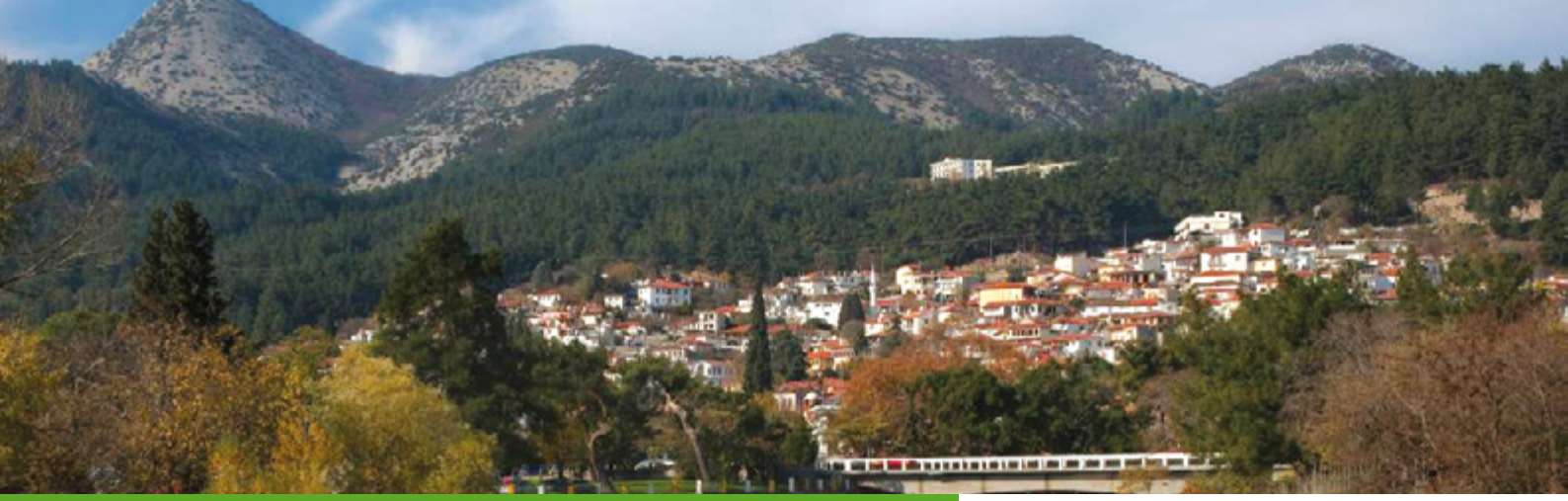

Case study

Managing energy in islanded multi-node microgrids involving hybrid storage technologies

The challenge

Xanthi pilot demonstrates the operation of an islanded microgrid network that fulfils local load demand with RES sources and energy storage using advanced control technology. Microgrids, according to CIGRE, are electricity distribution systems containing loads and distributed energy resources that can be operated in a controlled, coordinated way either while connected to the main power network or while is islanded.

The microgrid, which consists three portable nodes, is owned by Sunlight and located in its premises and is used to power auxiliary equipment and charge the factory electro-vehicles (forklifts). The nodes are set up in such way that different power production and storage dynamics are met in order to cover different set up topologies depending on user needs.

The microgrid is powered by photovoltaics and wind generators. Lead-acid battery arrays are utilized to store energy and to provide the necessary power to the systems when needed. As a backup option each system has a diesel generator. A Polymer Electrolyte Membrane (PEM) electrolyzer produces and stores hydrogen and a PEM Fuel Cell system produces power when required using the stored hydrogen. The energy exchange within each standalone node where DC and AC busses exist, is established through power converters. A high voltage DC bus bar is used to exchange energy between the nodes using DC/DC Bidirectional converters.

The operational objectives of the microgrid are to exchange power based on demand-response strategies, to maximize the usage of available stored power at network level and to utilize the total amount of available renewable energy. The desired features for the overall behavior of the network is to ensure the security of supply, to reroute the energy based on dynamically evolving conditions and to provide an automatic decision support mechanism based on available network resources.

The solution

Xanthi pilot addresses all four of the InteGRIDy's project pillars. Demand Response, Smartening the Distribution Grid, Energy Storage Technologies and Smart Integration of grid users from Transport.

In the Xanthi pilot, the concept of demand response is viewed from a broader perspective. Being an isolated microgrid, an internal energy management is being prioritized. This means that apart from controlling the internal auxiliary loads, upper level DR mechanisms among the distributed microgrids are implemented in order for the entire grid to be able to fulfil the individual loads. This is achieved by interconnecting the microgrids, enabling the ability of energy exchange.

To achieve nodes cooperation and improve the energy exchange at the distribution level, smart and adaptable energy management strategies are used. Advanced Model Predictive Control using system/network models is applied in order to achieve optimum power distribution in the grid. Furthermore, supervisory monitoring options and services provide to the grid operator knowledgeable actions using multi-criteria decision analysis and capitalizing

on the historical data of the network behavior. The information/notification and status metrics are included in the multipurpose dashboards for visual analytics of the distribution domain status, in local and remote HMIs.

Concerning the Energy Storage Technologies, an optimization of the energy storage usage within each station is performed. The field trial, is carried out on the 3 nodes with active serving to storage and load demand, utilizing flexible storage management algorithms for charging/discharging. The formulation of a Virtual Central Storage from aggregated distributed storage systems offers balancing solutions among hybrid storage options (electricity, hydrogen) utilizing Smart Energy management tools with RES-enabled storage systems.

The last aspect involves smart Integration of grid users from Transport. The energy management methods are being evaluated considering the forklift charging at dynamically changing schedules using RES, batteries or stored hydrogen options on demand. The integration of EVs offers grid balancing solutions through the ability to provide flexibility in demand side management and, in the case of the EV charging unit, returning power to the grid at peak network demand.

Three tools, developed by CERTH/CPERI-PSDI, implement the above-mentioned functionalities. Data Exchange Tool, as the name indicates, is a tool that manages transmission of selected data from the SCADA system to the other tools using IoT technologies.

The Integrated Decision Support & Supervisory EMS tool, targets the Integrated Optimum Operation, Advanced Control, Energy Monitoring & Energy Management Strategies for autonomous energy networks. The tool is designed to assist the end-users to gain the most out of their available resources. The resulting automation and control systems are monitored with data and network security considerations. The main functions of the tool are the collection, processing and visualization of real-time data, the implementation of automated algorithms and the implementation of Energy Management Strategies

The Supervisory Model Predictive Control technologies for Energy Systems tool is developed to give the ability of the unattended operation and supervision of an isolated power grid consisted of multiple microgrids. Its purpose is to be used in RES microgrids where latest power systems technologies are installed, with the objective of smartening the grid. The tool is based on the model-based control concept. Using model predictive methods and appropriate setpoints of operation, future control actions are provided in order to guide the operation to the desired levels. Energy that should be exchanged is calculated and control actions are sent to the field devices for energy storage balance assuring the energy integrity of the grid.

The benefits

Within InteGRIDy project, the focus is towards isolated smart-grid networks and more specifically to their operations domain in terms of information exchange and distribution of energy. The deployed tools provide online information about the grid operation both to the user and between the microgrid nodes. The integrated solutions offer online optimum decision making for the distribution of energy for isolated smart grids with an option of charging batteries for EVs. In short, the benefits of applying the deployed technology are:

- Microgrid autonomous operation relying on RES and energy storage that serves varying load profiles in areas where the transportation of fuel is difficult.
- Formulation of a Virtual Central Storage from aggregated distributed storage systems delivered from the smart energy management.
- Grid balancing through the ability of flexible energy distribution and, in the case of the EV charging unit, returning power to the grid at peak network demand.
- Emission reduction. The usage of RES combined with the stored energy at batteries or hydrogen will minimize the use of a diesel generator which is installed to operate in case of emergence or critical energy deficiency.
- Energy consumption savings derived by the optimum operation of the subsystems and the maximum utilization of available RES.

Overall, Xanthi microgrid incorporates advanced technologies that smarten the grid and makes it an example among low voltage, smart autonomous microgrids.

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