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Aging study of a second-life battery in a PV-based charging station

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Context and Objective

CUMIN Program (**C**ampus of **U**niversity with **M**obility based on **I**nnovation and carbon **N**eutrality)

Different projects and disciplines to reduce GHG emissions due to transports

TESSA Project : Techno-Economical Study of Stationary life batteries for Affordable e-mobility campus

Using EV battery for solar-based EV charging station

Technical question

First life

Second life (PV based charging station)

recycling

C (%)

100 %

When ?

Economic question

How to predict battery aging?

EoL
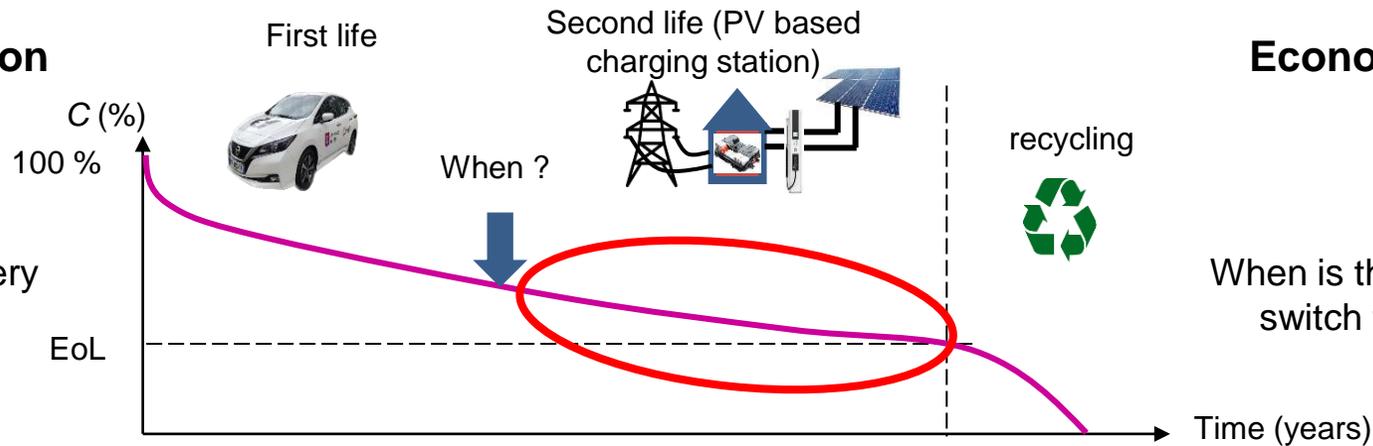
When is the best moment to switch to second life ?

Time (years)

Objective: Estimate the power demand of a stationary battery (Energy Storage System) used in PV-based EV charging station

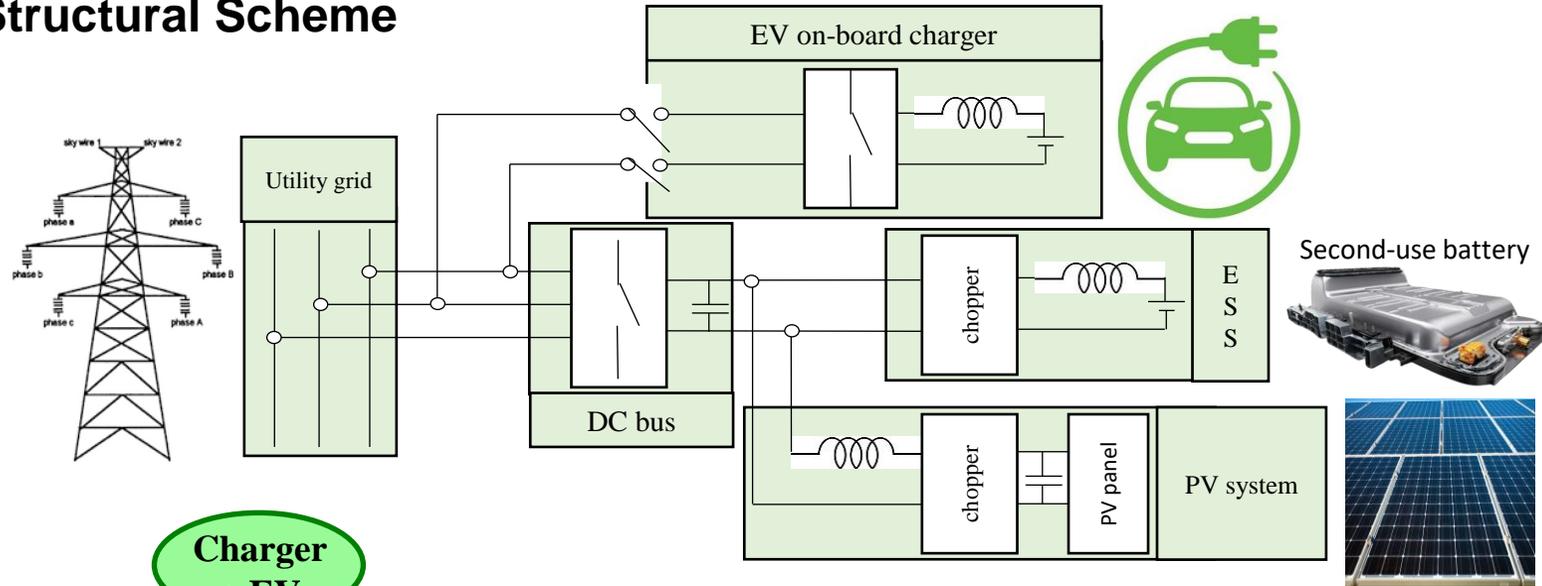https://cumin.univ-lille.fr/

Modelling, control and EMS of solar-based EV charging station

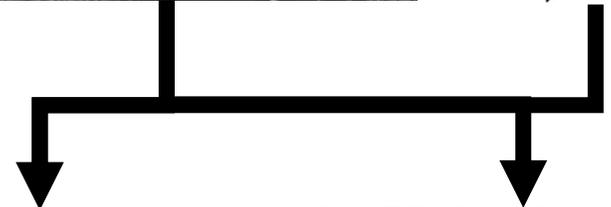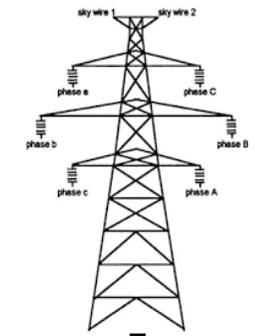# PV-based charging station model and EMR

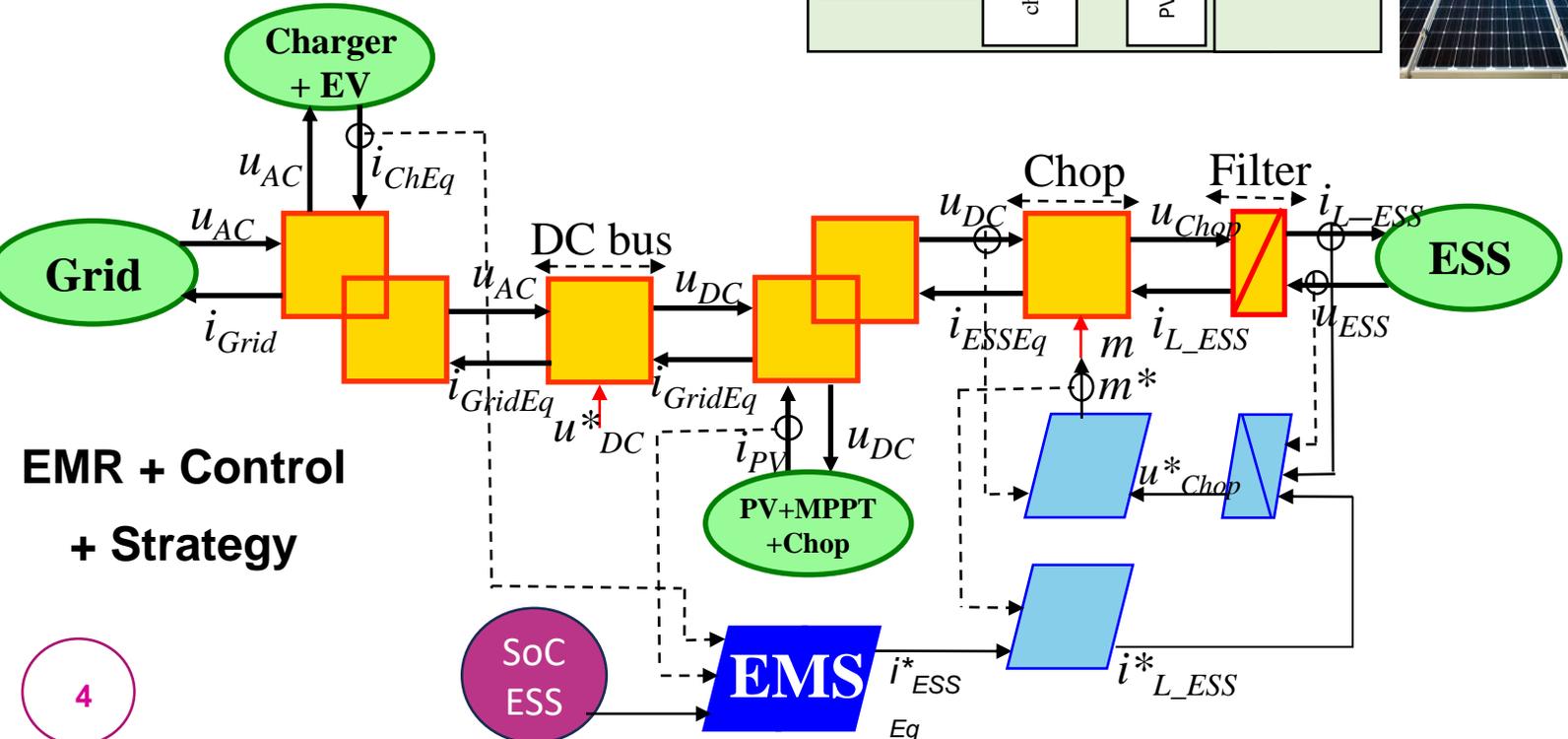## Structural Scheme

Studied Setup

PV: 68 m² Monocrystalline

ESS: 40kWh
(Renault Zoe)
Second-use battery

EV: Nissan Leaf
Charger: Type 2

EMR + Control + Strategy

Energy Management Strategy

EMS Main Objective: Maximum use of PV energy to charge EVs

Only ESS power is controllable

$$P^*_{ESS} = P_{ch} - P_{SPV} - P_{grid}$$
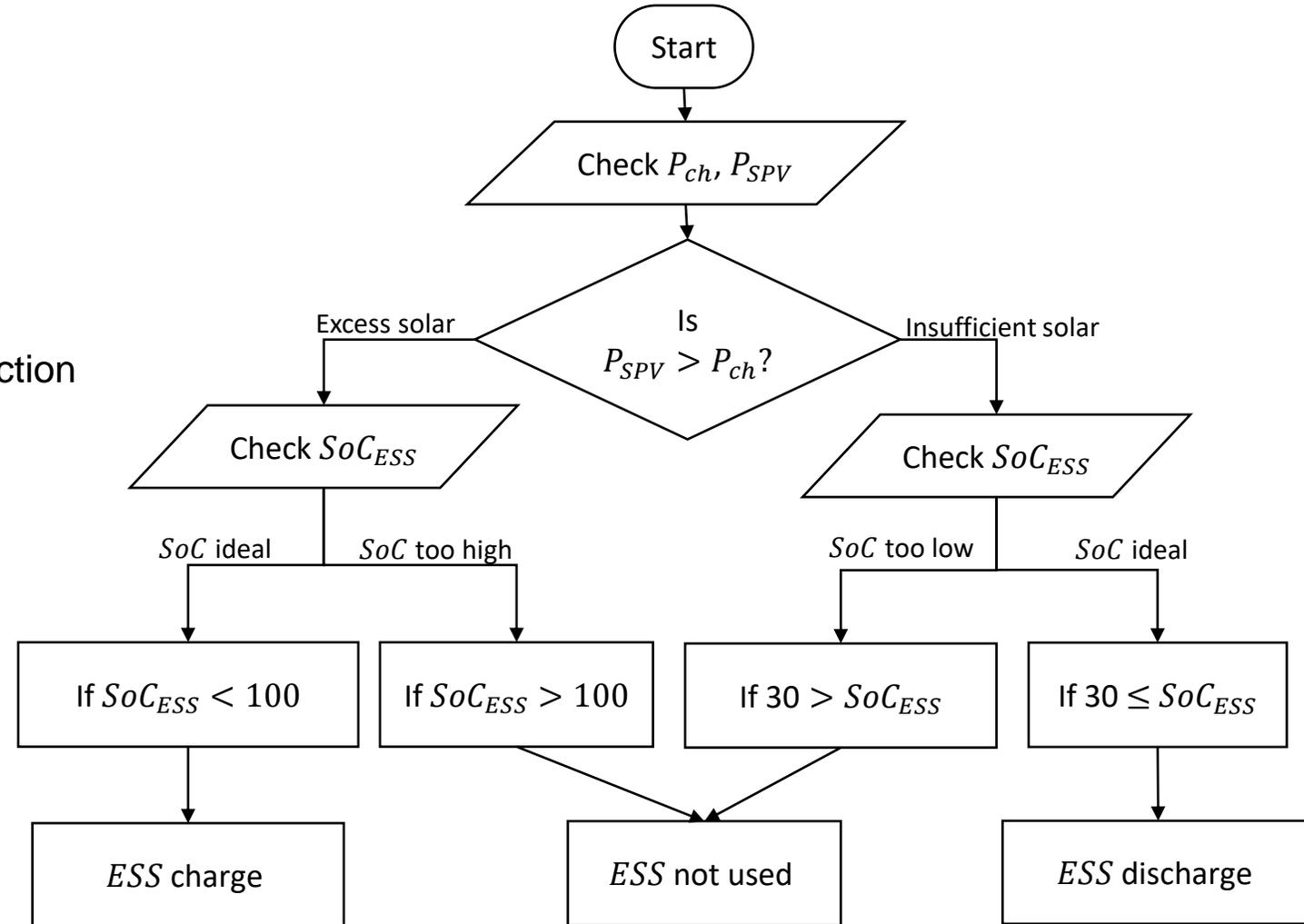
P_{ch} = Demanded power from EV charger
P_{SPV} = Power supplied by PV system
P_{ESS} = Power supplied by ESS

Check solar production

Check ESS SoC

Action on ESS

```
                        ┌─────────┐
                        │  Start  │
                        └─────────┘
                             │
                   Check $P_{ch}$, $P_{SPV}$
                             │
                   Is $P_{SPV} > P_{ch}$?
        Excess solar                    Insufficient solar
             │                                │
        Check $SoC_{ESS}$              Check $SoC_{ESS}$
      SoC ideal   SoC too high    SoC too low   SoC ideal
          │            │               │            │
   If $SoC_{ESS}<100$  If $SoC_{ESS}>100$  If $30>SoC_{ESS}$  If $30 \leq SoC_{ESS}$
          │                                             │
     ESS charge          ESS not used            ESS discharge
```

➡ Maximum EV charging from PV system
ESS is not charged from grid

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Solar modelling and results

PV system modelling

- Methodology

INPUT → Irradiance / NREL / Temperature → PV system model+ MPPT + chopper → Simulated Power → OUTPUT

- Identification
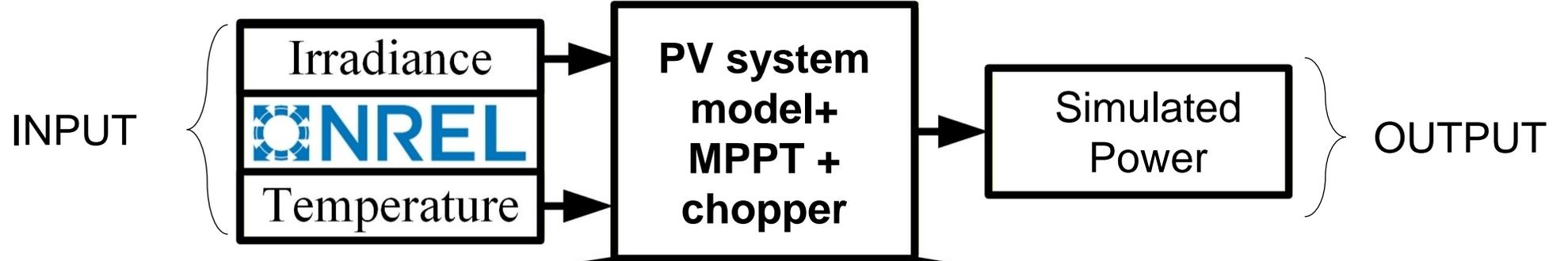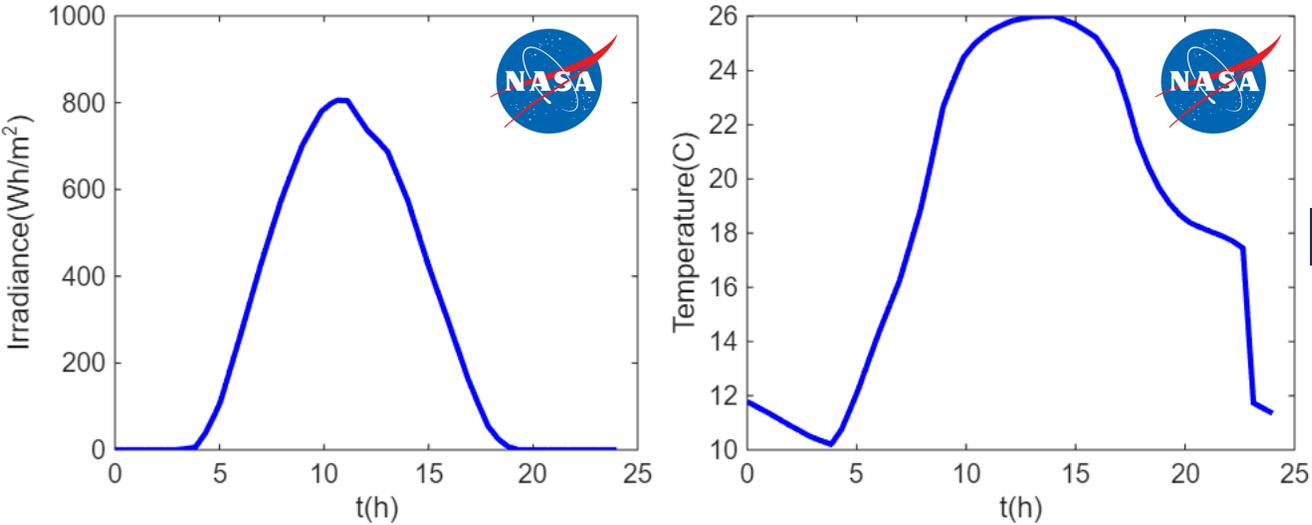
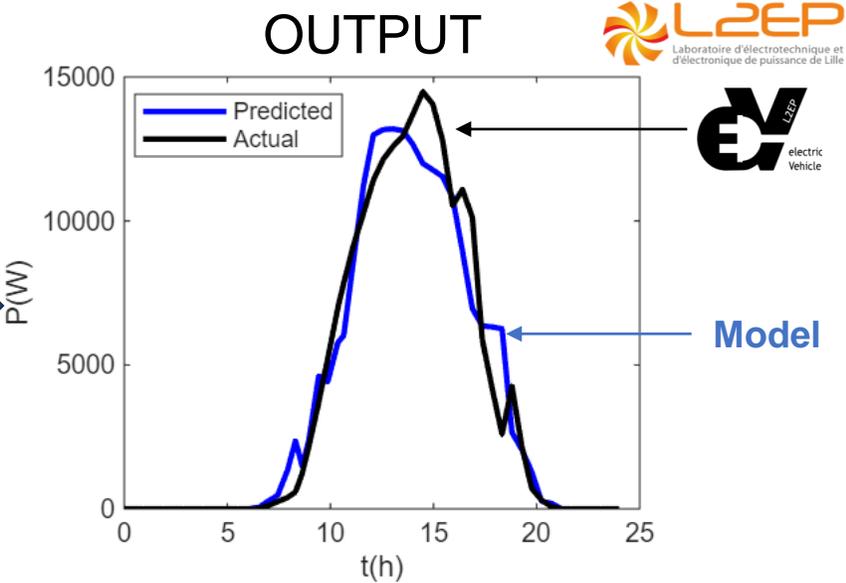- Building 3D table model
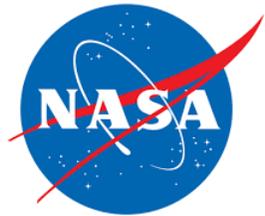
Recording → Irr. & Temp.

Recording → Power
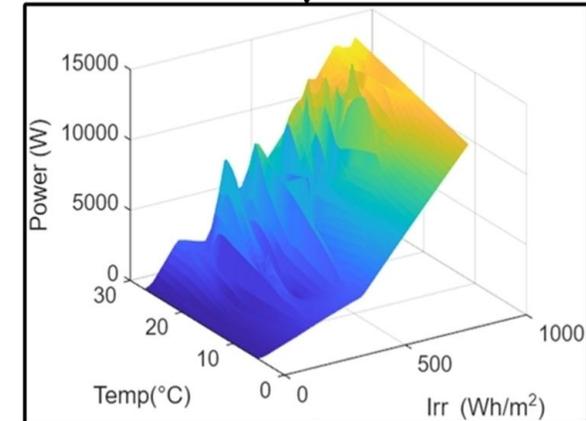
Model validation

27th April 2025 chosen for validation

INPUT

OUTPUT
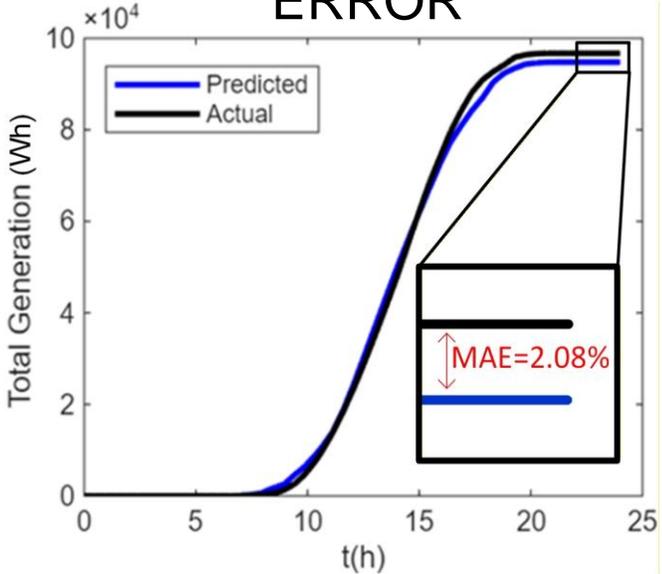
Model
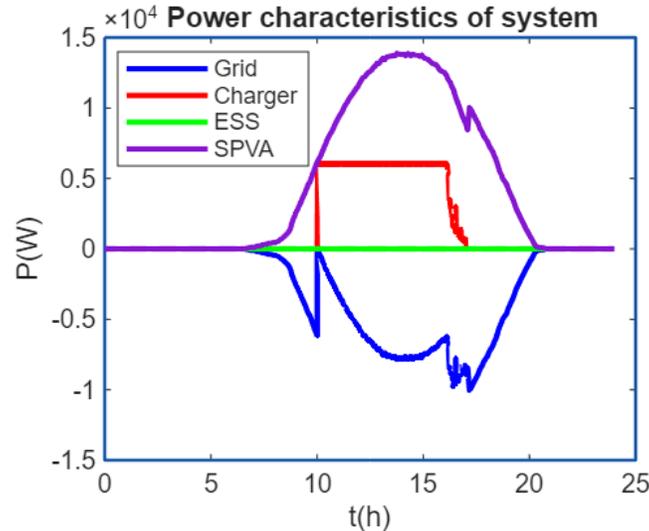
2% error on energy production ➡️ Model validated

ERROR

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Case scenario results

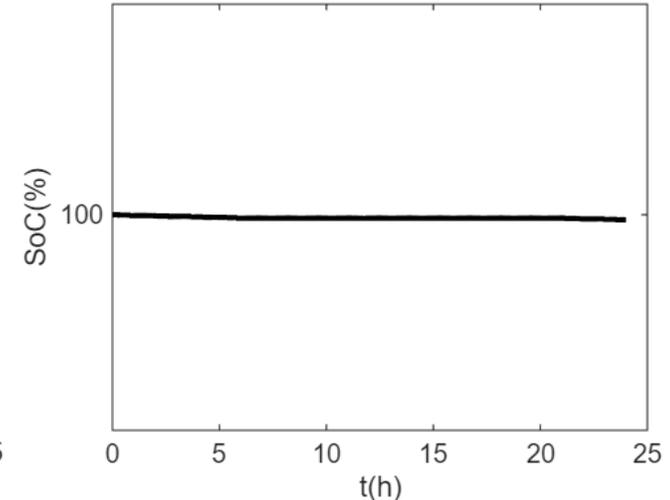# PV-based charging station results for 2 days

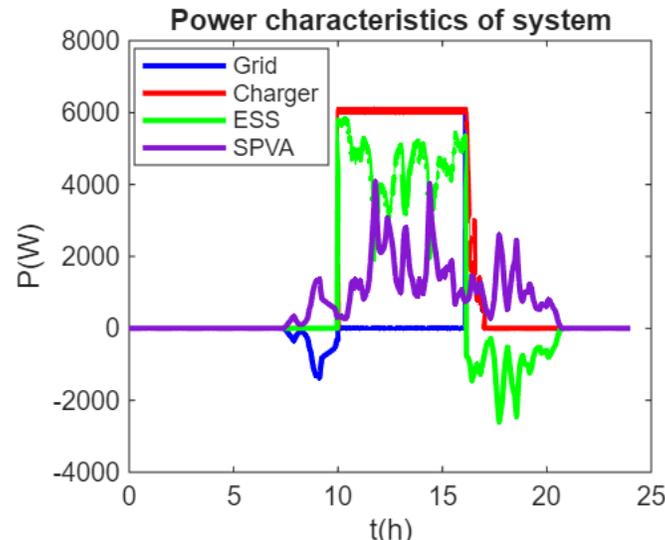Sunny Day- 29th April 2025

EV charging- 7hrs

Sufficient PV Energy

ESS usage- None

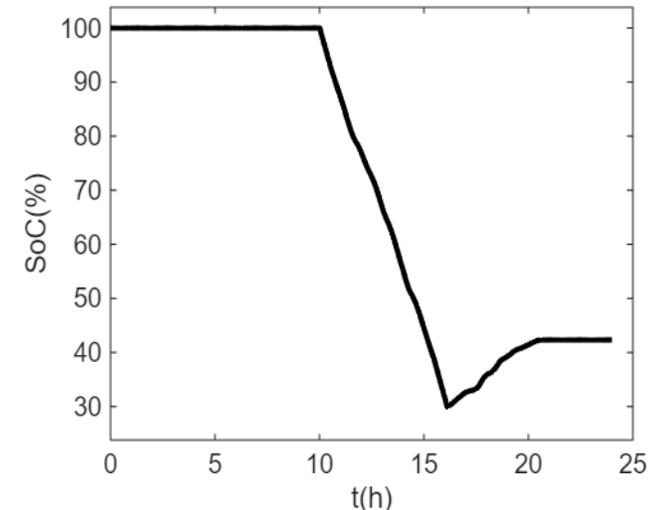Cloudy Day- 20th April 2025

EV charging- 7hrs

Insufficient PV Energy

ESS usage- Maximum

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ESS Aging Results

Second Life battery aging in a PV-based charging station

- Aging model

$$C_{loss_{t \to (t+dt)}} = d\left[(A + BSoC)e^{\frac{-Ea}{k_B T_{Bat}}}t^z + k_{FEC}FEC^\alpha\right]$$

→ $SoH = 100 - C_{loss_{0 \to t}}$

Parameter Identification for Zoe [Ndiaye 2024]

- Simulation results (second life)

Initial point 80% SoH, 8 years

10 years

-13% SoH

→ 13% SoH degradation in 10 years

SoH (%) vs Time(Year)
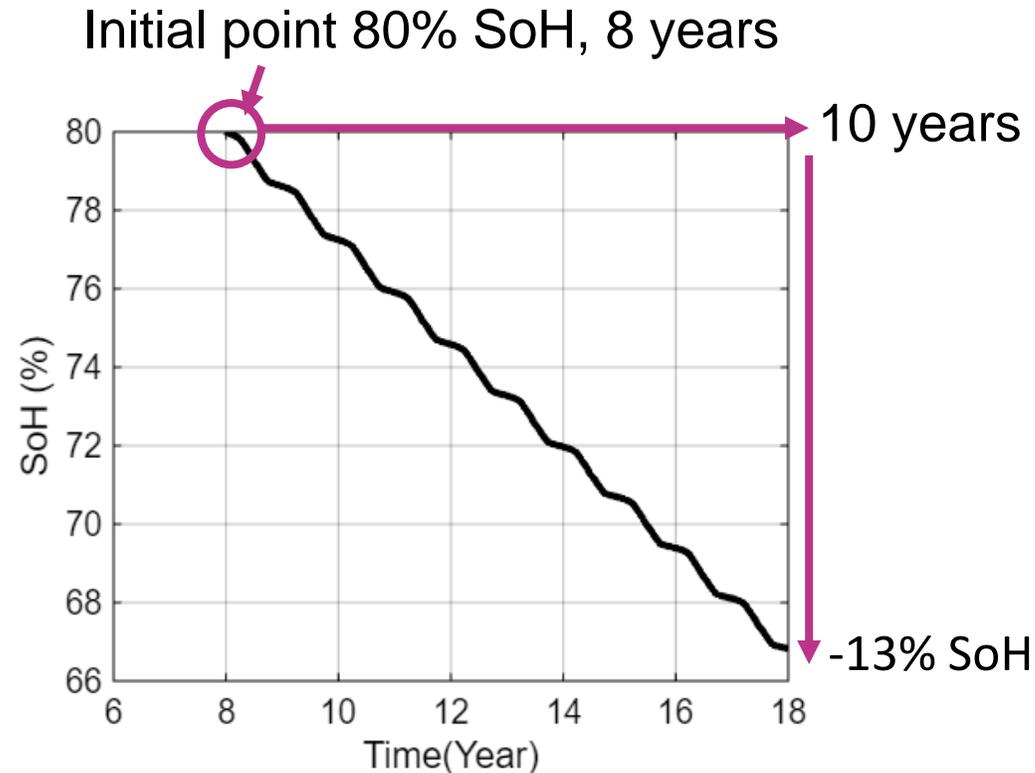
Conclusion, and perspective

- Conclusion

  - 13% SoH degradation in 10 years
  - 2% error on SPV power prediction

- Perspective

  - Simplified model of PV-based charging station
  - EMR of the system
  - Validated model of SPV
  - Model battery aging in second life

Acknowledgement

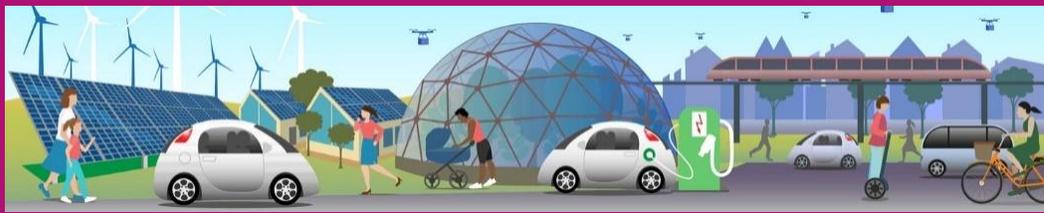# Questions?

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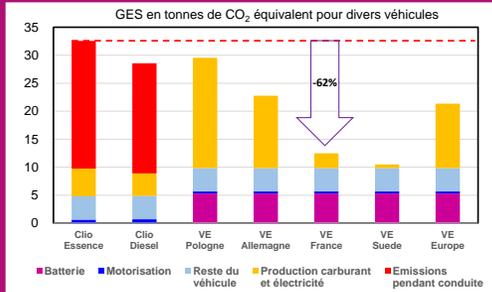
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