ON THE CHARACTERIZATION AND EVALUATION OF FLEXIBILITIES IN REAL-TIME TRADING AND PORTFOLIO OPTIMIZATION

Carlo CORINALDESI[1], Daniel SCHWABENEDER[1], Georg LETTNER[1]

Introduction

The need for flexibility in the power grid increases because of the growing share of volatile renewable energy resources. Flexibility is the capability of power plants and/or loads to alter their scheduled production and/or consumption in reaction to external signals like spot market prices and balancing market activations.

Flexibility of distributed Energy Management Systems represents an enormous potential to reduce the energy costs. A simple and exhaustive description of flexibilities is needed to efficiently coordinate and aggregate multiple flexible actors. Hao [1] presents a method to describe the flexibilities of different technologies as virtual batteries. In this document, we describe the flexibility of an Energy Management System as a combination of non-flexible loads and virtual batteries with variable capacities, power inputs and outputs. This method allows to describe the flexibilities of electric cars, batteries, heat pumps, boilers and photovoltaic panels as virtual batteries. The flexible components that are analyzed in this work are illustrated in Figure 1.

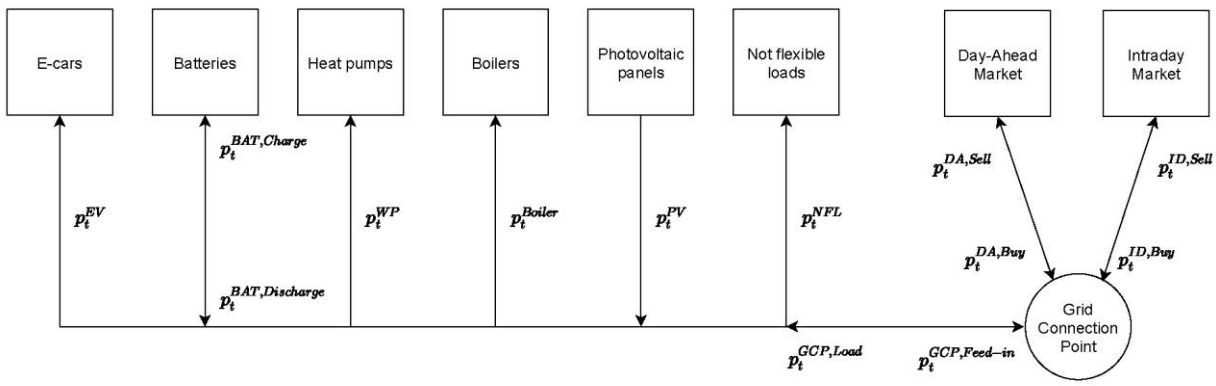

Figure 1: Graphic representation of an energy management system and the associated power flows.

Furthermore, we define a mathematical optimization problem aimed to minimize the energy costs and to best allocate the flexibilities of the Energy Management System between spot markets and self-consumption.

Methodology

In this work, we propose a simple and complete method to describe flexibilities of Energy Management Systems. In order to deal with uncertainty associated to production and consumption, a rolling-horizon optimization framework is introduced. This approach allows updating input parameters, in order to react to variations from the nominal schedule. The mathematical formulation of virtual batteries allows to best allocate the energy flows of the Energy Management System through an optimization model, which aims to find the most costs-efficient strategy to employ the aggregated flexibilities. The overall flexibility of the Energy Management System is used to optimize (1) the self-consumption and (2) the trading on the energy spot markets. Figure 2 shows the market-oriented operation of a virtual battery.

[1] Energy Economics Group / TU Wien, Gußhausstraße 25-29/E370-3, +43-(0)1-58801-370370, {corinaldesi, schwabeneder, lettner}@eeg.tuwien.ac.at, www.eeg.tuwien.ac.at

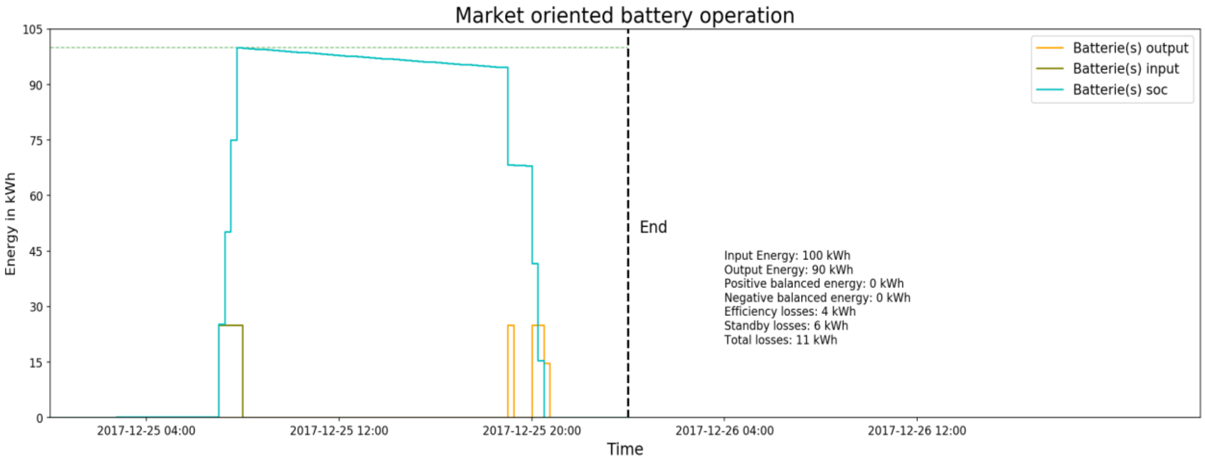

Figure 2: Market oriented operation of a virtual battery

Use Cases

In this work, two different Energy Management Systems are considered. The first one is an office site of an electric utility company. The second one is a purification plant. Both Energy Management Systems are located in Austria and provided their metered data for this work. The analyses are aimed to investigate the value that the flexibilization of the technologies of an Energy Management System may create in a period of one year. The real-time optimization framework represents a realistic way to evaluate the potential of the aggregation of small flexibilities, since it takes into account the uncertainties related to consumption, generation, price variability, and is able to react to unpredictable variations of the optimization inputs.

Results and Conclusions

This work presents a comprehensive overview of modeling and evaluating flexibilities of an Energy Management System composed by different technologies. Comparing these different flexible technologies, we identify various diversities and potentials. We describe multiple flexible technologies as virtual batteries and implement them in a mathematical optimization problem. With the experimental results, we investigated the value of the flexibilities distinguishing between the single technologies. Moreover, we show how aggregating flexibilities can result in further energy costs reduction and how the precision of the forecasts (consumption, generation and prices) influences the value created by the real-time optimization.

References

[1] H. Hao, „Generalized aggregation and coordination of residential loads in a smart community.," International Conference on Smart Grid Communications, Bd. IEEE, pp. 67-72, 2015.

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