Finanziato dall'Unione Europea - NextGenerationEU a valere sul Piano Nazionale di Ripresa e Resilienza (PNRR) – Missione 4 Istruzione e ricerca – Componente 2 Dalla ricerca all'impresa - Investimento 1.1, Avviso Prin 2022 indetto con DD N. 104 del 2/2/2022, dal titolo ««Next-generation distributed synchronized measurement systems for smart grids with self-diagnostics capabilities and self-improvement of information quality», codice proposta 2022RYZJT9_002 - CUP J53D23000850006

Project Description

PRIN 2022 – Lorenzo Peretto

State of the Art and motivations

Due to the proliferation of new architectures of distribution networks (ac and dc power lines with different nominal voltages and with increasing penetration of distributed renewable generation), the number of measuring devices deployed in the networks is exponentially increasing. A common terminology for defining such novel and modern power networks is "Smart Grid (SG)". Measured quantities include: electrical quantities (voltages and currents, harmonic distortion, powers, energies, loss factors, partial discharges, etc.), environmental quantities (temperature, humidity, ozone, flooding, solar irradiation, wind, dust, pressure, Dissolved Gas (DGA) in power transformers, etc.), Boolean quantities (state of reclosers and switches, etc.).

All such quantities will require that many sensors and instruments are deployed in the whole network, like:

- smart meters featuring more and more complex and complete set of measurements, including active, reactive, apparent powers in the loads/generators/prosumers' sites, Power Quality (PQ), high-frequency disturbances detection, partial discharge detection, etc.;
- advanced synchronized measurement devices, such as Phasor Measurement Units (PMUs), which were originally conceived for high voltage transmission networks, but are now available at an affordable cost also for Medium Voltage (MV) distribution grids;
- Low-Power voltage and current Instrument Transformers (LPITs), which are going to be widely installed in several nodes of the MV distribution systems, due to higher bandwidth, compactness in size and lightness in weight, as well as lower prices compared to inductive conventional ITs;
- a large number of heterogeneous sensors and instruments (for environment data and network operation readings) that will be installed in the context of Internet of Things (IoT).

In addition, other non-measured data, e.g. weather forecasts, will be used and merged along with all other data from the field for improving the power network reliability and control.

As a consequence, massive volumes of data will be generated every second in SGs.

The main concept to be taken into account is that this huge amount of data becomes actual information and knowledge (which means that decisional tasks can rely upon them) only when they are accompanied by an indication about their quality.

Project Description

The first step of this research project therefore consists in assessing the impact on information quality of each measurement device (instrument transformers, sensors, meters, relays, etc.).

Then, the study of their combined effects is performed. By considering the size and heterogeneity of the available data, which are characterized by different nature, accuracy, synchronization, measurement rate, etc., a new approach is required to merge traditional methods, based on the propagation of uncertainty, with new techniques needed suitable for big data analytics.

On this basis, at first a low-cost synchronized measurement system with capabilities to work in a network of instruments will be developed; then a smart self-improving measurement system will be defined and studied to actively supervise and optimize the quality of the information, as well as to solve contingencies and criticalities.
To reach these goals, the project is divided into three 3 main work packages (WP):

- WP1 Review of all kind and typologies of data available in Smart Grids for power networks observability;
- WP2 Design of a low-cost synchronized measurement system for voltage and current phasor measurements;
- WP3 metrological characterization of the developed synchronized measurement system and uncertainty propagation analysis in a distributed measurement system scenario.