Case study

Network reconfiguration and energy storage systems real-time dispatching for a more sustainable power system operation

The challenge

Renewable Energy Sources (RES) are the main driver of the ongoing energy revolution all over the world. In order to manage RES, electric networks infrastructure and the relevant regulatory/market frameworks need to be properly updated. InteGRIDy (www.integridy.eu) is one of the H2020 projects activated by EU Commission with the aim of identifying adequate approaches to manage this revolution.

Within the InteGRIDy project, the San Severino Pilot involves the medium voltage distribution grid of San Severino Marche, a small town in the center of Italy, managed by the local Distribution System Operator (DSO) ASSEM SpA. The pilot is based on three InteGRIDy pillars (Demand Side Management, Energy Storage and Smart Grid) and involves a few Italian partners: ASSEM SpA, Politecnico di Milano, UNE and E@W.

The project aims at performing an optimized reconfiguration of the medium voltage distribution network and at exploiting distributed Energy Storage Systems (ESSs) for the provision of ancillary services to the electricity market.

In the demonstrator, an already existing Smart Grid architecture is exploited, which has been displaced on the distribution network by a past experimentation promoted by the Italian Energy Authority. Thanks to this architecture, the DSO's control center has been equipped with a SCADA able to manage innovative functions, such as the real-time monitoring of grid parameters, the active and reactive power control of dispersed generation, generators remote disconnection, advanced protection techniques (logical selectivity), etc. Moreover, a communication system based on different TLC vectors (fiber optic, Wi-Fi and LTE technologies) has been deployed and is used to enable the real-time communication between the DSO, electrical substations and customers, required to implement the features envisaged by the InteGRIDy project.

The solution

The San Severino Marche pilot has been designed in order to achieve benefits both in the DSO's perspective and in the customer's one. It focuses, in particular, on two main sets of functionalities:

- the management of the topology of the medium voltage grid (by delivering suitable information to the DSO, in real-time and in advance) to improve the network's operational efficiency (e.g., reducing energy losses, maximizing the grid's hosting capacity for RES);
- the collection of ancillary services (frequency regulation, congestions mitigation, etc.) on active and passive users, by means of Energy Storage Systems.

The pilot foresees the installation of new equipment in the ASSEM control center and on the distribution network, and the development of some software tools.

Some residential users are equipped with Energy Storage Systems able to adjust their working point according to remote setpoint signals sent by the core unit developed in the project and installed in the DSO's control center. Moreover, the project enables the real-time monitoring of the storage devices, in the perspective to allow Aggregators to manage and take advantage of these new control resources within the Ancillary Services Market. In addition, to support the DSO in adopting an optimal network configuration, some secondary substations are equipped with monitoring devices devoted to collecting grid measurements and with remote-controlled switching devices.

A set of software tools is deployed on a workstation in the ASSEM control center. A first tool is designed to compute a forecast of RES production and load over the network. Predictions are evaluated also with the support of weather forecast collected from an external web service provider.

The optimization of the network topology is performed by another tool, which models the medium voltage distribution network from a mathematical point of view. With the purpose to implement the algorithms required to optimize the grid configuration, based on power flow calculations, the tool needs in input the forecast profiles of generation and load, and the monitoring data collected over the network. The tool identifies the optimal grid topology considering as fitness function energy losses on grid's conductors or other operating indexes (quality of service, hosting capacity, etc.). As a main output of the optimization process, the tool provides suggestions regarding which switching devices over the network should be opened/closed by the facility manager in the DSO's control center to adopt the configuration considered the optimal one.

Further tools perform a simulation of the Ancillary Services Market and define the optimal strategy to charge/discharge Energy Storage Systems at the residential users' premises. This is carried out by considering different working parameters such as the batteries' state of charge, the local production and actual rate of self-consumption of users and the requirements in terms of provision of ancillary services to the electricity market.

The benefits

The first benefit expected from the pilot is an improvement of the distribution grid efficiency and quality of supply; such goals drive to economic income to the DSO thanks to an optimal management of the distribution grid. Also the grid's Hosting Capacity (capability to connect new generators) will benefit of the solutions designed in the project, thanks to the minimization of grid congestions obtained by the adoption of energy storage solutions and Demand Response strategies. These aspects will allow the DSO to avoid/postpone some structural investments in the distribution network.

Benefits on energy losses reduction are also of great interest for the DSO, because according to the reward/penalty mechanism enforced by the Italian Energy Authority, if the actual losses on the network are lower than the conventional ones (value defined according to a national average), this originates an income for the DSO.

In the other side, the final user will have an economic gain thanks to an effective participation to the Demand Response logics, providing services to the local grid or to the market. These functions are nowadays under evaluation in the Italian framework. Nevertheless, the regulatory framework is not yet completely defined, consequently the project results particularly on-time to provide useful on field results. Eventually, thanks to the ESS apparatuses, the active users will be able to better manage the energy needs in their houses (increasing the self-consumption), minimizing the energy bill.

Finally, the better energy efficiency of network operation, the increase in hosting capacity and users' self-consumption are expected to bring to a reduction in carbon dioxide emissions. The opening of the Ancillary Services Market to distributed generation would lead to a greater and better exploitation of renewable energy resources, with economic and environmental advantages in the management of the power system.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731268.