

# **Integration of electric vehicles into microgrids and distribution grid**

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## **Research program**

The central theme of the research activity concerns the integration of electric vehicles (EVs) into microgrids and distribution grids. EV charging stations play a fundamental role in the diffusion process of EVs, especially microgrid architectures that integrate Renewable Energy Resources (RES), Battery Storage Systems (BESS) and charging stations. In literature, this architecture is the most promising one for its several fields of implementation. Vehicle-to-Grid (V2G) technology is an essential part of this process of integration, because EVs could be seen as an additional storage system, able to exploit different operating modes. The potential lies in the possibility to coordinate all the resources by means of optimization algorithms, in order to achieve economic and technical targets, and to enable the microgrid to different functions, such as active power support for power grids, peak shaving and load shifting control, voltage and frequency regulation.

The control of microgrid is entrusted to the Energy Management System (EMS), able to set optimal level of power exchanges among components, depending on economic and/or technical targets. In microgrids with EV charging stations, intermittent sources, like photovoltaic and wind, and intermittent loads (EVs), energy management procedures take places in several stage. Day-Ahead scheduling aims at programming resources 24 hours in advance, on the basis of assumptions and forecasts (PV availability or wind power production). Real-Time programming aims at minimizing deviations of the actual state from the planning. Real-time applications are included in ICT field: Smart Grids are designed to adapt to consumer consumption levels, and this requires the collection of real-time data from a large number of smart meters. The network must also be able to process that data and make changes based on it, in a near real-time operation. Moreover, the use of predictive algorithms on the consumption of network loads is useful for this type of operation. One of the objectives of the research is to apply energy managements techniques and procedures to microgrids that integrate EVs charging stations, then including also Fast Charging Stations and Ultra-Fast Charging Stations.

Smart Grid concept plays a fundamental role in industry 4.0 framework in integrating renewable resources into industrial sites and power grid, by means of information and communication technologies aimed at increasing reliability, stability, and efficiency of the

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system. Moreover, the virtual power plant (VPP) concept represents a promising solution for the integration of controllable industrial assets and RES. One of the topics of the research activity could be aimed at investigating the integration of industrial plants into the electricity market framework for the provision of ancillary services, investigating different offer strategies and comparing them by means of economic and technical indicators.

Monitoring and measurement systems of smart grids represent one of the Industry 4.0 milestones. Therefore, it could another research topic to analyze a smart metering architecture in all its features, for the acquisition of measurements and the communication of component control commands. A study of the communication systems of the measurement and control devices could be a predominant part of the research, in order to have the possibility to develop a proper one. The system developed could be eventually tested on the Polytechnic microgrid or applied to an industrial architecture.