

# Battery Health Analysis of a very distributed power plant

Authors: Abdulsalam Fawaz, Matin Moradi, Mukhtar Rabayev, Tariq Aziz

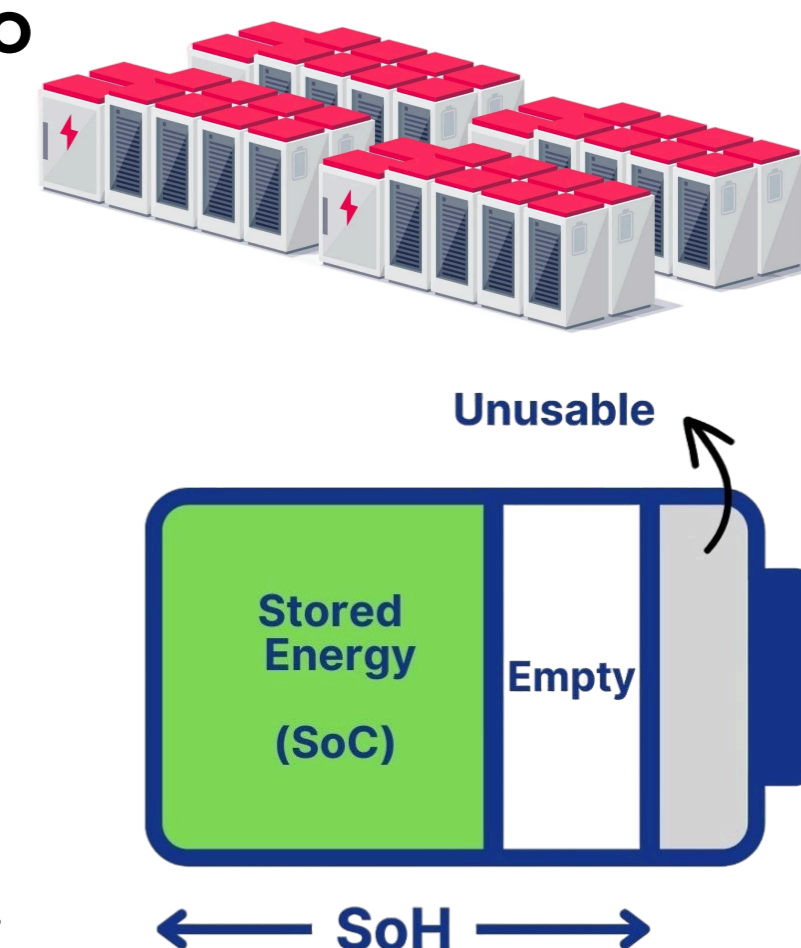
Supervisors: Sebastien Lafond, Hergys Rexha, Simon Holmbacka



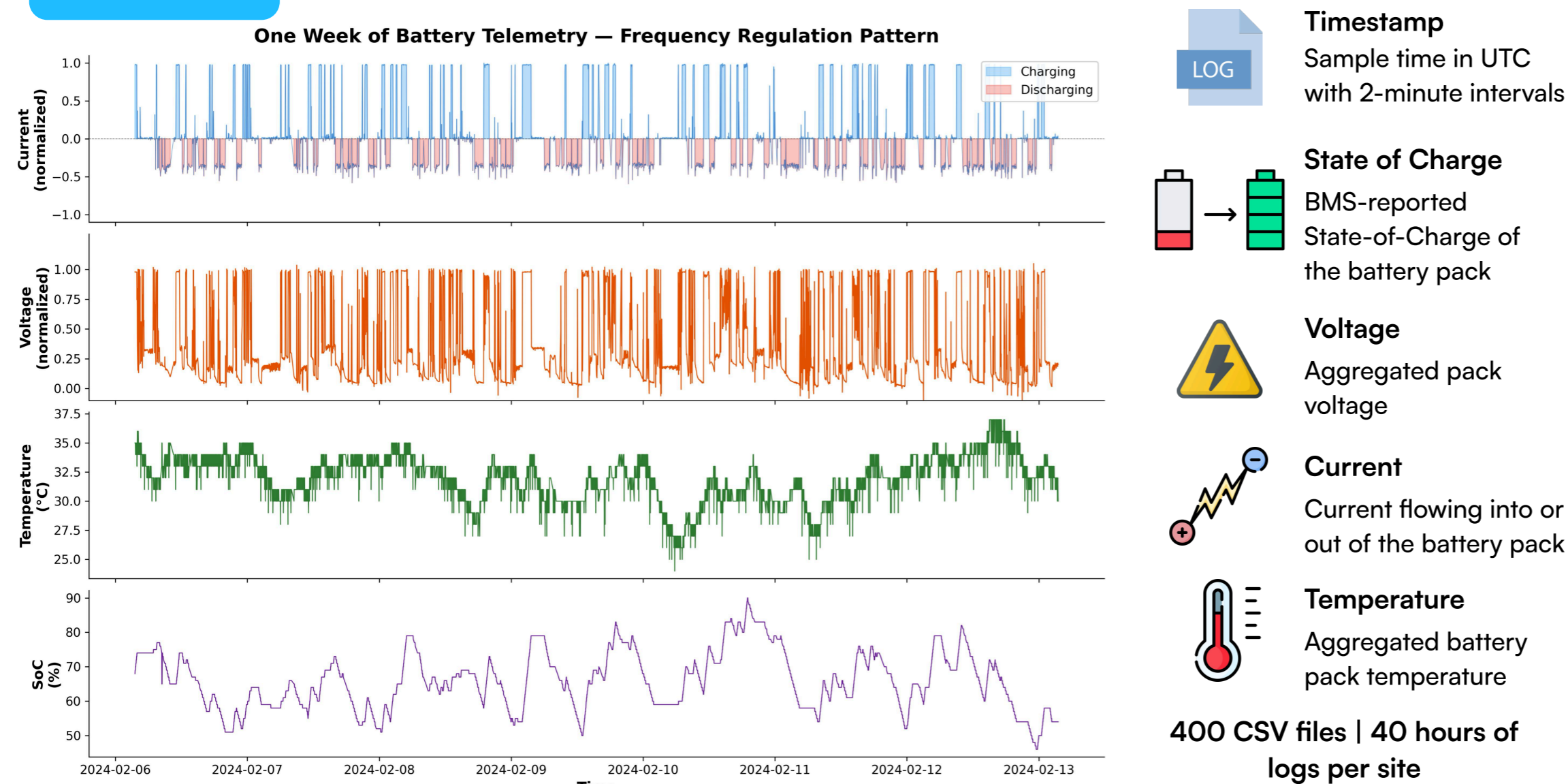
## Problem Statement

Finland's grid operator Fingrid uses automatic Frequency Restoration Reserve (aFRR) to maintain grid frequency at 50.0 Hz. Elisa, a Finnish telecom company, participates by aggregating backup LFP batteries from over 1,000 base stations into a virtual power plant - during up-regulation, stations switch to battery power, reducing grid consumption.

These batteries degrade over time, losing capacity and increasing internal resistance. Tracking this degradation is essential for maintenance planning, warranty assessment, and ensuring the batteries can still serve both as backup power and as a grid resource.



## Dataset



## Objectives

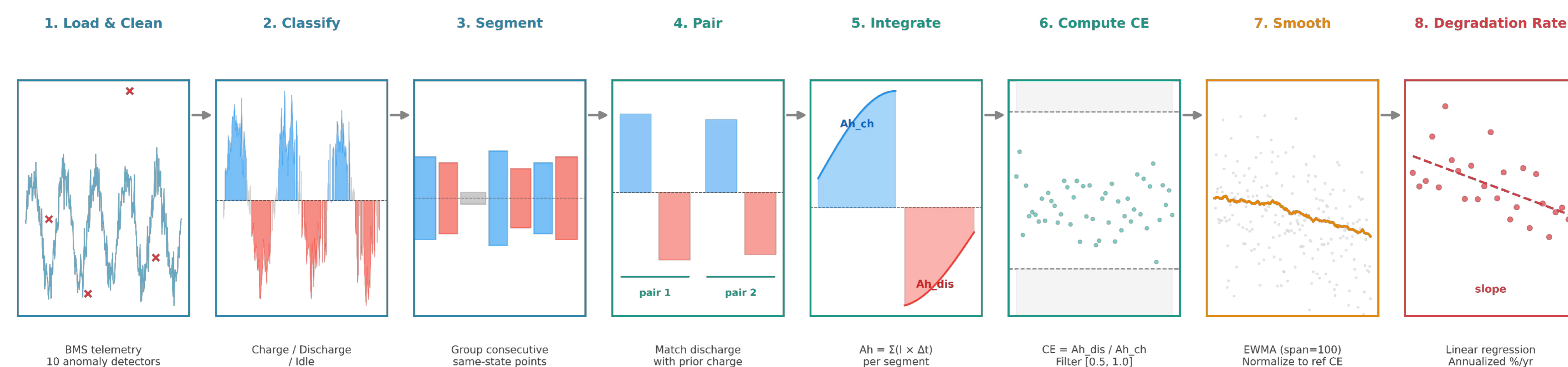
- Calculate the current degradation state of each battery pack from operational data
- Predict the remaining operational lifetime of each battery pack by modelling degradation trends under real-world usage conditions

## Challenges

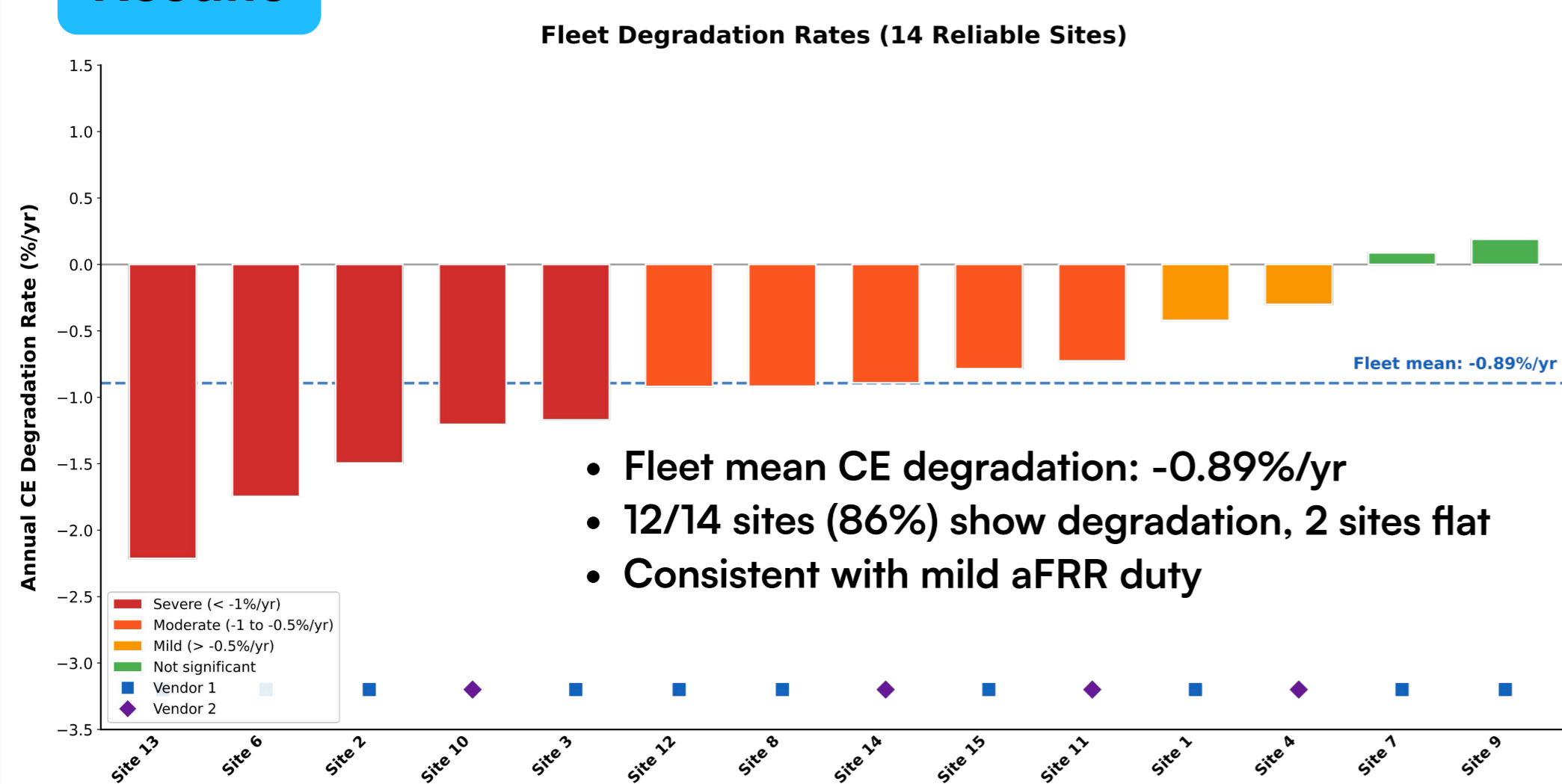
- No complete cycles | Short observation window
- No controlled conditions | BMS logging errors
- No ground truth
- Large time gaps

## Pipeline

As batteries age, parasitic side reactions (SEI growth, lithium loss) consume a small fraction of transferred charge. We track this through Coulombic Efficiency (the ratio of charge out to charge in) for each micro-cycle. Individual CE values are dominated by grid noise, but averaging over thousands of pairs cancels the noise while the degradation signal accumulates. The downward trend in CE over time reveals how fast the battery is aging.



## Results



## References

1. Grimaldi et al., J. Energy Storage 65 (2023) 107232. <https://doi.org/10.1016/j.est.2023.107232>
2. Smith et al., J. Electrochem. Soc. 158(10) (2011) A1136. <https://doi.org/10.1149/1.3625232>

## Future Work

- Optimize pipeline configuration to improve degradation detection sensitivity
- Estimate relative Remaining Useful Life (RUL) from CE trend extrapolation