Electrical Energy Optimization at District Level

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The goal of the European project AMBASSADOR is to look for technological strategies to optimize the electric energy usage at district level. The proposed optimization aims at reducing the operational costs (i.e. global electricity bill) by taking into account all electric power generators and consumption elements of the districts and taking advantage of storage elements. In order to reach that goal, model predictive control (MPC) is applied. The latter relies on adaptive models that predict the energetic behavior (production and/or consumption) of the various elements. Extensive simulations were carried out under various simulation conditions and showed that significant savings can be achieved.

AMBASSADOR is a 48 months FP7 project that started in December 2012. It is coordinated by Schneider Electric and is composed of 15 partners from different European countries. The project's main objective is the reduction of exploitation cost of districts by maximizing the benefits linked to renewable production and storage. The emphasis is put on electrical flux management at district level. The cost reduction is achieved by exploiting the flexibility of the district. In the current context, the flexibility relies on storage elements such as batteries.

The district optimization is performed by DEMIS (District Energy Management Information System). Input to DEMIS are the predicted consumptions and productions of all district elements. These values are forecasted by the controllers of the various elements of the district, which are also called eNodes. In addition, DEMIS is running its optimization procedure aiming at reducing the costs by using the available batteries and their usage level in an optimal way. Once the best solution is found, the command signal is sent to the storage elements. This is illustrated in Figure 1.

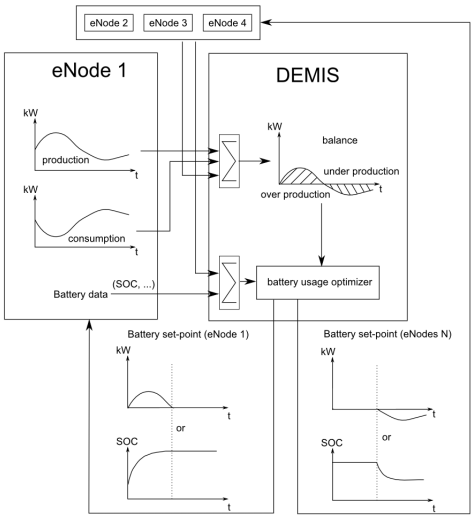

Figure 1: Ambassador district optimization procedure overview.

In the context of AMBASSADOR, eNodes for the following elements were developed and simulated:

- Wind turbines
- Photovoltaic panels
- Consumers (offices, villas and public lighting)

These eNodes are able to forecast the production/consumption of the corresponding system by using the available information, such as weather forecast and time. All these eNodes rely on adaptive models that are continuously trained by minimizing the difference between the measured value and forecasted value. Forecasting results for a wind turbine are provided in Figure 2.

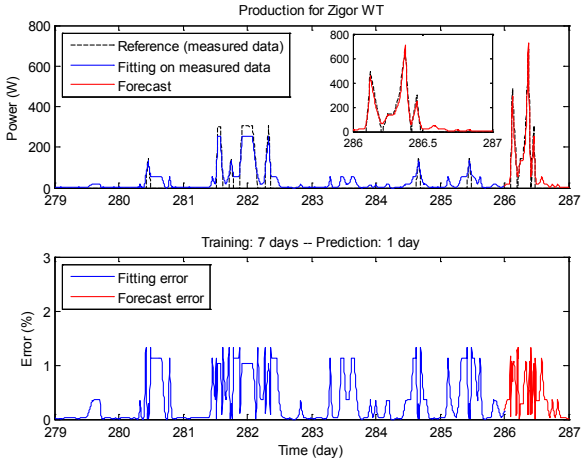

Figure 2: Wind turbine production, measurement and forecast (top) and relative error between the two values (bottom).

A validation of the district optimization concept was carried out under various simulation conditions:

- District size (ratio between consumption and production)
- Electricity tariffs (variable selling and buying tariffs)
- Different storage element sizes
- Allowing or preventing the usage of grid energy (i.e. not produced within the district) to load the storage elements

The benefits of the battery optimization (compared to the scenario to not using any battery at all) are maximal when:

- ratio between production and consumption is close to one;
- the battery size is large enough to cover one day of consumption
- tariffs are time-varying
- buying and selling tariffs differ

On a test site, where most of the above criteria are fulfilled, the simulation study point to a cost reduction of up to 80%. In very unfavorable cases (i.e. none of the above criteria is fulfilled), the benefits of optimizing the battery usage can drop drastically[1]. In order to confirm the above mentioned simulation results, the deployment of DEMIS is foreseen on a Greek test site by the end of 2015.

[1] Y. Stauffer, S. Arberet, M. Boegli, Centralized energy optimization at district level, Energycon 2016, submitted