European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-r06**
Version: 1.0

Title: Novel metrological capabilities - Measuring impact of biofilms on solar panel efficiency

Abstract

With the increasing need for renewable energy, it is crucial to maintain the efficiency of photovoltaic solar panels. However, solar panels are susceptible to the deposition of particulate matter and to biofilm growth, which can reduce energy conversion efficiency by > 10 %. Therefore, a reference measurement framework needs to be developed to support the management, control and prevention of biofilm formation on solar panels. This should include efficiency measurements, the development of a straightforward and reliable biofilm sampling procedure, and the development of accurate microbial identification and quantification methods, with appropriate reference materials.

Keywords

Biofilm sampling, microbial communities, photovoltaic, reference isolates, reference measurement system, solar panel efficiency, solar panel maintenance / cleaning, solar panel soiling, subaerial biofilms, surveillance

Background to the Metrological Challenges

Photovoltaic solar panels are one of the most widely used sources of renewable energy. However, their exposure to ambient atmospheric conditions means that they are susceptible to the influences of precipitation, atmospheric chemistry, and the deposition of particulate matter and its constituents. The issue of diminishing solar panel efficiency due to deposition of particulate matter on their surface has been investigated. However, the impact of biofilms on solar panel efficiency is less well known.

It is believed that initial colonisation of the surface of solar panels is by microorganisms deposited from the ambient atmosphere. However, detailed sequencing and other analyses, have shown that organisms are then selected, from the initial colonising species, based on their ability to withstand the desert-like conditions on the surface of solar panels. For example, cyanobacteria, which are normally prevalent in subaerial biofilms are less common on the surface of solar panels, whereas black rock-inhabiting fungi, which are highly adapted to living in extreme environments, and other extremophiles (e.g. bacteria) are more prevalent. These populations of stress-tolerant organisms often contain photosynthetic or other pigments to protect them from radiation damage. These organisms can attenuate light transmittance either by directly absorbing light of various wavelengths (due to their pigments) or by scattering the incident light. Laboratory studies have shown that light transmittance can be decreased by 30 % to 70 %, depending on the wavelength. Further information is needed on the microbial composition of biofilms. Therefore, a straightforward and reliable procedure is needed for sampling them from the surface of solar panels, whilst maintaining their integrity, in order to enable their accurate downstream identification and quantification using high-throughput microbiological and molecular biological reference measurement procedures. A culture collection of reference materials of different complexity also needs to be prepared using model organisms (e.g. fungi, prokaryotes, phototrophs) to support the development and evaluation of these procedures.

Previous studies have shown that the formation of biofilms on solar panels can decease the energy conversion efficiency by > 10 %, but this varies with the inclination of the solar panels and with the geographical region. Biofilms firmly attach to the glass surfaces of solar panels and microbial soiling exacerbates the trapping and binding of inorganic matter, preventing it from being removed by rainfall. Even self-cleaning glass, which relies on photocatalytic activity, has limited efficacy. It allows some inorganic particles to be removed, but it has also been shown to form biofilms with selection for black rock-inhabiting fungi. Therefore, the effects of biofilms and dust deposition on solar panel efficiency need to be further measured with correlation between the electrical behaviour and the 3D topography of the solar cells' silver contacts. Having a well-established reference measurement framework will contribute to the development of a unified strategy for the surveillance of biofilm formation on solar panels and for their maintenance and cleaning.

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 development of metrology capability in measuring the impact of biofilms on solar panel efficiency.

The specific objectives are

1. To develop a straightforward and reliable procedure for sampling biofilms on the surface of solar panels. This procedure should maintain the integrity of the biofilm components to enable their downstream identification.
2. To develop high-throughput microbiological and molecular biological reference measurement procedures for the accurate identification and quantification of biofilm components. Reference materials of different complexity should be prepared using model organisms (e.g. fungi, prokaryotes, phototrophs) to support the development and evaluation of these procedures. In addition, a culture collection should be developed comprising reference isolates from solar panels.
3. To measure how solar panel efficiency is affected by the formation and growth of artificial biofilms and by the deposition of dust. Electrical behaviour should be correlated with the 3D topography of the solar cells' silver contacts.
4. To facilitate the take up and long-term operation of the capabilities, technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs/DIs, calibration and testing laboratories, CCQM working groups), standards developing organisations (ISO/TC 213), and end users (e.g. industry, regulators). The approach should be discussed within the consortium and with other EURAMET NMIs/DIs e.g. EURAMET TCs or EMN for Advanced Manufacturing, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the area for which the capabilities will be built (Green Deal, Digital Transformation, Health, Integrated European Metrology, Industry, Normative or Fundamental Metrology) and in which future main call the developed research capabilities are planned to be employed,
- the impact the developed research capabilities will have on the industrial competitiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

The development of the research potential should be to a level that would enable participation in other TPs.

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 0.5 M€ and has defined an upper limit of 0.9 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 20 % 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 JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health or protection of the environment,
- Transfer knowledge to the renewables sector and the metrology community.

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 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.

Time-scale

The project should be of up to 3 years duration.