Household batteries and grid congestion management

ES-ONSEMINAR

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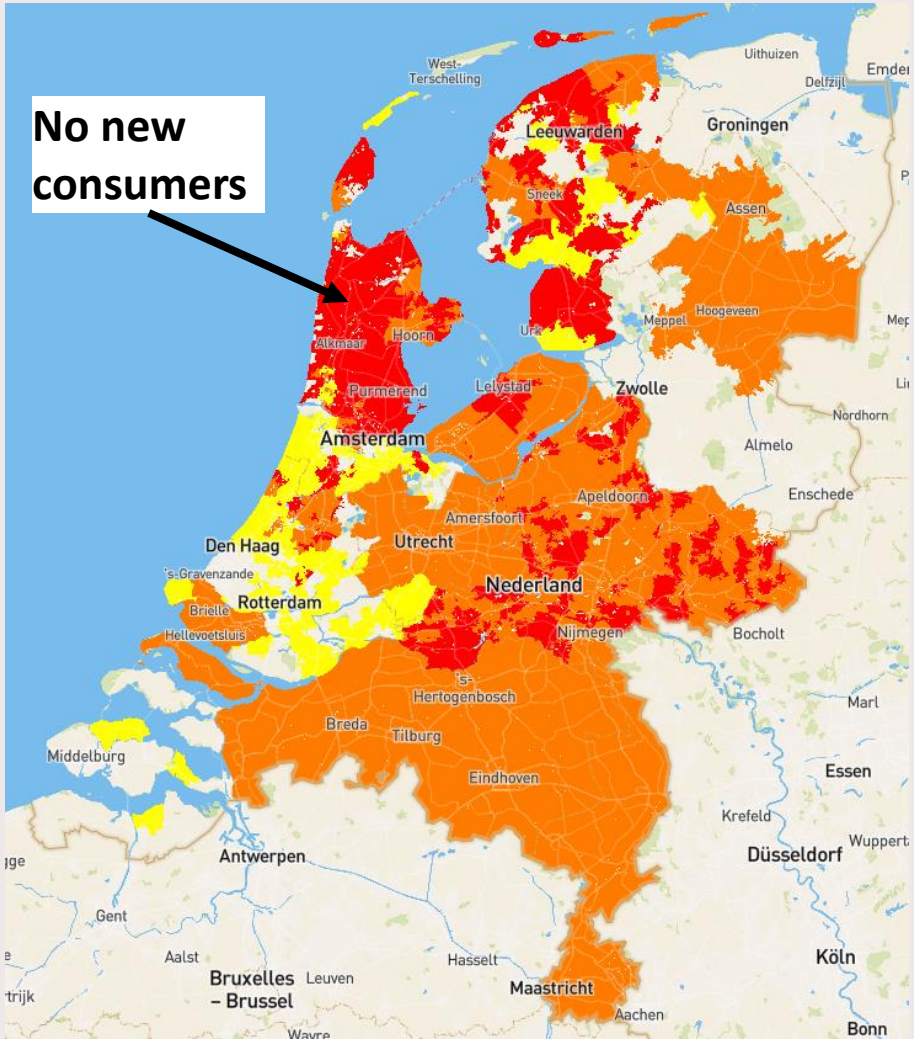
Introduction

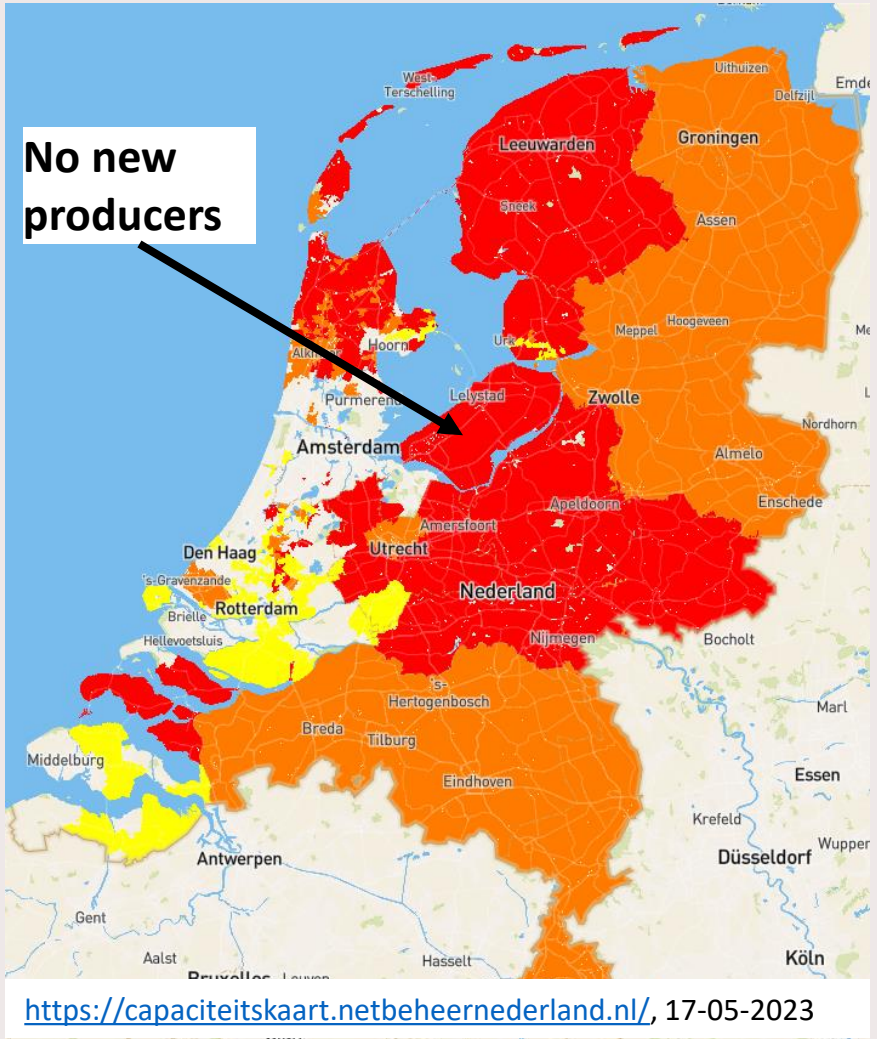
- Teacher-Researcher at Hanze University of Applied Sciences
- PhD candidate at Technical University of Eindhoven
- Research focus is congestion in LV and MV distribution grids

Agenda

1. What is grid congestion and why is it occurring?
2. How can we address grid congestion issues with batteries?
3. NO GIZMOS: A practical use case of household batteries used to manage grid congestion.

The Problem





https://capaciteitskaart.netbeheernederland.nl/, 17-05-2023

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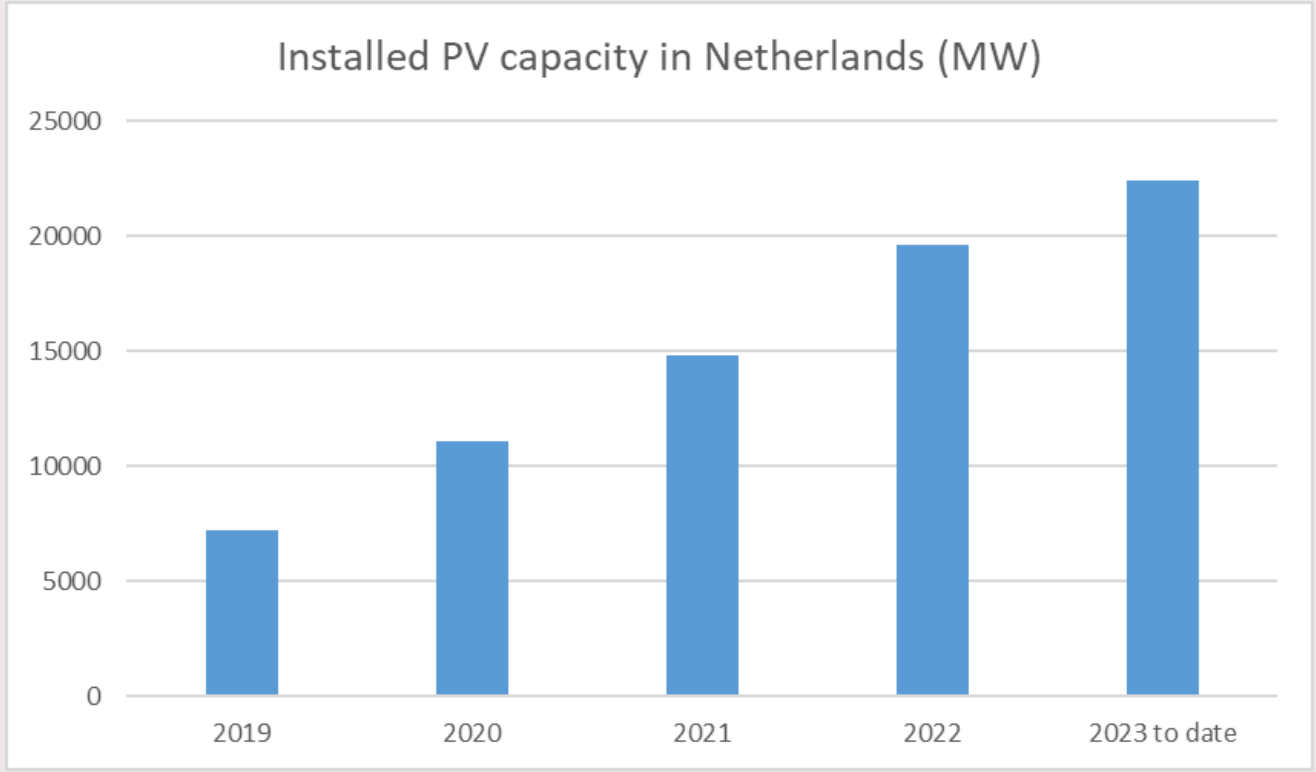
Rooftop PV



Source: CBS

- Roughly half of this capacity is rooftop PV.
- Larger PV plants tend to be installed in rural areas with relatively weak electricity grids.
- PV tends to generate electricity at the same time (peaks from 12:00-15:00).

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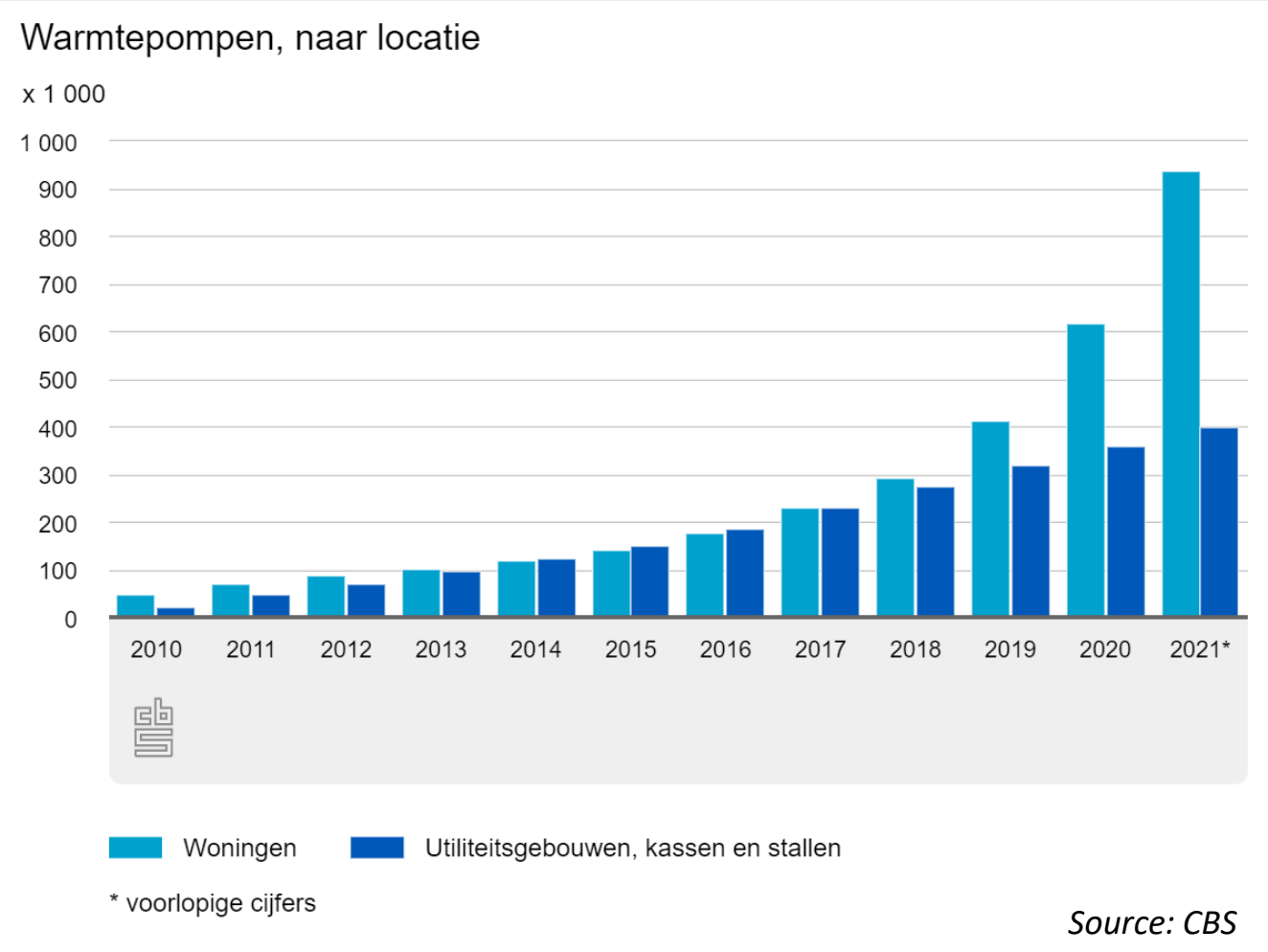
Heat Pump Growth



Source: CBS

- Residential heat pumps are nearly doubling each year.
- Heat pumps roughly double household electricity use.
- Heat pumps have a relatively high simultaneity (i.e., they tend to run at the same time).

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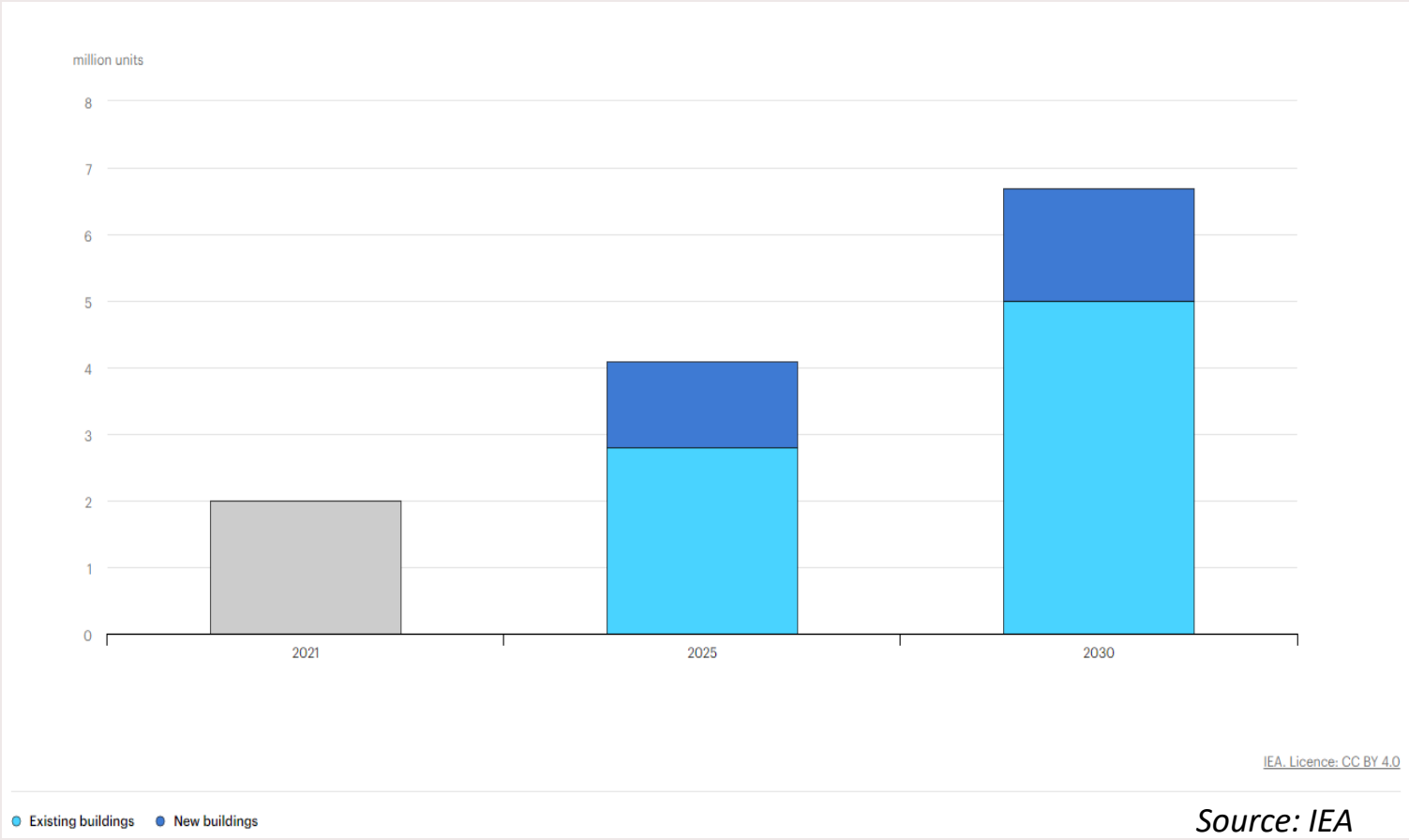
Heat pumps in Europe

- The IES expects roughly 7 million heat pumps in Europe by 2030.



Source: IEA

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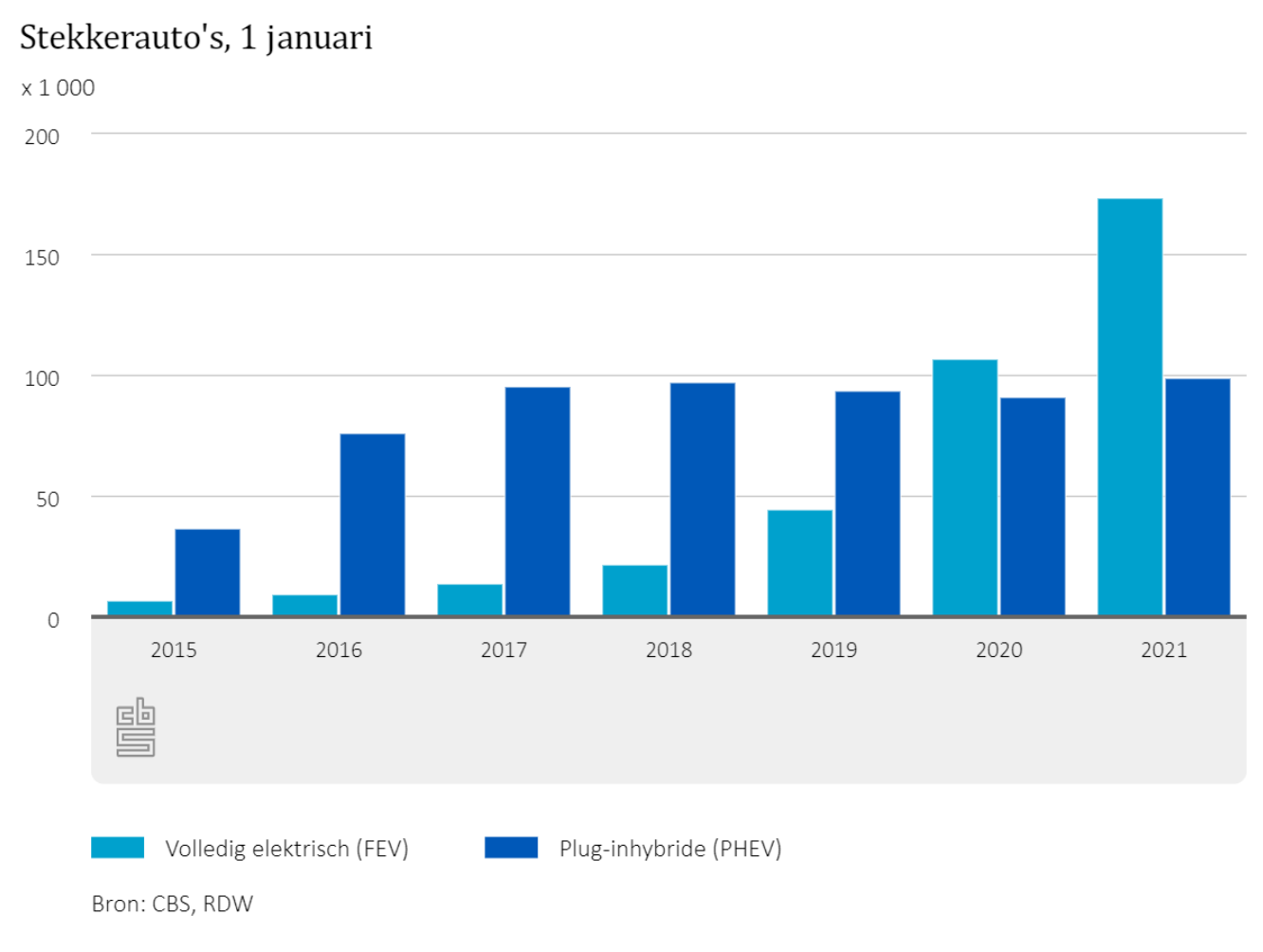
EV Growth



- EVs roughly double traditional household electricity consumption.
- EVs tend to be charged at similar times (peaks around 17:00-19:00).
- The Netherlands is expecting roughly 2 million personal EVs by 2030.

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Electrification Leads to Increasing Simultaneity

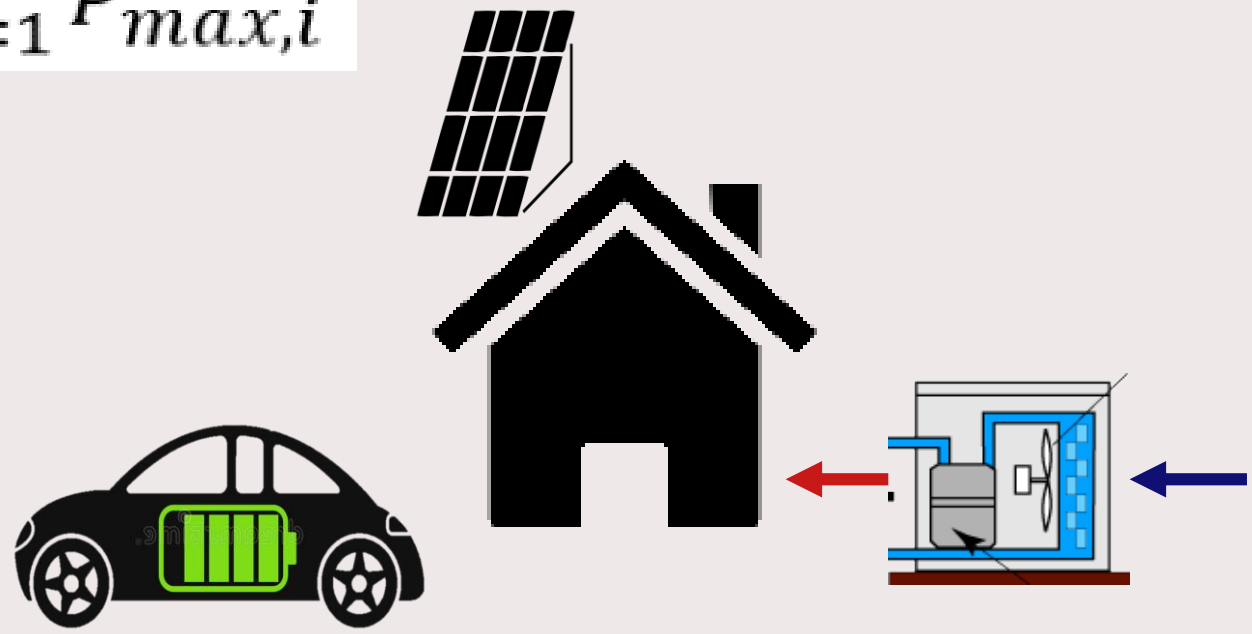
$$g = \frac{P_s}{\sum_{i=1}^{n} P_{max,i}}$$

$g_{traditional\_neighbourhood}$ = 20%

$g_{rooftop\_PV}$ = 50-90%

$g_{EV\_charging}$ = ~50%

g_{heat_pump} = 30-50%



Addressing grid congestion issues

a) Some grid congestion issues can be relatively easily addressed. For example, curtailing peak PV generation by 30% results in loss of only 5-6% of annual energy generation.

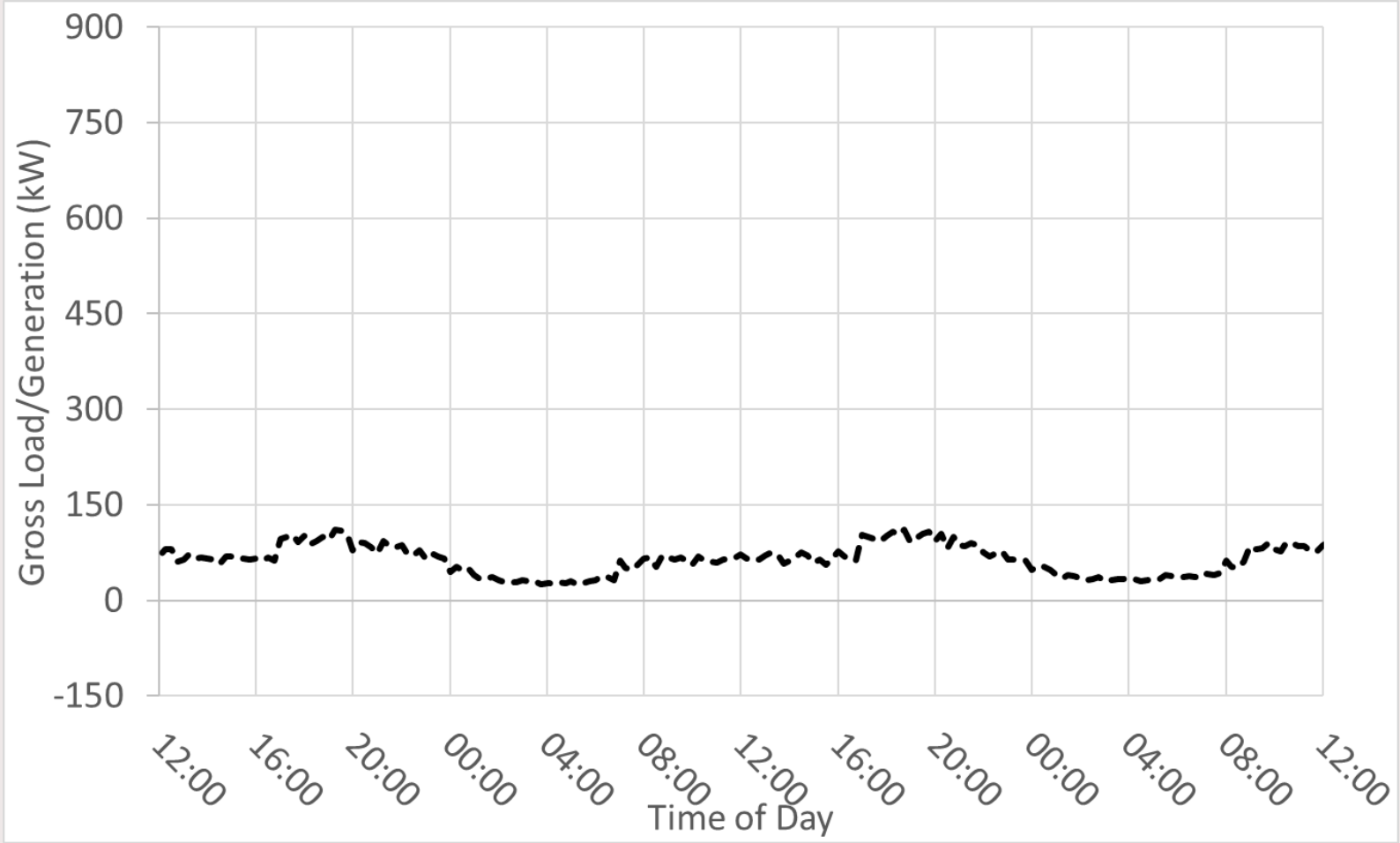
b) EV and heat pumps can be coordinated such that their peak loads do not coincide (i.e., reduce simultaneity).

c) Batteries can be used to keep generation local, thereby reducing electricity transport needs.

All of these approaches (and many others) have pros and cons, but today let us look more closely at **batteries**.

Future Load Pattern Case Study

Measurements
(**base load**)



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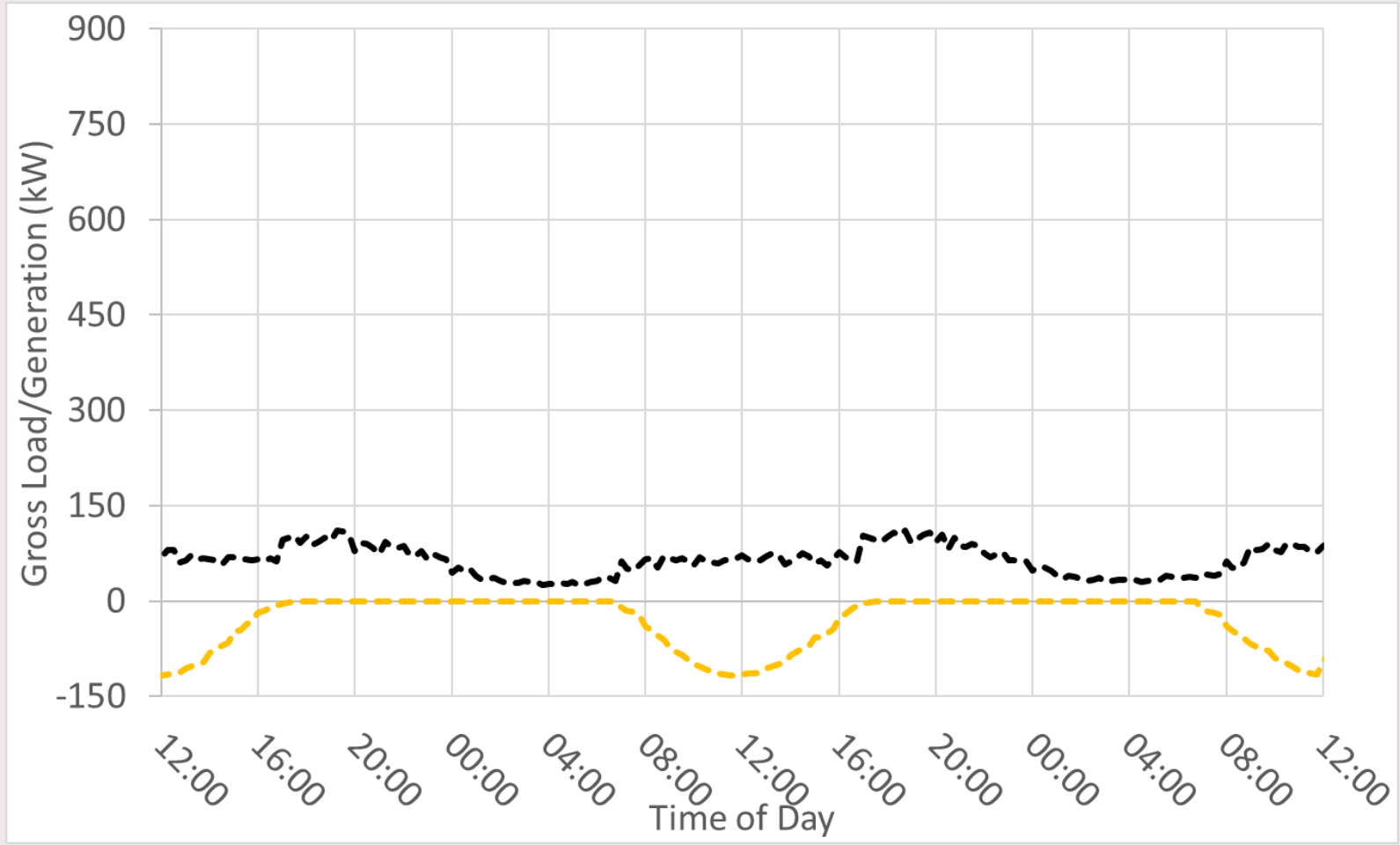
Future Load Pattern Case Study

Measurements
(**base load**)

+ PV (30 additional houses with 6 kW_{peak})



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Future Load Pattern Case Study

Measurements
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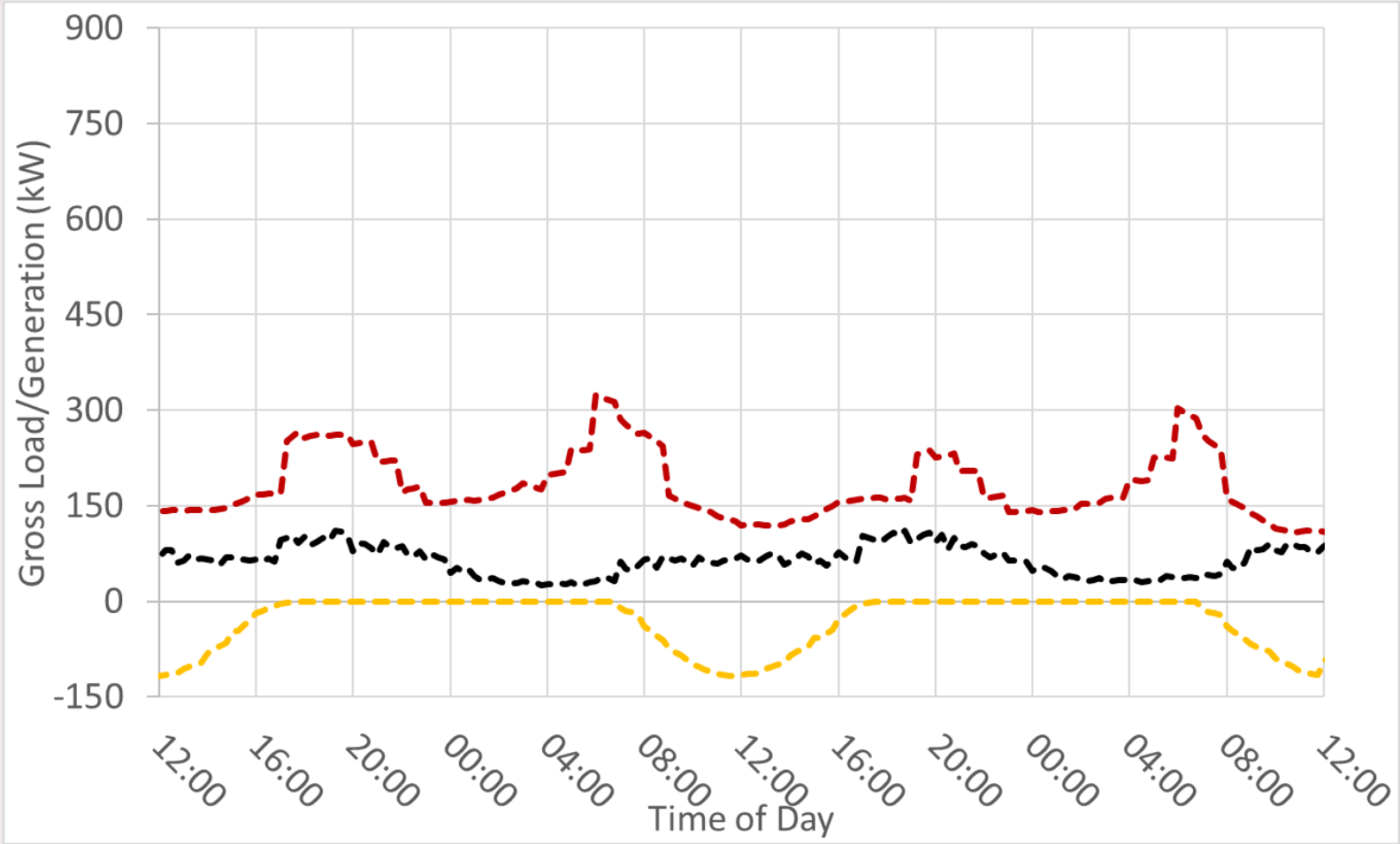
+ PV (30 additional houses with 6 kW_{peak})

+ Heat pumps
(80 houses)



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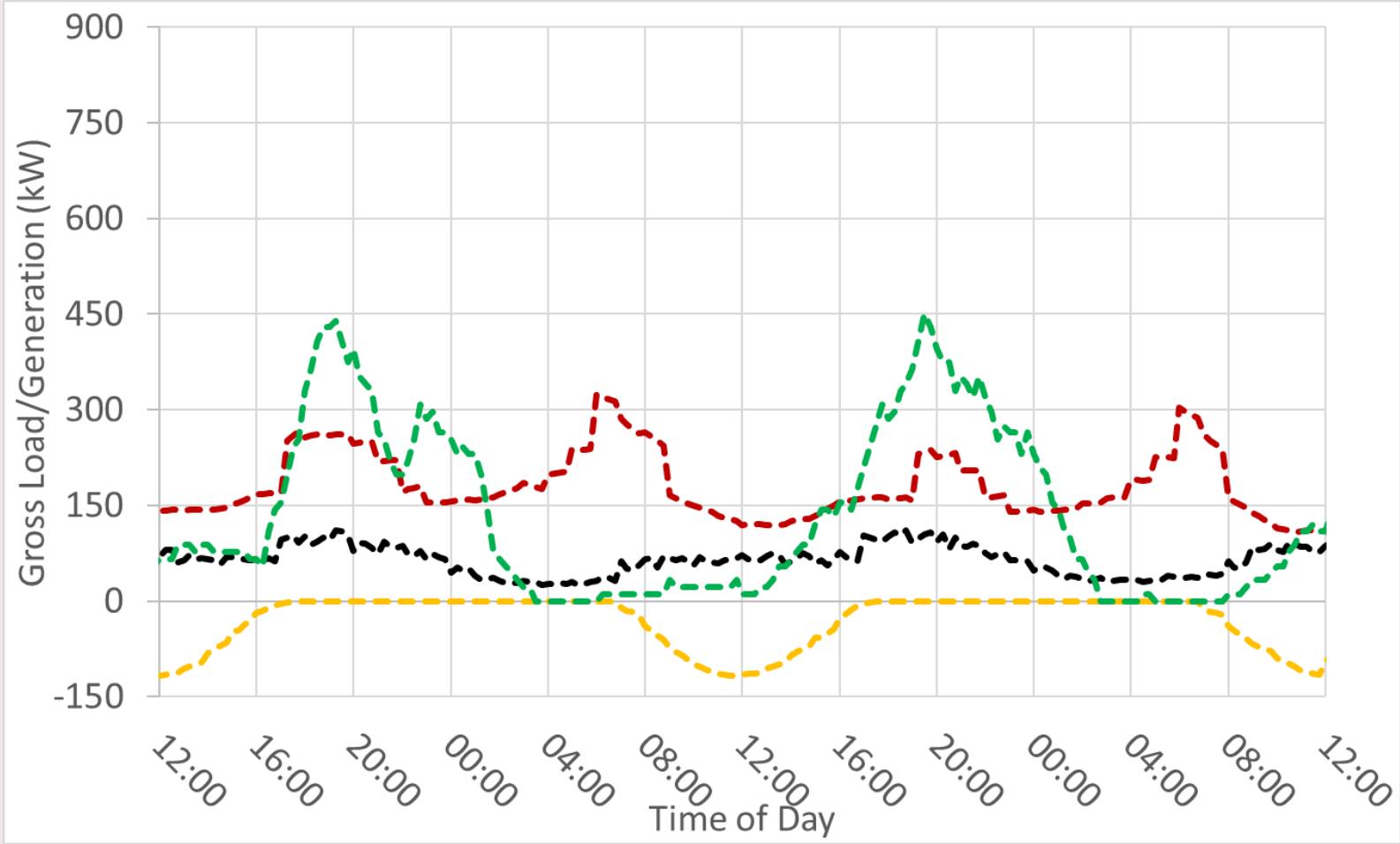
Future Load Pattern Case Study

Measurements
(**base load**)

+ PV (30 additional houses with 6 kW_{peak})

+ Heat pumps
(80 houses)

+ EV (95)



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Future Load Pattern Case Study

Measurements
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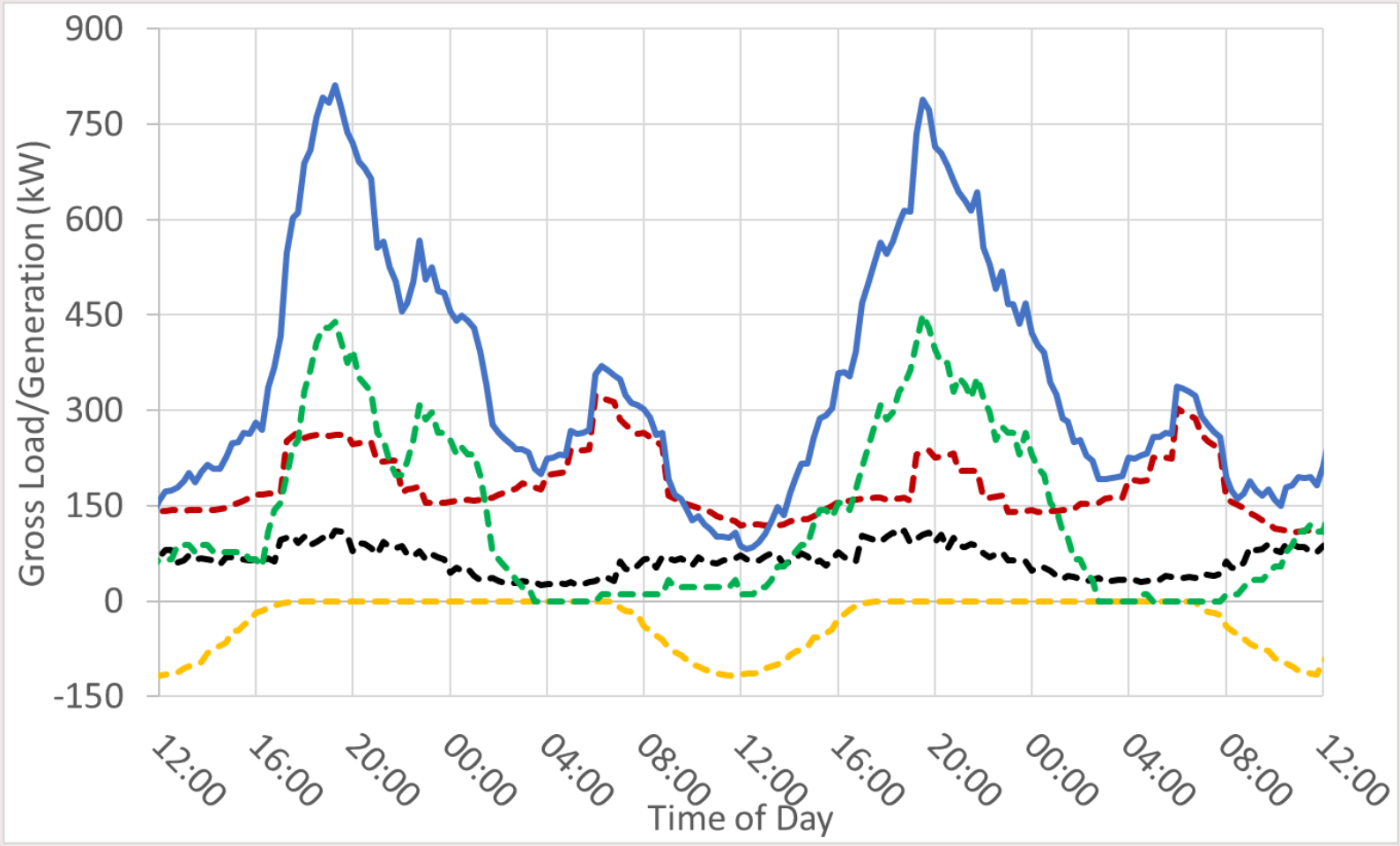
+ PV (30 additional houses with 6 kW_{peak})

+ Heat pumps
(80 houses)

+ EV (95)

= **Load Pattern**



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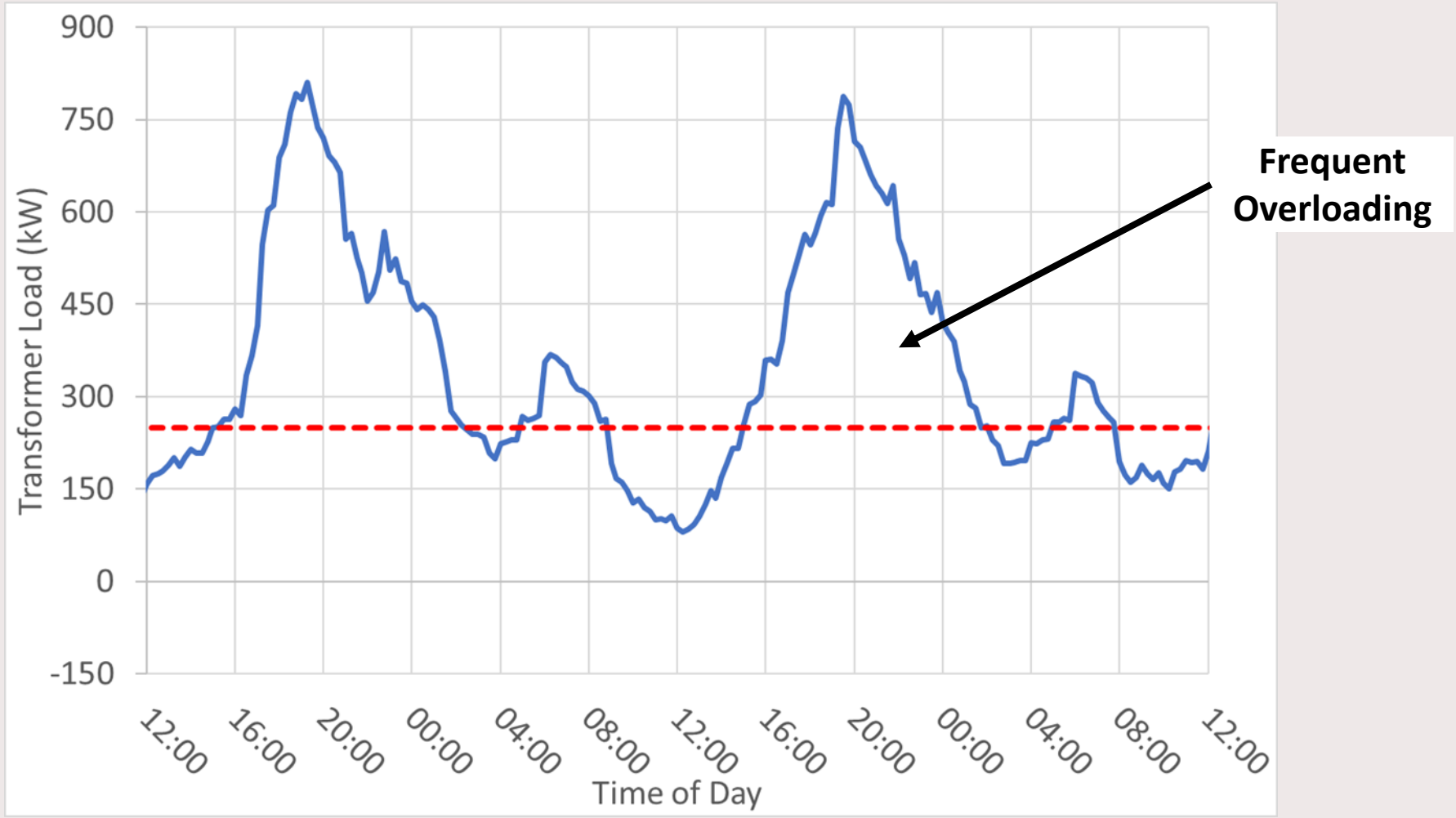
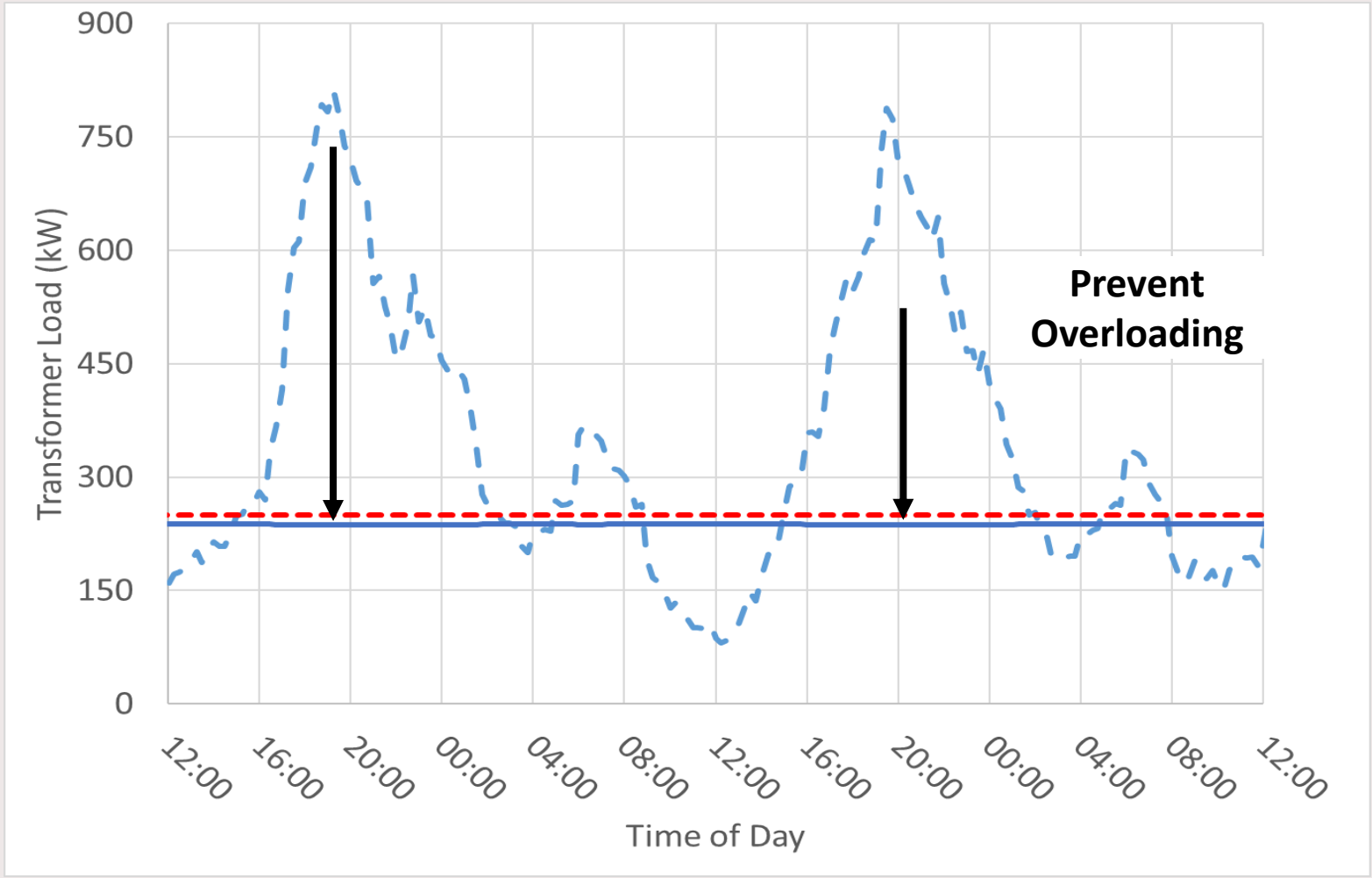
Grid Model Results Case Study



Battery Energy Storage Case Study



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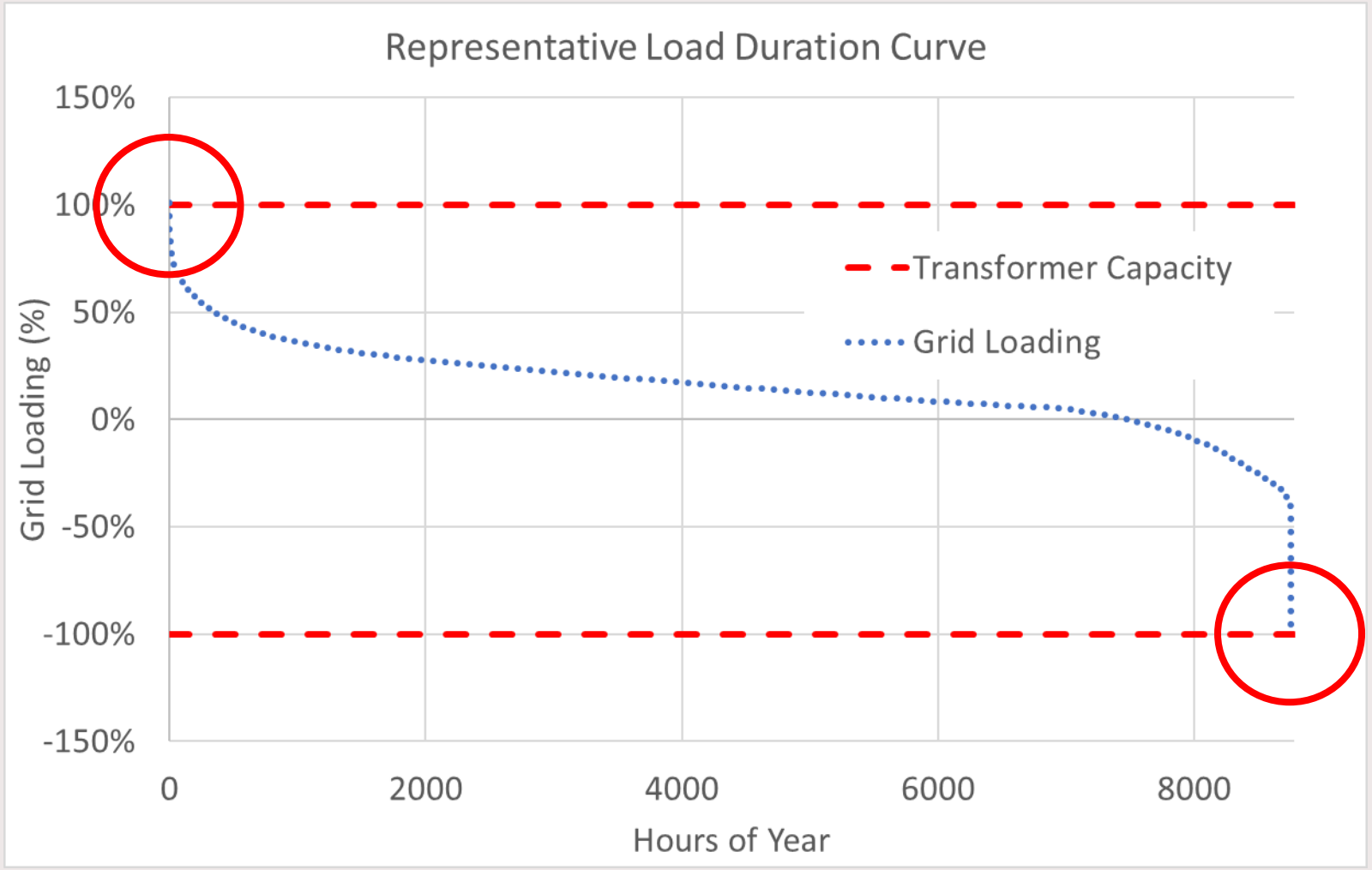
Grid Congestion



Data from Enexis Netbeheer B.V.

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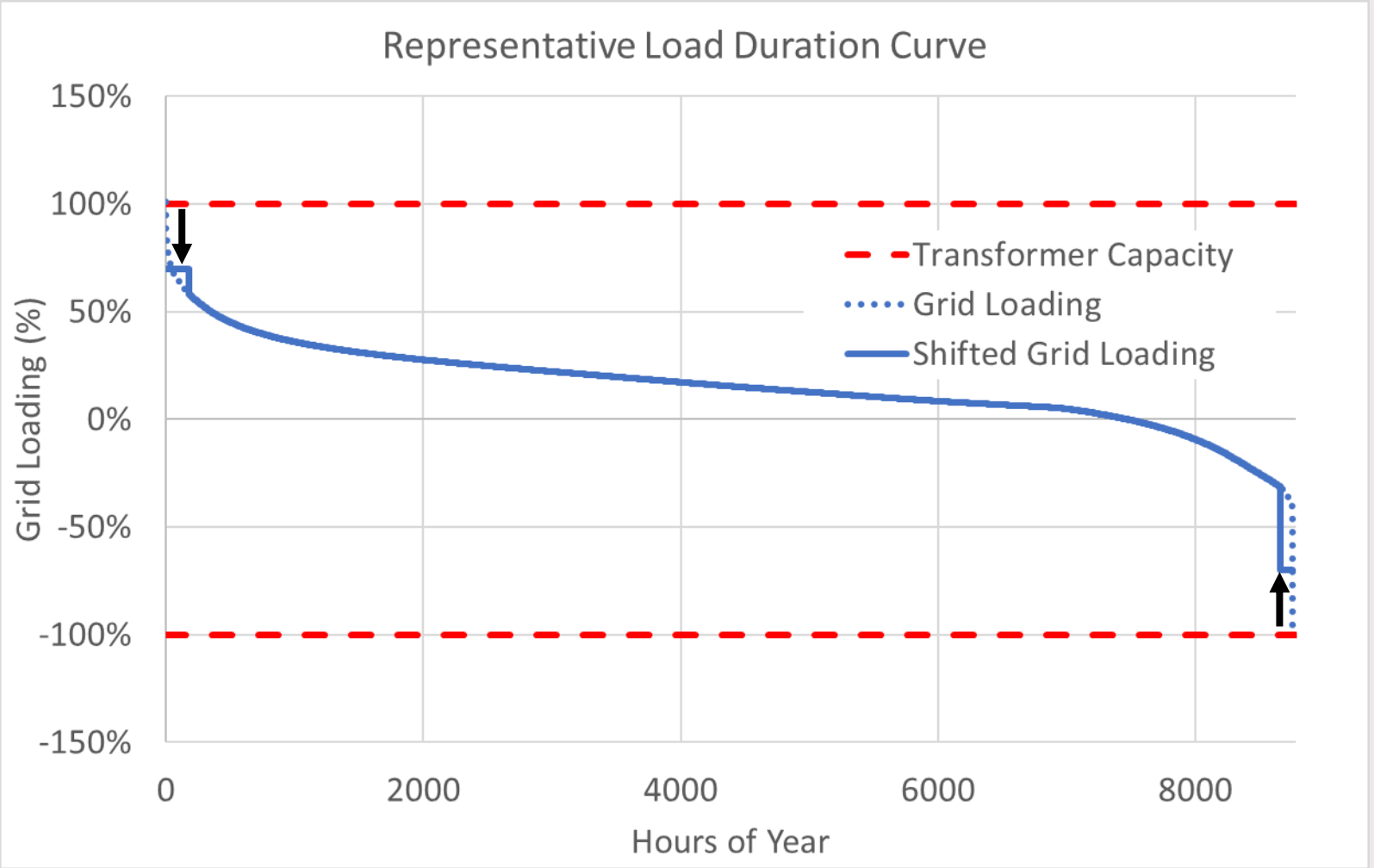
Battery Energy Storage



Data from Enexis Netbeheer B.V.

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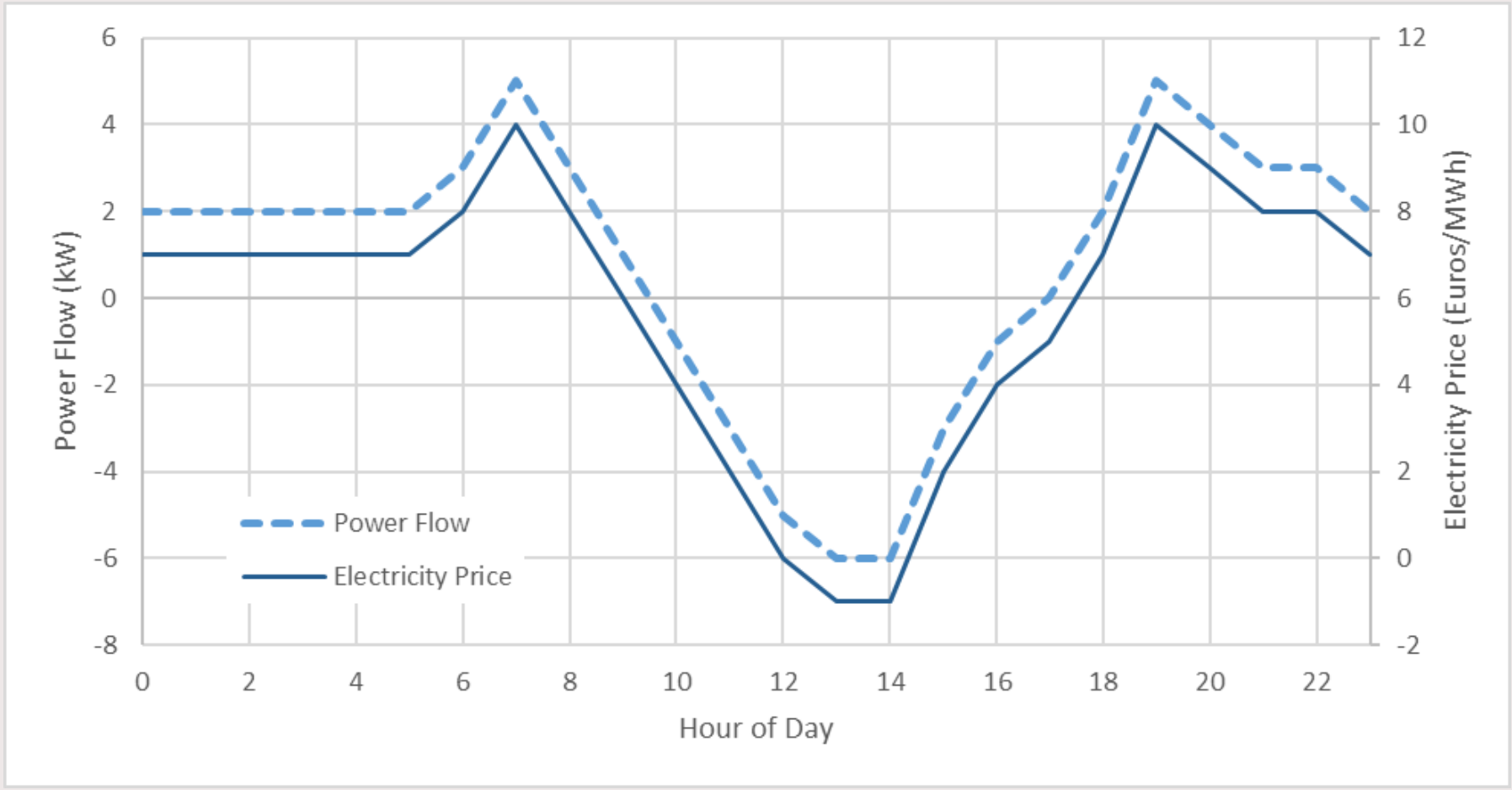
How we expect household batteries to act



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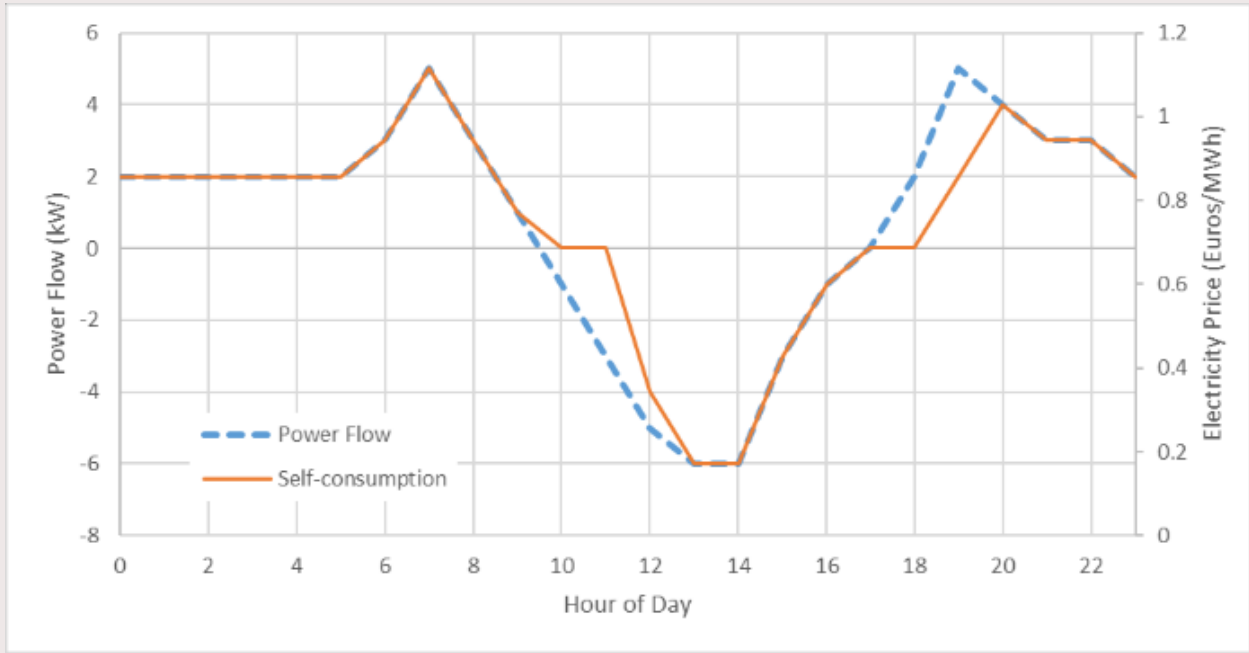
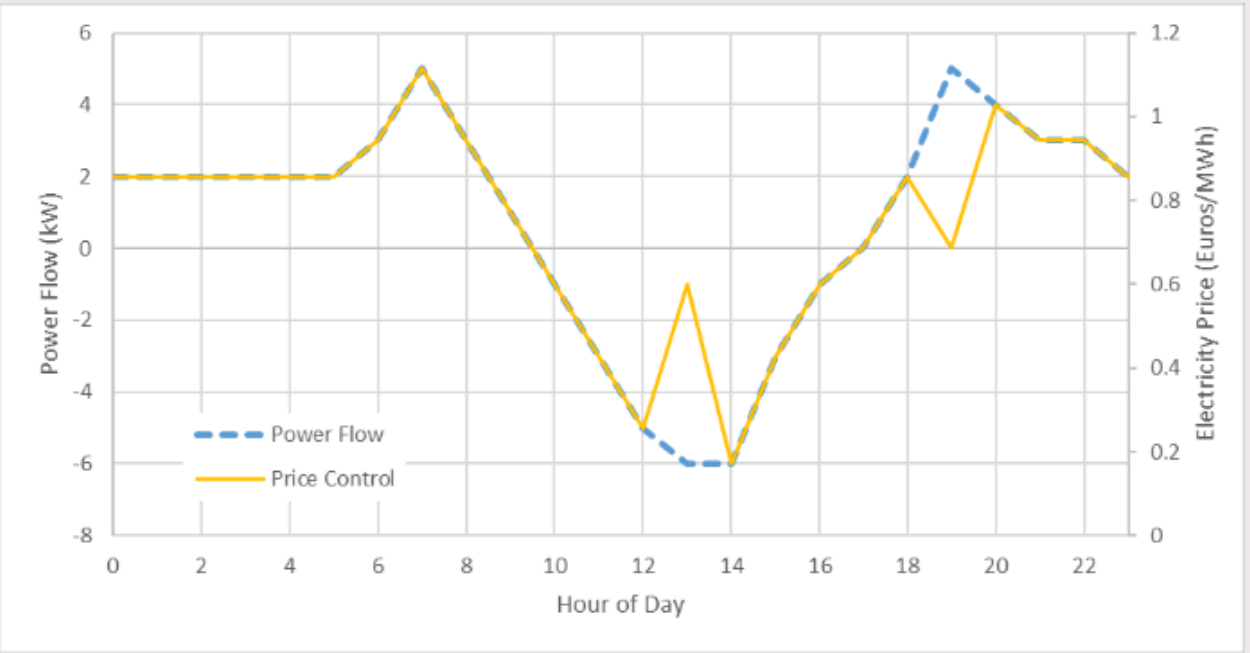
“Greedy” batteries

Self-consumption vs. Price control





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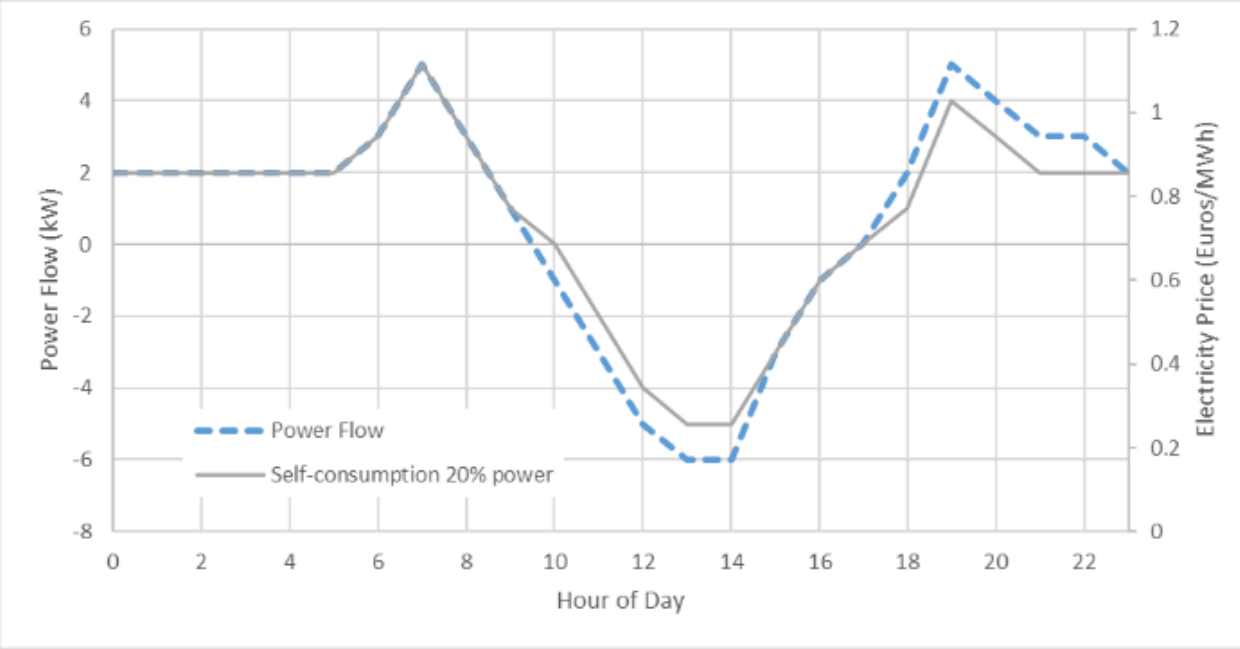
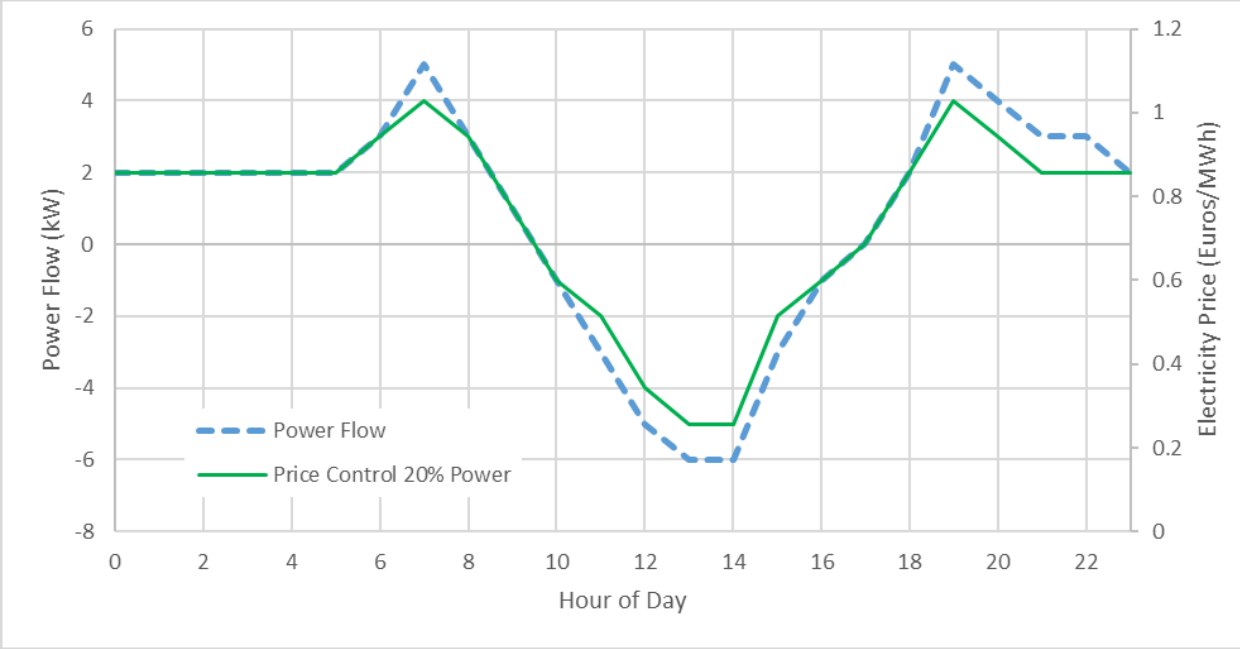
“Greedy” batteries with limited power (20%)

Self-consumption vs. Price control





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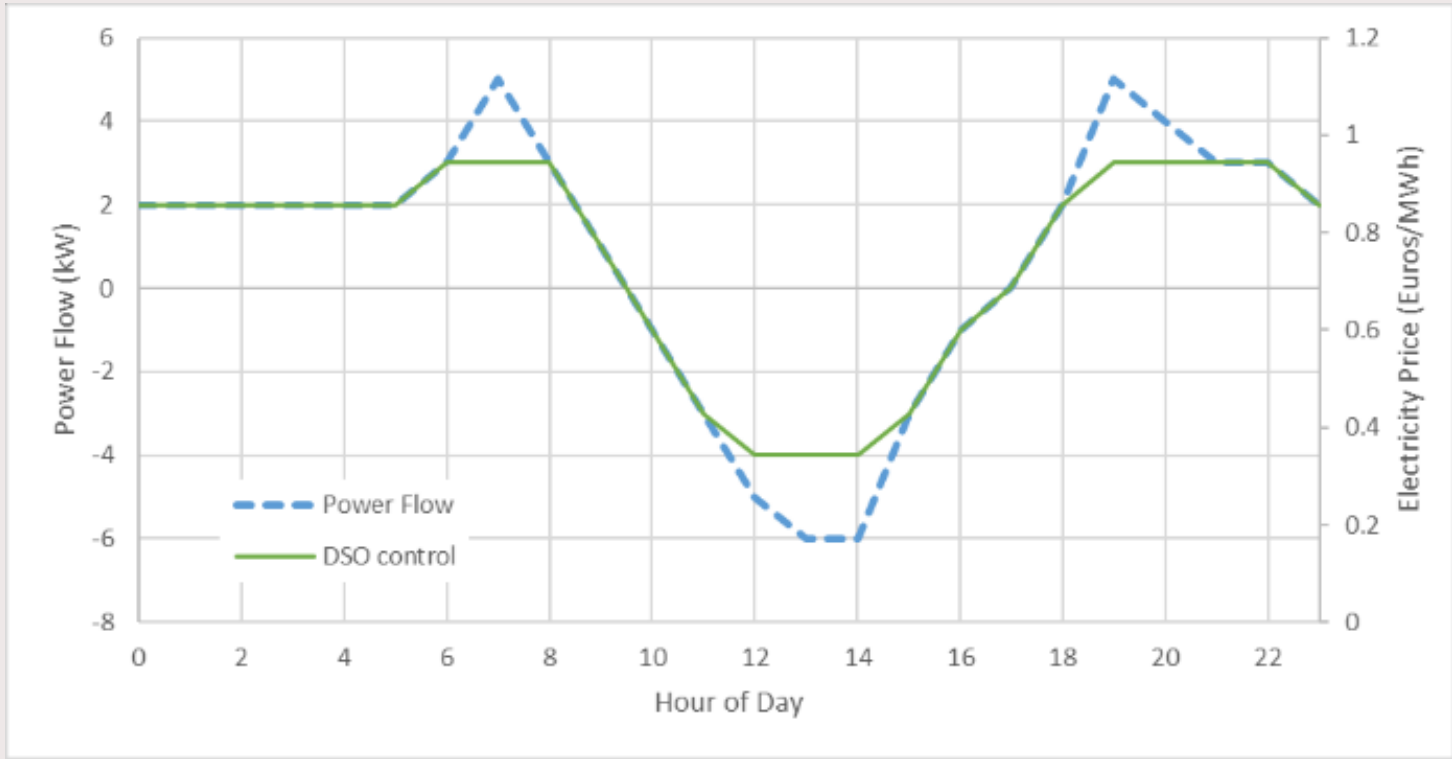
DSO control batteries



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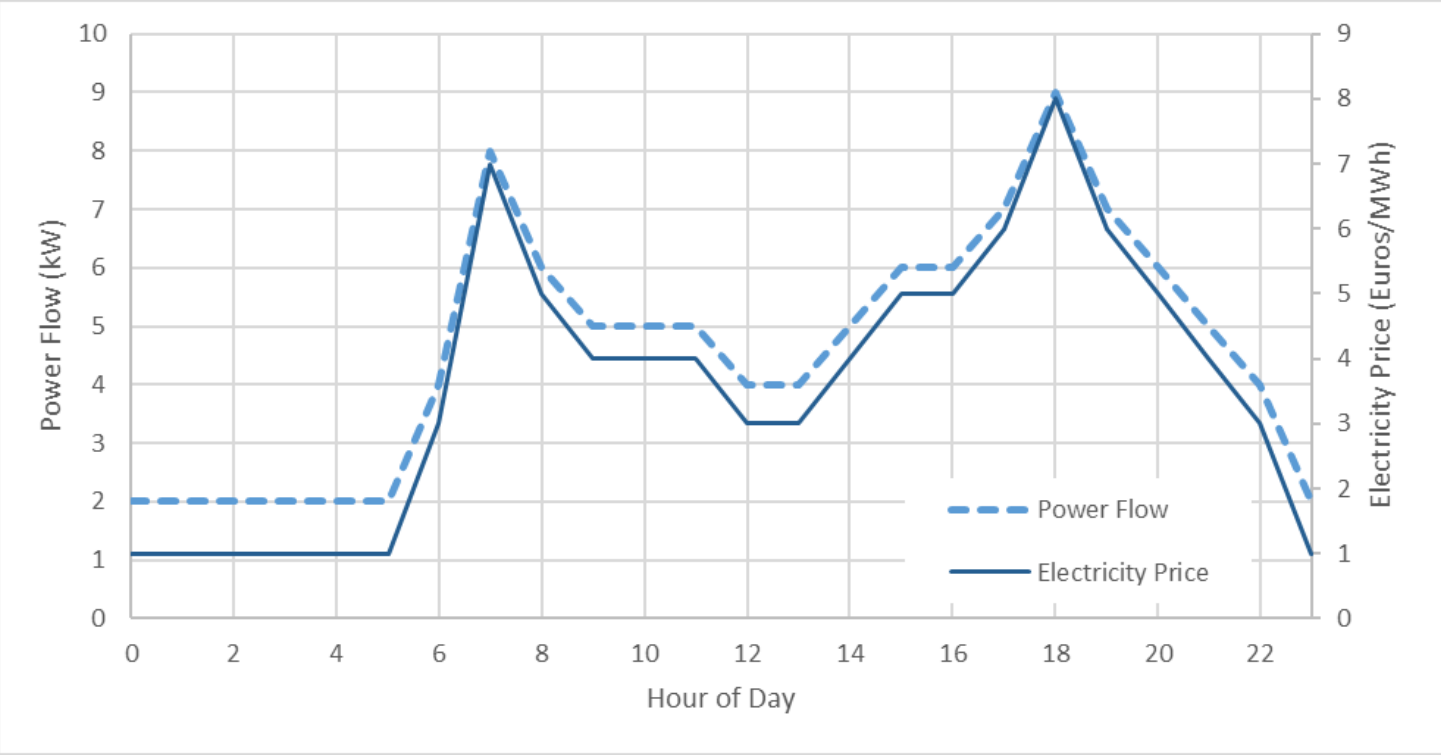
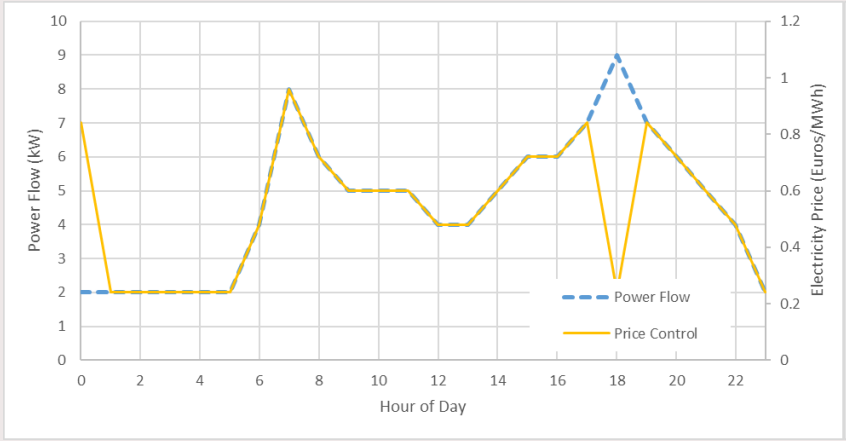
“Greedy” batteries

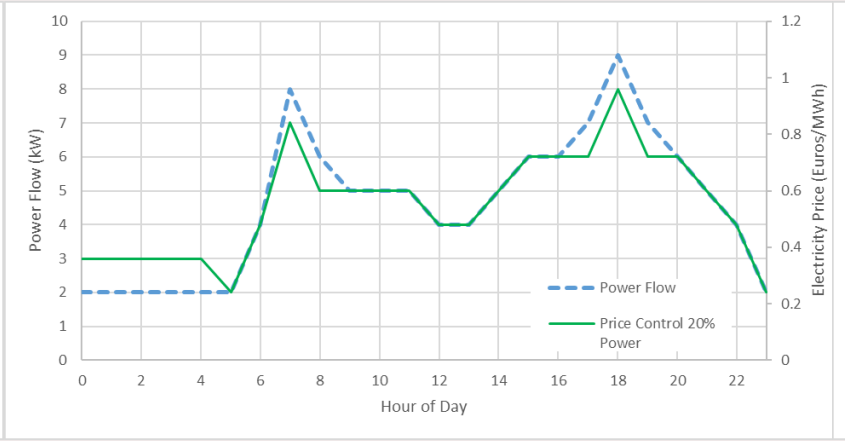
Winter pattern

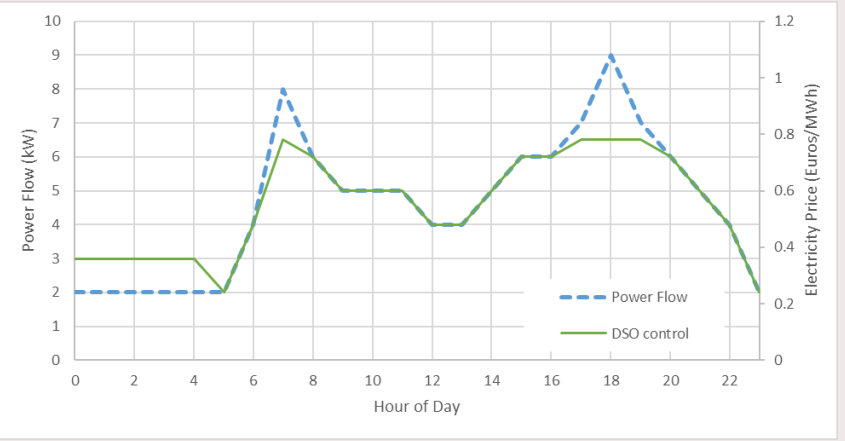


Greedy batteries

Self-consumption vs. Limited power vs. DSO control







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Questions

- To what extend are household batteries able to reduce grid congestion in practice?
- What is the impact of DSO control on battery (or EV) owners?
- Are household batteries a (cost) effective solution for energy transition problems?

NO GIZMOS

- NO GIZMOS (NetOptimalisatie voor Grootschalige Inpassing Zon- en windstroom Middels Opslag en Software) is a Topsector Energie project where we intend to answer just these questions.

- We analyze a rural area with lots of PV and initiatives to become free from natural gas use.

- Project partners include:

Ansen Aardgasvrij
energieKansen
ENEXIS GROEP
iwell
Saving nature's energy
CGI

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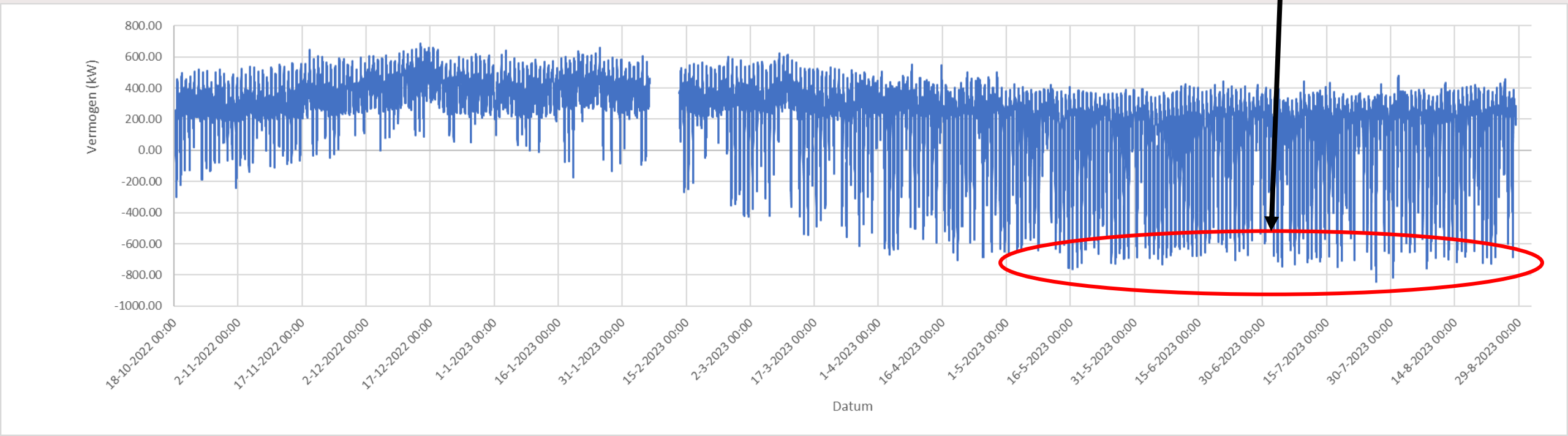
Case in Ansen today

1 MW electricity grid

On several days of the year, this grid is experiencing congestion, primarily from PV generation.



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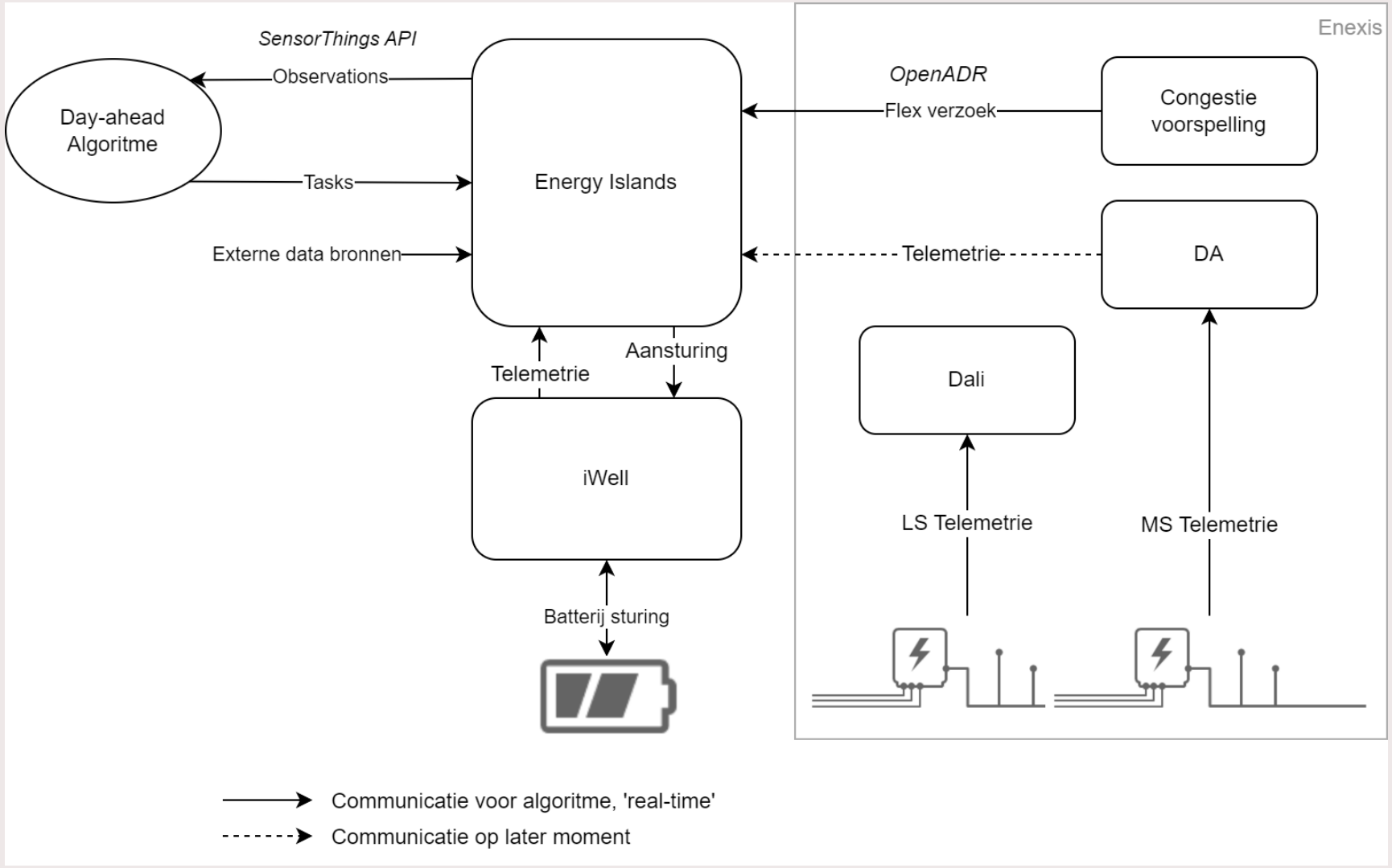
NO GIZMOS

We have installed 140 kWh of household batteries which can be (indirectly) controlled by the DSO.



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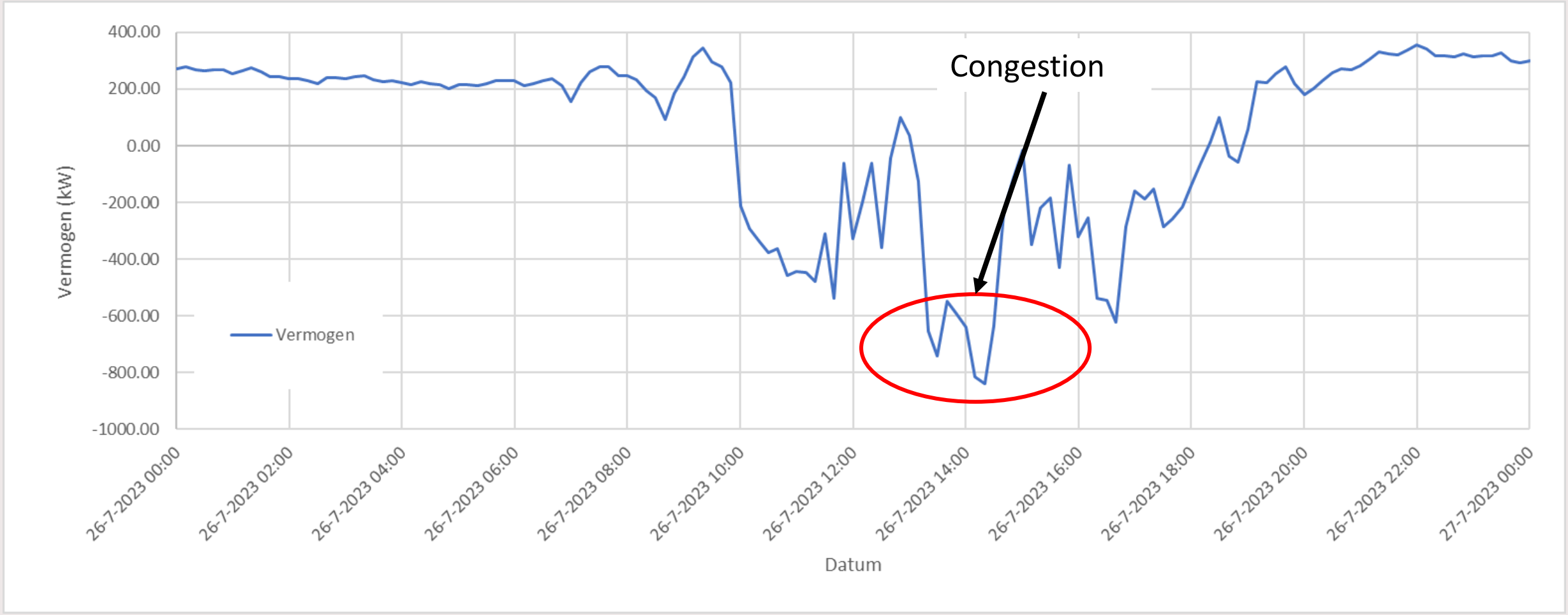
“Worst day” last year



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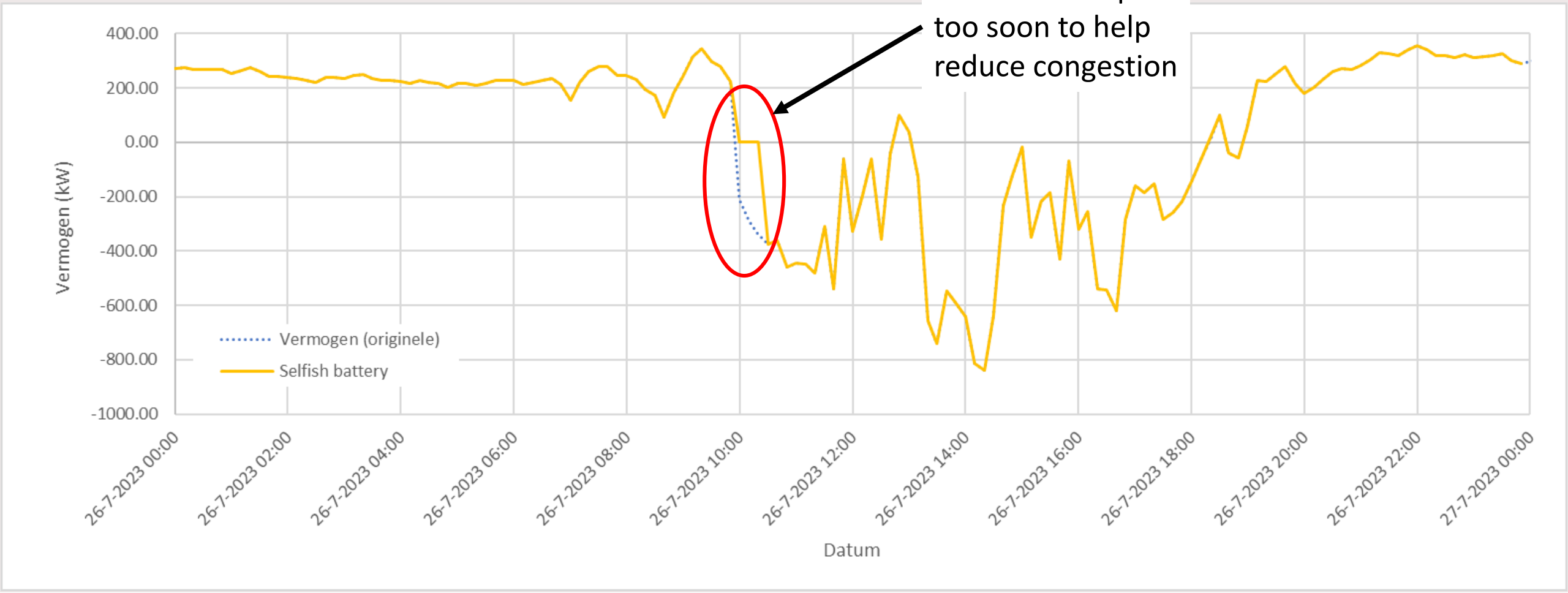
“Greedy” batteries (self-consumption)



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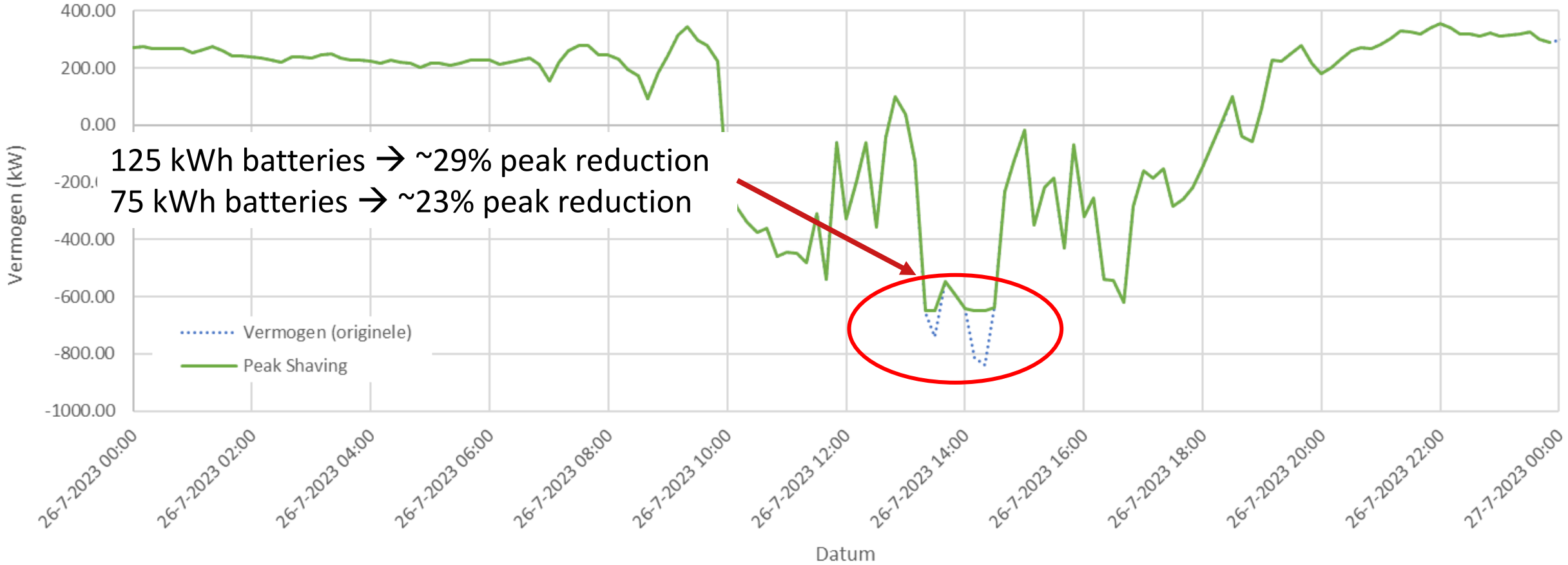
Collective solutions



Hypothesis: With (household) battery coordination, we can reduce PV congestion by 25-30%

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Research aim

1. How much can we reduce grid congestion using household batteries?

2. How often do we need to control household batteries to manage grid congestion? And what is the impact on the battery owner?

3. What other grid services can household batteries provide in practice (e.g. voltage control)?

4. Can we use these techniques to help mitigate the negative impacts of other energy transition developments (e.g. EV charge control / heat pump control)?

Conclusions

1. Household batteries may help or hinder grid congestion, it all depends on how we regulate them.

2. Currently no clear regulations on DSO control of batteries.

3. Currently unclear what the costs/benefits of DSO control of household batteries will be.

Questions?