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

Selected Research Topic number: **SRT-s10**
Version: 1.0

Title: Metrology infrastructure for characterisation of electric vehicle charging stations

Abstract

According to EU strategy on climate neutral Europe, or the European Green Deal, electromobility remains the best solution to achieve the climate and industrial ambition of the European Green Deal for transport. With the ongoing integration of Electric Vehicles (EVs), EV Charging Stations (EVCSs) are a key element in facilitating electromobility development. However, at present there is no appropriate metrological infrastructure to support the European EVCS industry. This project will develop a European network of laboratories and on-site metrology services and facilities necessary for the development of an EV charging infrastructure in support of the EVCS industry, fair trade metering of energy, smart charging and vehicle-to-grid (V2G).

Keywords

electromobility, electric vehicle, charging station, energy metering, efficiency, electrical metrology, vehicle-to-grid, EV-battery state-of-charge/state-of-health, bidirectional transfer, EV impedance, smart charging, grid disturbances

Background to the Metrological Challenges

Sales of electric cars in Europe surpass 1,2 million in 2021 and now represents over 10 % of the total new car market. Since 2010, the number of models offered, the size segment coverage, the number of registrations, the electric vehicle market share and available recharging infrastructures have increased significantly. To boost this development, a significant infrastructure of EVCS is being rolled out in Europe. However, related metrological framework and regulatory measures to support the EVCS industry are missing. The EVCS regulations widely differ across the EU countries, ranging from very well-developed national regulations to hardly any. In general, to measure the energy transferred to the EV, the EVCS should incorporate an electrical energy meter meeting the requirements of 2014/32/EU Measuring Instruments Directive (MID) and have an EU type examination certificate. However, this approach does not fit with the optimal design for mass manufacturing and operation required for the development of an ECVS infrastructure where the electricity meter needs to be integrated as an electronic component in the ECVS. Thus, there is a need for specific regulation for the ECVS as a measurement instrument. Besides, the charging conditions of the EV are very specific (e.g. AC and DC, at slow, medium, fast charging, smart charging, V2G) and need to be considered. A common European regulation ensuring fair trading of the products is fundamental and urgently needed to support the e-mobility industry. The development of this regulation calls for metrological research support and the establishment of an integrated European metrology infrastructure. The legislation needs on EVCS are stated by OIML TC 12, and its specific subgroup created to establish appropriate metrological regulations for electric vehicle charging stations. This OIML working group has started a project to elaborate an OIML guide concerning EVCS on a very short time scale, as a first step towards the publication of a new OIML International Recommendation on electric vehicle charging systems. This research topic is also supported by WELMEC WG 11 and its subgroup for electrical energy meters. This subgroup has confirmed that there is a very strong need for harmonised regulation for EVCS across Europe. Recently, WELMEC WG 11 created a mandate for a new ad-hoc group to develop EVCS guidance. Practical and technical knowledge is needed to complete this guidance.

Pushed by the fast developments in the electromobility, there is an urgent need for traceable measurements to support accurate EVCS metering, determine the losses, and support its incorporation in the grid, guaranteeing the Power Quality (PQ) and the optimal management of the energy incorporating functions in EVCS as Vehicle-to-Grid (V2G) capabilities especially for DC charging, smart charging and fair energy trading. EV charging technology currently undergoes rapid development. For instance, the charging power of fast

charging keeps increasing, at present to levels as high as several hundreds kilowatts; charger architectures have evolved to accommodate such increasing power levels, encompassing neutral point clamped, interleaved, and dual active bridge arrangements. Furthermore, bidirectional charging, enabling V2G power flows, tries to minimise the impact of EV charging on the grid and to support the grid by load balancing and frequency and voltage regulation. These developments involve sudden changes of operating conditions and switching patterns, and besides negative impedance values, they strongly complicate the accurate measurement of the total net energy transfer and the charging losses.

Up to now, there is no specific metrological infrastructure nor traceable methods for EVCS characterisation, including energy losses and PQ parameters. Energy transfer efficiency is based on energy and power measurements used for electricity metering. However, the charging station constitutes a very specific and different transfer of energy from the grid to the EV (and from the EV to the grid) that requires the development of specific metrology considering several contributions, such us different working modes (AC and DC, at low, medium and high-power charging) and real working conditions (including grid disturbances and dynamic EV impedance). During the last years, in the context of power and energy related research and development, a great effort has been made to transfer from analogue to digital power metrology, within projects such as EMRP ENG04 SmartGrid, EMPIR 16ENG04 MyRailS, EMPIR 16ENG08 MICEV, EMPIR 17NRM01 TrafoLoss, EMPIR 17NRM02 MeterEMI, and EMPIR 18NRM05 SupraEMI. However, even though these projects have made significant progress with respect to the state of the art, they have not resulted in the required infrastructure for EVCS. The digital technology and the knowledge acquired within these projects should form the basis for the development of the necessary metrological methods and techniques for EVCS characterisation.

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 Electronic Vehicles Charging Stations (EVCSs).

The specific objectives are

1. To determine on-site operating conditions and charging process for different types of EVs including smart charging and vehicle-to-grid (V2G). To carry out on-site measurement campaigns at different charging power levels (low, medium, high) considering the EV-battery state-of-charge and state-of-health. To develop instrumentation for investigation of the relevant background grid disturbances, the conducted emissions up to 150 kHz induced by the switching power electronics in the charger or EV, and the dynamic EV impedance during charging at a large variety of environmental conditions.
2. To develop metrological infrastructure for accurate EVCS evaluation of energy metering and energy losses under real operating conditions. This should include developing methods for characterisation of EVCS for different charging modes at AC and DC (at low, medium, and high power), covering smart charging, bidirectional transfer of energy (G2V and V2G), and the influence of real working conditions (e.g. temperature, grid distortion), with target uncertainties of 0.1 % for power and 5 % for losses, (with respect to nominal power) for voltages up to 800 V, currents up to 500 A and charging power levels up to 350 kW.
3. To develop metrological infrastructure for on-site verification and simplified laboratory testing of EVCS energy metering, ensuring accurate measurement at minimum cost, including smart and bidirectional charging. This should include developing simplified methods, procedures and instrumentation for laboratory testing and for on-site verification with a target uncertainty of at least 0.5 % for power.
4. To demonstrate the establishment of an integrated European metrology infrastructure and to facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (e.g. NMIs, accredited laboratories), standards developing organisations (e.g. CLC/TC 13, IEC/TC 13, OIML/TC 12) and end users (e.g. EVCS/grid operators, EV/EVCS manufacturers).

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 work, the involvement of the larger community of metrology R&D resources both within and outside Europe, plus engagement with existing European research infrastructures and European Partnerships is recommended. A strong industry

involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry and end users.

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 EMRP ENG04 SmartGrid, EMPIR 16ENG04 MyRailS, EMPIR 16ENG08 MICEV, EMPIR 17NRM01 TrafoLoss, EMPIR 17NRM02 MeterEMI, and EMPIR 18NRM05 SupraEMI, and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.9 M€ and has defined an upper limit of 2.6 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 25 % 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,
- Develop an integrated self-sustaining European metrology infrastructure,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the transportation 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 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.