EMRP Call 2013 – Energy and Environment

Selected Research Topic number: **SRT-g16**
Version: 1.0

Title: Sensor network metrology for the determination of electrical grid characteristics

Abstract

Metrology for Smart Grids is becoming increasingly important as centralised passive generation is replaced by active distribution networks where energy is fed in at the Low and Medium Voltage (LV and MV) levels. Knowledge of the topology and power flow of such grids is limited, but will become vital to enable effective grid control and continuity of supply.

Mathematical and statistical procedures and security measures are required for advanced measurement sensor networks used for grid monitoring and control. Such procedures will minimise the need for costly instrumentation. In addition, techniques must be developed to determine the structure of existing grids and to optimise their use of distributed generation and controllable loads.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on "Grand Challenges" related to Energy and Environment on pages 23 and 24.

Keywords

Sensor Networks, State Estimation, Electricity Distribution Grids, Measurement Optimisation, Information Security, Power Flow, Phasor Measurement Units, Sensitivity Analysis

Background to the Metrological Challenges

Traditional electricity distribution consists of centrally managed passive grids; however the need to integrate renewable generation has led to the development of active distribution grids where energy is fed in at the LV and MV levels. Knowledge of the voltage levels and power flow at nodal points and branches in distribution grids is required in order to determine the generation requirements and to control the power flow using generation and demand side management. With the large number of nodal points in distribution networks it is impractical and uneconomical to measure at every node and branch. A compromise must be reached between the cost of purchasing and placing a large number of sensors and the accuracy of the knowledge about the state of the grid.

This approach leads to a need for a sensor network that is optimised to provide the necessary information to effectively control the Smart Grid at the distribution level, while minimising the cost of the required sensors. Supervised control and data acquisition (SCADA) systems are only suited to centrally managed grids. These systems treat the MV and LV distribution networks as "black boxes" and little is known about the power flow and often even the topology of these networks. As such, new metrological techniques are required to ensure observability of these grids and enable their effective control. These techniques must expand on traditional metrology, which is focussed on individual measurements, and address the additional challenges when multiple simultaneous measurements are required. The distributed measurement system must be treated as a whole. Recently developed state estimation and measurement placement methods have been shown to lend themselves well to this purpose. However, existing procedures employ simple random walk models for the system state dynamics without assessment of their applicability and they assume exact knowledge of the network topology and line impedances.

It is essential that the data flow between all components of sensor networks is secure and reliable as it is impossible to have a measurement system without a secure means of communication. To address these issues the European Commission has issued a mandate to the European Standardisation Organisations to support European Smart Grid deployment[1] Smart Grid measurement systems must fulfil the requirements of the mandate, and the implications of security measures on the uncertainty of sensor networks and their dynamic behaviour must be addressed.

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on the traceable measurement and characterisation of sensor networks used for grid monitoring and control.

The specific objectives are

1. To develop and test sensor network metrology algorithms for state estimation and optimal sensor placement. The algorithms should be applied to actual LV and MV grids.
2. To investigate the use of Phasor Measurement Units (PMUs) for power flow calculation and state estimation in LV grids.
3. To develop a distribution network model to determine uncertain distribution network topologies and line impedances and verify existing models using a series of on-site measurements and state estimation techniques.
4. To apply Smart Meter data to network state estimation. This will involve investigating how low accuracy Smart Meter data can be aggregated to provide a similar or greater level of understanding of the grid state as measurements made at the MV level.
5. To implement and validate a secured distributed measurement system in LV microgrids in order to address the impact of security measures in the measurement system on the metrological requirements and uncertainties.

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 R&D work, the involvement of the user community such as industry, and standardisation and regulatory bodies, as appropriate, is strongly recommended.

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 EMRP project ENG04 “Metrology for Smart Electrical Grids” and how their proposal will build on those.

EURAMET expects the average size of JRPs in this call to be between 3.0 and 3.5 M€, and has defined an upper limit of 5 M€ for any project. The available budget for integral Research Excellence Grants is 30 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (e.g. letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies.
- transfer knowledge to the energy network sector.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased

- outside researchers & research 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/490 Smart Grid Mandate: Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment