A Software Solution to Manage Local Energy: from the House to the District

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The local management of energy systems will be a key enabler in the future of a power grid incorporating more and more decentralized resources. CSEM has developed a software solution to manage energy at the district scale that focuses on energy cost reduction. It implements a predictive control approach where weather forecasts are used in combination with prediction models for the district subsystems to determine in real time the best strategy to store, produce and consume energy. This solution was deployed in several buildings' energy managers in partnership with a consortium of startup led by Soleco.

Buildings are increasingly being outfitted with solar panels, heat pumps, electric batteries, electric vehicles (EVs) charging stations and other means of producing and storing energy, all of which interconnect with the electrical grid. At the level of a neighborhood, these decentralized energy sources form a complex network.

Managing these multi-energy systems and optimizing energy costs raises several questions. Should energy be consumed when it is produced, sold to the grid, or stored for later use? And how should energy sources be distributed if there are groups of consumers generating their own energy? In the framework of the European project PENTAGON, CSEM has developed smart, predictive software capable of providing real-time answers to these questions. Designed for non-specialists, it uses weather forecasts, data from local infrastructure, residents' consumption habits and market energy costs. As its name indicates, Maestro is like an orchestra conductor that automatically manages resources and keeps costs down. An online simulator, based on a building with eight family apartments, has been developed to demonstrate its potential and is accessible on the CSEM website.

The software is easy to use and can be flexibly adapted to different neighborhoods. To start with, parameters such as solar panel size, buildings' surface area, battery storage capacity and user preferences and priorities are fed into a configuration file. The system combines state-of-the-art control algorithms, namely mixed-integer linear model predictive control, and forecasting algorithms to calculate minimum cost operation strategies. Production data from energy installations, provided by sensors, are collected, and then sent to the cloud, where Maestro automatically compares possible consumption decisions and identifies the most cost-effective one, considering both energy power consumption peak costs. Instructions are sent back to a local gateway computer, which carries them out on site. Through a feedback loop, the plan is updated every 15 minutes in response to new events (such an electric vehicle arrival).

Maestro can incorporate boilers, heat pumps and EV charging stations, as well as electric batteries, renewable energy sources such as solar panels, power-to-gas facilities, thermal storage tanks, and more.

Competitor systems on the market are designed for single-family homes and often apply a simple strategy: increase consumption when photovoltaic energy is produced. This can lead to over-consumption of energy and as a result to very marginal cost savings, if any [1]. Maestro does not use predefined rules but calculates the best use of energy at any point in time, based on weather forecasts and energy costs. In addition, it integrates new elements such as EVs, heating & cooling of the house, etc. With Maestro, cost savings will vary from home to home and user to user. A preliminary study on the first house running Maestro revealed an approximately 20% reduction in heating costs alone.

Maestro works for individual buildings, but it could also prove very useful for a prosumer community, where renewable energy sources are shared across several buildings. In 2018, Soleco, based in Maur in the canton of Zurich, won CSEM's Digital Journey Award together with its partners Geminise and Vela Solaris. The award came with CHF 100,000 in technical assistance for the development of a digital project. The teams have developed an energy management system which integrates the Maestro software and have installed it in two single-family homes and an apartment building. With this deployment, several practical challenges were addressed, from interfacing to different technical equipment reliably, comparing local and on-the-cloud deployment, to dealing with equipment failures and forecast errors.

A proof-of-concept simulation was run to demonstrate the ability of Maestro to manage consumption peaks for this district, served by a district heating system with several large heat pumps. New challenges will have to be tackled in deploying Maestro at this scale, from user interfaces to data management and computational issues, but the experience and data currently gathered in the field help us make Maestro more and more deployable and reliable. A future development is the integration of learning elements that improve the performance of the controller over time in an automated fashion.

Maestro was presented at the IFAC World Congress in Berlin. [2]

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[1] A. Hutter, N. Koch, Y. Stauffer, T. Gorecki, "Augmenter l'efficacité des prosommateurs," bulletin.ch, vol. 8/2019, Jan. 08, 2019.

[2] T. T. Gorecki, W. Martin, "Maestro: A Python library for multi-carrier energy district optimal control design," presented at the 21st IFAC World Congress 2020, Berlin, Germany, Jul. 2020, Accessed: Aug. 06, 2020. [Online]. Available: http://arxiv.org/abs/1911.12661.