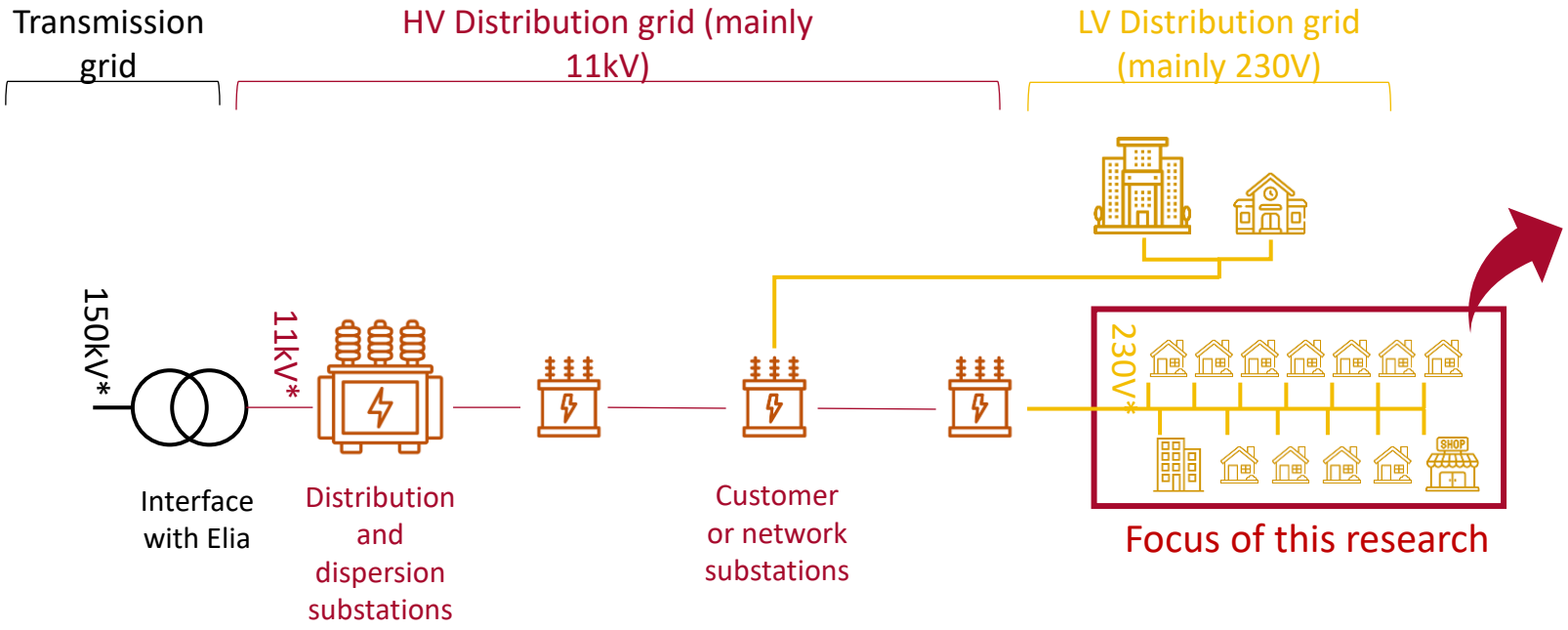
The impact of frequency ancillary services on LV distribution networks

ETF event

December 7, 2023

Context and research question

LV assets can provide frequency ancillary services



Focus on Low Voltage (LV) assets providing Frequency Containment Reserve (FCR):

- Encouraged in the Clean Energy Package for TSO to access LV assets
- In Belgium, possible for LV assets to pre-qualified for FCR (6-8MW → 10% of the total pre-qualified capacity)
- LV assets access to aFRR by 2024

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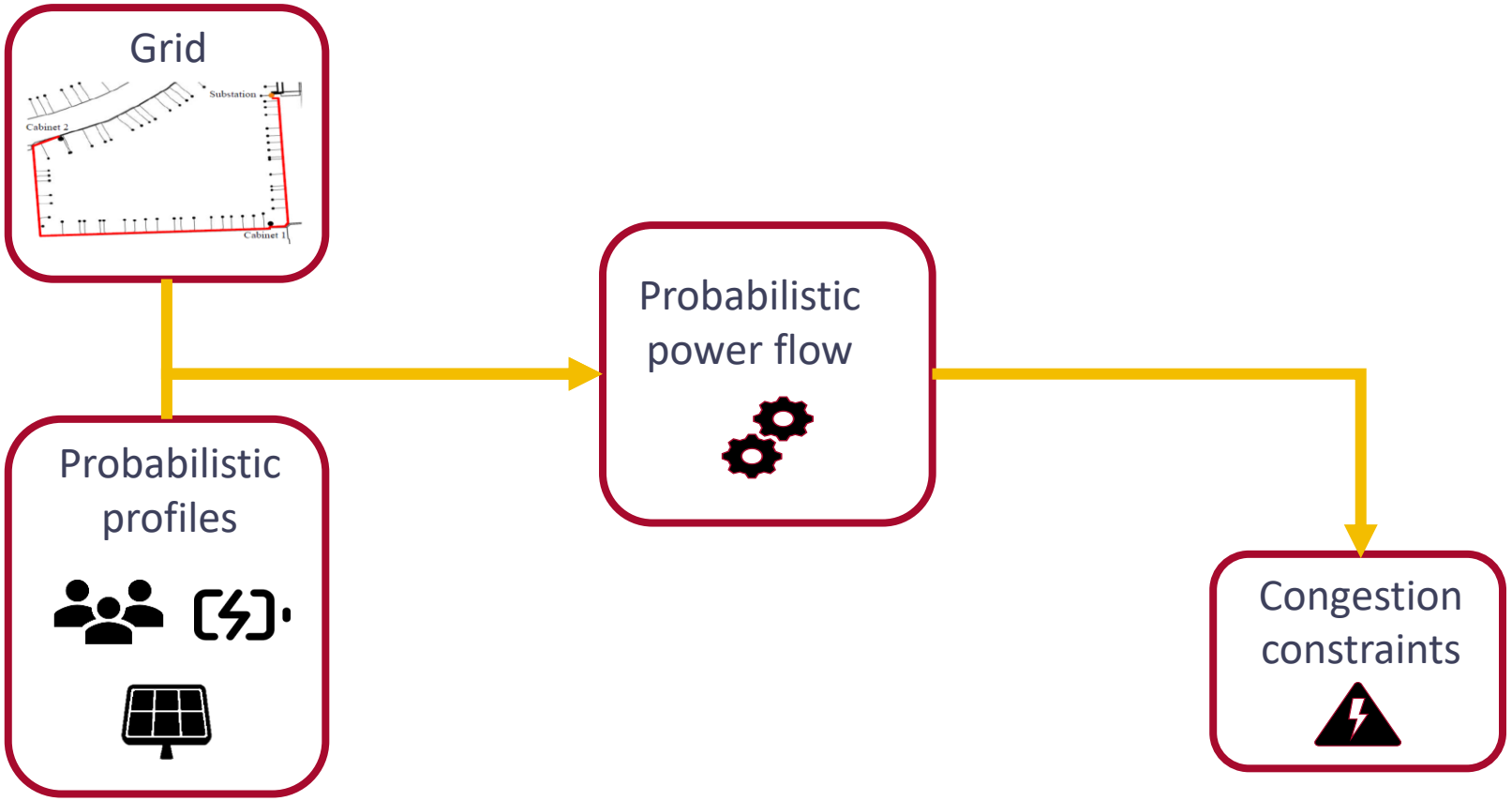
Research question

How do LV assets providing frequency ancillary services impact the LV distribution grid?

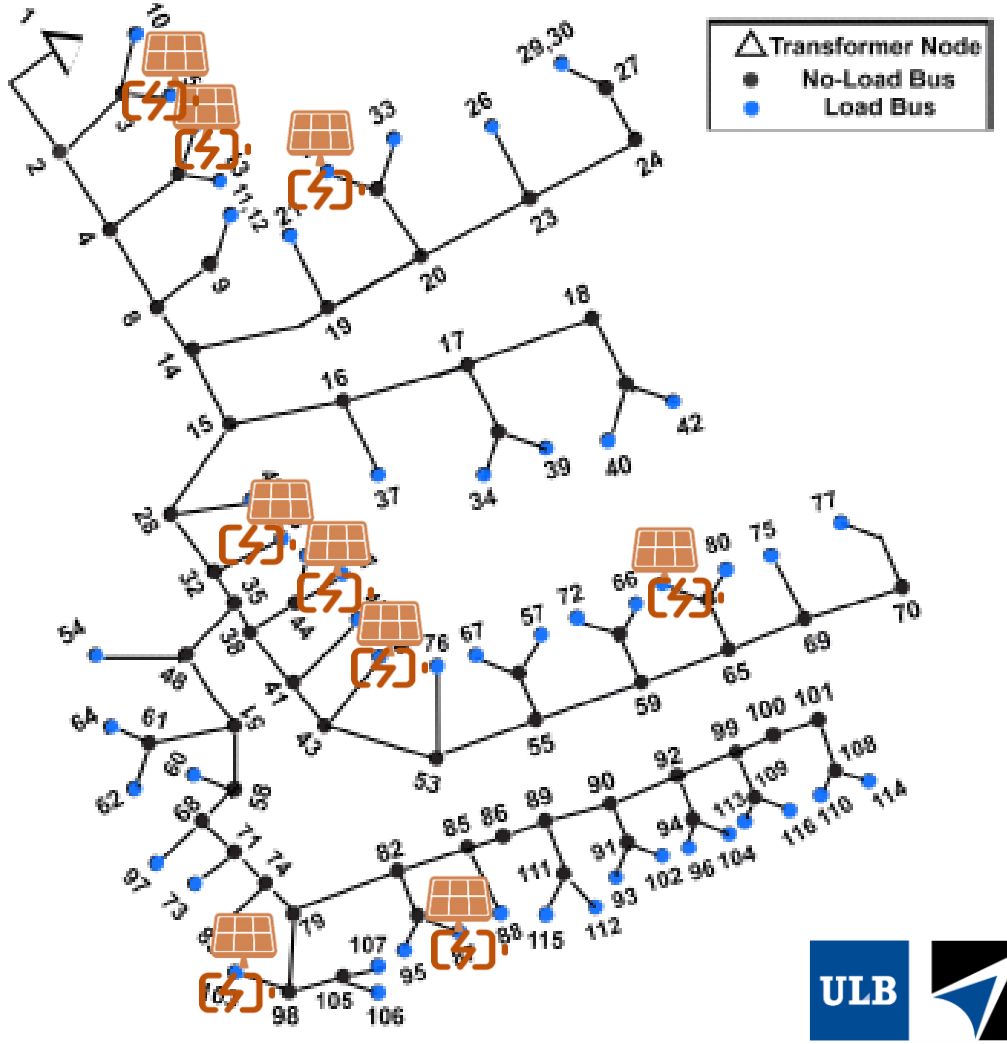
Method, case study and results

Method – Stochastic power flow



Case study

Grid	IEEE LV EU testfeeder
Load profiles	55 end-users randomly chosen from the IEEE and proportionally modulated to fit 3500kWh per year and 9.2kVA
Assets	• 9 PV panels (5kWp) with inverter (5kVA) • 9 LV assets (5kW/10kWh)
Services	• Comparison between determinist FCR and ARMA FCR • aFRR

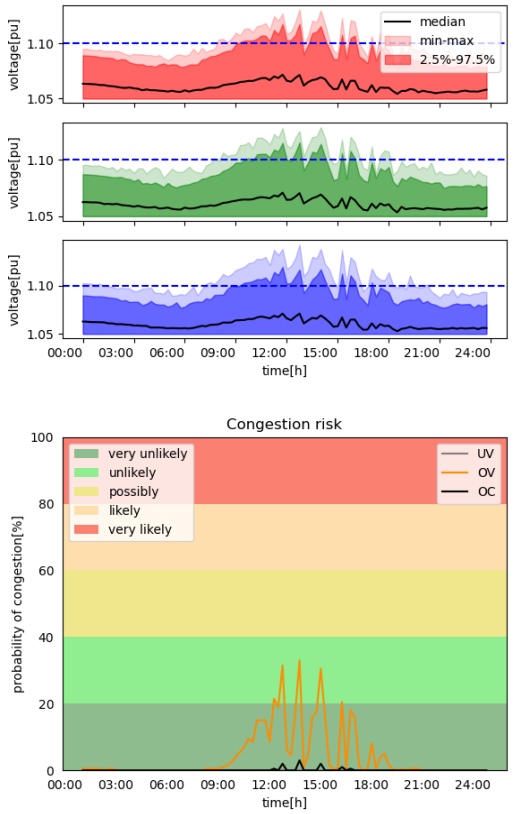


Results

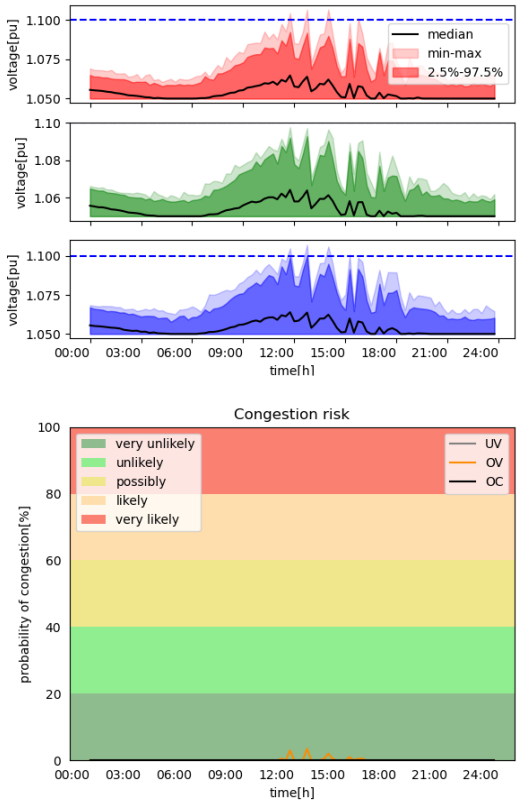
Case where batteries provide FCR (deterministic vs. probabilistic)

- Considering worst-case when LV assets are injecting maximum power into the grid
- Summer case when PV production particularly high
- Probability congestion risk negligible when using ARMA and reaching 35% when using worst-case method

Worst case scenario (deterministic)



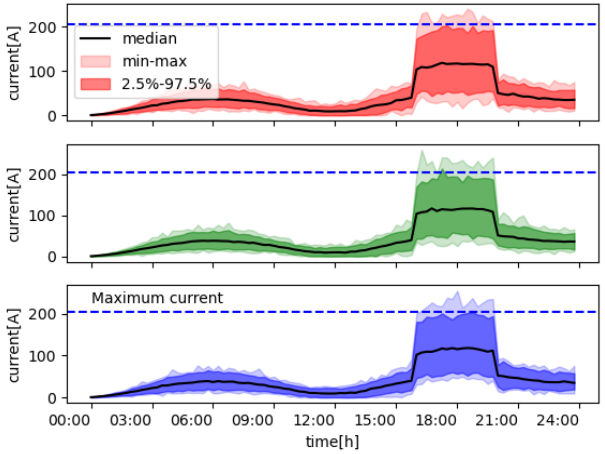
Worst case probabilistic

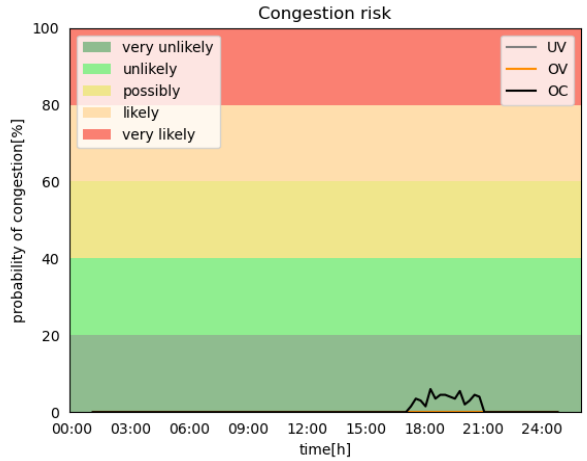


Results

Case where batteries provide aFRR

With no reservoir consideration, risk of congestion when only 9 LV assets provides aFRR N5 in winter





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Conclusions

Conclusions

1. Probabilistic method captures the frequency evolution with more accuracy than a worst-case scenario, which helps to better characterize how LV assets cause network congestion. This can avoid unnecessary investment when considering grid reinforcement.

2. In case of unexpected events, the probabilistic method (ARMA) seems to be suitable for characterizing the evolution of frequencies on a granularity of less than 15 minutes. Additionally, no OC is expected due to unexpected frequency drop.

3. The risk of congestion increases if reservoirs limit is not considered when LV assets provide aFRR.

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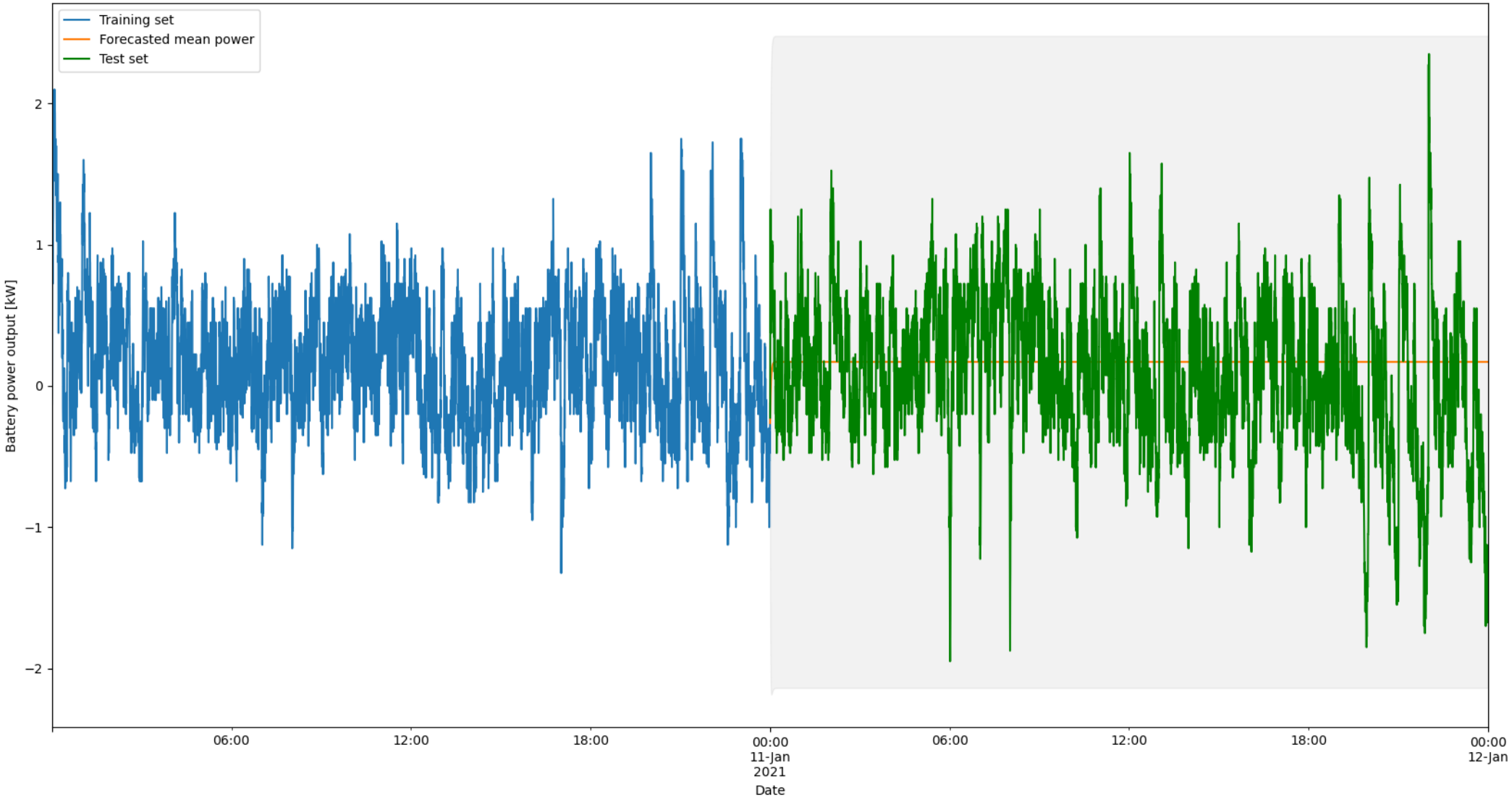
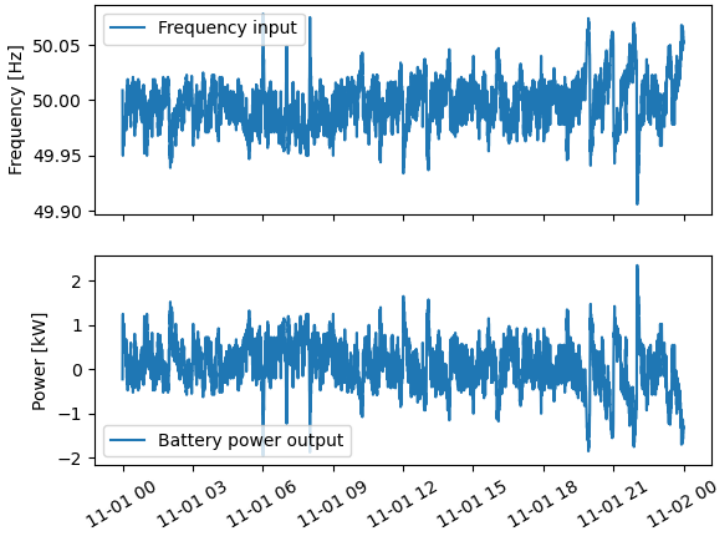
Arma model

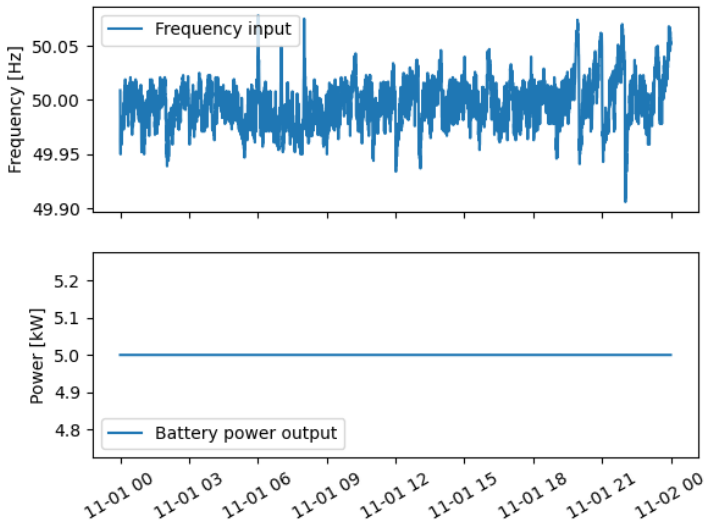

Training set
Forecasted mean power
Test set
Battery power output [kW]
2
1
0
−1
−2
06:00
12:00
18:00
00:00
11-Jan
2021
06:00
12:00
18:00
00:00
12-Jan
Date

FCR models

- **Historic data**

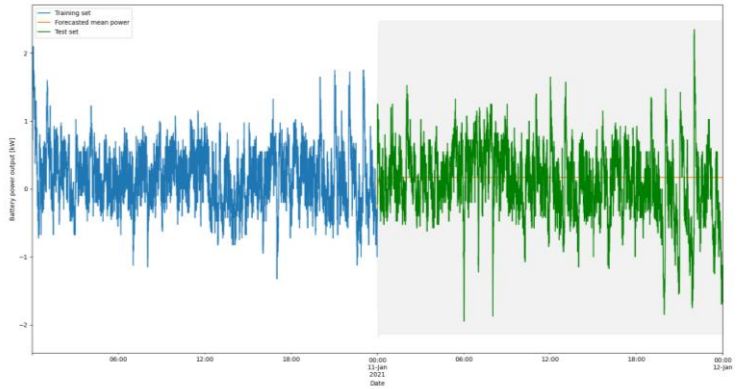


- **Worst case scenario**



Upper/lower limit: ± 5kW

- **ARMA**

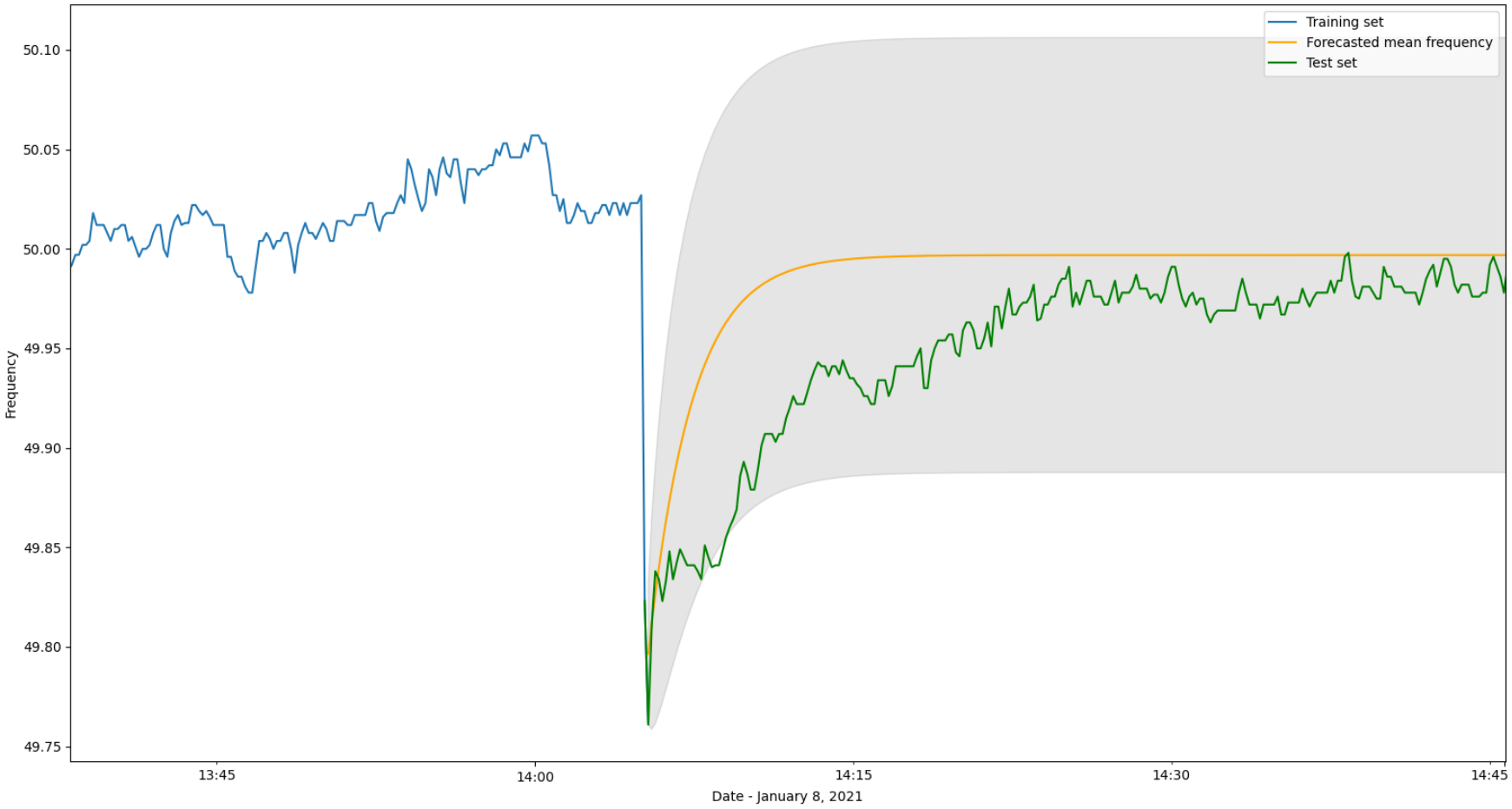


Upper limit: 2.478 kW

Lower limit: -2.138 kW

Prediction interval: 99.99%

ARMA model when unexpected event



In case of unexpected event:

- Frequency is restored within 5 minutes
- Extreme values of frequency will not contribute to OC
- ARMA seems to capture correctly frequency restoration