CINELDI

Centre for intelligent electricity distribution
- to empower the future Smart Grid

PhD: Flexibility potential in the smart distributional grid and Zero-Emission Neighbourhoods to cope with imbalances and CO_{2eq} compensation

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Challenge and objectives

To create a smart future grid, there is potential and a need to include the flexible resources that are existing within the grid. Therefore, the flexible units that exist within needs to be investigated to find their value and contribution to the total distributional grid. Some of the possible contributors to this is the Zero Emission Neighbhourhoods (ZEN) that FME ZEN is working on. However, the level of flexibility and their value for flexibility is something that must be found. Some of the objectives that are expected to be investigated are:

- What is the relation between long-term and short-term value of flexibility for building scheduling, and how can this be represented and calculated to improve short-term scheduling?

- How does different flexible assets in building scheduling impact long-term value of flexibility?

- What is the potential of CO_{2eq} emission savings for a ZEB/ZEN during the operational phase over the course of a year considering uncertainty?

- What is the expected potential of different aspects in a ZEN and within the future smart distributional grid?

- What is the value of flexibility in a local distributional grid with congestion problems?

Research tasks

- Development of an algorithm using Stochastic Dynamic Programming to capture the long-term effects of flexibility usage for a ZEB and ZEB, with detail on different flexible mechanisms

- Analyzing flexibility contribution from ZEN towards the local distributional grid

- Modelling of a local distributional grid consisting of an aggregated ZEN, energy storage and local RES.

Approach

- The plan is to make use of Stochastic Dynamic Programming (SDP) to capture the long-term effects different flexible assets have in their surroundings. This can be used to see how a ZEB, ZEN or other parts of a local distributional grid have the capability to utilize flexibility based on the surroundings.

- Analyze each part in the grid and their functionality considering an operational manner will be investigated.

- Based on the results from the SDP approach, the value of flexibility in the system can be analyzed and investigated. Then, combining the SDP together with a rolling horizon operational model will enable to see the forecasting accuracy of this approach.

Significant results

A Zero-emission building (ZEB) has been used to investigate how flexible assets contribute on electricity usage when exposed to long-term price signals. This has been combined with the SDP method mentioned for a case study where a monthly power tariff based on highest peak power has been included. The household demand is considered uncertain. The aim is to find the optimal peak power for the household to minimize total electricity cost.

The results from this test shows that the SDP method develops non-linear future cost curves based on the peak power level. These curves help find the cost-optimal level for the building, based on the cost of utilizing flexibility. The peak power level is set based on the value of allowing more flexibility in electricity scheduling versus the added cost from the power tariff. The expected future cost curves created showcases the cost of the household based on the different values of peak power the household sets. In Figure 1, these non-linear cost curves illustrate how flexibility utilization can lower the peak, decreasing future cost.

The study has been investigated further, where Space heating, EV charging, and a stationary battery has been analyzed for a ZEB. Each flexible asset has been controlled individually, to see how each asset differs in flexibility contribution on the same case study as described above. The results showcased high peak shaving potential from EV charging, and that space heating has high capability to cut peak to a level where Real-time pricing savings combined with peaks shaving is co-optimized, depending on the temperature boundary. Figure 2 showcases how the cost and peak shaving changes for each flexible asset.
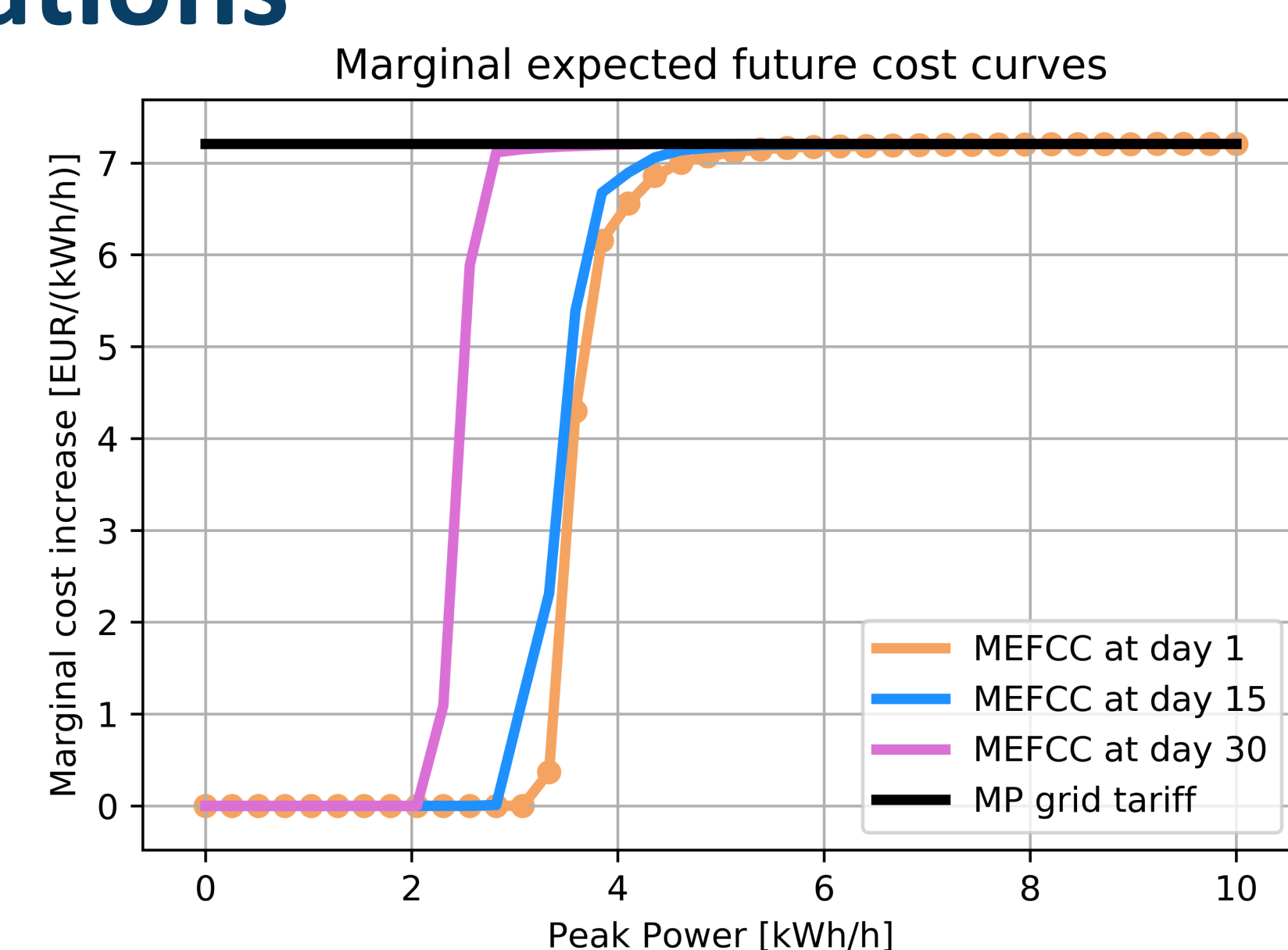
Illustrations

Figure 1: Marginal expected future cost for different days over a monthly measured-peak grid tariff structure for a building
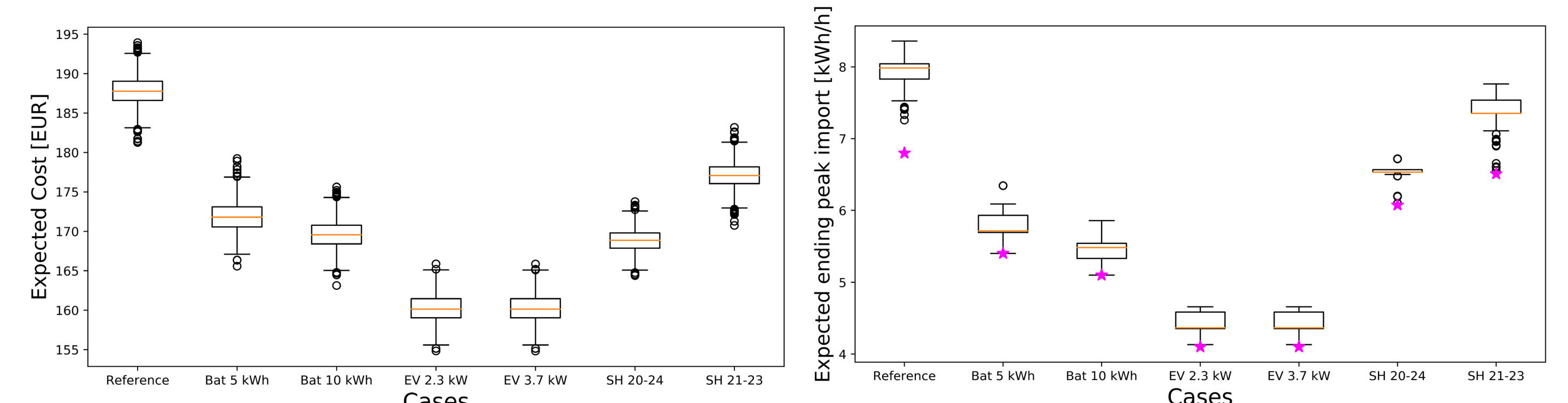

Figure 2 left: Boxplot of expected monthly cost for a building with different flexible assets enabled

Figure 2 right: Boxplot of ending peak level for a building with different flexible assets enabled