Title: Applications for turning smart grid measurement data into actionable information

Abstract

In order for utility companies to be able to monitor and control smart grids, so that they can cope with the instability issues associated with renewable energy sources (RES), actionable information is required. Currently, phasor measurement units (PMUs) are used by grid operators to provide real-time monitoring of abnormal grid dynamics and for post-mortem fault analysis. However, the huge volume of data from multiple locations can overwhelm end-users and this is compounded by a limited number of data analysis tools available. The data is also, often of variable quality with missing or spurious results, and beset with noise leading to high uncertainties. Therefore, new validated and traceable data processing, statistical and uncertainty analysis methods are required to convert large volumes of Smart Grid measurement data into actionable information.

Keywords

Electricity grids, smart grids, synchronised data, renewable energy sources, phasor measurement units, power quality

Background to the Metrological Challenges

The detection of abnormal events in response to faults or changes to electricity grid dynamics is vital for utility companies, in order to safeguard power supply. Real-time actionable information on accurate fault locations and levels is necessary for reducing grid down time and blackouts. However, false alarms can be as destructive as real events, leading to erroneous control actions and possibly cascading grid failure. Despite this, utility companies currently suffer from a lack of traceable metrics and associated statistical confidence levels that they can use as alarms and inputs for grid control systems.

With declining levels of traditional synchronous power generation, so the levels of RES in our electricity grids has increased. However, the power converters used by RES have difficulty locking-on to a stable grid frequency, and with high levels of RES they start to synchronise to each other and desynchronise the wider grid. Instead of exchanging power with loads, power convertors exchange power with other RES, leading to sudden and potentially serious power oscillations propagating over hundreds of kilometres. These low frequency power waves can build-up in seconds and produce large amounts of power leading to grid failure. This has already been experienced in Ireland, where wind generation must now be limited to approximately 50 % of grid capacity in order to safeguard supply.

As higher levels of RES are introduced in electricity grids, so parts of the grid will become overloaded for short periods. To address this, utility companies can either invest heavily in installing new substations to reinforce their network against short-term peak power, or they can use advanced data processing and analysis of real-time data to better monitor and control power levels. PMU data can already be used to dynamically monitor real-time power flow in electricity grids. However, PMUs also produce huge volumes of data, and validated data analysis techniques for converting PMU based data into actionable information are currently lacking.

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 monitoring of smart grids and their ability to absorb RES without instability issues.

The specific objectives are:

1. To develop traceable applications for grid monitoring and control, based on PMU data, from electricity grids containing significant renewable energy. The applications should use real synchronised data for event detection, in order to be able to distinguish real grid events from normal grid behaviour, including correlating grid events and bad power quality with RES generation.
2. To develop validated measurement algorithms for the detection and analysis of (non-synchronous) power oscillations using synchronised smart grid data. This should include the use of big data analytics and data mining in order to determine the contribution of increased RES uptake to power network oscillations and instabilities.
3. To reliably measure power system inertia in the presence of power system anomalies by applying estimator methods to PMU data. The goal is to balance grid energy in the presence of significant RES by providing actionable information to fast frequency response control schemes.
4. To develop validated real-time applications (i) for dynamic line rating in order to allow increased RES generation in electricity grids, and (ii) for fault level and fault location in order to minimise the duration of grid black outs.
5. To disseminate and facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations and bodies (CENELEC, IEC TC 8, the European Network of Transmission System Operators) and end users (e.g. energy utility companies, renewable energy providers, Supervisory Control and Data Acquisition (SCADA) system users). In addition, to support the European Metrology Network on Smart Grids.

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. In particular, proposers should outline the achievements of the EMRP project ENG52 Smart Grids II and the EMPIR project 15NRM05 ROCOF and how their proposal will build on 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.

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 electricity and renewable energy 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 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.