On the Characterization and Evaluation of Flexibilities in Real-Time Trading and Portfolio Optimization

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Graz

Session: Flexibilitätsmärkte

The Flex+ project (No 864996) is being funded under the 4th call of the energy research program of the Austrian Research Promotion Agency (FFG) and the Climate Energy Fund.

About the Project „Flex+“

- **Target country:** Austria
- **Start:** 05.2018
- **Duration:** 36 Months (04.2021)
- **Coordinator:** AIT Austrian Institute of Technology GmbH (AIT)
- 15 Partners

The Flex+ project (No 864996) is being funded under the 4th call of the energy research program of the Austrian Research Promotion Agency (FFG) and the Climate Energy Fund.

Motivation

- *"The need for flexibility in the grid is increasing, because of the growing share of renewable energy resources and it's volatility. (R.A. Verzijlbergh et al. 2017)"*
- *"The power system is moving from a central to a decentralized energy system. The new system includes more distributed generation, energy storages and requires a more active involvement of consumers, e.g. through demand response. (P. D. Lund et al. 2015)"*
- *"Appropriate building energy management systems, coupled with an optimized bidding strategy, can provide significant cost savings for prosumers. (M.S.H. Nizami et al. 2019)"*

Research Questions

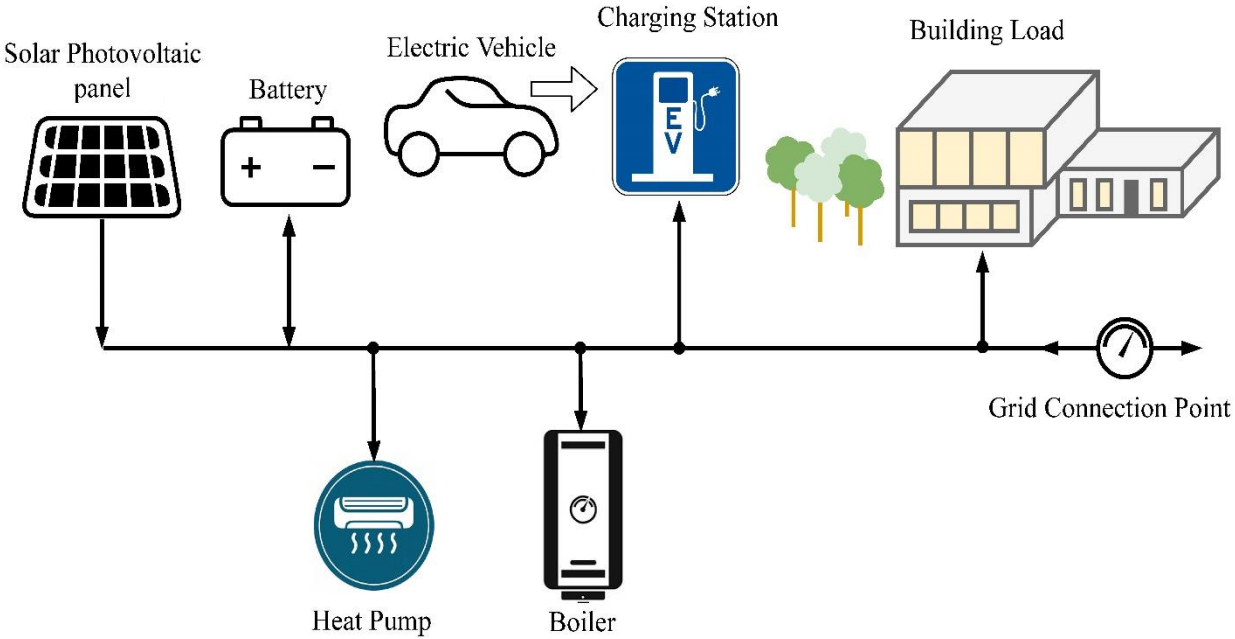
- *"A simple and exhaustive description of flexibilities is needed to efficiently coordinate and aggregate multiple flexible actors. (Valsomatzis et al. 2017)"*

➢ Research question 1: How to formulate flexibilities of different technologies?

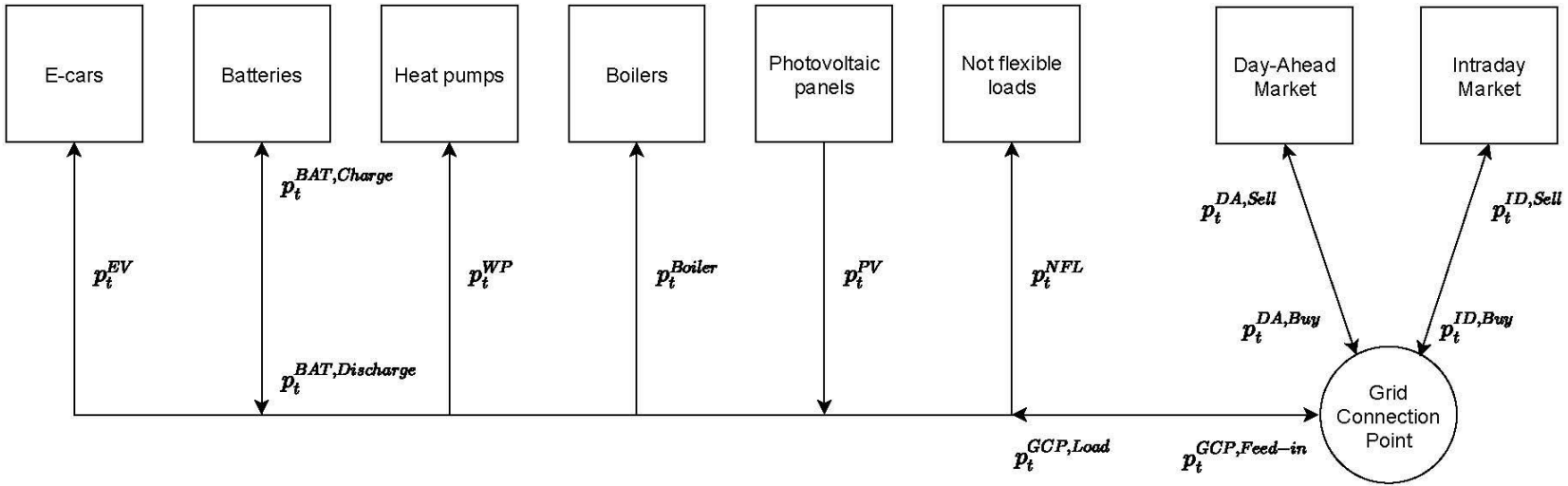
- *"One of the objectives of smart grid is to enable participation by informed customers in order to realize money and energy savings. (T. Hubert et al. 2012)"*

➢ Research question 2: What are the financial benefits of Real-Time Trading and Portfolio Optimization for customers?

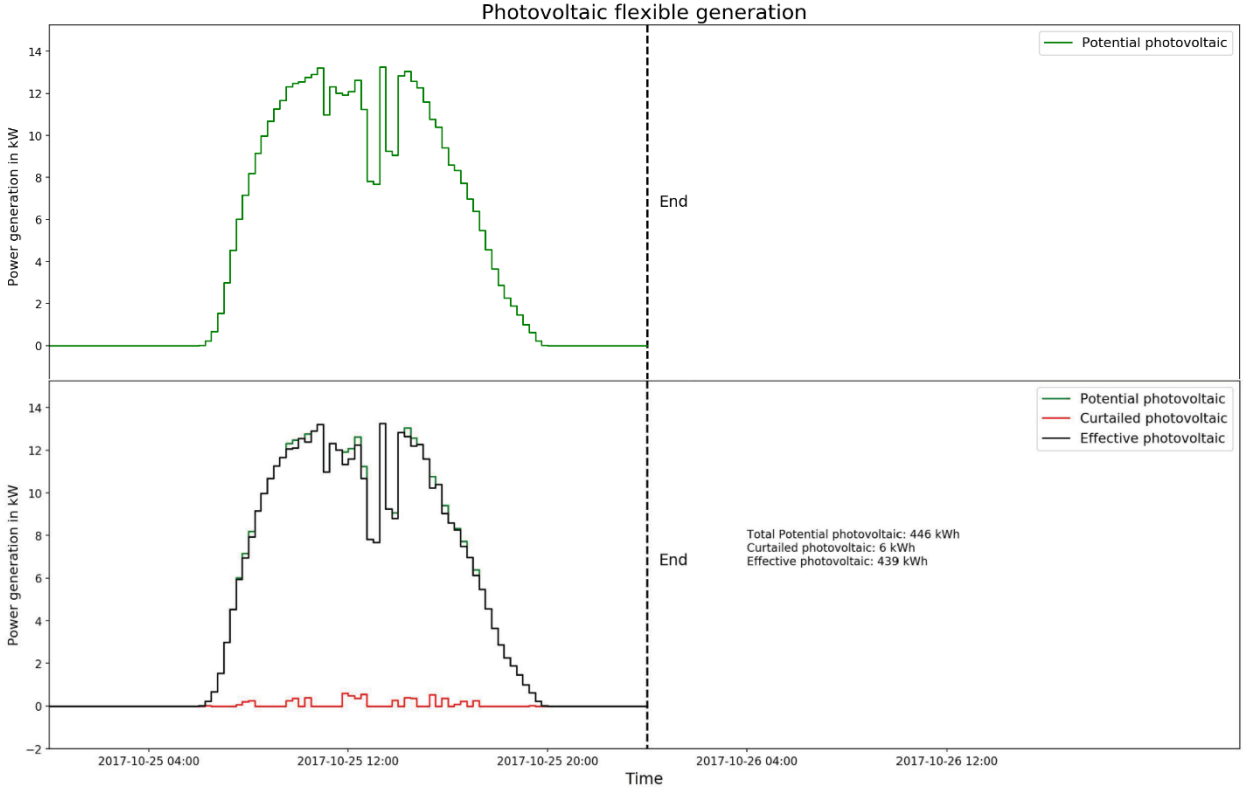
What is an „Energy Management System“?



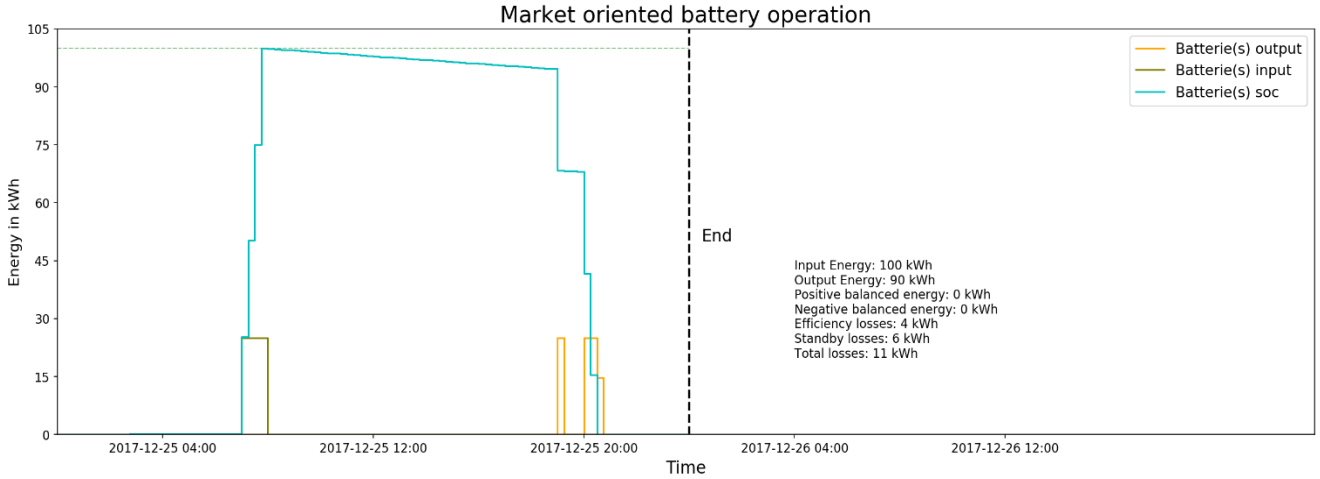
Power flows of an Energy Management System



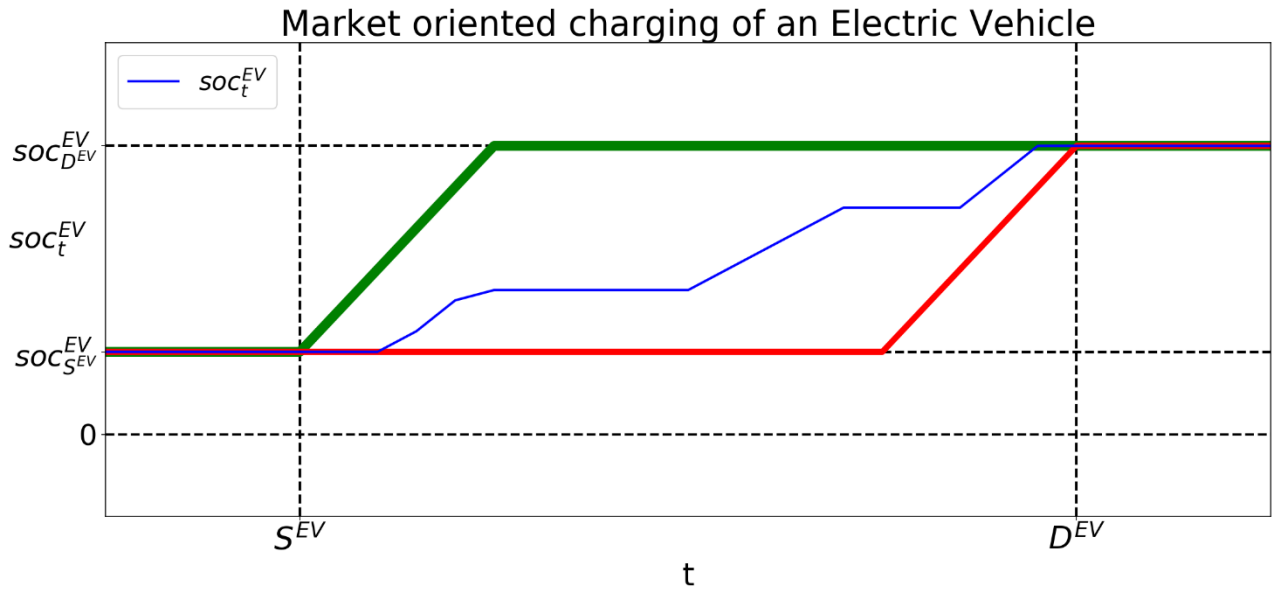
Flexibility of a Photovoltaic Panel



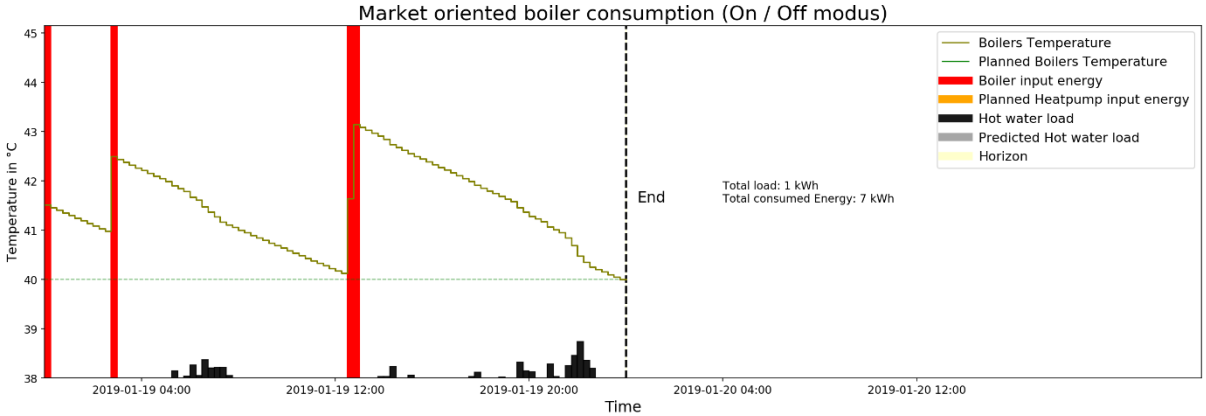
Flexibility of a Battery



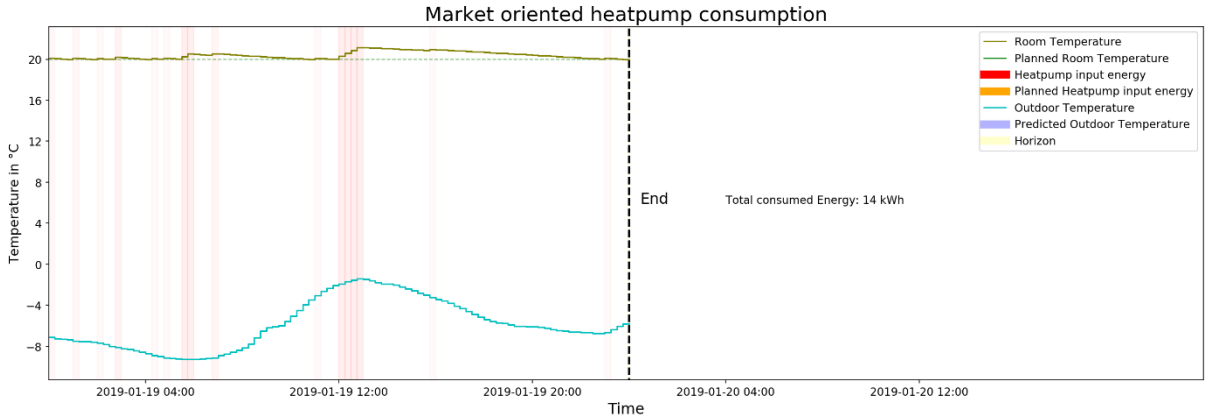
Flexibility of an Electric Vehicle Charging Process



Flexibility of a Boiler



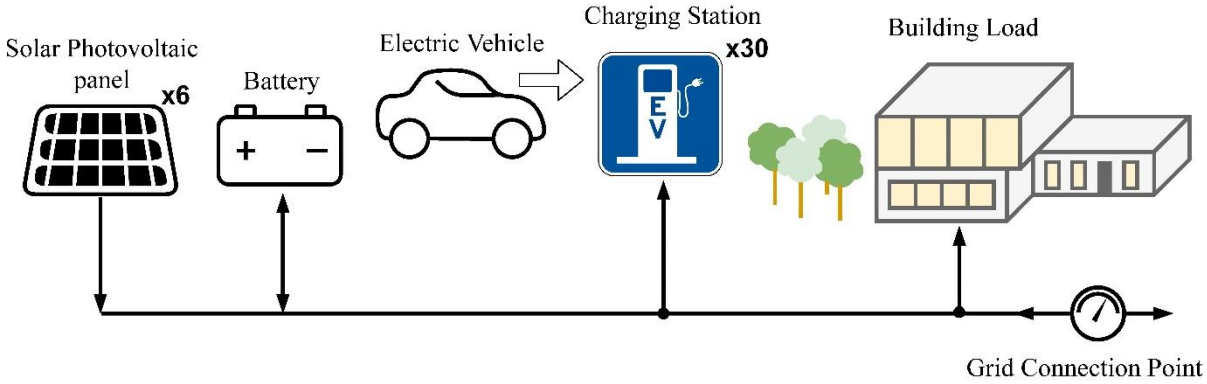
Flexibility of an Heat Pump



About the Optimization Framework…

- In order to settle the optimization problem of the Energy management System, we use the *Python* optimization modeling language *Pyomo* to implement the model and the *Gurobi* solver to solve it.
- It is a rolling optimization.
- An optimization problem (*MILP*) is defined and solved every hour, in order to update the schedules.
- The intraday marketing takes place every hour.
- On the intraday market, purchases / sales are dealt for the next 3 hours.

Real Life Use Case - Setting:
WEB, Windenergie AG, Pfaffenschlag, Austria



Energy markets:
- Day-ahead spot market (EPEX)
- Intraday spot market (EPEX)

Assumptions:
- Perfect Load Forecasts
- No Power Tariff

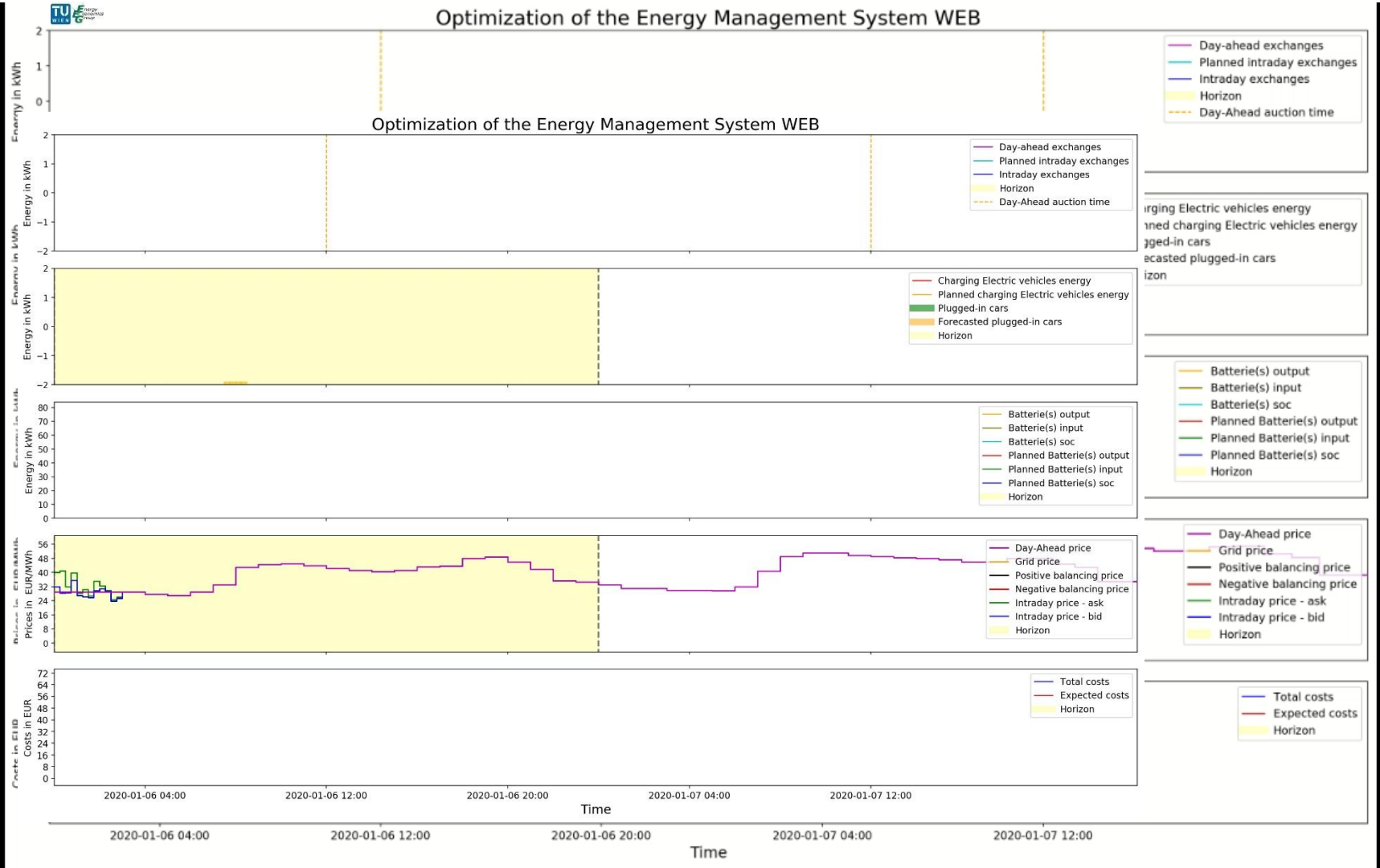
Optimization Inputs:

Data
- 30 Charging Stations *(136 Charging Processes)*
- 1 Battery *(80 kWh, 80 kW)*
- 6 Photovoltaic panels *(3.6 MWh, 190 kWp)*
- Building Load *(10 MWh)*
- Grid Connection Point limitation *(100 kW)*

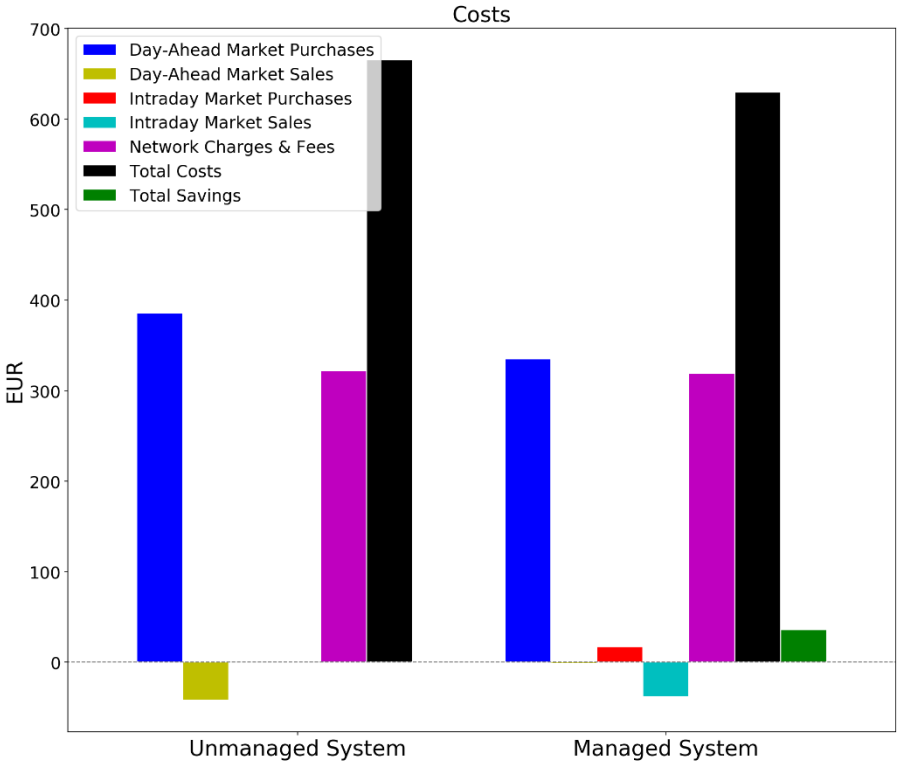
Period
- *06.01.2020 – 20.01.2020*

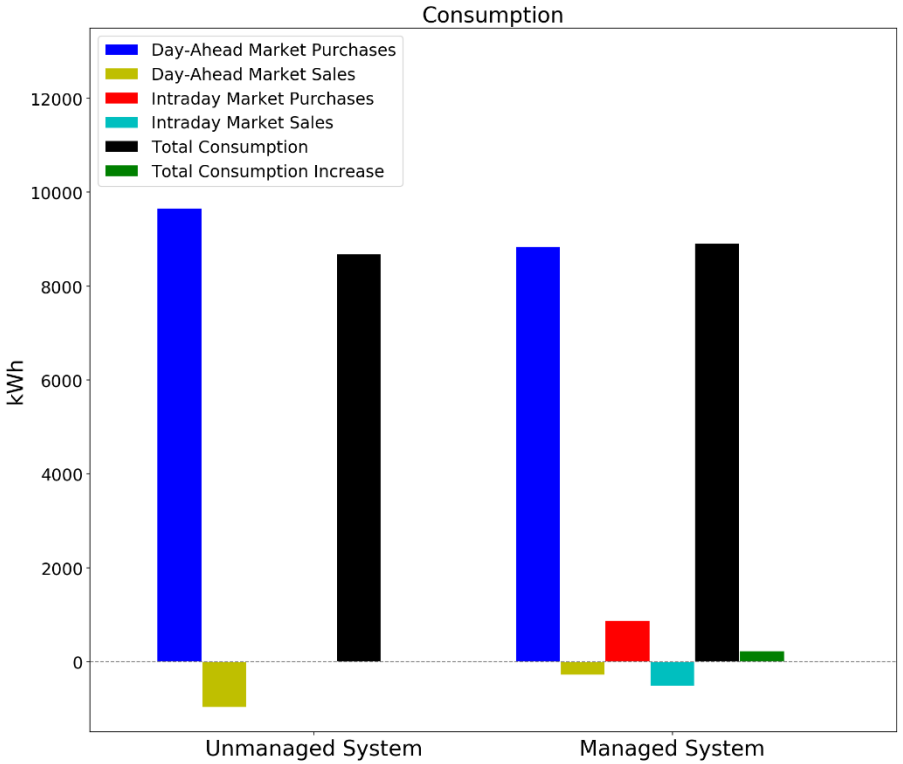
Goal:

Investigate the value that the flexibilization of the technologies of the WEB Energy Management System may create in a period of two weeks.

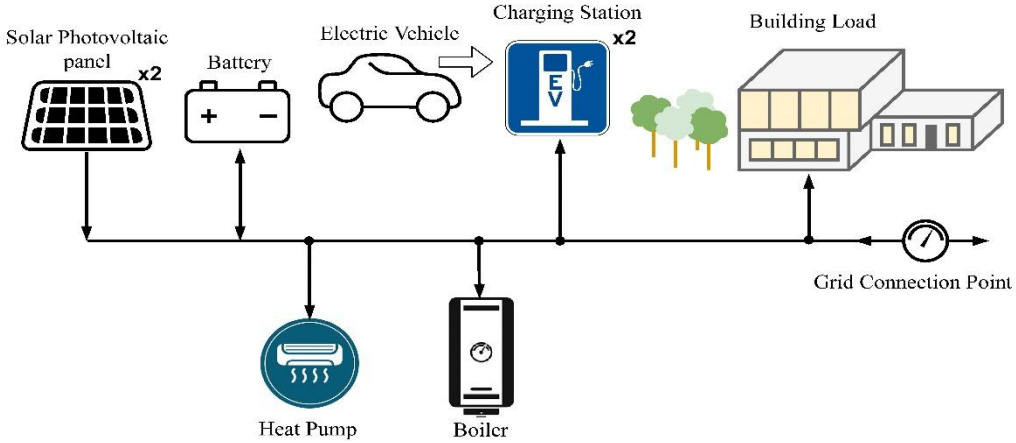

Optimization of the Energy Management System WEB
Energy in kWh
Day-ahead exchanges
Planned intraday exchanges
Intraday exchanges
Horizon
Day-Ahead auction time
Optimization of the Energy Management System WEB
Energy in kWh
Day-ahead exchanges
Planned intraday exchanges
Intraday exchanges
Horizon
Day-Ahead auction time
Energy in kWh
Charging Electric vehicles energy
Planned charging Electric vehicles energy
Plugged-in cars
Forecasted plugged-in cars
Horizon
Energy in kWh
Batterie(s) output
Batterie(s) input
Batterie(s) soc
Planned Batterie(s) output
Planned Batterie(s) input
Planned Batterie(s) soc
Horizon
Prices in EUR/MWh
Day-Ahead price
Grid price
Positive balancing price
Negative balancing price
Intraday price - ask
Intraday price - bid
Horizon
Costs in EUR
Total costs
Expected costs
Horizon
2020-01-06 04:00
2020-01-06 12:00
2020-01-06 20:00
2020-01-07 04:00
2020-01-07 12:00
Time

Real Life Use Case - Results:
WEB, Windenergie AG, Pfaffenschlag, Austria





Real Life Use Case - Setting:
Sonnenplatz, Großschönau, Austria



Energy markets:

- Day-ahead spot market (EPEX)
- Intraday spot market (EPEX)

Assumptions:

- Perfect Load Forecasts
- No Power Tariff

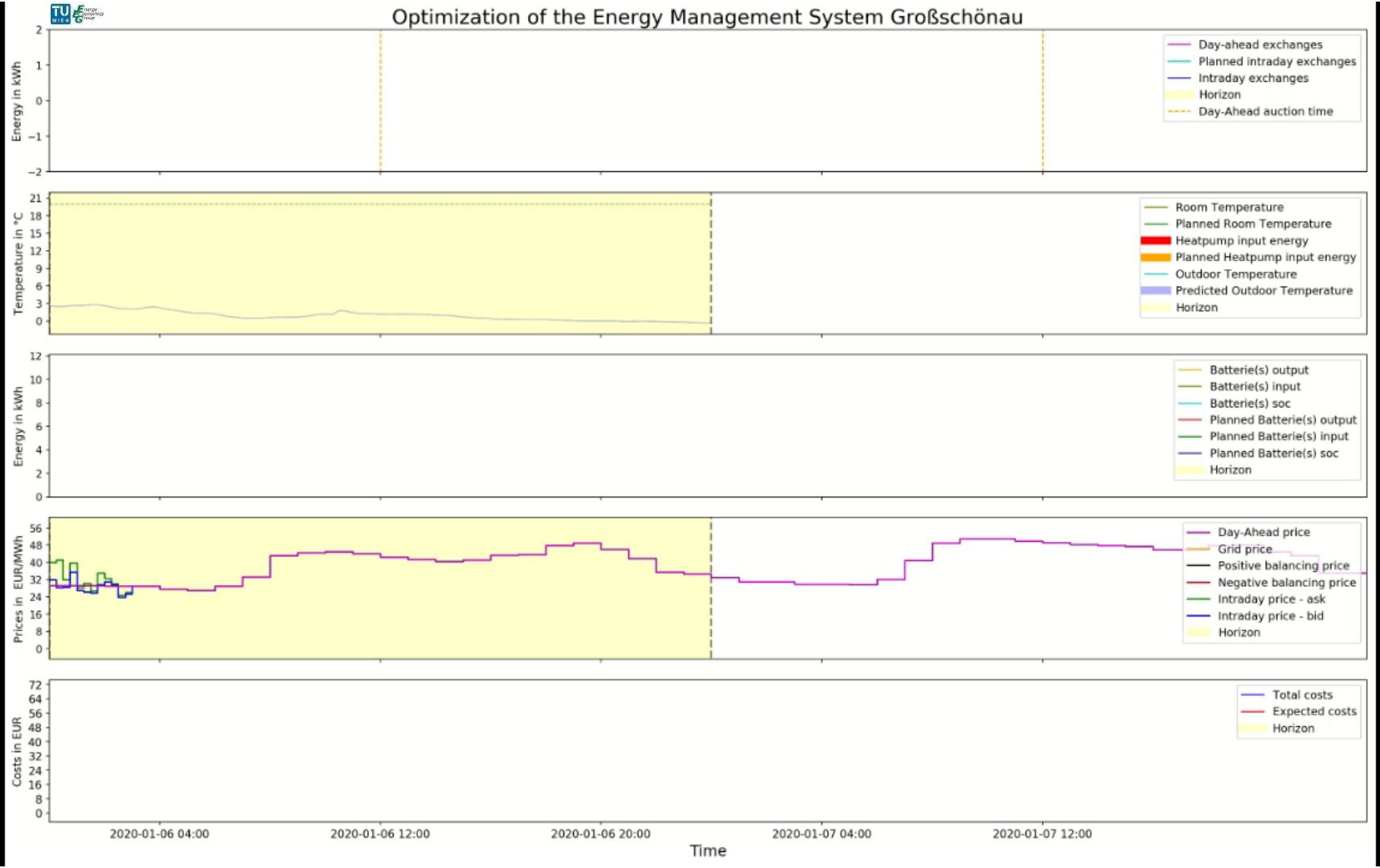
Optimization Inputs:

Data

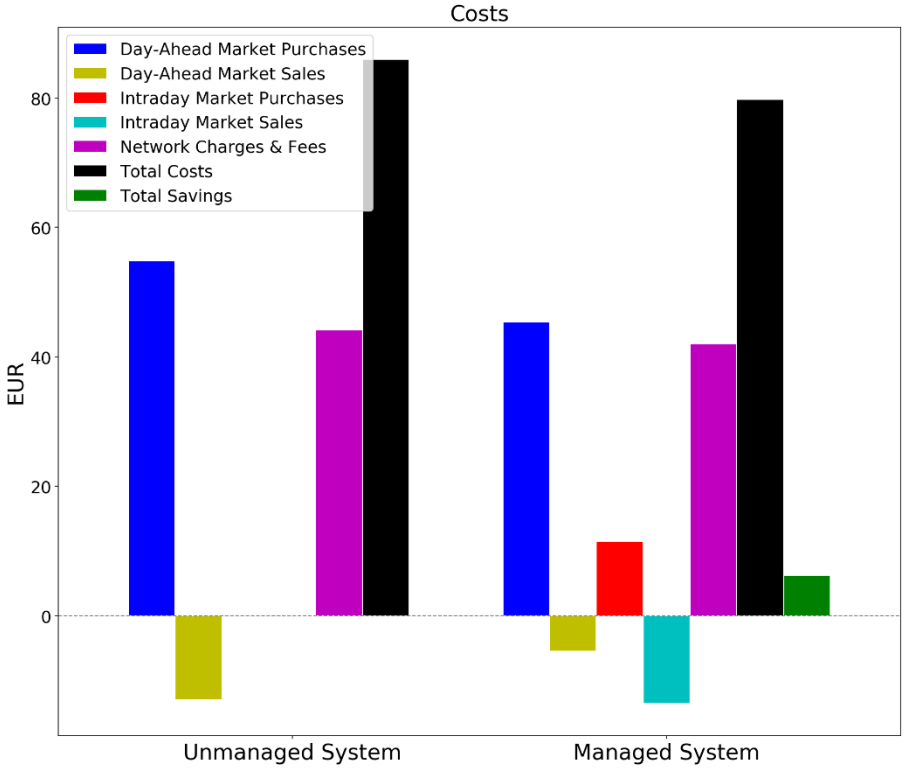
- 2 Charging Stations *(1 Charging Processes)*
- 1 Battery *(12 kWh, 6 kW)*
- 2 Photovoltaic panels *(0.49 MWh, 82.3 kWp)*
- Building Load *(1.4 MWh)*
- Grid Connection Point limitation *(40 kW)*
- 1 Boiler *(6.6 kW)*
- 1 Heat Pump *(2.78 kW)*

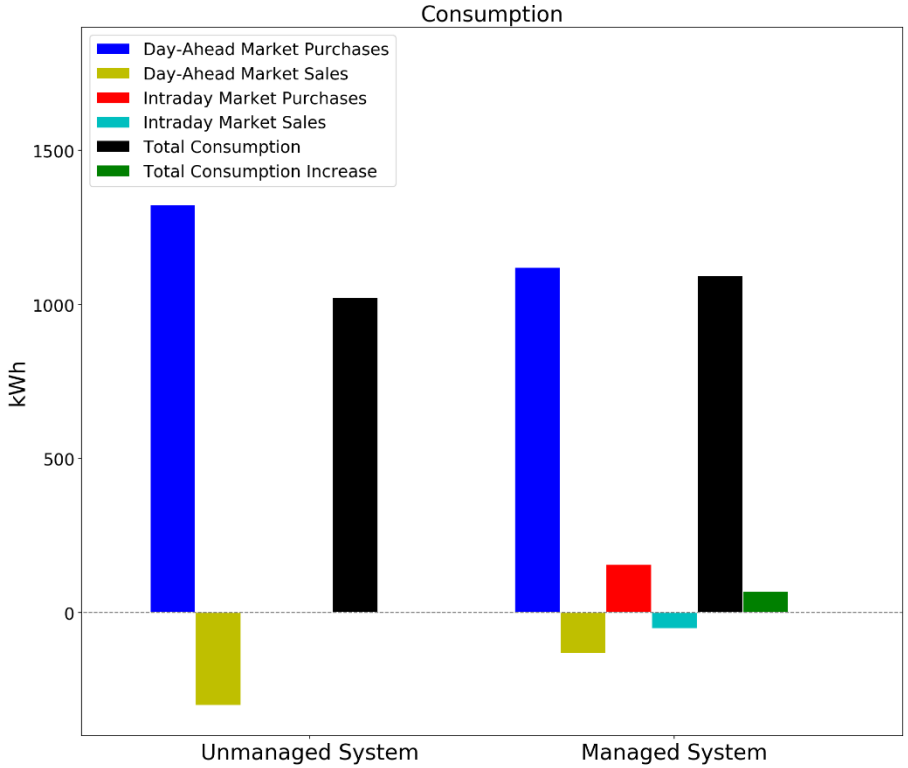
Goal:

Investigate the value that the flexibilization of the technologies of the WEB Energy Management System may create in a period of two weeks.


Optimization of the Energy Management System Großschönau
Energy in kWh
Day-ahead exchanges
Planned intraday exchanges
Intraday exchanges
Horizon
Day-Ahead auction time
Temperature in °C
Room Temperature
Planned Room Temperature
Heatpump input energy
Planned Heatpump input energy
Outdoor Temperature
Predicted Outdoor Temperature
Horizon
Energy in kWh
Batterie(s) output
Batterie(s) input
Batterie(s) soc
Planned Batterie(s) output
Planned Batterie(s) input
Planned Batterie(s) soc
Horizon
Prices in EUR/MWh
Day-Ahead price
Grid price
Positive balancing price
Negative balancing price
Intraday price - ask
Intraday price - bid
Horizon
Costs in EUR
Total costs
Expected costs
Horizon
2020-01-06 04:00
2020-01-06 12:00
2020-01-06 20:00
2020-01-07 04:00
2020-01-07 12:00
Time

Real Life Use Case - Results: Sonnenplatz, Großschönau, Austria





Conclusions

- Our work presents a comprehensive overview of modeling and evaluating the flexibilities of an Energy Management System.
- We describe multiple flexible technologies as virtual batteries and implement them in a mathematical optimization problem.
- We control the power flows of the Energy Management System through a rolling optimization framework.
- We applied our proposed methods to two different real-life use cases in Austria with metered data.
- Our work shows, how aggregating flexibilities results in energy costs reduction.

It's all very well to have principles, but when it comes to money you have to be flexible.
(*Eugene Ormandy - Hungarian-American conductor and violinist*)

Thank you for your attention

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