

## **Title: Metrology for electric vehicle charging systems**

### **Abstract**

Electrical Vehicles (EVs) and a growing EV charging system (EVCS) infrastructure are essential to the European Commission's plans to build a competitive and sustainable transport system by 2050. However, as EVCSs push the limits of energy transfer technology, suitable methods and standards for their evaluation are needed. Traceable metrological methods, together with harmonised European regulation and standardisation, need to be developed for independent performance evaluation of EV charging systems. This will ensure accurate metering and efficiency and allow the characterisation of grid distortion caused by EVCS under realistic operating conditions.

### **Keywords**

Electromobility, electrical vehicle, EV charging system, EV charging station, metering, performance evaluation, conformity assessment, power quality, efficiency assessment

### **Background to the Metrological Challenges**

All EU Member States have committed to achieving climate neutrality by 2050, pledging to reduce emissions by at least 55 % by 2030, compared to 1990 levels. Transport emissions account for around 25 % of the EU's total greenhouse gas emissions and by 2030, it is expected that there will be at least 30 million zero-emissions cars and 80,000 zero-emission lorries in operation. EVCSs are key to facilitating electromobility development and therefore the EU 'Alternative Fuels Infrastructure Directive 2014/94/EU' and 'Proposal of a new Regulation for the deployment of Alternative Fuels Infrastructure (AFIR)' have taken measures to increase the number of recharging points, and to ensure that they have a standardised design and use. However, important metrological tools and infrastructure are needed to support the performance evaluation of EVCS, including ensuring the accurate metering of EVCS, demonstrating minimum energy transfer efficiency, and demonstrating the maximum levels of disturbances injected in the grid.

In order to conduct performance evaluations on EVCS, it is vital to define their operating conditions and hence a representative set of test conditions. Harmonic and supra-harmonic disturbances in the grid and local grid impedance can both affect metering accuracy and efficiency. The variety of charging modes (slow, medium, fast, smart charging and Vehicle-to-Grid (V2G)) and the impedance of the connected EVs also have an effect.

Existing metrology standards for power and energy focus on DC/AC measurement around 50 Hz under static conditions, with power quality limited to distortions up to 2.5 kHz. EVCSs are pushing energy transfer to its limits to quickly charge EV batteries, using switching mode power electronics with switching frequencies up to 150 kHz. The current, voltage and power levels seen at EVCSs are therefore far beyond the intended use of metrology standards currently available at NMIs, a problem further compounded when multiple EVCSs are co-located.

Both OIML TC12 and WELMEC WG11 have initiated sub-groups to work out detailed guidance for metering accuracy for EVCS. This is because current requirements do not fully cover the behaviour of EVCS in different operating conditions, in particular, immunity to supra-harmonic distortion coming from the grid and to grid impedance dynamics in the frequency range up to 150 kHz. Presently, general requirements on power quality parameters can be found in EN 50160 and IEC 61000-3-2 but these lack the required level of detail with respect to supra-harmonics in the frequency range up to 150 kHz for EVCS evaluation. Thus, conformity assessment based on these standards is insufficient for distribution grid operators to judge whether installation of a specific type of EVCS in the grid is acceptable or not.

Finally, EU efficiency targets and EVCS operators require their equipment to have the highest possible energy transfer efficiency. But there are currently no standardised methods for this type of performance evaluation for EVCS in real operating conditions. To ensure public confidence in the metering of EVCS, periodic verification

is also required to demonstrate that metrological performance is maintained over time. Therefore, traceable methods and accurate field reference instruments are needed for on-site verifications.

## Objectives

The JRP shall focus on the development of metrology capabilities for the traceable evaluation of EVCS under realistic operating conditions.

The specific objectives are

1. To define representative on-site operating conditions for EVCS and use them to characterise local grid disturbances and local grid impedance up to 150 kHz under live grid operation. In addition, to develop dedicated equipment for sites with a variety of (i) chargers, (ii) operating modes and (iii) charging power levels.
2. To develop traceable methods and measurement standards for the characterisation of EVCS under representative operating conditions for both AC and DC charging, at low, medium, and high-power levels and in accordance with IEC 61851-1. This will include the evaluation of (i) metering accuracy and energy transfer efficiency with a target uncertainty of 0.1 % (with respect to nominal power) for voltages up to 800 V, currents up to 500 A and charging power levels up to 350 kW and (ii) generated conducted emissions up to 150 kHz. Methods will also be applicable for a variety of test scenarios including smart charging, bidirectional transfer of energy (G2V and V2G), dynamic loading and different levels of grid distortion and grid impedance.
3. To develop the required metrological infrastructure for on-site verification of EVCS energy metering, in support of legal metrology and acceptance testing, with a target uncertainty of 0.5 %. This will include the development of reliable methods for EVCS energy metering evaluation based on commercially available equipment, which have been validated under representative operation conditions, including smart charging and bidirectional energy transfer.
4. To facilitate the uptake of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (IEC TC 69, WELMEC WG 11, OIML TC12/p3, EC WgMI E01349), and end users (e.g., EMN Smart Electricity Grids, EMN Clean Energy, EVCS operators, grid operators, EVCS manufacturers).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

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 projects 16ENG04 MyRailS, 17NRM02 MeterEMI and 19NRM05 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 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 35 % 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the energy and transport sectors.

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.