Flexigrow: Modeling the impact of future “all-electric” neighborhoods for Dutch DSOs

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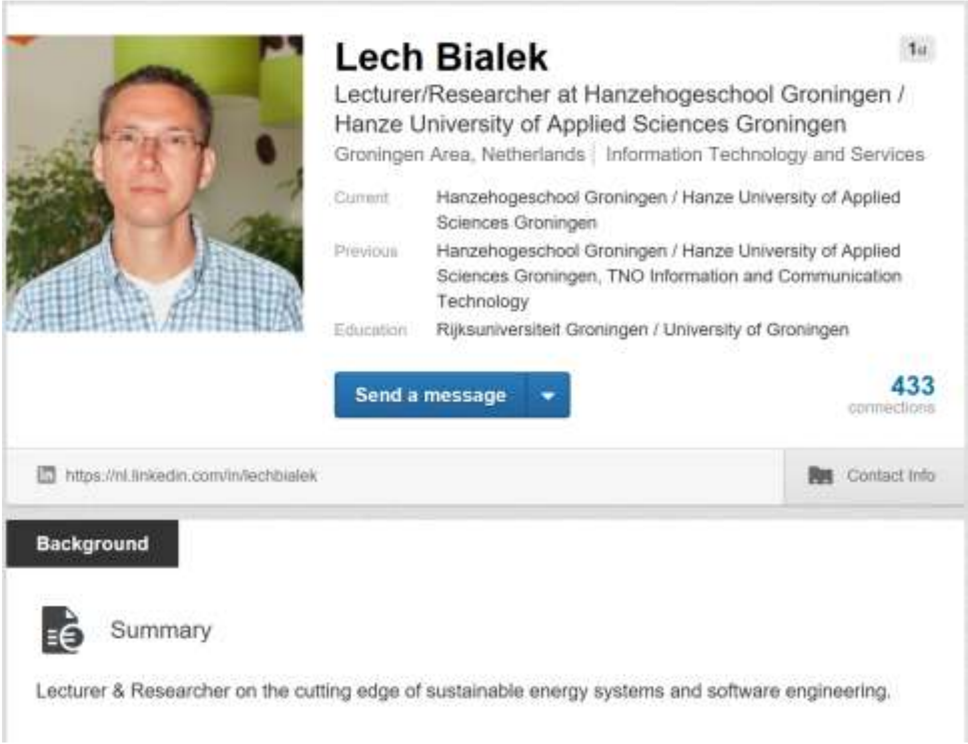
Outline

- Introduction
- Research aim & methodology
- Scenarios & outcomes
- Flexigrow: 3 iterations
- Discussion
- Questions?

Quick introduction

- Hanze UAS
- Lecturer/Researcher
- CS BSc & EES MSc
- CS Lecturer
- Coördinator Minor SE
- Flexigrow researcher



The Flexigrow project

- Three year research project
- Funded by TKI Systeem Integratie
- Hanze UAS
- Enexis
- Gasterra
- EnerGQ

DIT PROJECT WORDT MEDE GEFINANCIERD DOOR
HET MINISTERIE VAN ECONOMISCHE ZAKEN

Ministerie van Economische Zaken

enerGQ™ create awareness. reduce energy

Hanzehogeschool Groningen University of Applied Sciences

ENEXIS

GasTerra

All-electric case study: Meerstad

All-electric neighbourhood of 165 houses, near Groningen

MS-Transformer station data:
- 41 households + 1 pump
- 1 minute time resolution
- Current, Voltage (per phase)
- Power quality (per phase)

132 Households, survey data:
- Occupants (e.g. number & age)
- House (e.g. size & type)
- Occupant behaviour (e.g. domestic appliances)

10 Houses, smart meter data:
- Electricity production
- Electricity consumption

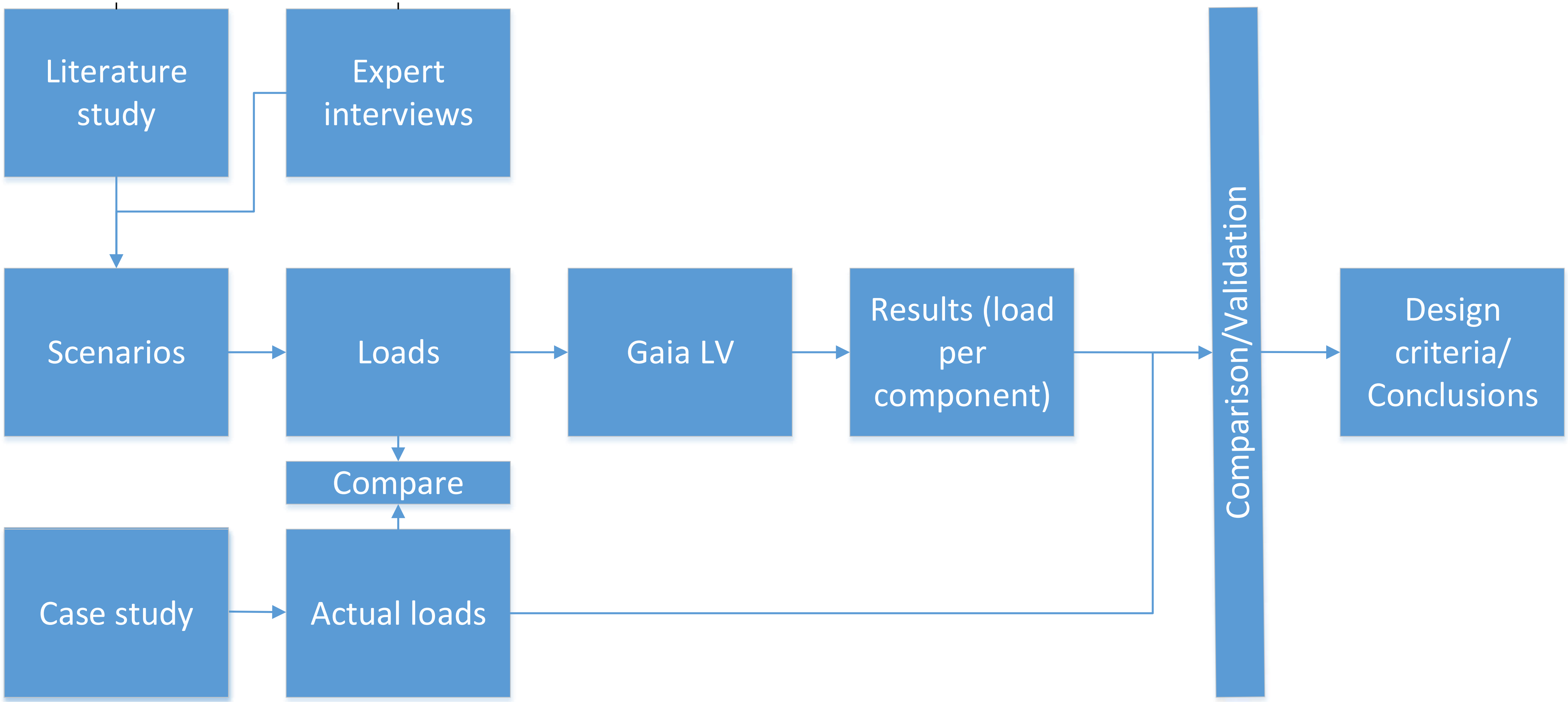
4 houses additional measurements:
- PV production
- HP thermal production
- HP electricity consumption

Research questions

How will future "all-electric" neighborhoods in the Netherlands influence the design criteria of low-voltage electricity distribution networks for Dutch DSOs?

1. What are the current **design criteria** for the low-voltage distribution networks in the Netherlands?
2. Which **future developments** are most likely to significantly impact the low-voltage distribution networks?
3. How will these future developments influence the **network expansion planning** of low-voltage distribution networks in the Netherlands in the case of "all-electric" neighborhoods?

Methodology



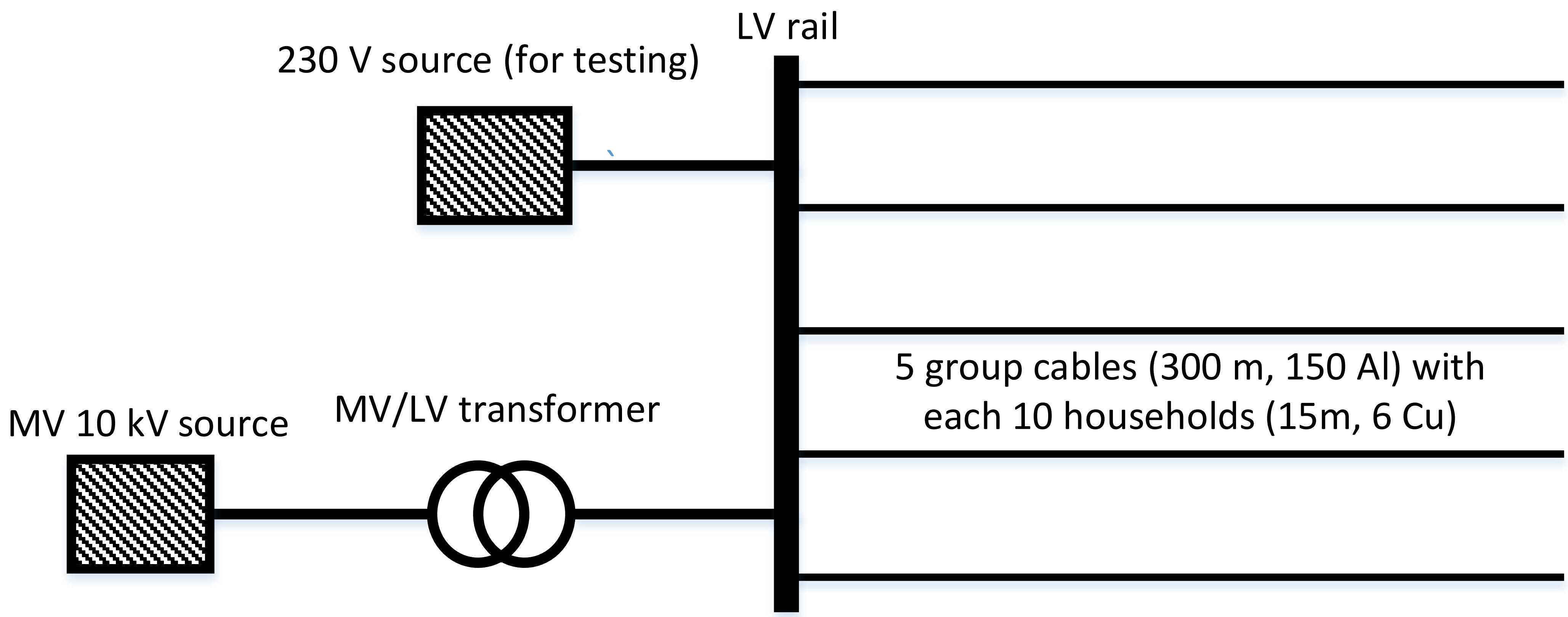
Design criteria

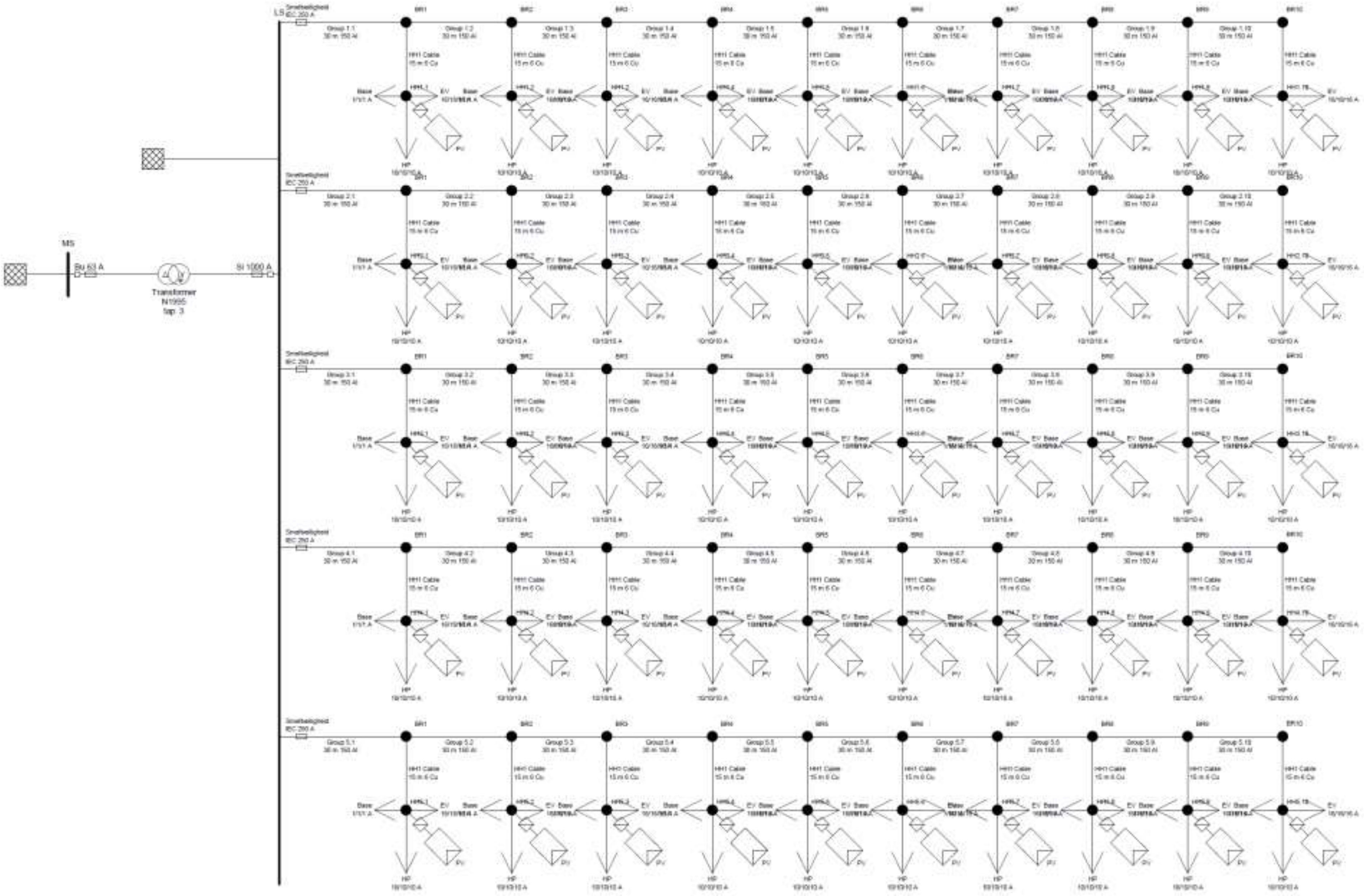
Criterion	Description
Component capacity	**Maximum allowable current (temporary overloading of components sometimes allowed)**
Voltage variation	**Maximum allowable deviation from nominal 230V (+/- 7% is used by Enexis for the LV grid)**
Reconfigurability	Required possibilities to restore power after faults (N-1 redundancy in the MV grid)
Touch safety	Faults should be cleared within an predetermined time to ensure people's safety
Grid impedance	Limiting the maximum impedance has a positive effect on voltage variation, short circuit currents and power quality

Enexis design currents

Connection capacity	Situation	Design current per connection
1x40 A / 3x25 A	Household with electricity and gas grid connection. (No electric cooking or heat pump)	2.4 A
1x40 A / 3x25 A	Household with electricity and heat grid connection (electric cooking, no heat pump)	3.1 A
1x40 A / 3x25 A	**Household with electricity but no gas grid connection. (Electric cooking and heat pumps for heating)**	**10 A**

Gaia LV model Meerstad (50 households)




MS
Bu 63 A
Transformer
N1995
tap: 3
Si 1000 A
LS

Future technological developments

Technology	Impact NL 2050	Description	Relevance for this study
Electric vehicles	Large	Large potential for reducing CO2 emissions from transport by using renewable electricity, possible role in smart grids (V2G)	HIGH
Electric heat pumps	Large	Important means to use renewable electricity for heating in industry, agriculture and the built environment	HIGH
Solar PV	Limited	Suitable with moderate penetration, but supply and demand patterns do not match.	HIGH

Technological developments most likely to impact the Dutch energy infrastructure in 2050 adapted from (PBL, 2011)

2016 scenario

Baseline scenario (2016)	EV	HP main	HP auxiliary	PV
% penetration	1.2%	100 %	100%	52%
Power demand/supply	3.3 kW	1.55 kW	5.45 kW	3.38 kWp
Current (1/3 phase 230 V)	1 x 14.35 A	3x 2.25 A	3x 7.9 A	3x 4.9 A

- HP already at 100% in case study, remains constant
- EV battery, 24 kWh, 80% charge, slow charging (single phase)
- PV based on case study average installed capacity

2035 scenario

Future scenario I (2035)	EV	HP main	HP auxiliary	PV
% penetration	**45%**	100 %	100%	**75%**
Power demand/supply	**11 kW**	1.55 kW	5.45 kW	**8.74 kWp**
Current (3 phase 230 V)	**3x 15.9 A**	3x 2.25 A	3x 7.9 A	**3x 12.67 A**

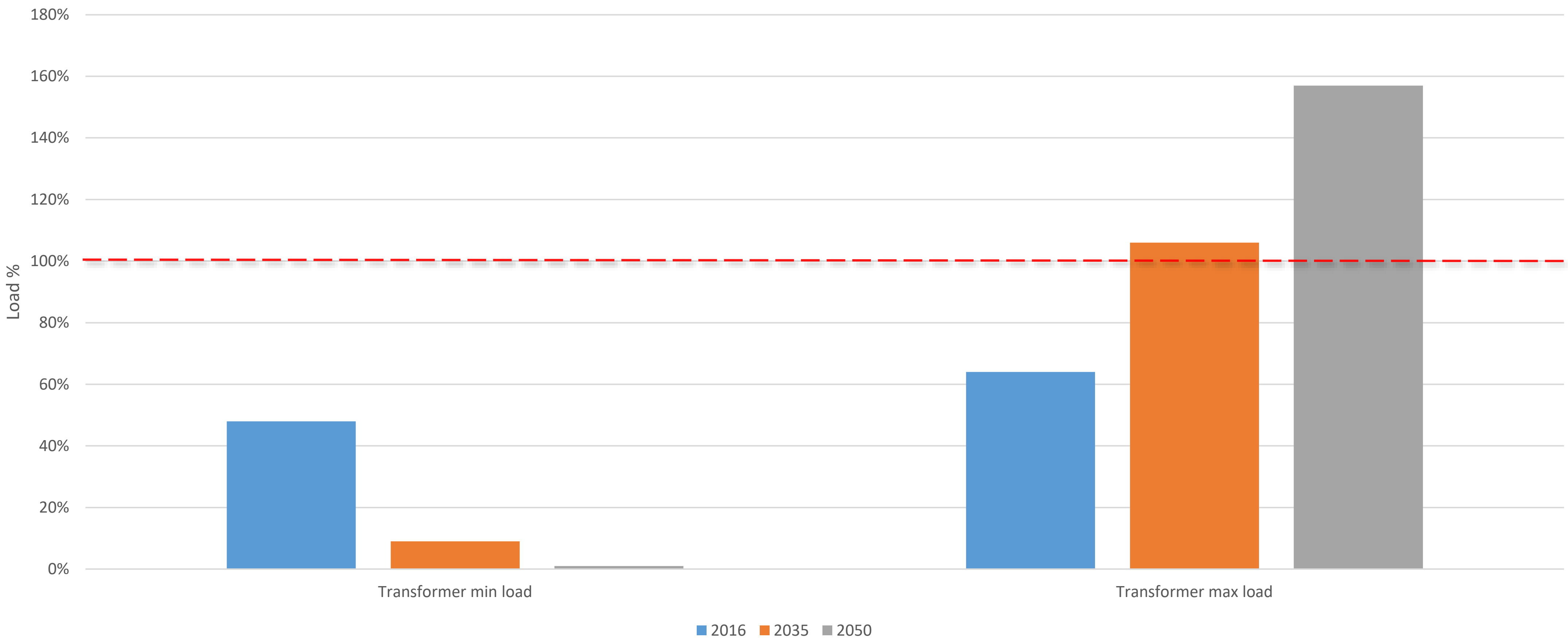
- Penetration increase due to adoption of technology
- EV battery, 85 kWh, 80% charge, fast charging (three phase)
- PV increase to 75%, 2016 max is now average installed capacity

2050 scenario

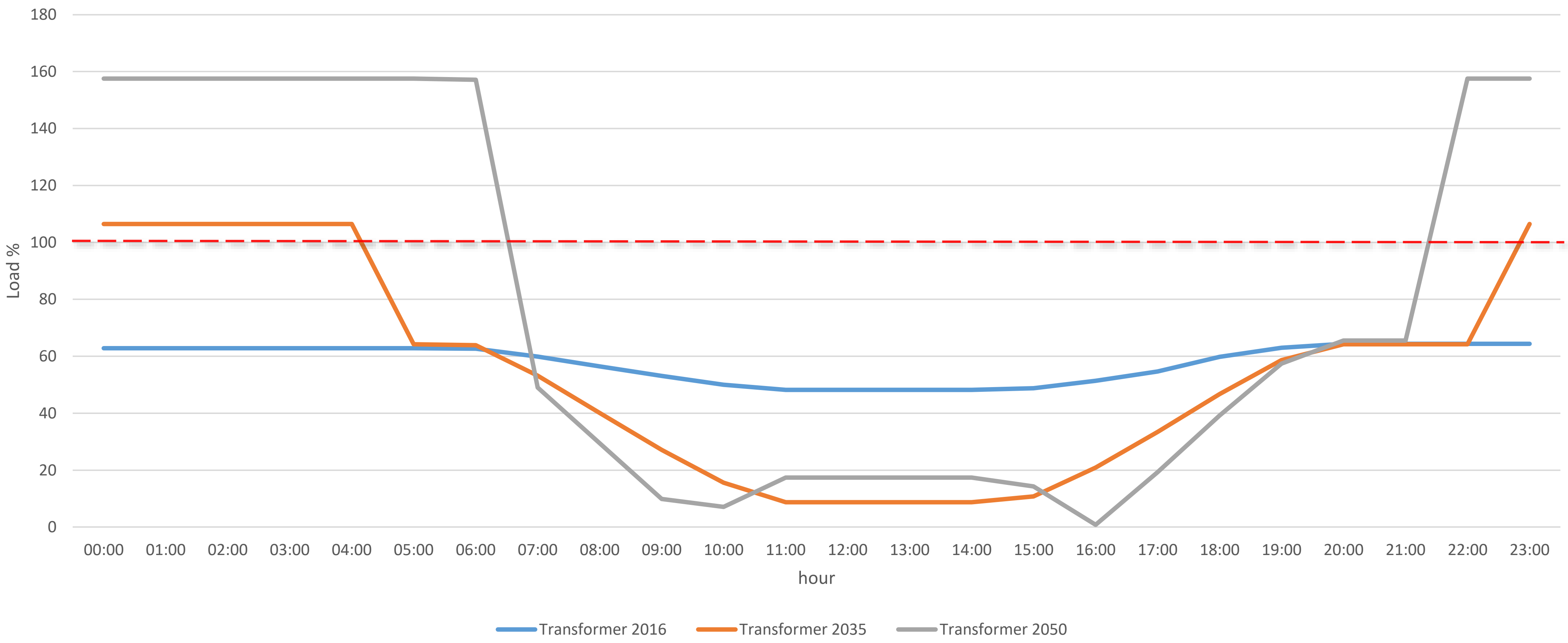
Future scenario II (2050)	EV	HP main	HP auxiliary	PV
% penetration	**100%**	100 %	100%	**100%**
Power demand/supply	**11 kW**	1.55 kW	5.45 kW	**10 kWp**
Current (3 phase 230 V)	**3x 15.9 A**	3x 2.25 A	3x 7.9 A	**3x 14.5 A**

- 100% penetration for all technologies
- EV battery, 120 kWh (600 km range), 80% charge, fast charging
- PV 10 kWp (efficiency increase, replacement of some old panels)

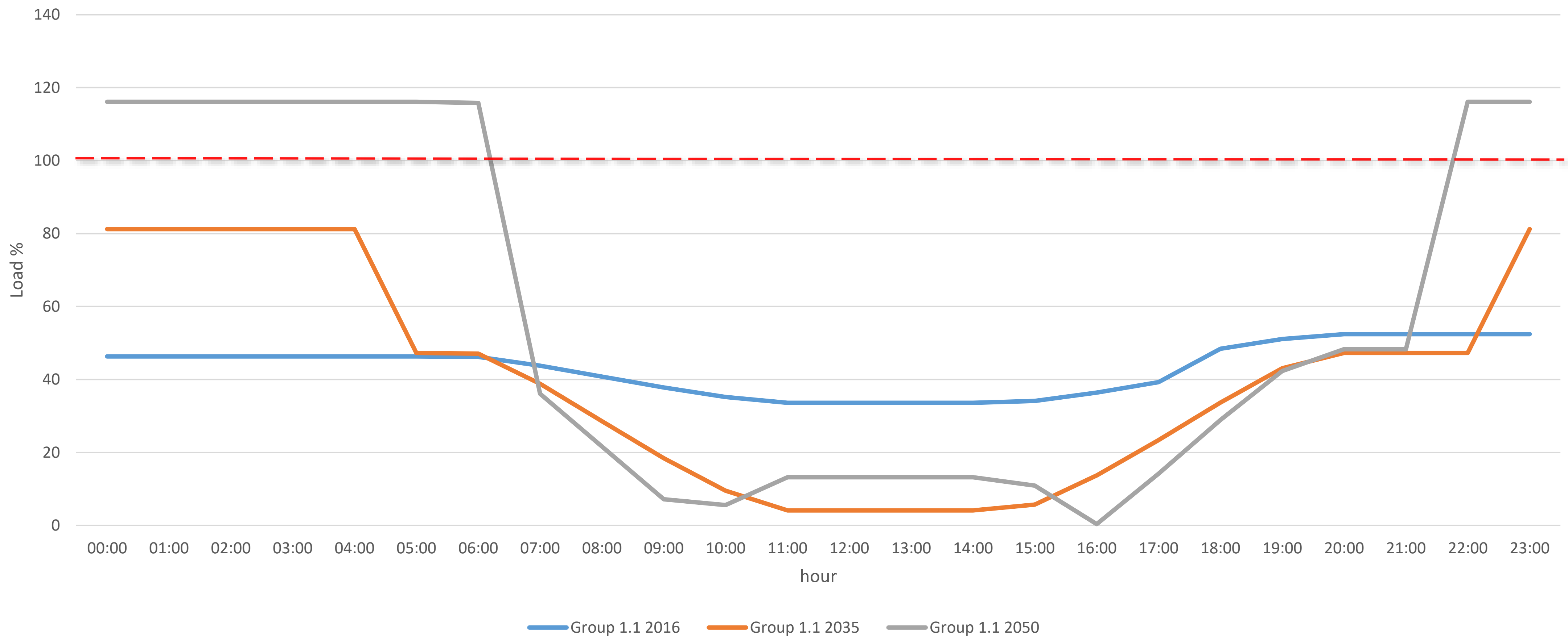
Results: No real issues for Meerstad 2050



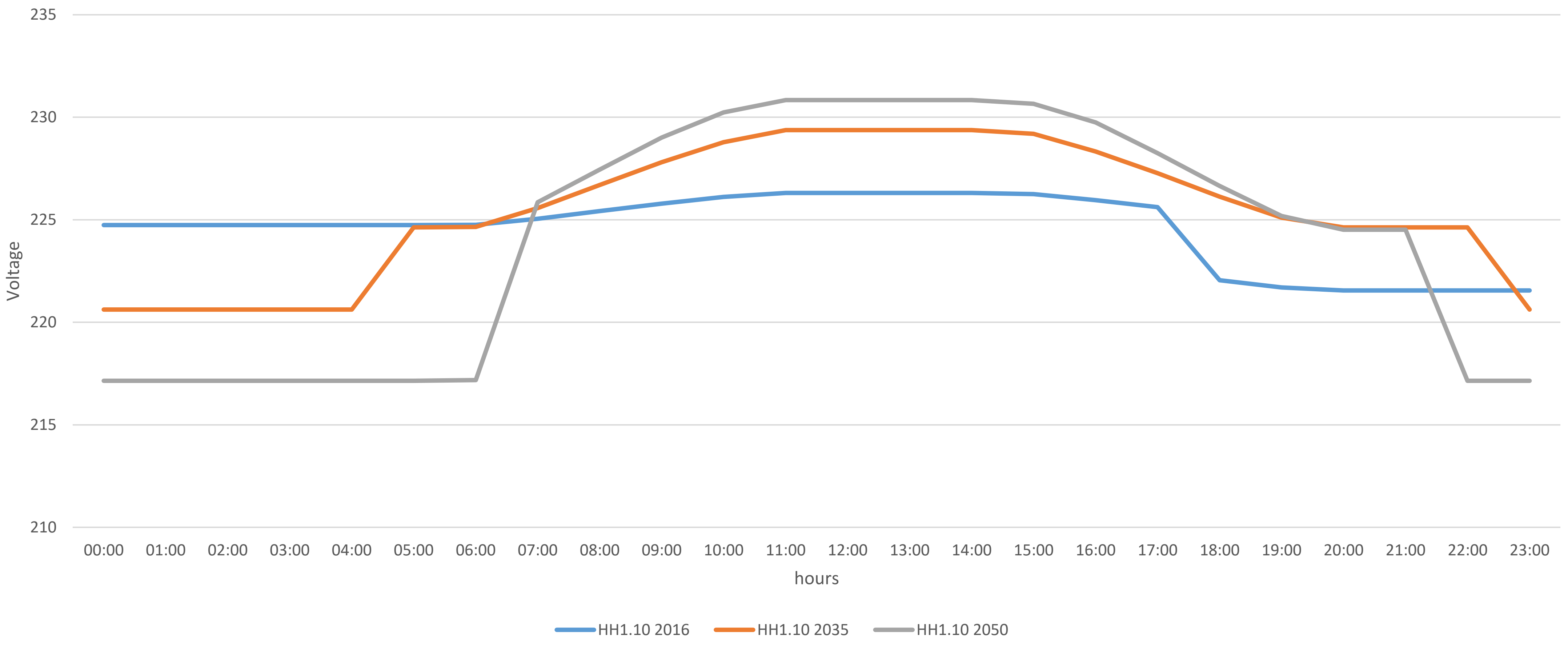
Results: 24h load (transformer)



Results: 24h load (group cables)



Results: 24h voltage deviation



Flexigrow: 3 iterations

Literature study
Expert interviews
“Worst case” assumptions
Meerstad 50 households
Scenarios for 2016/2035/2050

Transformer measurements
Cable level data
Week & weekend day
Summer & Winter seasons
Meerstad 50 households
Assen 150 households

Smart meter measurements
Validation of previous results
Updated assumptions EV, PV
Meerstad 50 households
Assen 150 households
Haren (GN) old network

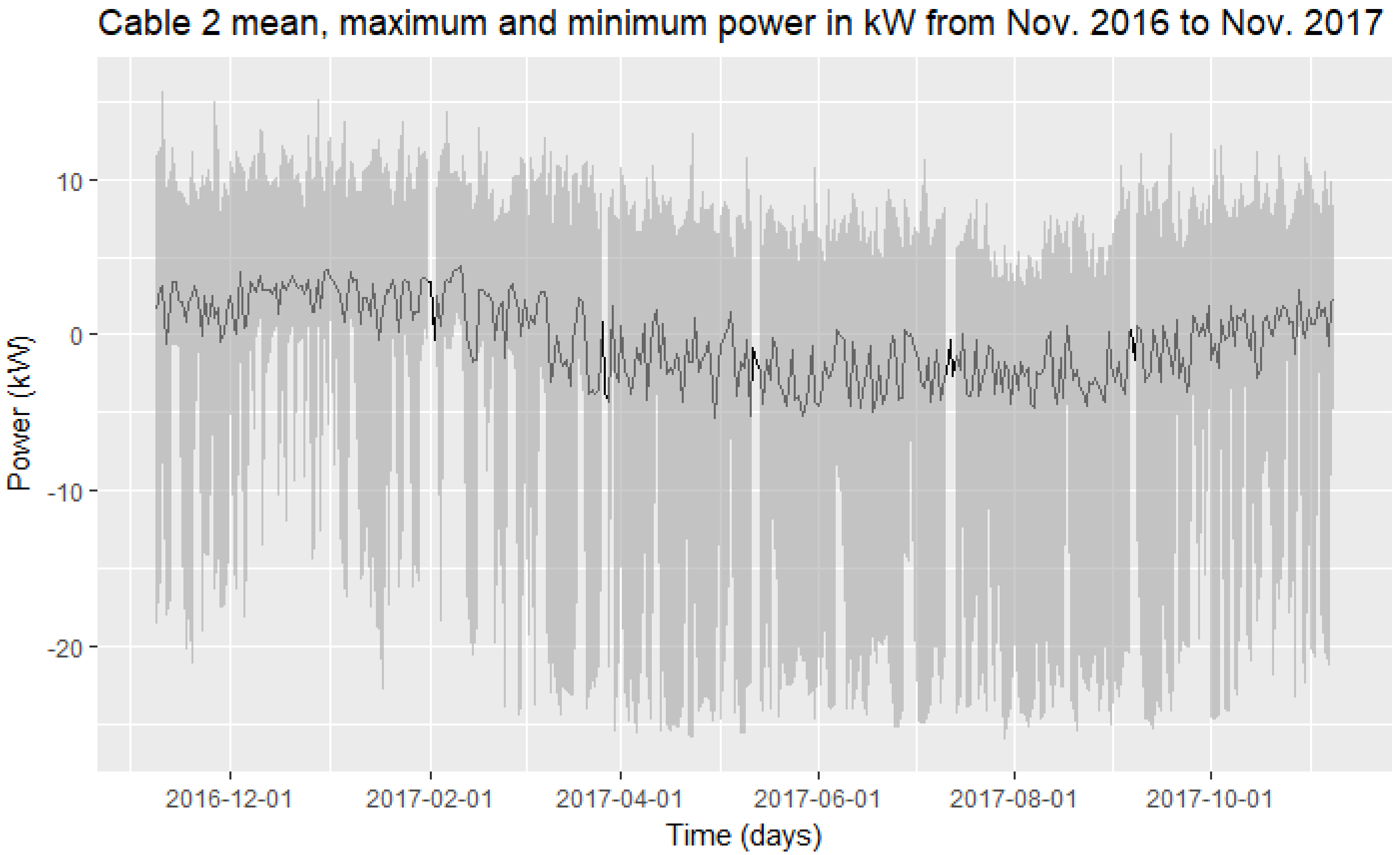
V1 → V2 → V3

Flexigrow: Second iteration

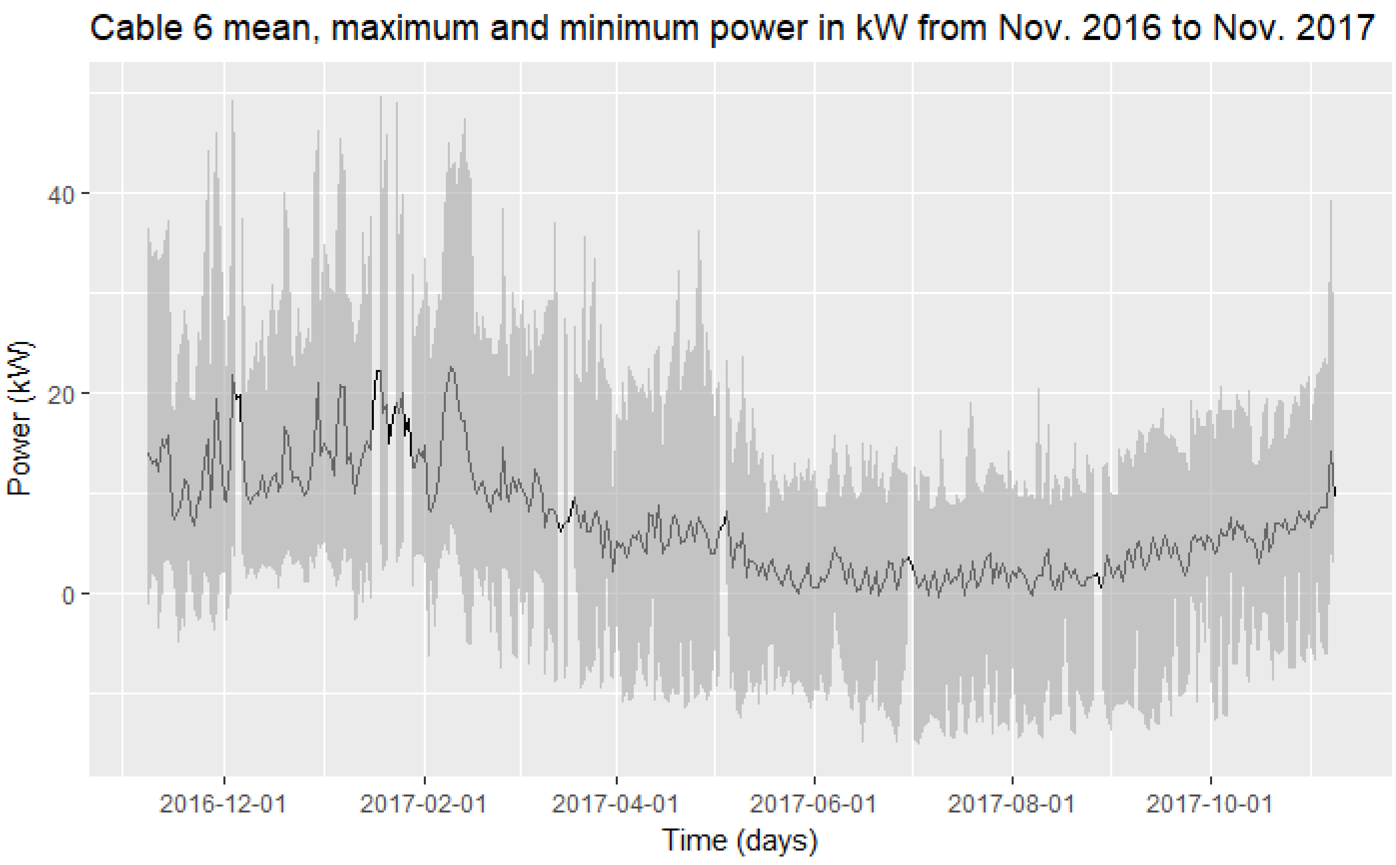
- Top-down analysis approach (transformer level => cables level => phases level => household level)
- Based on maximum peak-load and high load-volatility (with omitting the extreme outliers)
- Week and weekend day selection
- Summer and winter day for 2017/2018
- Adding additional EV & PV loads on top of 2017/2018 measurements of Meerstad for 2035 & 2050

Summer		Winter	
Week	Weekend	Week	Weekend
26-6-2017	6-8-2017	17-1-2018	22-1-2018

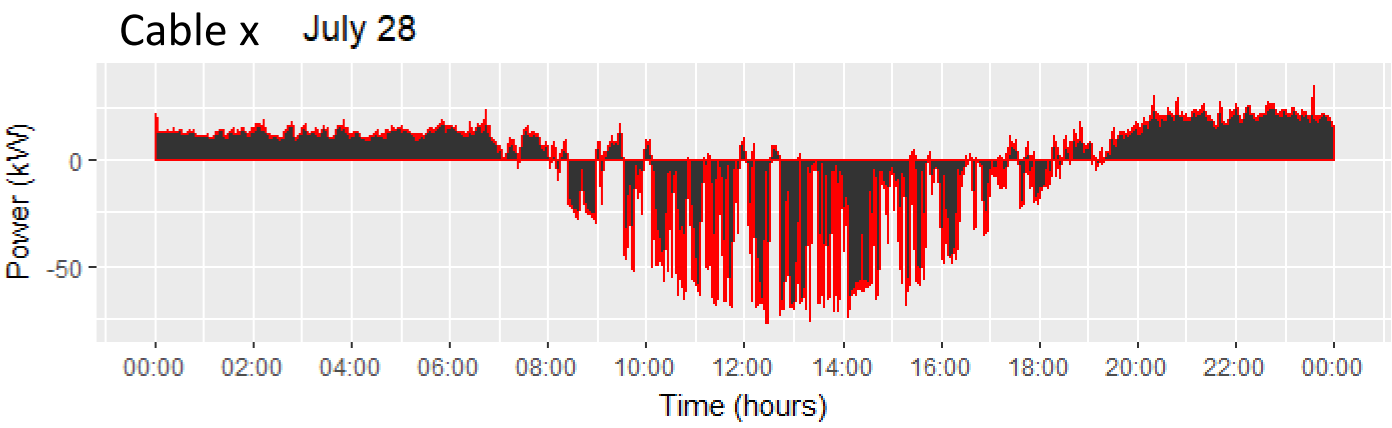
Cable level data: lot’s of PV

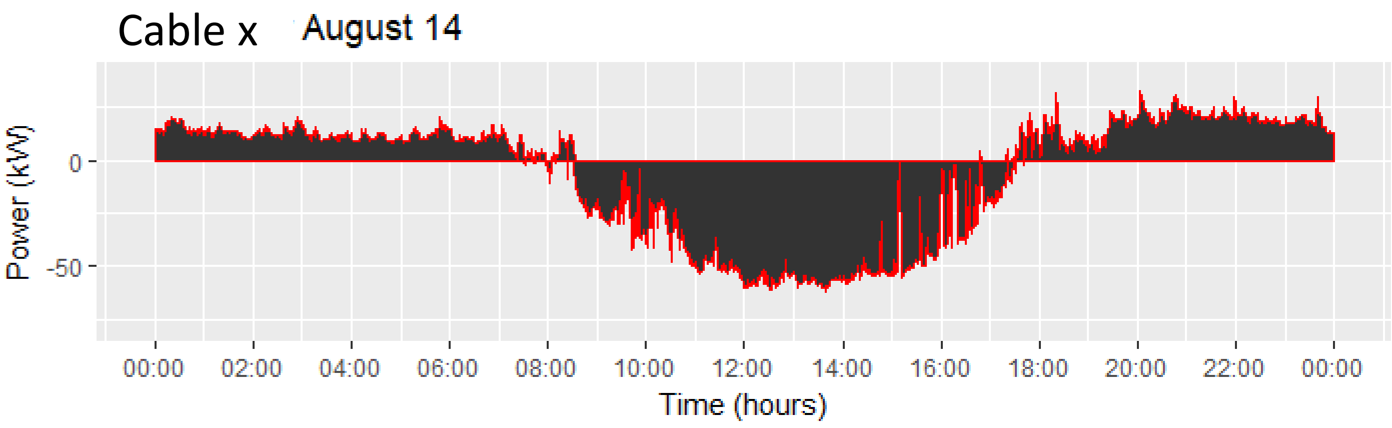


Cable level data: less PV more HP influence

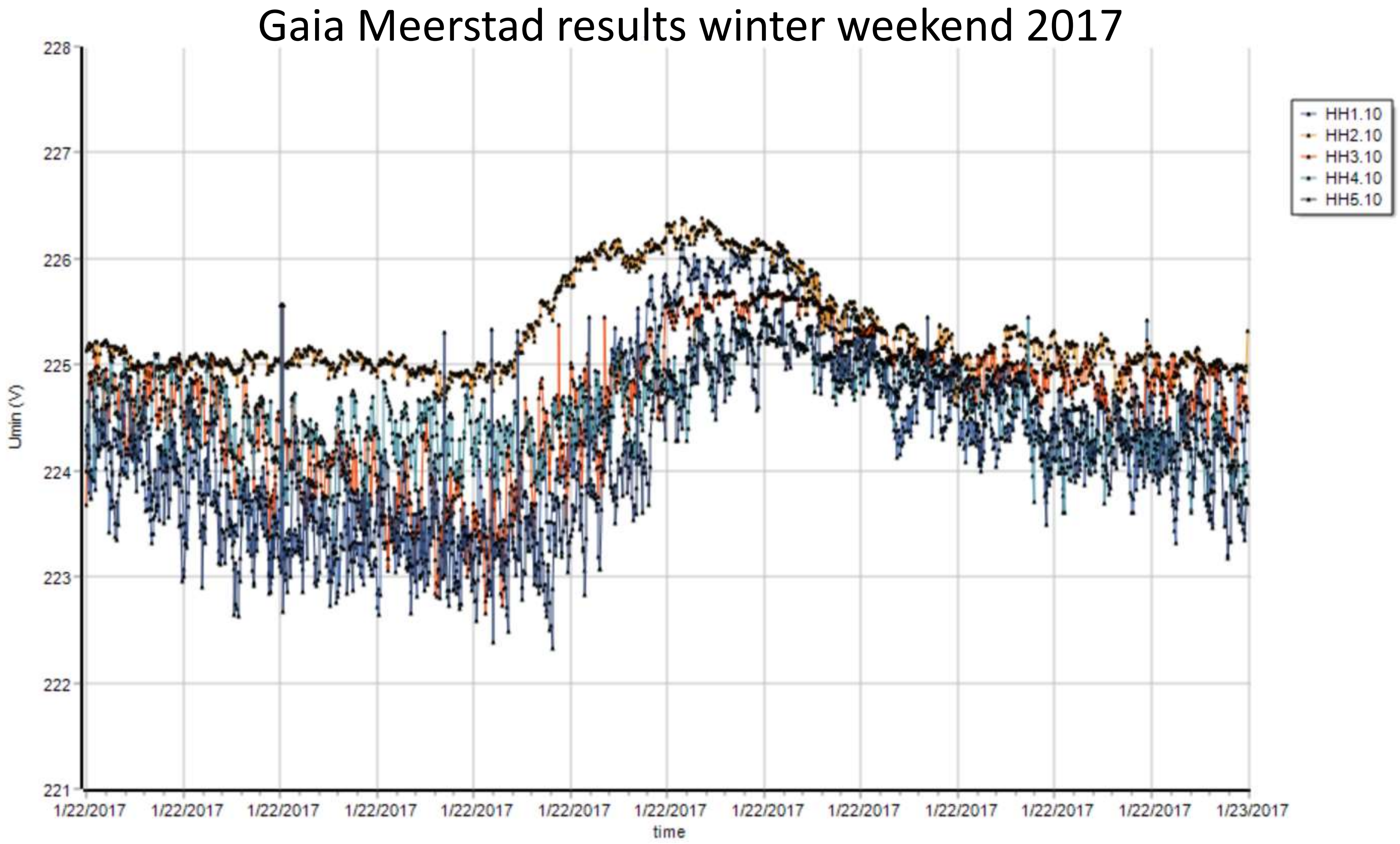


Example of day selection





Iteration 2 level of detail (modeling result)



Flexigrow: Third (and final) iteration

- Smart meter data per household (5x) for validation cable data
- Detailed EV charging profiles (15 min resolution, E-laad)
- High/Low scenarios for PV and EV assumptions 2035 & 2050
- Different distributions of loads over the cable
- Sensitivity analysis:
  - Very cold winter day (simultaneity of the HP loads)
  - PV potential, orientation (simultaneity)
  - EV charging, average vs worst case assumptions (*Onderzoek Verplaatsingen in Nederland (OViN) data)*

Discussion

Current project:

- Flexigrow focuses on the problem only and not on solution pathway
- 4 days per annum vs continuous data and load duration curves
- Worst case scenarios versus impact of “flexibility” for 2035 & 2050?

Future project:

- How to model the simultaneity PV, EV and HP loads?
- Quantify impact of “smart grids” on future loads (simultaneity)
- Load flow modeling as a tool for regional network reinforcement decisions
- How to model the cost/risk of “flexibility” vs network reinforcement?

Questions?