EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g14**
Version: 1.0

Title: Metrology for improved energy efficiency of smart lighting

Abstract

Solid State Lighting (SSL) technologies are flexible with regard to lighting level, colour and geometry. Smart lighting using SSL involves adaptation to real lighting needs, while still achieving comfort and well-being, therefore it may lead to energy savings. This smart control of lighting involves digital control by smart sensors. To assess the efficient-centric human lighting and to study well-being, new devices and measurement methods are needed for measuring the complex lighting environment and to validate smart sensors. Proposals addressing this SRT should develop methodology and metrology to assess the performance of smart lighting, and measurement protocols for energy regulations and standards.

Keywords

Smart lighting, solid state lighting, eco-design, well-being, lifetime, energy efficiency, energy saving, buildings, road safety

Background to the Metrological Challenges

Lighting in a modern building environment is a combination of artificial lighting and natural lighting filtered through selective energy saving windows. Smart control of lighting senses people and improves energy efficiency by switching off or dimming the lighting to the level needed. Illuminance or colour sensors provide feedback either to adjust lighting to maintain constant lighting level, or to adapt it under varying outside lighting conditions. Similar smart lighting systems are also used for exterior applications, such as road lighting, where the road luminance is the target quantity in the case of motorised traffic.

However, designing and implementing smart lighting involves several methodological challenges. The incident light is a spectral and spatial composition of exterior light coming through windows and artificial light produced by solid state lamps, thus, the spectral and spatial properties of the light change along the day. The spectrum of the mixed light is further affected by the transmittance of the windows and the reflectance of the walls, ceilings and floors. Modern windows have selective coatings to reduce heat loss of buildings, which also changes the spectral and directional properties of the light being measured in the visible region. Therefore, measuring smart lighting systems requires challenging measurement techniques and devices.

Smart lighting is not only about saving energy; it is also about good lighting. There should be a balance between energy saving and human visual comfort. One often overlooked part of smart lighting are the sensors used in lamps and luminaires Therefore test procedures or acceptance criteria for presence, light level, and colour sensors are still missing.

The frequency of replacing lamps is a key issue in energy efficiency and an environmental concern. Short lifetimes reduce the overall energy efficiency of lighting. Lifetimes may be affected by smart control of lamps and luminaires. Dimming or switching solid state lamps on and off frequently because of traffic situation or presence of humans may affect the lifetimes, but the effect is not well known. Detecting the need to change a lamp or to estimate its remaining or expectable life time is also challenging. Thus far, the effect of smart control on the lamp lifetimes has not been studied and there is no method for predicting lamp lifetime.

Currently there is no reliable protocol to assess the real performance of smart lighting systems. Furthermore, the varied quality metrics for energy efficiency of buildings is not verified and their consistency is not studied. The EC are requesting the European Standards Organisations to develop Standards in a related area [1].

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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 smart lighting both indoors, in energy efficient buildings, and outdoors, to ensure road safety with reduced energy costs.

The specific objectives are

1. To survey the metrological specifications of the factors and conditions affecting smart lighting being used as input for indoor and outdoor smart lighting performance metrics. Factors to be surveyed shall include properties of transmissive and reflective surfaces, light sources, and sensors. Conditions to be surveyed shall include lifetime with smart control, discomfort glare, and disability glare. In addition, to identify the need and carry out measurements of relevant factors and conditions.
2. To develop measurement, calibration and testing methods for smart lighting. This shall include i) radiometric and photometric measurements in cylindrical and semi-spherical coordinate systems; ii) the use of LED calibration sources; iii) the measurement of spectral and spatial light conditions; iv) the use of handheld instruments for spectra and flicker; v) test methods and criteria (both optical and electrical) for control systems and vi) develop a method for predicting flux maintenance of solid state lamps or measuring their aging for better servicing.
3. To develop reliable measurement protocols to assess the real performance of smart lighting systems in terms of i) energy use, ii) energy costs, iii) CO_2-emissions and iv) user-experienced lighting comfort including flicker, glare, and quality of light.
4. To apply and demonstrate the developed methods and protocols by i) verifying the quality metrics of lighting for energy efficiency of buildings, especially in different working conditions and with changing conditions; ii) testing the new smart lighting assessment protocol in a building equipped with smart lighting solutions; and iii) testing the quality metrics of energy efficient road lighting.
5. To facilitate the take up of the project outputs, including an improved quality metrics of lighting for energy efficiency of buildings, by stakeholders from e.g. lighting and building sectors. In addition, to disseminate the new measurement protocols to organisations developing national and international building energy regulations and standards e.g. ISO TC 274, and road lighting standards.

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 research goes beyond this. In particular, proposers should outline the achievements of the EMRP projects ENG05 Lighting and ENG62 MESaIL and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the lighting 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 EMPIR 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.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] M/519, Mandate addressed to CEN, CENELEC and ETSI to develop standardisation in the field of light emitting diodes (LEDs), 2013