ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DIPARTIMENTO
DI INGEGNERIA
DELL'ENERGIA ELETTRICA
E DELL'INFORMAZIONE
"GUGLIELMO MARCONI"

Research project

Title

Management of the controllable resources and of flexibility services of microgrids and energy communities

Renewable Energy Communities (RECs) have recently garnered significant attention as a means to accelerate the transition to clean energy and enhance energy efficiency. For optimal operation, RECs require an Energy Management System (EMS) to manage generation and load resources effectively, including Battery Energy Storage (BES) systems.

The optimal scheduling of controllable resources within an energy community typically aims to minimize the overall energy procurement cost for all users in the community. Uncertainties in load forecasts can be managed using intra-day adjustments to day-ahead scheduler decisions. Three-stage scheduling process (day-ahead, intra-day, and real-time) are also proposed to handle these uncertainties. Load forecasts in RECs are challenging due to their small size and consequent larger variability. The research project is addressed on the selection of the most suitable method to manage uncertainties in the load and production resources of microgrids and energy communities, as a trade-off of accuracy and computational cost, to be compliant with real-time schedulers. The final aim of the project is the implementation of an EMS containing a real-time scheduler to be executed with a rolling horizon time window. The optimization time window is to be selected to leverage up-to-date forecasts of load and renewable production, and in particular photovoltaic, as well as of time-of-use energy prices. Due to the time constraints of the real-time schedulers, simplified forecasting methods could be necessary.

To test the EMS's capability to handle real-time operation and data exchange with the database collecting available measurements, a digital simulator is to be used to allow the evaluation of different scenarios, enabling safe testing and selection of new equipment and strategies.

The optimization problem can be differently formulated depending on the particular legal form of the REC, which is different in the various European countries, even though they all transpose the same directives. One of the outcomes of the research project is to formulate a unique objective function to be minimized, encompassing the technical rules of several individual countries, requiring only minor modifications of the mathematical constraints.

The energy measurements may come from smart meters at the Points Of Delivery (PODs) of industrial, commercial and civil users, installed in the framework of the GECO climate-kic project and in the ongoing ECOSISTER and NEST PNRR projects.

The proposed approach addresses this issue by incorporating appropriate weights for selling and purchasing energy prices. The EMS offers a set of features that, when combined, represent an advancement over the current state of the art.

The measurement of energy consumption of final user of the distribution network can be carried out together with indoor and outdoor air quality measurement in order to infer a model that relates the climate and perceived temperature-related needs of the end-user with the cost of energy supply related to the use of air conditioning or electrical heating systems. The objective is to predict the energy consumption of individual users based on events such as the change in humidity and temperature as well as the occupancy rate inside the facilities, but also to estimate aggregated consumption at the condominium or district level. The aggregated consumption will be used for planning purposes of electrical infrastructure of neighbourhoods in the light of the challenges posed by electro-mobility and the reduction of climate-altering emissions, which is one of the aims of the monitoring campaign that is starting in the ECOSISTER project. Such models may help to better manage electricity production and consumption resources, which, as recent Energy Community legislation seeks to incentivise, should be offset as far as possible locally at the urban district level.

Activity Plan

The activities envisaged for this research project will cover the following topics:

- analysis of the state of the art in the field of the real-time management of the controllable resources of renewable energy communities;
- management of databases collecting data coming from 'smart-meters' and air quality measurement systems;
- development of stochastic optimization models for managing uncertainties in load and photovoltaic forecast;
- implementations of algorithms for bad data recognition and replacement in power systems state estimation;
- implementation of an Energy Management System prototype to be tested in a laboratory using a real-time simulator and measurements from sensors installed in distribution networks.