Automated demand-side flexibility identification and utilization in energy optimization

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Background

Energy demand has traditionally been regarded as an inflexible load supplied by central flexible production units. However, as the penetration of renewable energy resources grow, such as solar or wind, the production side becomes increasingly inflexible. Therefore, in order to balance energy production and demand, flexibility must be incorporated on the demand-side. This is typically done through either Demand Response techniques, where no storage conversion losses are introduced, or through energy storages where the consumption habits are not disrupted [2-4]. While the control strategies in energy services traditionally have been rule based, more advanced control methods are needed, such as Model Predictive Control (MPC), in order to fully utilize the flexibility potential present at the demand-side. To facilitate this and ensure broader commercial adoption, a data-driven and autonomous approach is needed for the modeling of these energy systems.

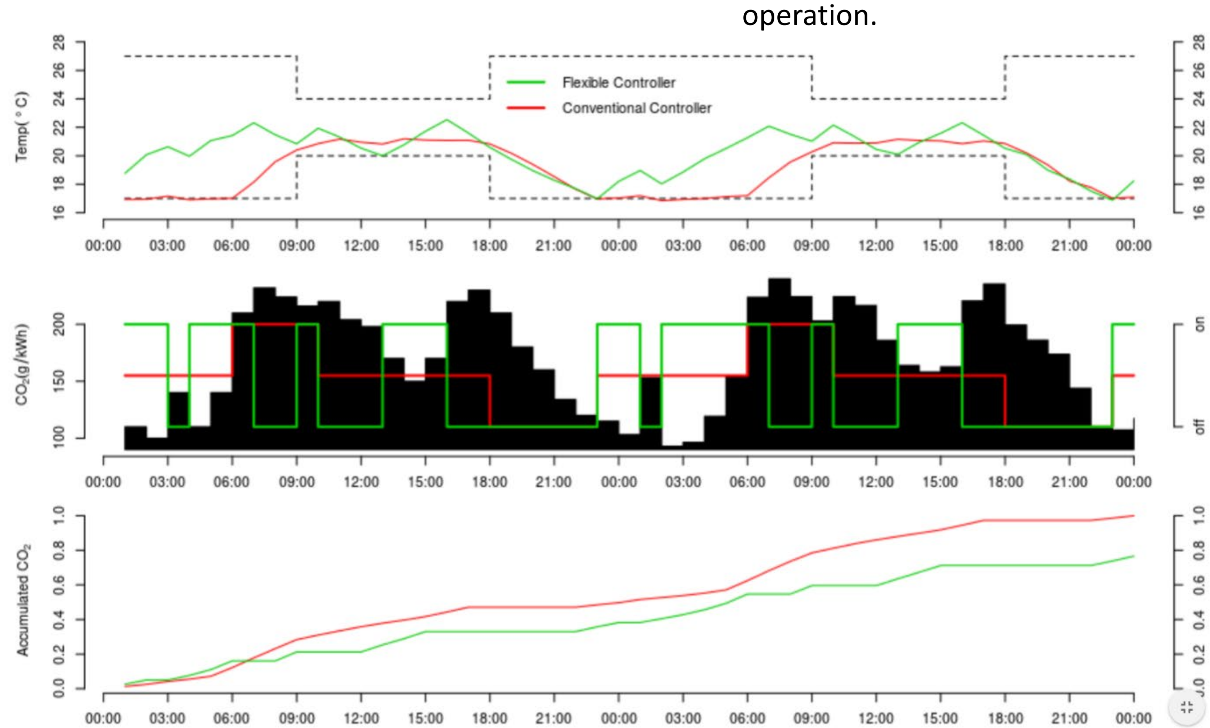
Objectives

The overall goal of the PhD-project is to investigate automated demand-side flexibility identification and utilization in energy optimization. This will be done through the following objectives:

1. Identification of data-driven energy modelling algorithms to support energy flexibility identification and utilization.

2. Design and development of an automated demand-side flexibility methodology to form the basis for energy operational optimization

3. Implementation of the automated demand-side flexibility methodology in multiple case studies to assess the impact on the energy system operation.



Example on demand-side flexibility using the thermal mass of a building. The conventional controller minimizes electricity usage while flexible controller minimizes CO2-emissions [1].

Methodology

In objective 1, the use of statistical methods and machine-learning will have a major role for modeling parts or the whole energy system as an attempt to standardize and automatize the modeling phase. An important aspect here is to compare the identified methods with alternatives and establish conditions for the type of systems as well as the quality or amount of data for which the data-driven modeling methods can be successfully implemented.

To utilize the demand-side flexibility and complete objective 2, the generated system models must be compatible with the chosen optimization algorithms. For the methodology to be automated, it is important to establish which modeling and optimization methods that can satisfactorily fulfill this criterion and under which conditions.

Objective 3 will be completed in cooperation with industry through a series of case studies in the form of buildings, clusters of buildings, districts, smart grids and ports facilities. In this way, the validity of the automated methodology will thus be demonstrated and tested in real-life applications.

[1] Søren Østergaard Jensen et al., »Energy Flexibility as a key asset in a smart building future«, November 2017.
[2] N. G. Paterakis, O. Erdinç and J. P. Catalão, »An overview of Demand Response: Key-elements and international experience«, Elsevier, 2017.
[3] P. D. Lund, J. Lindgren og J. M. Salpakari, »Review of energy system flexibility measures to enable high levels of variable renewable electricity«, Elsevier, 2015
[4] IEA, »Energy in Buildings and Communities Programme, Annex 67 Energy Flexible Buildings«, September 2019.