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

Selected Research Topic number: **SRT-g12**
Version: 1.0

Title: Metrology for Smart Energy Management in Electric Railway Systems

Abstract

The overall annual energy consumption of the European railway system is 36.5 TWh and reduction of this consumption will contribute to the ambitious target of reducing specific CO_2 railway transport emissions. Distribution and transmission grids require accurate metrologically characterised measurement systems as an essential tool for smart energy management and the challenge of this SRT is to develop energy exchange traceable measurements methods and reliable system monitoring under strongly variable electrical conditions currently faced by the railway systems. This SRT also focuses on the characterisation of the railway subsystem as a producer-consumer, with a view to its integration in a wide smart grid and the assessment of eco-driving performances.

Keywords

Railway, energy efficiency, energy metering, power quality assessment, eco-driving, reversible substation, energy braking, dynamic measurement conditions, harsh environment, calibration system

Background to the Metrological Challenges

According to recent studies on sustainable and intelligent management of energy for smarter railway systems in Europe, there are major concerns on the voltage and current systems currently supplied to the railway systems. Poor power quality on the railway system can cause resonant overvoltage causing damage to the insulators and transformers and leading to costly maintenance, unreliability, cancellations and delays. Circulating harmonic currents give rise to energy losses and overheating in transformers and other assets and voltages supplied to trains are often distorted harmonically at a higher rate when compared with the usual electricity network. Currents drawn by trains also contain high levels of harmonics, inter-harmonics, ripple and step changes in magnitude associated with train acceleration and braking. The combination of these effects result in the accurate determination of real-time power consumption, cumulative energy, efficiency and metering causing significant challenges.

The European Commission has regulated energy measurement/billing through two Technical Specifications for Interoperability, one related to the “energy” subsystem and the other on rolling stock. By 2019, Member States must have implemented an on-ground data collection system for billing based on energy metering and EN 50463-2 gives requirements for current/voltage sensors and energy calculation functions. In several parts, it adopts the requirement given for energy measurement for fixed installation working at 50 Hz. This is a crucial point if the dynamic effects of a railway supply system are considered (e.g. catenary pantograph contact). In respect of active and reactive energy, no information is given on the data processing algorithms adopted in the energy measuring system; and calibration issues and the need for agreed calibration procedures are still unresolved.

An accurate knowledge of real-time power quality of the railway supply system is a valuable tool to foster the efficiency of the whole railway system and success in addressing these challenges will significantly influence different aspects relevant to metrological, technical and societal challenges. The development of methods to support the implementation of Reversible DC Substations would contribute to the reduction of energy consumption and to the smart management of the whole electrical system. The identification of calibration and periodic verification procedures widely recognised at the European level would simplify the bureaucratic burden and the identification of a detailed power quality definition reached by a consortium that involves European NMIs, infrastructure managers and rail operators will facilitate the development of standards, optimises the railway infrastructure usage and underpin the development of the interoperability.

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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 development of the metrological framework and measurement infrastructure that underpin the adoption of energy efficient technologies in European railway systems.

The specific objectives are

1. To develop a metrological framework (comprising laboratory and on-board train calibration / measurement set-ups and robust data processing algorithms) to enable high accuracy power-quality measurements and to approach the uncertainty limits stated in the EN 5463-2:2013-05 for the energy measurements also under highly dynamic electrical conditions. All major European supply systems (25 kV/50 Hz, 15 kV/16.7 Hz, 3 kV/DC, 1.5 kV/DC, 750 V/DC and 600 V/DC) will be considered.
2. To develop a wide-area real-time power quality monitoring architecture. This will include data processing algorithms, power quality indices, centralised data collection for quantifying the efficient use of the railway infrastructure, and diagnostic studies and merging the results against circuit models (including resonance effect at higher harmonic frequencies).
3. To set-up combined measurement-simulation tools. This will include predicting the impact of new Reversible DC Substations on both the railway system and the medium and high voltage supply grid side. The tools will be integrated with real time eco-driving strategies to allow efficient real-time management of power flows and will be applied to real test cases.
4. To analyse, to develop and to implement validated real-time eco-driving algorithms to optimise the speed profile and to reduce the energy consumption for a given train journey. This will include developing traceable measurements of energy savings by the actual implementation of the eco-driving algorithms.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories), standards developing organisations (EN, ISO) and end users (train manufacturers, railway 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 research goes beyond this. In particular, proposers should outline the achievements of the EMRP projects ENG04 and ENG 52 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 railway 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.