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

Selected Research Topic number: **SRT-v14**
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: Metrological framework for passive radiative cooling technologies

Abstract

Cooling systems account for nearly 20 % of electricity consumption and 10 % of greenhouse gas emissions, globally. With demand for cooling expected to grow tenfold by 2050, improving the efficiency of cooling systems plays a critical role in addressing the global climate challenge. Passive Radiative Cooling (PRC) materials that can dissipate heat as infrared radiation, have recently emerged. However, a preferred configuration for PRC solutions has not yet been established and more research is needed to establish standardised methods, validate the claims associated with cooling materials, test their actual cooling performances under controlled conditions and evaluate the potential energy savings that could derive from such technologies.

Keywords

Passive daytime radiative cooling, Heat transfer, Radiative transfer, Thermal infrared, Atmospheric transmission, Angular resolved emissivity, Solar reflectance, Energy efficiency, Urban heat islands

Background to the Metrological Challenges

Cooling systems are estimated to cost approximately $300 billion and produce 1 Gt of CO_2 per year; a figure that may increase dramatically with the expected growing demand for cooling systems. PRC materials are able to dissipate heat as infrared radiation in the transparency window of the atmosphere (8 – 13 µm), reaching sub-ambient temperatures and equivalent cooling power exceeding 100 W m^{-2} even under direct sunlight owing to their tailored spectral properties, i.e. high emittance in the mid and long infrared, especially between 8 µm and 13 µm, and vanishing absorptance in the solar spectral range from 0.25 µm to 2.5 µm.

Established applications of PRC materials include the cooling of residential and commercial buildings, but also of photovoltaic cells to increase their efficiency and lifespan, freshwater harvesting from moist air, thermoelectric generation, personal thermal management and supplemental cooling for condensers of air conditioners and power plants. Considering that virtually all thermal power plants use water for cooling, accounting for 42 % of freshwater draws in the EU and significant thermal discharges into the environment, the development of technologies enabling cost-effective net-zero water consumption will be a key factor in decoupling this major connector in the Energy-Water nexus. However, unlike other sky-facing technologies in the renewable energy sector such as solar thermal and photovoltaics, a preferred configuration for PRC solutions has not yet been established. A major obstacle in this respect is represented by the lack of agreement on standardized testing conditions and key performance indicators for these new materials.

The sub-ambient radiative cooling under direct sunlight was demonstrated for the first time in 2014 for a complex nanostructure with engineered photonic properties. To date, the most promising solutions for large-area coatings exhibiting passive daytime radiative cooling are based on strong infrared emitters e.g. SiO_2 microspheres and polymer-based coatings. However, due to the composite nature of these materials and the synergistic interactions between their components, specific optical and thermal characterisation methods must be developed.

Existing standards are not applicable to PRC materials. The so-called solar reflectance index (SRI), defined in ASTM E1980 as a measure for the temperature of a solar-irradiated surface with respect to standard white and black reference surfaces, depending on its solar reflectance and thermal emittance, is often used for evaluating and comparing cool-roof products. However, this is not suitable for sub-ambient radiative cooling materials, as neither the atmospheric IR-window nor other key variations of surrounding conditions (such as solar irradiation, humidity, cloudiness, etc.) are considered. Additionally, the definition of the SRI value is restricted to opaque surfaces and the measurement procedures for deriving the solar reflectance and the thermal emittance are only valid for well-defined specimens described in the standards. Hence, existing measurement procedures must be adapted to derive reliable results, as passive radiative cooling materials are mainly optically complex materials. Moreover, more explicit and detailed criteria are needed to quantify the performance of passive radiative cooling materials. Similarly, regarding infrared emissivity measurements, almost all techniques available to end-users in the field measure total near-normal emissivity while the parameter required for heat-balance calculations is the total hemispherical emissivity. The critical conversion and extrapolation from directional to hemispherical emissivity must be investigated. Angular resolved emissivity will need, in turn, to be combined with proper radiative transfer modelling of the spectrally resolved thermal infrared emission (mid and far-infrared) coming from the atmosphere and reaching the samples at different zenith angles, for both clear-sky and cloudy conditions, including high-altitude thin-clouds.

Due to the inherently "outdoor" nature of this technology, which depends critically on atmospheric and sky access conditions of the cooling surface, dedicated validation protocols and best practices guidelines must be established for reliable in-field measurements. In many cases, these protocols are based on portable instrumentation and real-time techniques, whose limitations will need to be assessed to ensure they fulfil the uncertainties required for validation and quality control of the target performance indicators.

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 passive radiative cooling materials, components and systems.

The specific objectives are

1. To develop a metrological framework for the classification and comparison of passive coolers based on key performance indicators (KPIs) for appropriate categories of passive cooler architectures. For this:
   (i) laboratory test methods should be surveyed, and boundary conditions identified for the measurements to ensure comparability in the determination of the KPIs under appropriate conditions
   (ii) benchmark materials need to be selected (e.g. SiO_2 microspheres) exhibiting reproducible passive daytime radiative cooling performance, to develop micro and nano-structured model systems with well-defined thermal and optical properties.
2. To develop and validate modelling methods to correlate the cooling performance of model systems with the thermal and optical properties of their components, and to establish the materials' specifications and associated tolerances for quality control. To carry out the thermal infrared spectral modelling of the transmission and emission of the atmosphere at different zenith angles. Additionally, to evaluate the impact on energy savings and heat-island effect for urban environments in different geographic regions on a year-to-year basis under different atmospheric conditions (e.g. humidity, cloud cover).
3. To perform an interlaboratory characterisation and comparison of the reflectance and emittance of benchmark passive cooling materials over a broad spectral range (200 – 50 000 nm) encompassing the solar spectrum and the infrared transparency window of the atmosphere (8 – 13 µm). To develop and validate methods to convert measured infrared radiometric quantities (e.g. total near-normal or near-grazing emissivity) into a usable form for simulations and heat-balance calculations. In addition, to develop best practice guidelines for the conversion of directional to hemispherical emissivity, based on measurements obtained using commercial instruments.
4. To design a testing setup and validate protocols for testing KPIs (e.g. tracking solar irradiance, humidity and wind speed) of candidate passive cooling materials for both indoor and outdoor use and to perform a systematic error analysis, validating the determination of important KPIs at 10 % uncertainty level.
5. To produce a good practice guide on the on-site determination of the performance of passive cooling solutions and their degradation with time and ageing in terms of the above KPIs. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (testing laboratories), standards developing organisations (CEN/TC 89) and end users in the commercial, residential, and photovoltaic sectors.

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 EMPIR project 16NRM06 EMIRIM and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.2 M€, and has defined an upper limit of 2.7 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 sustainable technologies 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.