

# Smartness of hybrid storage technologies

## Operating Multi-Carrier Energy Systems

FLEXINet Workshop – Realizing Hybrid Storage  
11/04/2024

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01

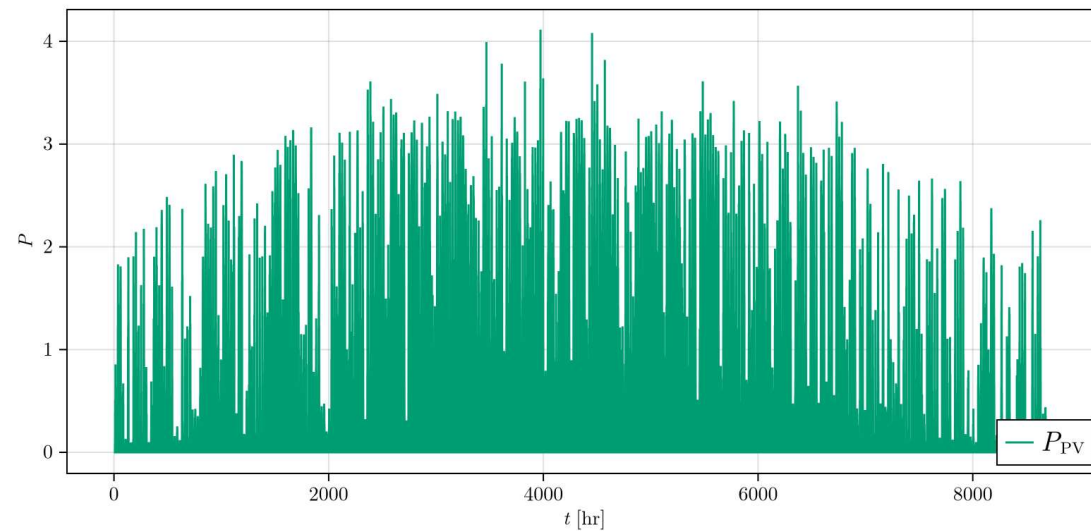
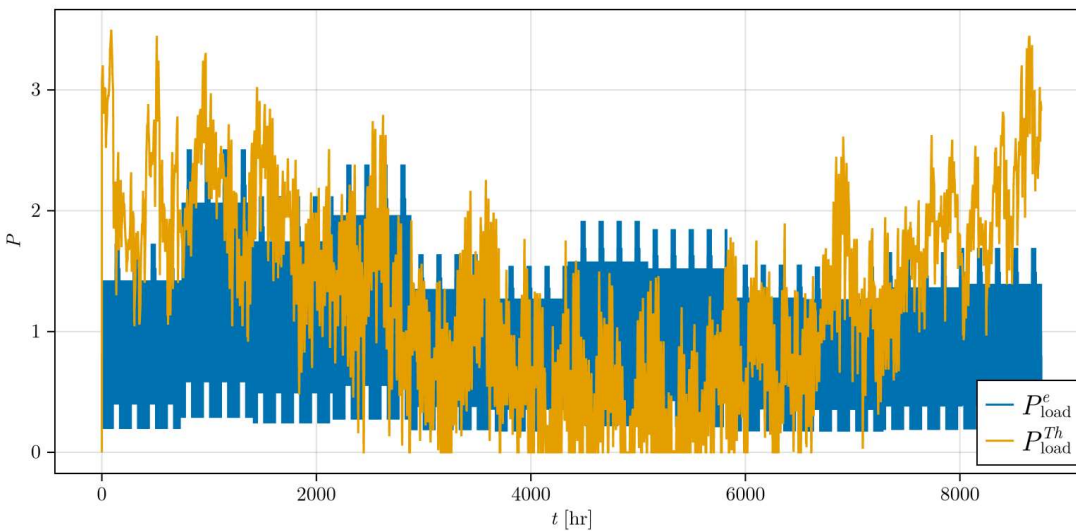
# Motivation

What are we doing and why?

# Motivation

## Electrified building

- 2 biggest carriers: Thermal, Electrical
- +50% mismatch in most buildings
- Seasonal mismatch with the sun.

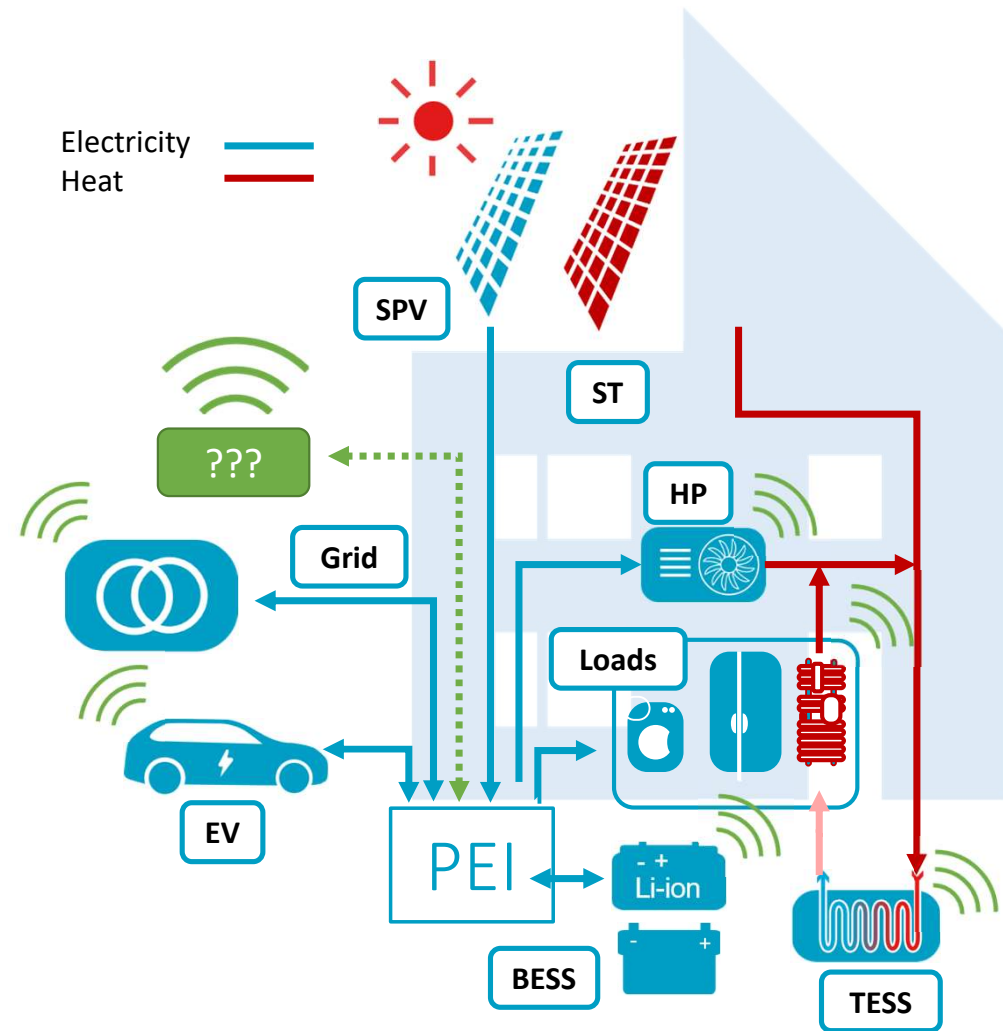


# Motivation

## Electrified building

- A lot of devices → complexity
  - Thermal
  - Electrical
- Diverse uncertainty → robustness
- Dynamic environment → speed

We need an automatic system that solves all three at the same time



Energy Management Systems (EMS) decide the **best way to operate** the Multi-Carrier Energy System (MCES)





02

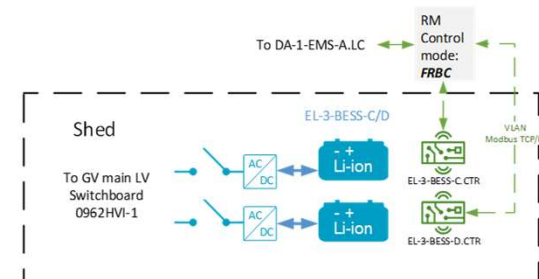
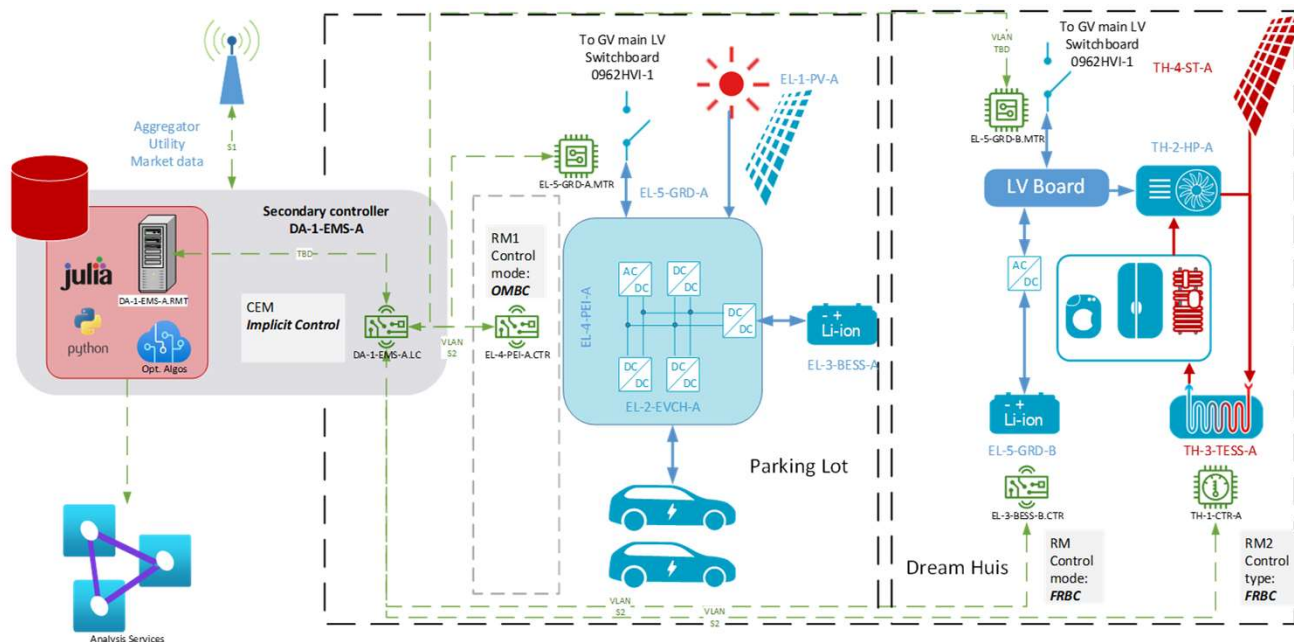
# Building our first EMS

How do we start?

# 2.1 Infrastructure

Let's get real

- Standardized connection to improve products (plug & play).
- Use flexibility focused comm. protocols (S1 and S2) to enable flexible services!
- Working closely with TNO and Flexible Power Alliance





## 2.1 – Plug & Play comms.



- Each device has a Resource Manager (RM)
- The RM receives instructions and sends measurements.
- The Customer Energy Manager (CEM) sends instructions and receives measurements.
- The messages are **standard** → reducing construction/engineering costs once developed.
- **Device states what it can do through RM**
- **EMA decides what it must do through CEM**
- **The external world connects to the CEM (S1)**



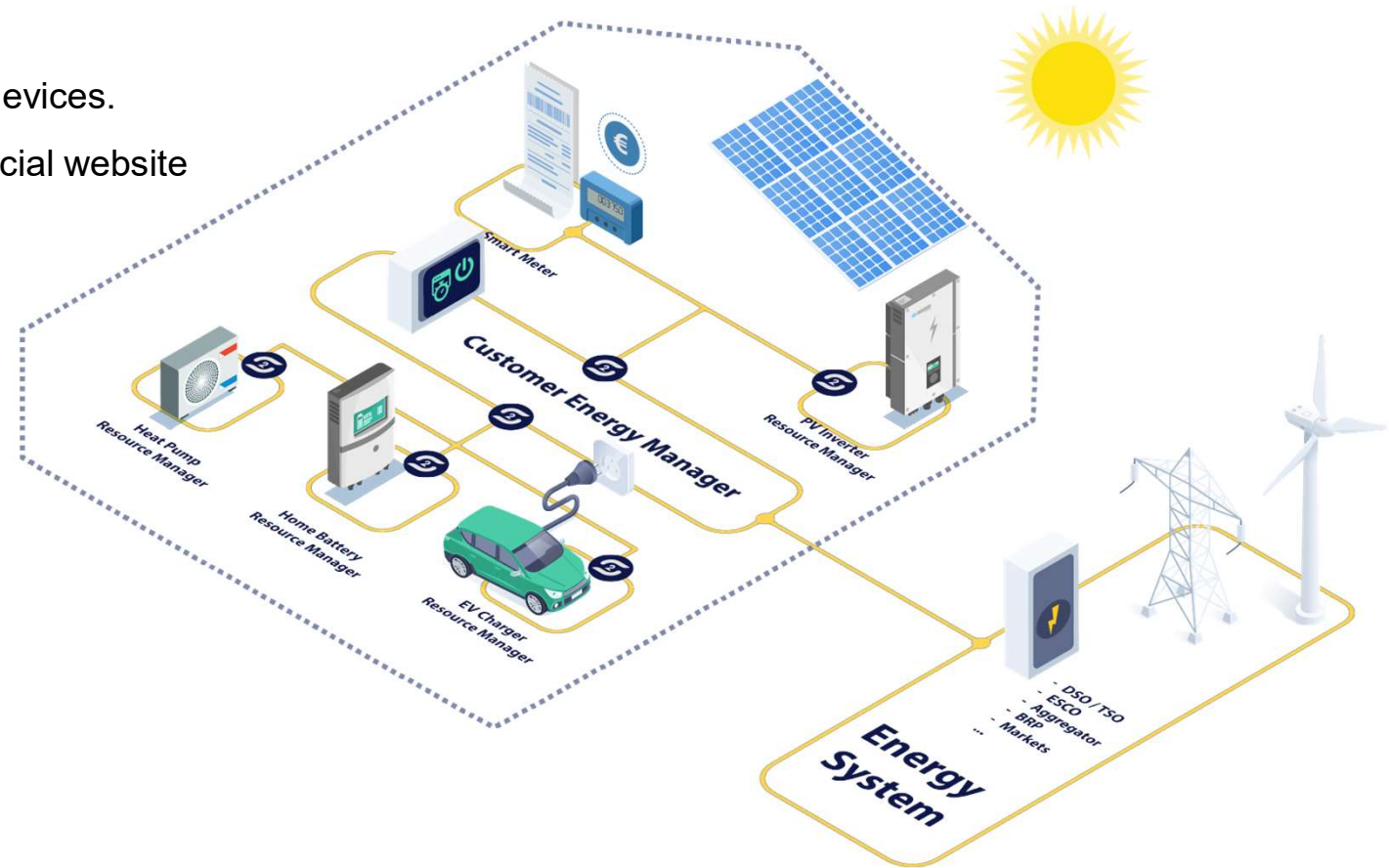
## 2.1 – Plug & Play comms.

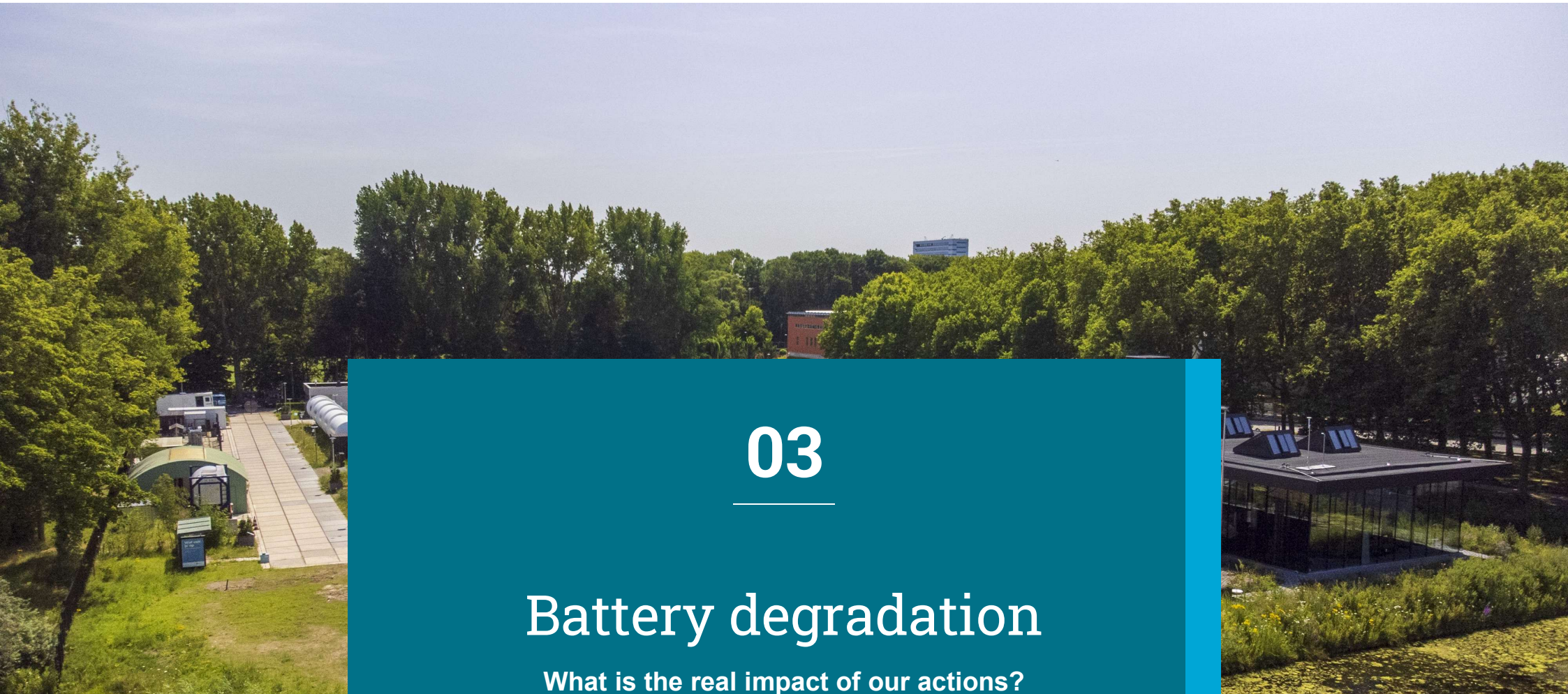


S2 Standard

- Easy to scale
- Simple extensions for diverse devices.
- For more info check out the official website

<https://s2standard.org/>





03

# Battery degradation

What is the real impact of our actions?



# Battery integration

- Collaboration with VITO to integrate battery models into the EMS algorithms.
- 3 relevant mechanisms
- Day-ahead planning
- Real-time optimization (under development)

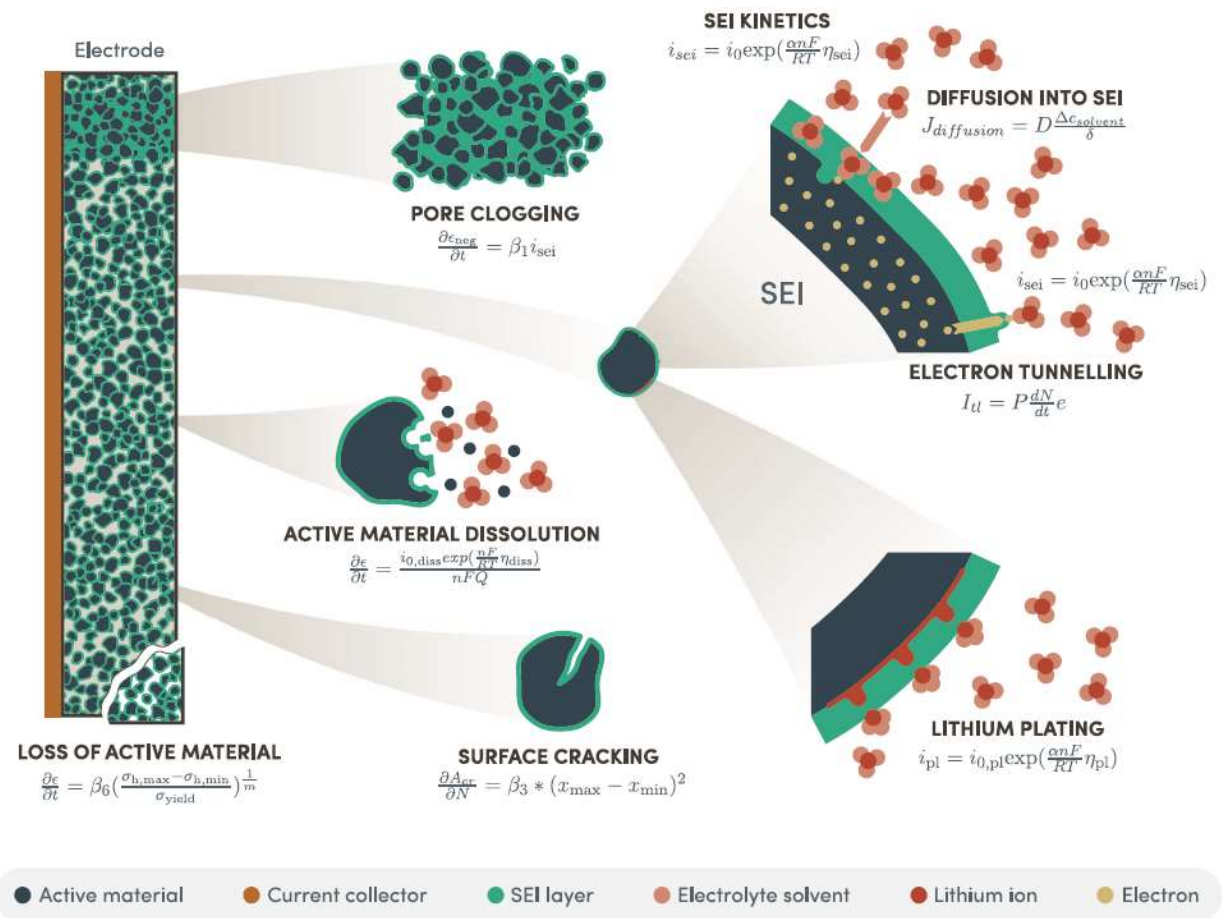
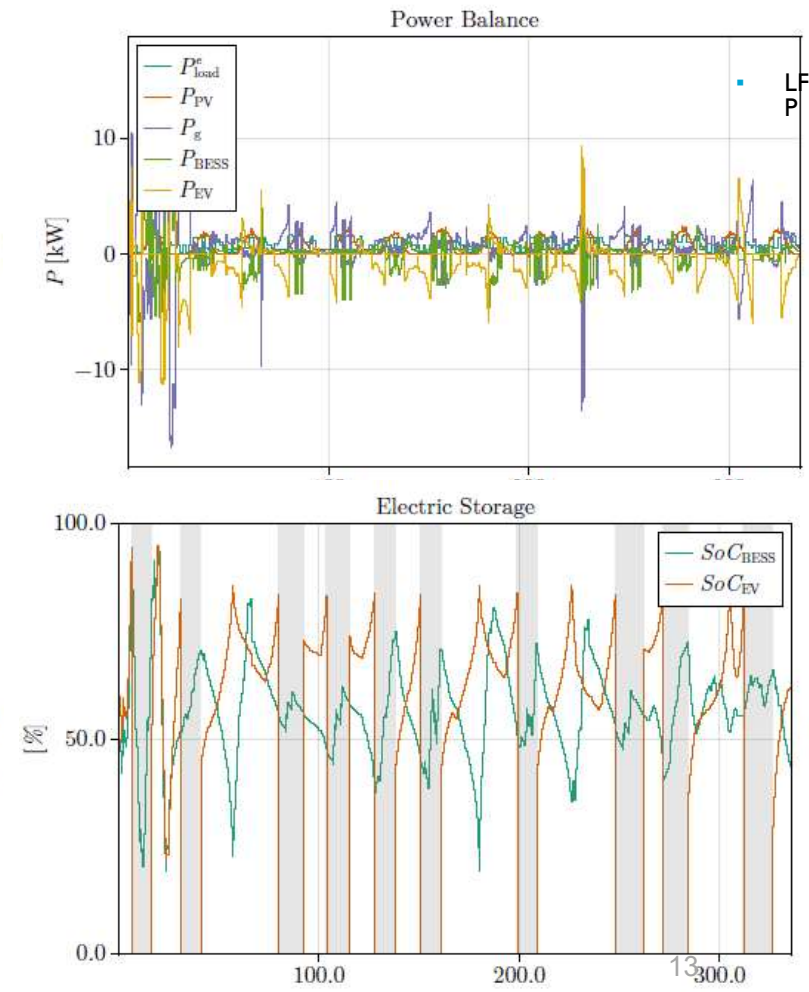
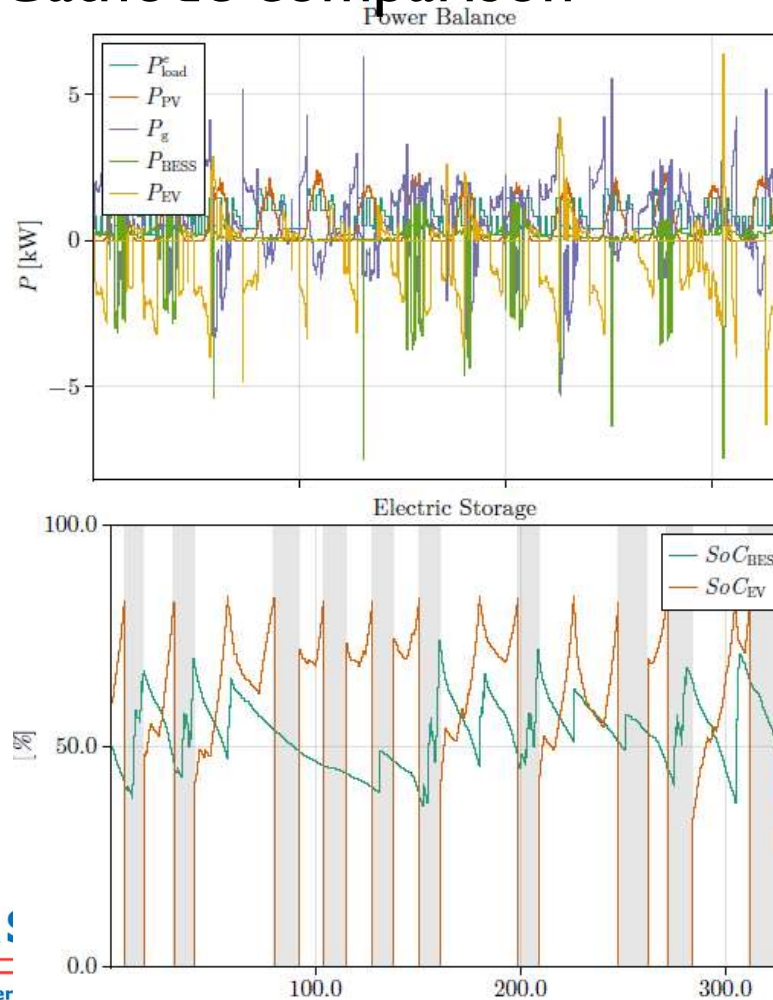


Figure 1. Graphical illustration of the various degradation mechanisms with typical equations modelling each mechanism.

# EMS operation – Cathode comparison

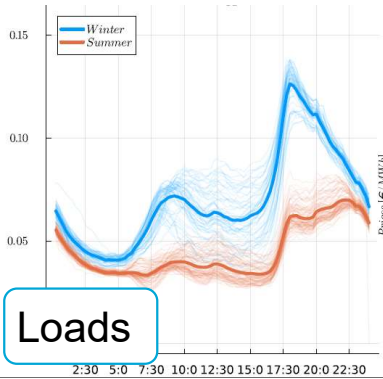
- Summer results
- By just changing the physical known parameters of the model we adapt the equations.
- Higher power peaks w/LFP,
- This is in accordance with previously known results.



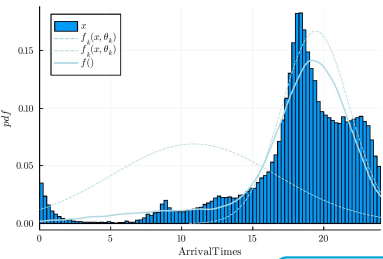
# 1.1 EMA detail

Settings

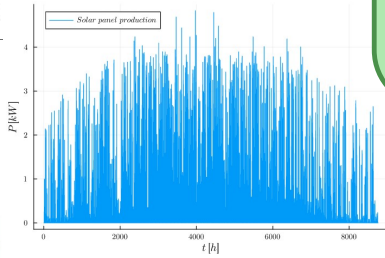
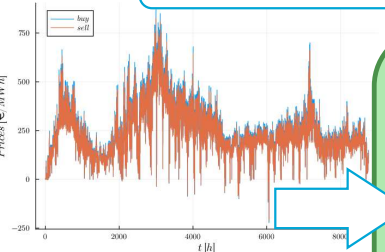
Tamb



Loads



Market Data



PV prod

EV av

**Sequential Decision Making**

$$\min_{\tilde{p}_{a,tt'}^* \in \mathcal{P}} \sum_{t=0}^T \tilde{c}(\tilde{S}_{a,t}, \tilde{p}_{a,tt'}^*)$$

$$\text{s. t. } \tilde{S}_{a,tt'+1} = \tilde{S}_{a,t}^M(\tilde{S}_{a,tt'}, \tilde{p}_{a,tt'}^*, \tilde{B}_{a,tt'})$$

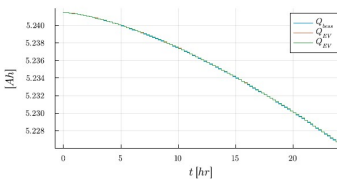
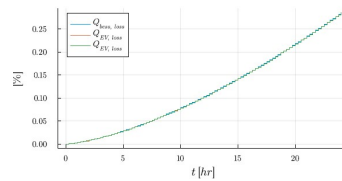
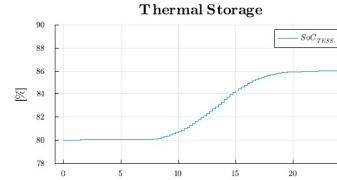
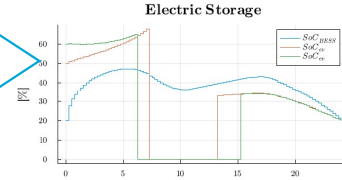
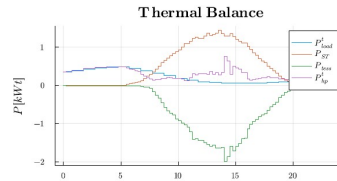
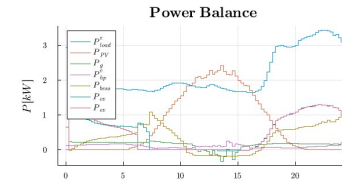
$$\tilde{S}_{a,tt'} \in \mathcal{S} \quad \forall a \in \mathbb{A}$$

BESS ageing.

**Sequential Decision Making**

$$\min_{\tilde{p}_{a,tt'}^* \in \mathcal{P}} \sum_{t=0}^T \tilde{c}(\tilde{S}_{a,t}, \tilde{p}_{a,tt'}^*)$$

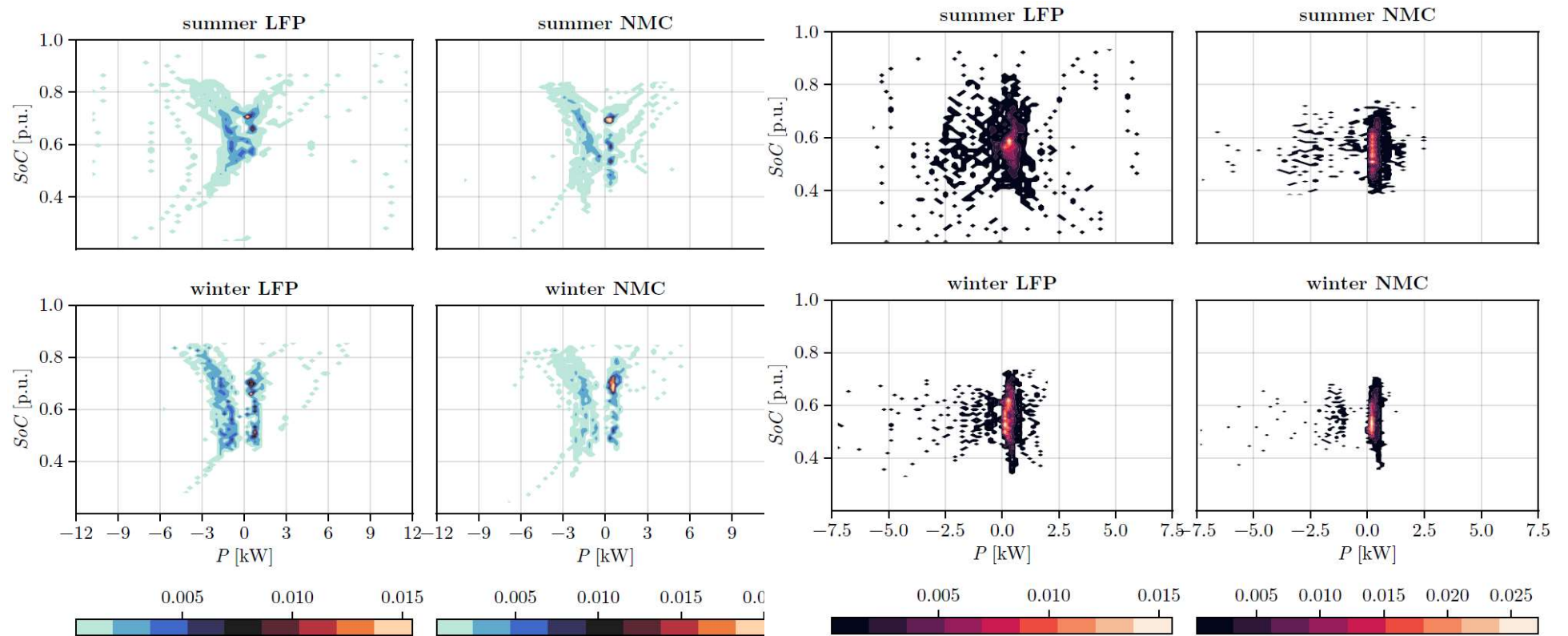
$$\text{s. t. } \tilde{S}_{a,tt'+1} = \tilde{S}_{a,t}^M(\tilde{S}_{a,tt'}, \tilde{p}_{a,tt'}^*, \tilde{B}_{a,tt'})$$

$$\tilde{S}_{a,tt'} \in \mathcal{S} \quad \forall a \in \mathbb{A}$$




# EMS Prelim. Results – LFP vs NMC Cathode comparison

Higher power peaks & surface coverage w/LFP → Better exploitation of the pack.



# Challenges & Ongoing research

- Implementing real time algorithms → possible solution with ML
- Price and cost challenges for the system
- Seasonal planning
- Identifying models online!
- Stacking services (FCR, mFFR, aFFR)

He project is uitgevoerd met Topsector Energie subsidie van het Ministerie van Economische Zaken en Klimaat, uitgevoerd door Rijksdienst voor Ondernemend Nederland. De specifieke subsidie voor dit project betreft MOOI-subsidie ronde 2020



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# Thank you!

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