**EMPIR Call 2019 – Energy, Environment, Normative and Research Potential**

Selected Research Topic number: **SRT-g02**
Version: 1.1

# Title: Metrology for DC electricity grids


## Abstract

The uptake of renewable energy sources (RES) and electric vehicles (EV) has increased the potential for local DC grids to act as an energy efficient alternative to traditional AC distribution networks. The reduction of power conversion between DC and AC will reduce the distribution of harmonics and improve voltage control in distribution networks. This requires the development of a metrology infrastructure for DC electricity distribution grids, to support the further development and installation of these grids. The use of real-world DC trial grids would enable the metrology gaps and operational issues to be addressed.



## Keywords

Electricity grids, DC grids, DC metering, DC power quality, energy efficiency, DC voltage sensors, DC current sensors


## Background to the Metrological Challenges

The shift towards renewable energy sources has seen an increase in the attractiveness of DC grids. Many sustainable technologies (such as LED lighting, photovoltaic cells and electric vehicles) are fundamentally DC which requires an inefficient step of power inversion when connecting to the AC grid. Metering of electricity is currently well regulated for AC grids however grid operators and meter manufacturers are in urgent need of regulation for metering of DC grids. The applications of DC power are very broad with a variety of voltage levels, ranging from residential and business buildings to hospitals, agriculture, lighting, electrified transportation, data centres and telecommunication. These different voltage levels lead to the inevitable use of DC-to-DC converters which have their own inefficiencies and characteristics which need to be determined. In 2018, IEC TC38 issued two new standards (IEC 61869-14 & 15) on specific requirements for DC current and voltage instrument transformers. These standards deal with ripple bandwidth, fast response, accuracy, stability in time, dependence on ambient conditions, and other specific requirements. However, standardisation for type testing of watthour meters is still only available for AC. IEC TC13 WG11 has established a project team that is developing a technical report 62053-41 on DC metering however the WG needs the missing traceability infrastructure.

Standardisation of DC grid control currently focusses on installations, wiring rules, safety for users (shock, burns) and equipment (discharges), voltage levels and detection of faults and the metrology aspect of DC grids is lacking. The equipment used in DC grids has new and challenging features but the PQ issues (e.g. current and voltage ripple, inrush currents, voltage fluctuations and short circuit events) associated with this equipment are currently treated as AC phenomena. These PQ parameters need to be reliably measured and defined in a real DC grid and measurement techniques developed to provide traceability for DC PQ parameters. Some initial standardisation work on DC power quality has been done. CLC TC8X is currently working on the definition part of the PQ parameters such as short circuit events, current and voltage ripple, inrush currents, voltage fluctuations, voltage dips and swells and interruptions, voltage fluctuations as well as DC adaptable AC parameters defined in IEC61000-4-30 Ed.3. However, the behaviour of DC grids is not very well understood, and the corresponding measurement techniques are needed. DC cables have lower voltage drop and more thermal capacity, so longer cables can be used and less substations are necessary. Furthermore, it is easier to reinforce distribution networks to meet for example EV demand. The use of DC power in domestic properties and the reduction of power conversion between DC and AC will reduce disturbing harmonics and improve voltage control in distribution networks. Finally, direct use of DC power will make battery storage schemes more viable. There are currently several trials of DC grids in place, including an industrial site in the Netherlands, local DC grids in Denmark and Finland and a Smart grid in Spain. However, at present, the operators of these trial grids are unsure as to the extent to which the claims above can be verified. These potential improvements need to be quantified.


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The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

## 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 PQ parameters to support the further development and employment of DC grids.

The specific objectives are

1. To develop measurement techniques for DC power, at voltage and current levels up to at least 1 kV and 800 A respectively, with target uncertainties below 0.01 % taking into account the presence of AC ripple and other disturbances. These techniques should apply to low voltage DC grids used in high-current DC charging of electric vehicles and corresponding DC current and voltage transducers and provide input into IEC 62053-41.
2. To perform and analyse on-site measurements in real DC grids to determine PQ parameters such as short circuit events, current and voltage ripple, inrush currents, voltage fluctuations, voltage dips and swells and interruptions as well as DC adaptable AC parameters defined in IEC 61000-4-30 Ed.3.
3. To develop measurement techniques for defined power quality (PQ) parameters in DC grids to provide traceability for DC PQ parameters for input to IEC TC8 WG01.
4. To determine the extent to which DC grids a) reduce losses by localisation b) have improved voltage drops c) reduce the number of substations d) improve the management of reactive power and PQ e) ease implementation of renewable energy sources f) reduce distribution losses.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs, calibration laboratories), standards developing organisations (IEC TC8, IEC TC77) and end users (electricity generators, network operators, utility companies).

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.

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 across all selected projects in this TP.

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 energy 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.