How to apply flexibility for congestion management in daily operation using a four-step approach

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Electrical Energy Systems

Agenda

1. Introduction
2. Flexibility and its operational challenges
3. Implementation
    - Step 1: Data acquisition
    - Step 2: Load forecasting
    - Step 3: Decision-making
    - Step 4: Flexibility mechanism interfacing
4. Results
5. Conclusions
6. Further reading

→ Same steps repeat in section 4.

1. Introduction

- The problem is congestion in the distribution networks
- Flexibility can provide a solution
- InterFlex implemented a flexibility market

- Different from other pilots, with a focus on:
  - Interoperability
  - Standardization
  - No longer showing flexibility can provide a solution, but on how to apply it as a solution

1. Introduction

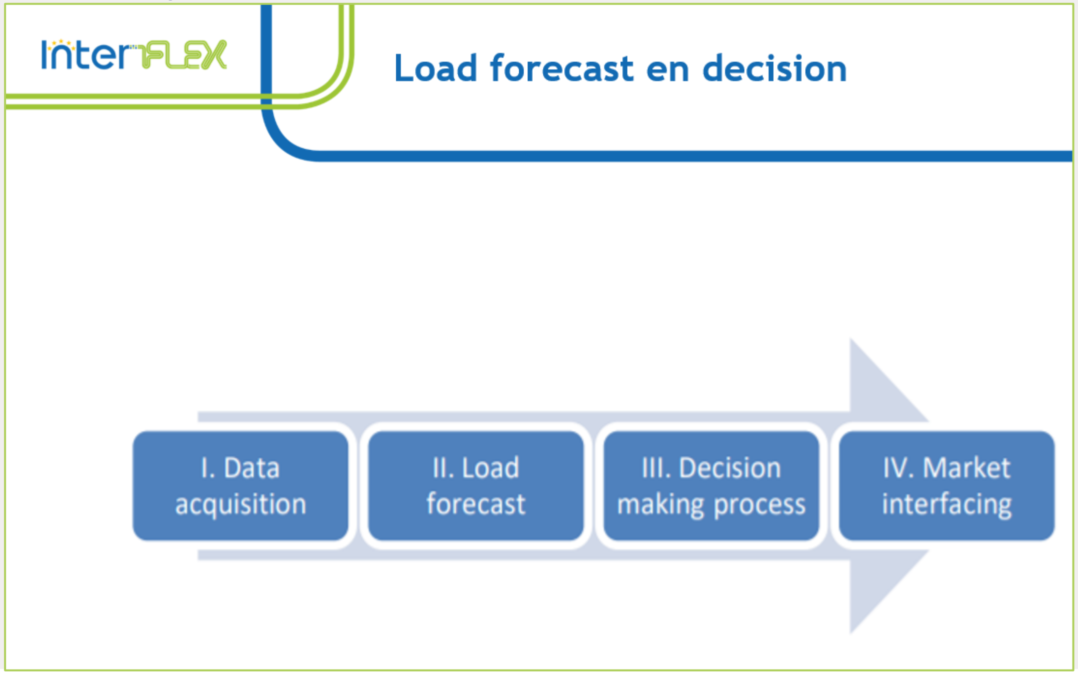
- The problem is congestion in the distribution networks
- Flexibility can provide a solution
- InterFlex implem…ted a flexibility market

Focus of this presentation

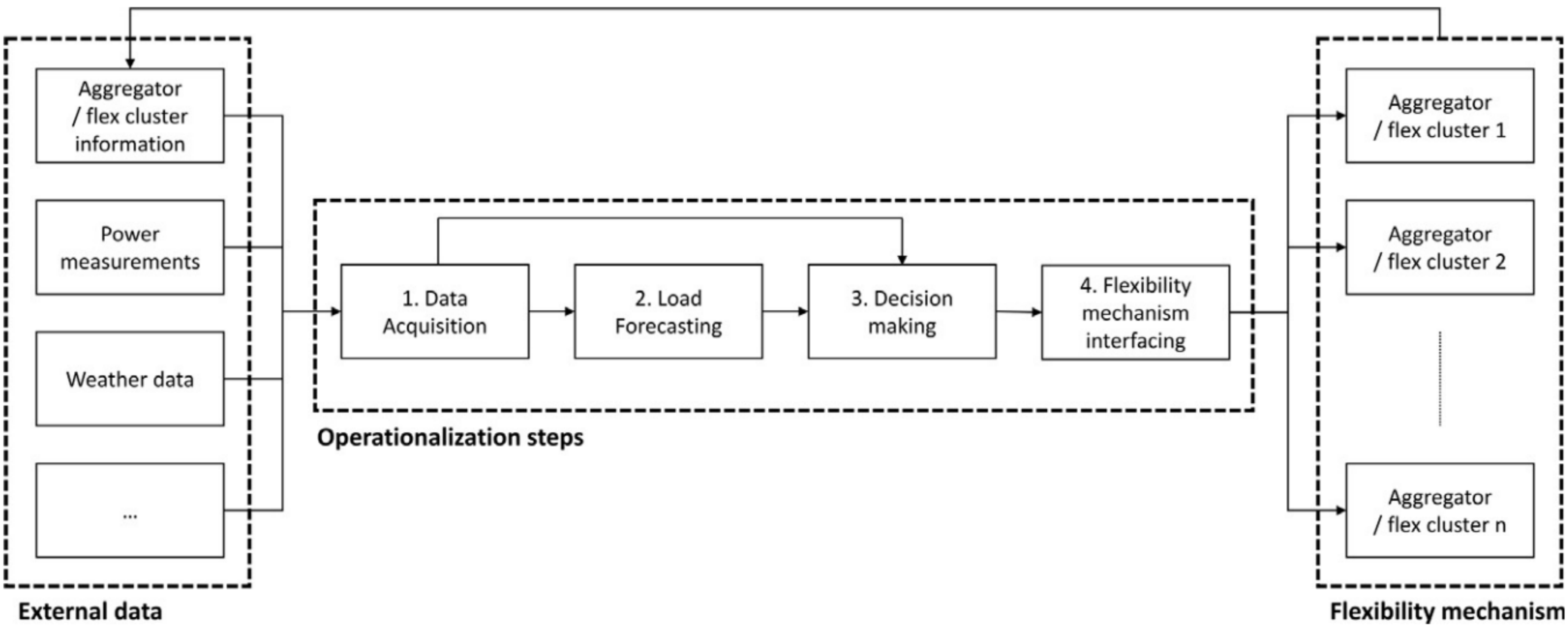
- Different fr… …ots, with a focus on:
  - Interopera…
  - Standardization
  - **No longer showing flexibility can provide a solution, but on how to apply it as a solution**

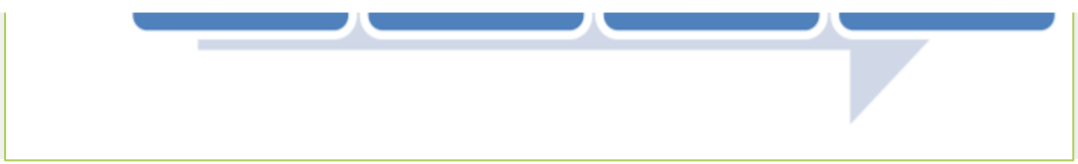
2. Flexibility and its operational challenges

- Flexibility is defined as:
  - the possibility to adjust power at a given moment in time for a given period at a specific location
- Four steps of operationalization:

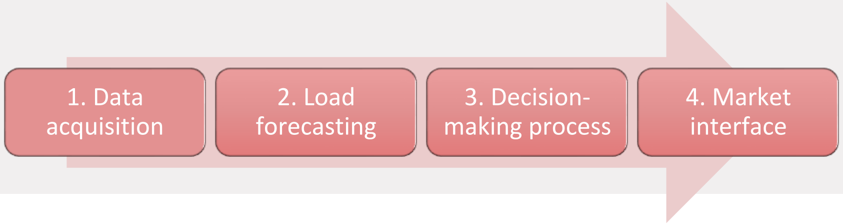


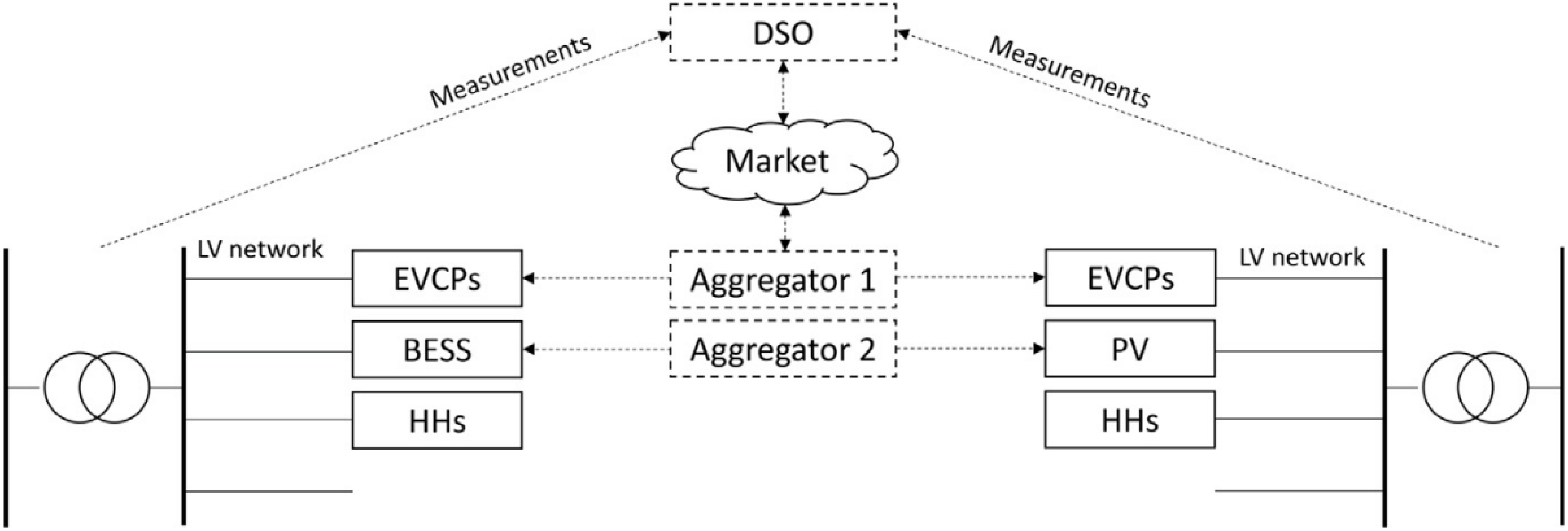
2. Flexibility and its operational challenges





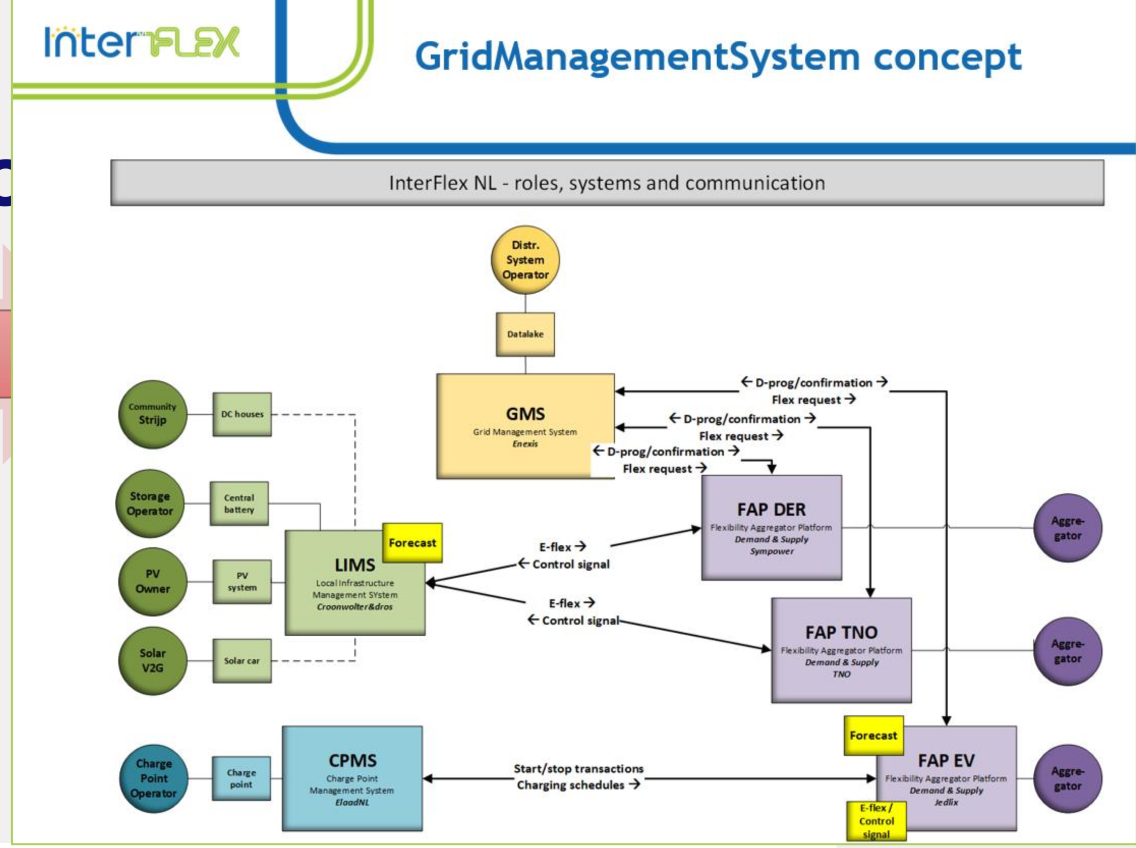
3. Implementation I/VI

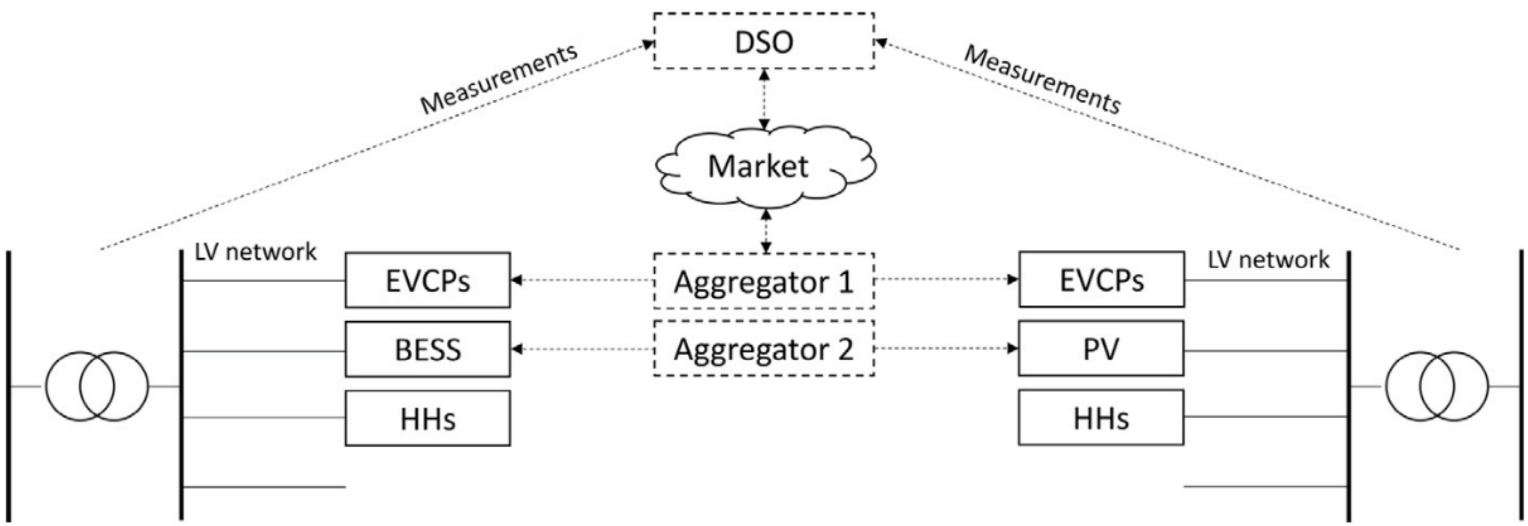




3. Implementatio

1. Data acquisition
2. Load forecasting
3. Decision-making process





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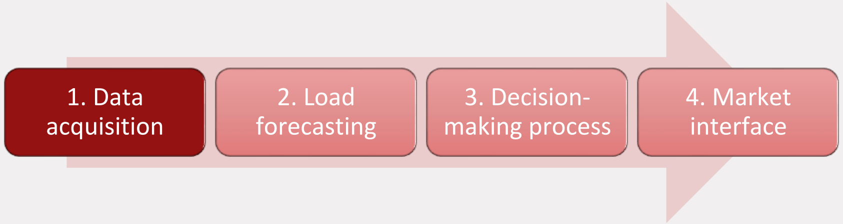
3. Implementation II/V



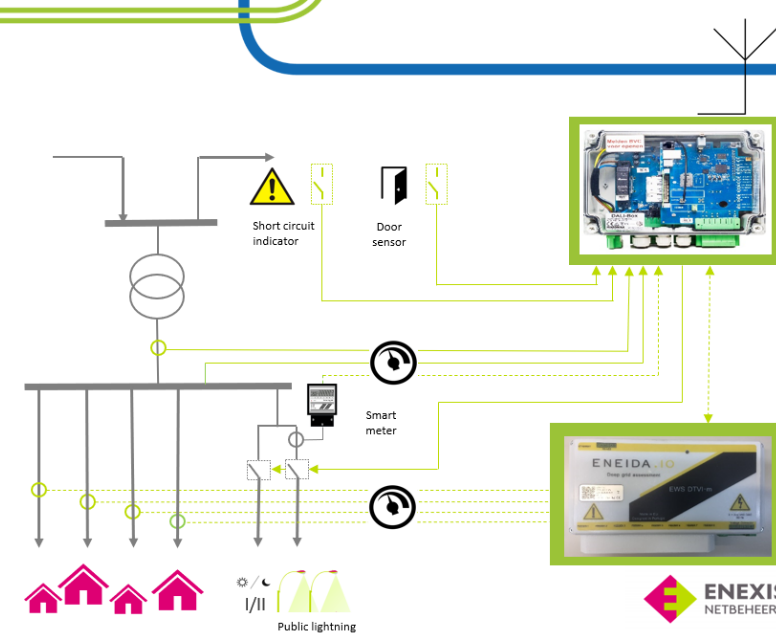
- Measurement data
- Network topology
- Prognosis flex sources
- Weather data

3. Implementatio

1. Data acquisition | 2. Load forecasting | 3. Decision-making process

- **Measurement data**
- **Network topology**
- Prognosis flex sources
- Weather data

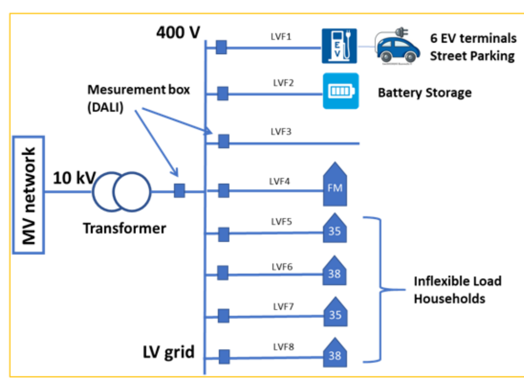
DaLi - Enexis MV/LV measurement solution



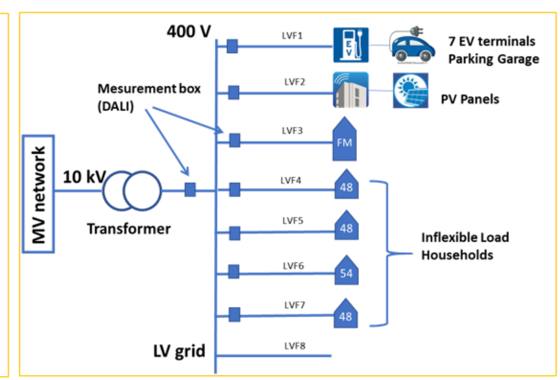
Three data streams:
- Daily max/min
- 15 minutes average values
- Realtime treshholds

Sensor data per phase (optional):
- Current per phase
- Voltage per phase
- Active power per phase
- Reactive power per phase
- THD per phase
- Status reports
  - Front panel (open/close)
  - Door
  - Short circuit
  - System indicators

Dutch Pilot: Eindhoven

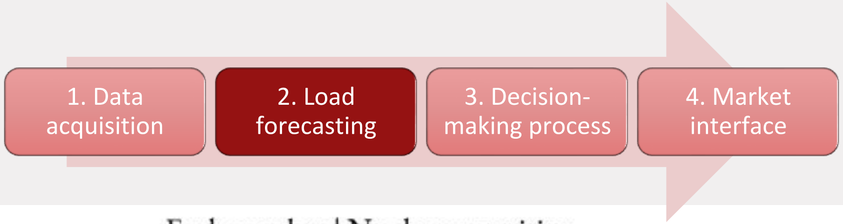


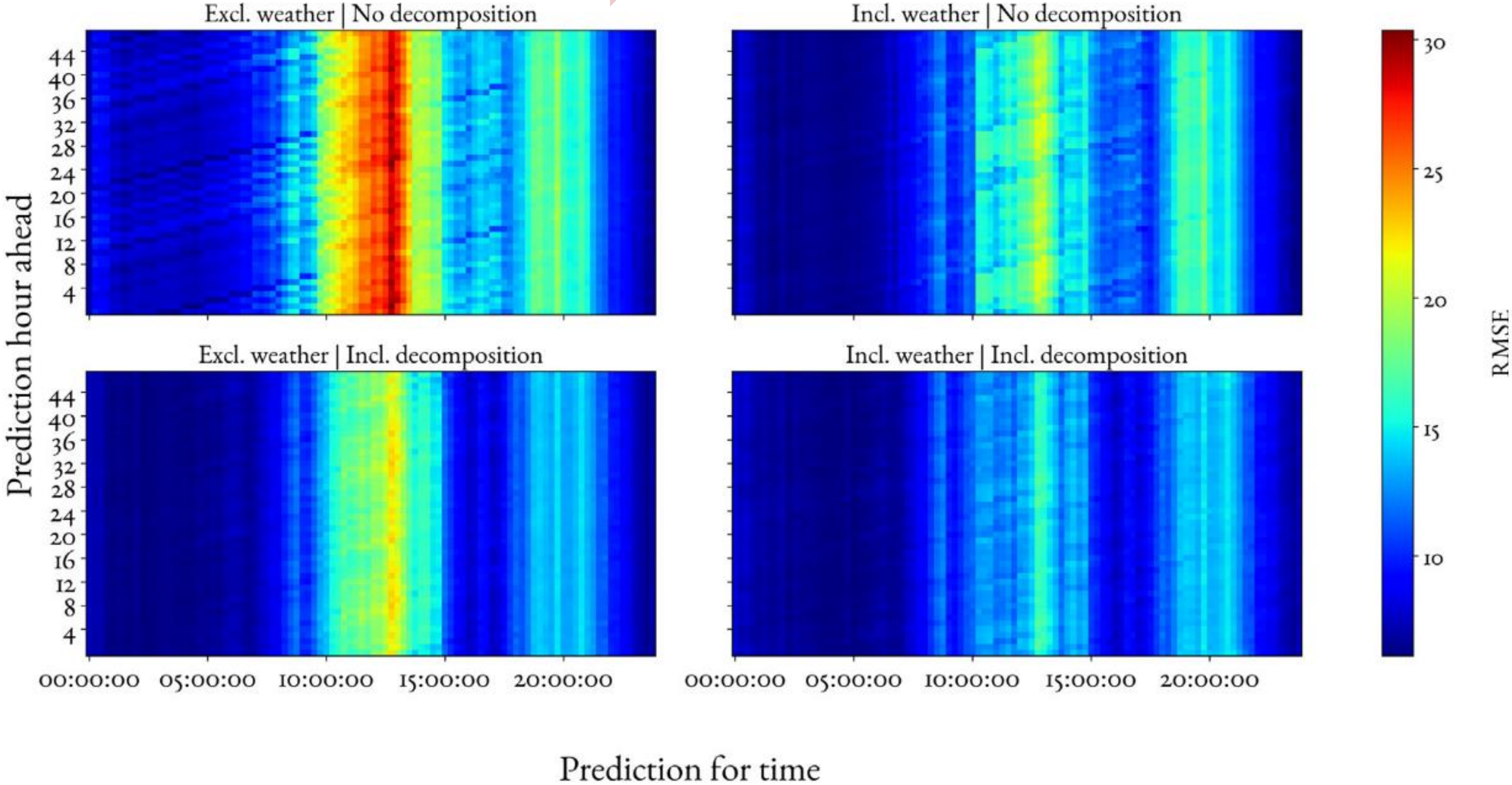
Congestion Point: Battery + EV street



Congestion Point: PV + EV parking

3. Implementation III/V



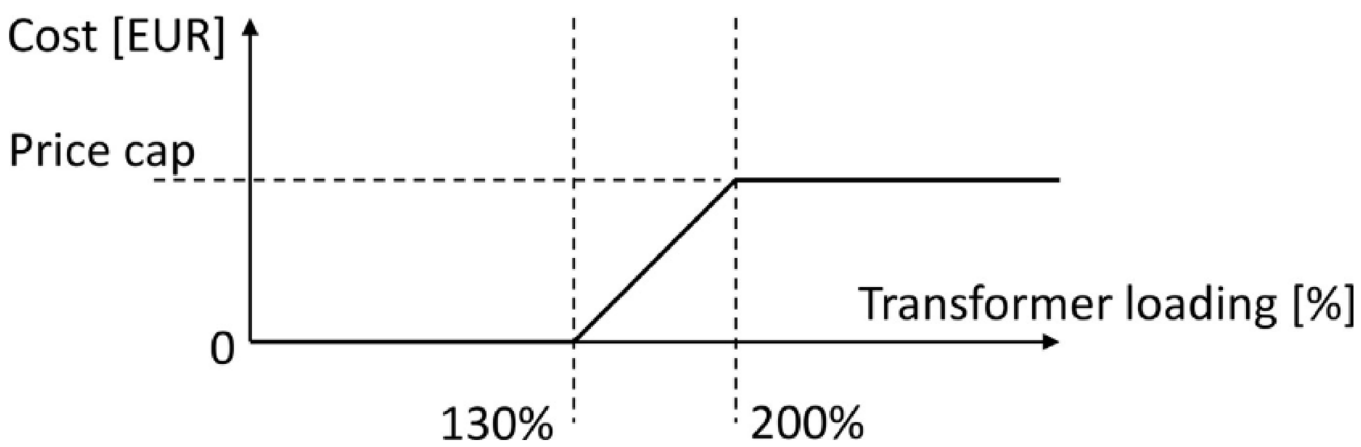


3. Implementation IV/V

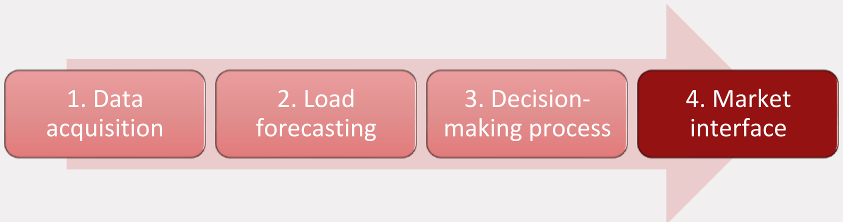
1. Data acquisition | 2. Load forecasting | **3. Decision-making process** | 4. Market interface

- Price of flexibility
- Based on transformer lifetime-reduction model *(IEEE, N. Haque)*
- Added risk of overloading

$$C_{flex} = \begin{cases} 0, & if \;\; P_l \leq P_{rated} \\ C_{ovl}(P_l, T), & if \;\; P_{rated} < P_l < 1.3 \cdot \mathrm{P}_{rated} \\ C_{ovl}(1.3 \cdot \mathrm{P}_{rated}, T) + C_{risk}(P_l, T), & if \;\; P_l \geq 1.3 \cdot \mathrm{P}_{rated} \end{cases}$$



3. Implementation V/V



- (mostly) USEF based implementation
  - Requesting flexibility
  - Receiving flexibility offers
  - Placing an order
  - Settling (afterwards) → Not the focus of the pilot, point for future research
- Deviation from USEF by including the maximum price in the flexibility request
  - Positive: no offers beyond the price of the DSO are sent and in a DAM this can be done with a single cycle
  - Negative: aggregators have knowledge of your maximum price, and can potentially use that to increase their prices

TU/e

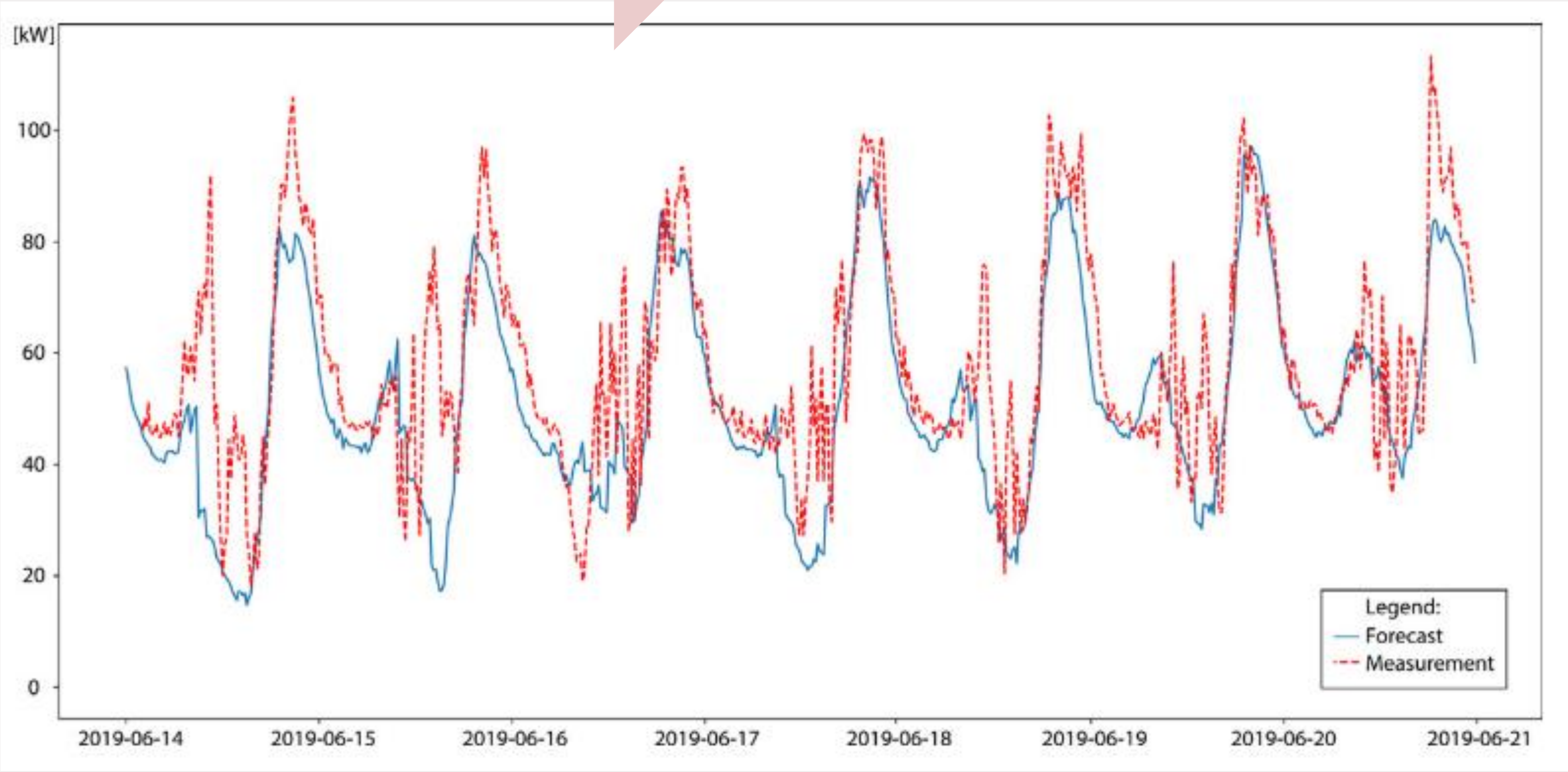
4. Results I/IV

1. Data acquisition → 2. Load forecasting → 3. Decision-making process → 4. Market interface

TU/e

4. Results II/IV

1. Data acquisition | **2. Load forecasting** | 3. Decision-making process | 4. Market interface



4. Results II/IV

1. Data acquisition
2. Load forecasting
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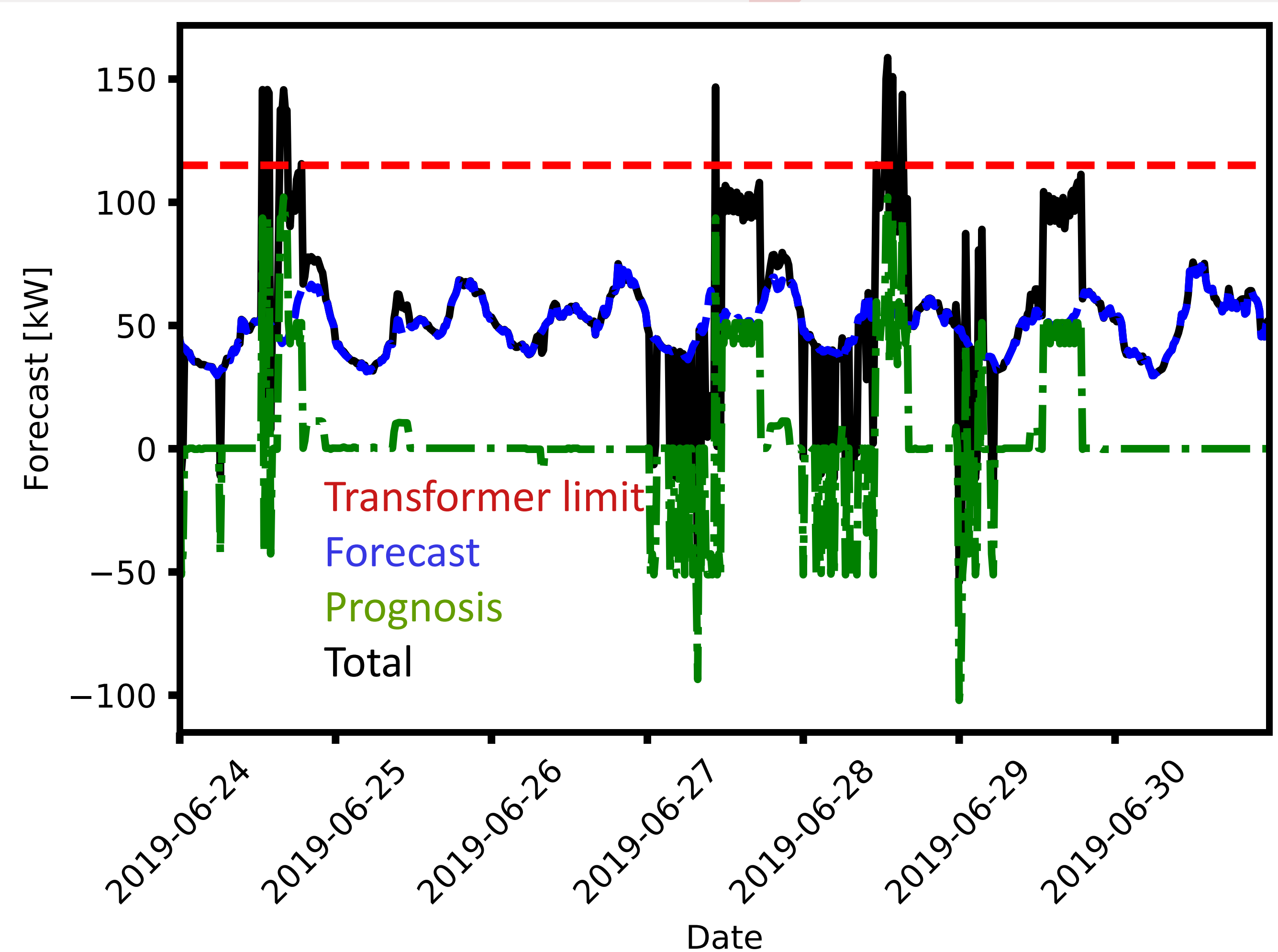
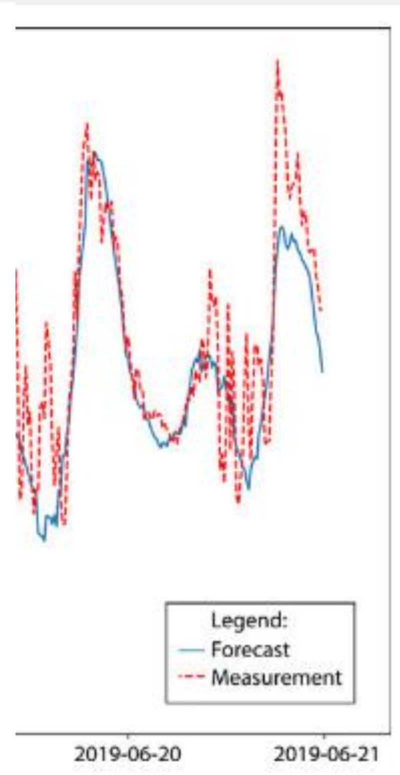
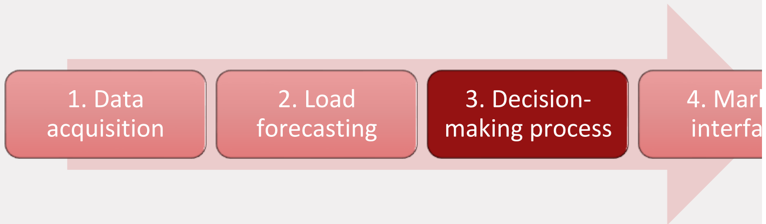
4. Market interface

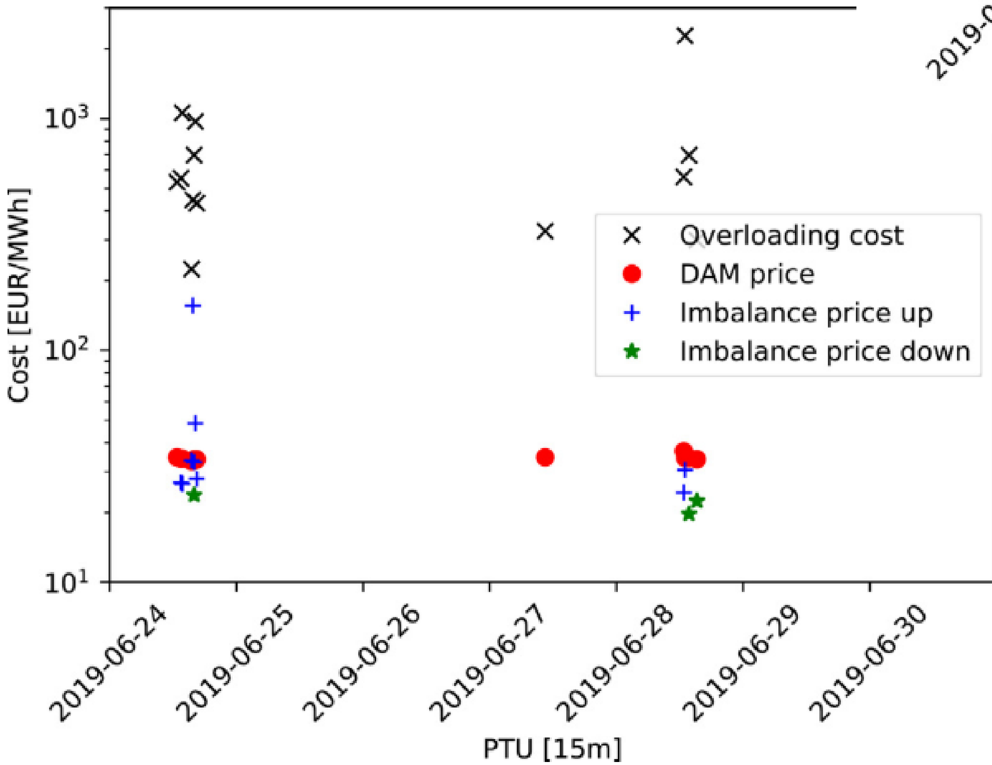


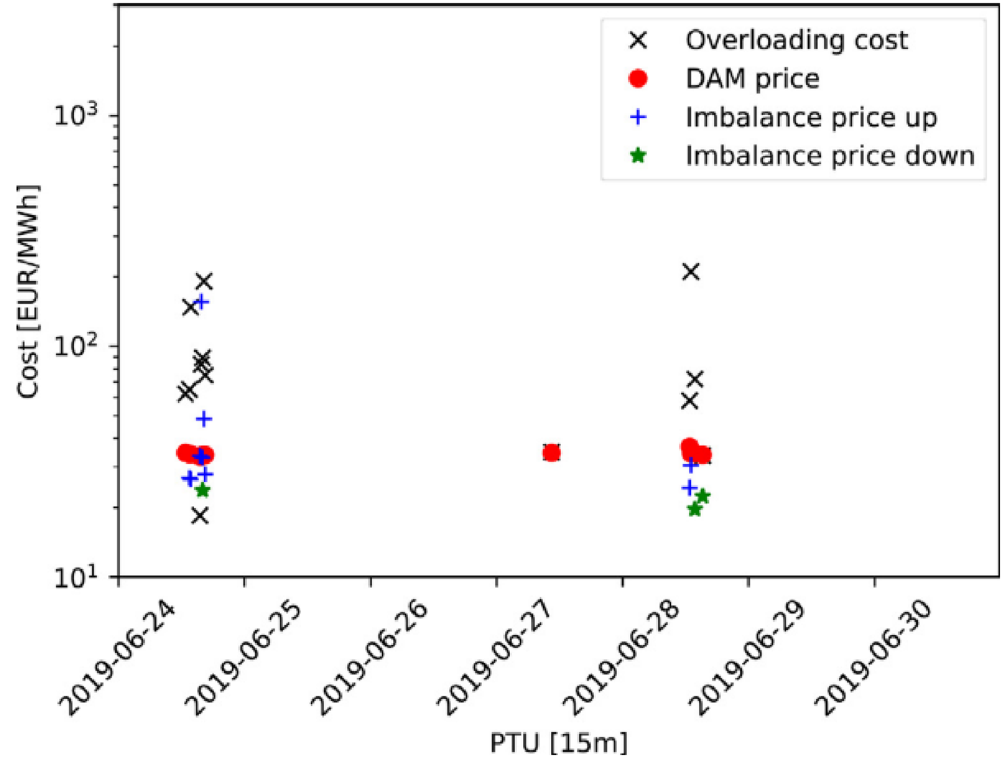


4. Results III/IV



P_{rated} 115kW

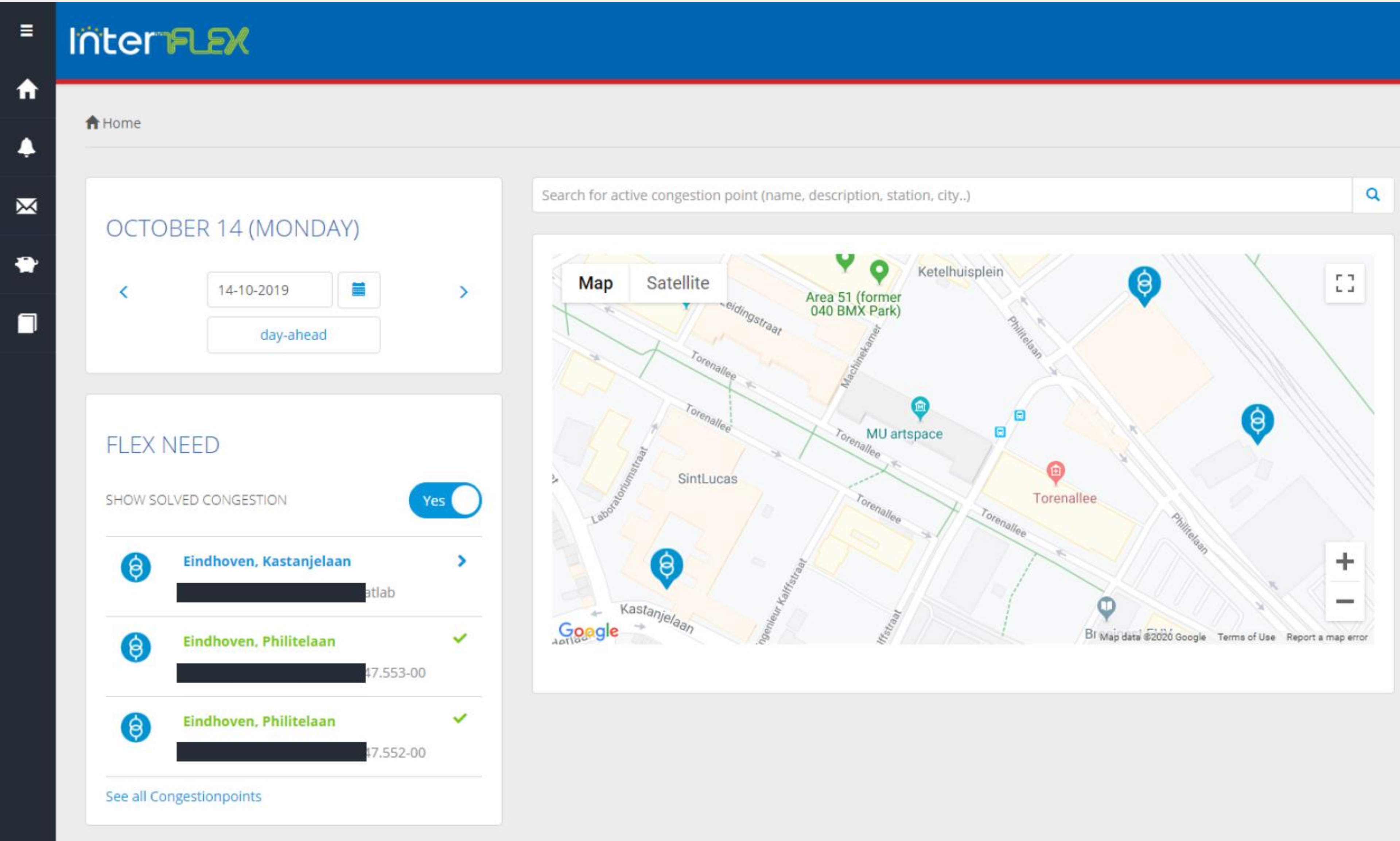




P_{rated} 130kW

1. Data acquisition → 2. Load forecasting → 3. Decision-making process → **4. Market interface**

4. Results IV/IV



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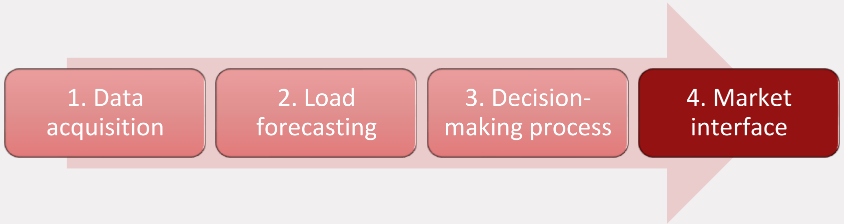

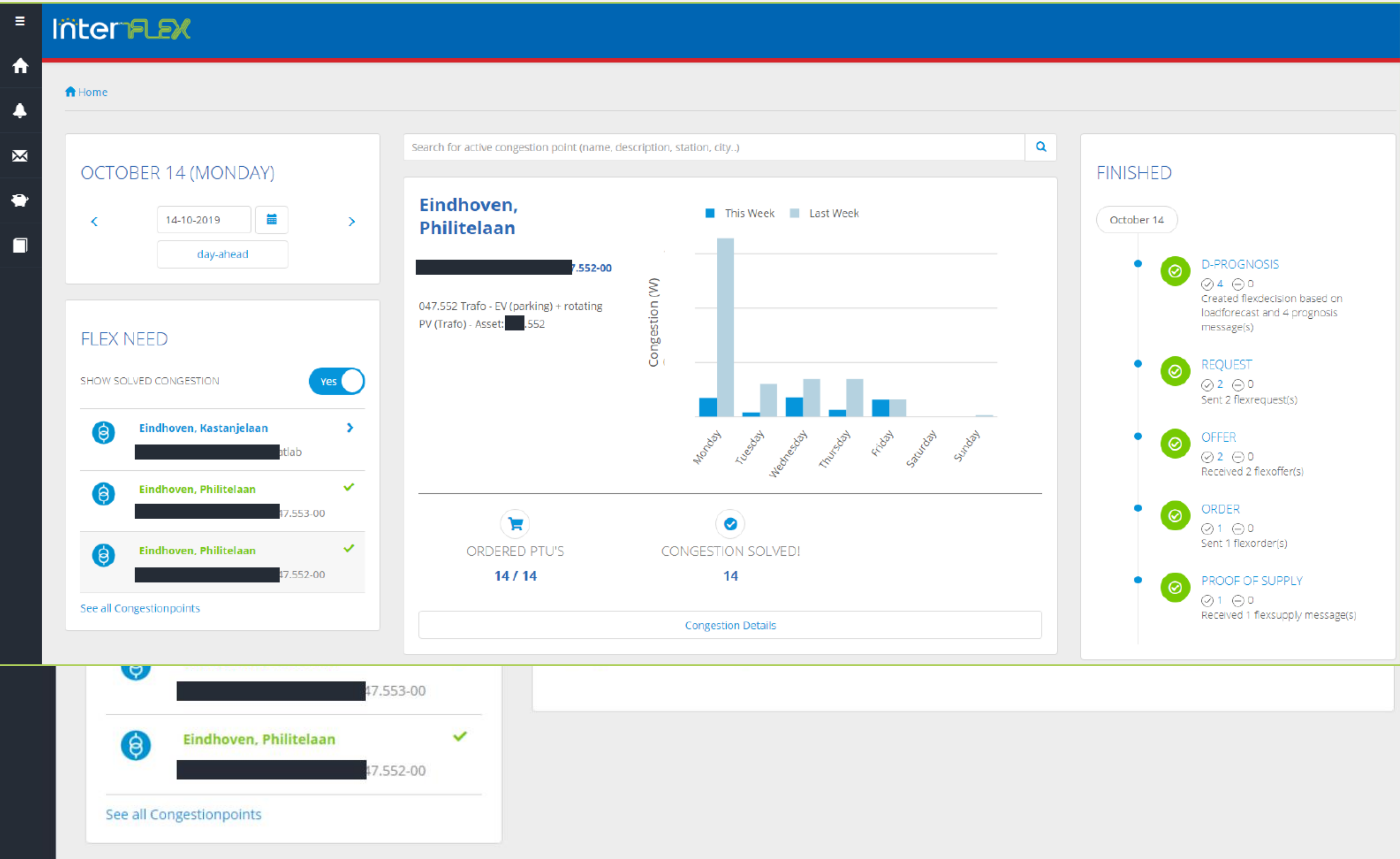

5. Conclusions

- The usability of the four steps is shown with the implementation in InterFlex.
- The proof-of-concept is therewith given.
- The basic algorithms of forecasting and decision-making provided in this research can, depending on the size of overloading, provide the DSO with competing market prices
- Next steps would be an analysis of including alternative algorithms, and mapping their impact on accuracy, computational intensity, complexity and input dependence.
- One of the main problems for future work is the settlement of flexibility: How do you know what would have happened if no flexibility was provided?

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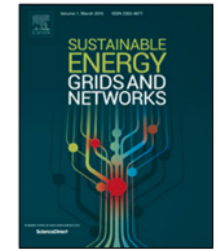

Demonstrating a generic four-step approach for applying flexibility for congestion management in daily operation

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New energy technologies like photovoltaics, electric vehicles, and heat pumps increasingly find their way to distribution networks. At the time the existing distribution networks were designed, only conventional loads were considered. The capacity of the (existing) distribution networks is therefore insufficient to handle the additional (bidirectional) peak load caused by these new technologies. The distribution system operator (DSO) is facing network congestion. Flexibility to shift and/or change power and energy in time and/or amount is considered as an option to mitigate network congestion with various implicit and explicit mechanisms. This leaves DSOs with the question on how to deploy

https://www.sciencedirect.com/science/article/pii/S235246772030309X?via%3Dihub

6. Further reading

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