature degradation.

IEC 61724-1, developed by IEC TC82 “Solar photovoltaic energy systems”, provides guidelines for measurement, data exchange and analysis of PV system performance monitoring. This includes calculation of performance ratio, the most crucial metric for the PV systems industry, but it does not include guidelines for uncertainty estimation. Instead, the industry uses conservative margins that underestimate yields to avoid disputes. Consequently, underperformance may be tolerated. Besides irradiance, the output of a system depends on secondary variables such as temperature, spectral and angular irradiance, ground albedo, soiling, inhomogeneity, as well as system design and degradation. These factors introduce errors between predicted and measured performance ratios. Corrections are available but they require additional measurements and parameters determined from laboratory measurements and validated models.

The introduction and improvement of module energy rating standards (e.g. IEC 61853, developed by IEC TC82) has helped towards the reduction of uncertainty through more accurate energy rating of PV modules, but there is need for improvement at the PV system level, where uncertainties can still be as high as 10 % for energy yield models. Understanding the differences between behaviour in laboratory conditions and in the field is becoming critical. Accurate correction of field-based power measurements requires further development, and the simulation of “standard test conditions” outdoors is not currently possible for strings of modules. Temperature measurement is also a challenge. Typical practice is to measure module rear-surface temperature at several points with ± 2°C uncertainty or worse. New alternatives (e.g. remote phosphor thermometry) may provide the solution but require demonstration and validation outdoors.

Bifacial systems, which harvest light from both sides of PV modules, have the potential to deliver significantly higher yields. These systems already make up > 10 % of new installations but raise additional metrology challenges. IEC TS 60904-1-2:2019, developed by IEC TC82 and supported by the EMPIR project 16ENG02 PV-Enerate, determines performance parameters in laboratory conditions. However, performance ratio calculation for bifacial systems remains a hot topic within that technical committee. Determining rear plane-of-array irradiance is a major obstacle, as any choice of sensor position and type (reference cell, photodiode, pyranometer) introduces systematic errors. Scenarios for optimal cost-effective combinations of sensors must be validated and uncertainty budgets assigned. Determination of site albedo and inhomogeneity is critical to predicting performance.

The adoption of airborne thermal imaging and recent introduction of in-situ luminescent imaging are revolutionising fault localisation and prediction. The industry strives for digitalisation of inspection but acquiring quantitative results for power losses is an ongoing challenge. Although resolution of thermal imaging instruments is sufficient, issues with absolute temperature values and, consequently, traceability remain. Furthermore, the required conditions, defined in IEC TS 62446-3 (developed by IEC TC82) and mandated in contracts, rarely occur in some climates, limiting availability of good data. Quantitative luminescent imaging is defined only for indoor conditions (IEC TS 60904-13, also developed by IEC TC82), and its use outdoors is generally limited to night-time. Drone-based daylight luminescent imaging has recently been demonstrated but its validation and development of protocols are required.

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 JRP shall focus on the traceable measurement and characterisation of photovoltaic systems.

The specific objectives are

1. To improve the quantification of uncertainty in PV systems by developing uncertainty budgets and best practice guidelines for performance indicators of PV systems (e.g. performance ratio and temperature-corrected performance ratio as defined in IEC 61724-1), yield prediction and related auxiliary measurements (e.g. spectral irradiance, spectral radiance, aerosol optical depth, cloud properties and soiling).
2. To optimise the cost-effective monitoring of bifacial PV systems by developing validated methods and publishing guidelines for bifacial PV systems' performance monitoring (e.g. rear side irradiance, sensor positioning, sensor selection). Additionally, to develop validated traceable methods for measuring site albedo, spectral reflectance and spatial uniformity on utility scale (≥ 1 hm^2).
3. To improve the uncertainty and traceability of outdoor measurements and characterisation tools by developing calibration and correction procedures, references, and carrying out comparisons with indoor laboratory measurements. This should include *in operando* PV module temperature with a target uncertainty better than 1 °C (k = 2), and power measurement comparisons between laboratory and outdoor conditions.
4. To develop validated inspection and monitoring tools by (i) supporting the improvement and harmonisation of imaging methods for PV modules through collaborative validation studies, (ii) ensuring traceability to international standards (e.g. IEC 61724-1-3, IEC TS 60904-13, IEC TS 62446-3) and (iii) improving accuracy and availability in sub-standard conditions. Additionally, this should include the improvement of digitalisation by validation of digital twin methods and fault detection algorithms based on machine learning.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (measurement laboratories), standards developing organisations (IEC TC82 WG2 "Modules, non-concentrating", IEC TC82 WG3 "Systems", and the International Photovoltaic Quality Assurance Task Force - PVQAT), international organisations (IEA PVPS) and end users (PV systems industry).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

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

EURAMET expects proposals submitted against this SRT to be below average size and has defined an upper limit for the EU Contribution of 2.2 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

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 JRP 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,
- Transfer knowledge to the photovoltaics 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 potential European Partnership on Metrology 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.

Time-scale

The project should be of up to 3 years duration.