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CUMIN – TESSA

Study of the impact of first life usage on EV battery aging

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Outline

-  **1 Context and objective**
-  **2 Vehicle and battery model**
-  **3 Impact of user charging habits on EV Battery aging**
-  **4 Study of the impact of usage on EV battery aging**



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Context and objective

Studied system in TESSA project

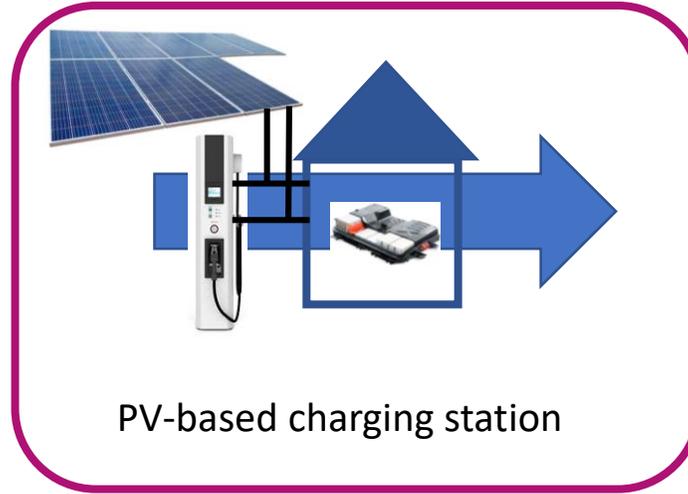
→ 3 possible phases for a EV battery

First life



Traction supply

Second life (TESSA)



PV-based charging station

Recycling

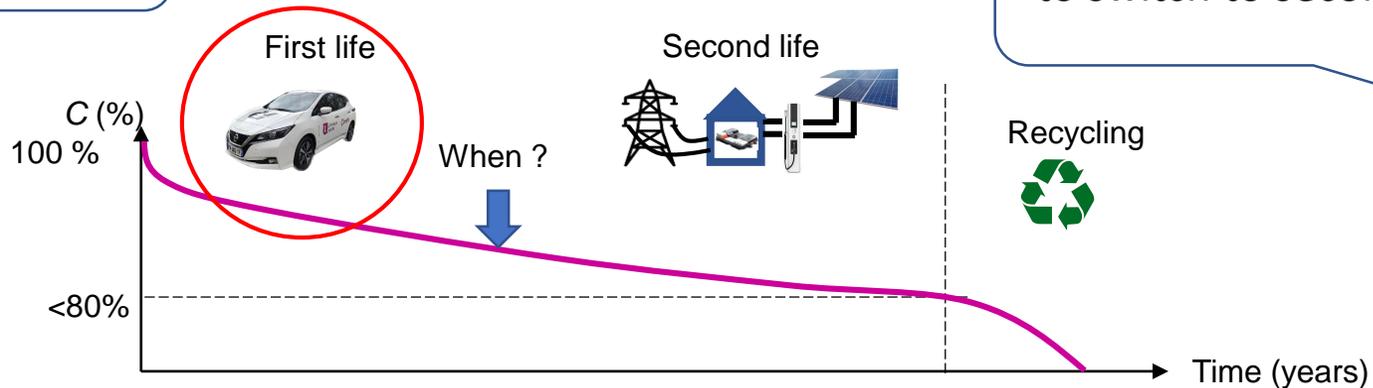


How to predict battery aging?



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When is the best moment to switch to second life ?

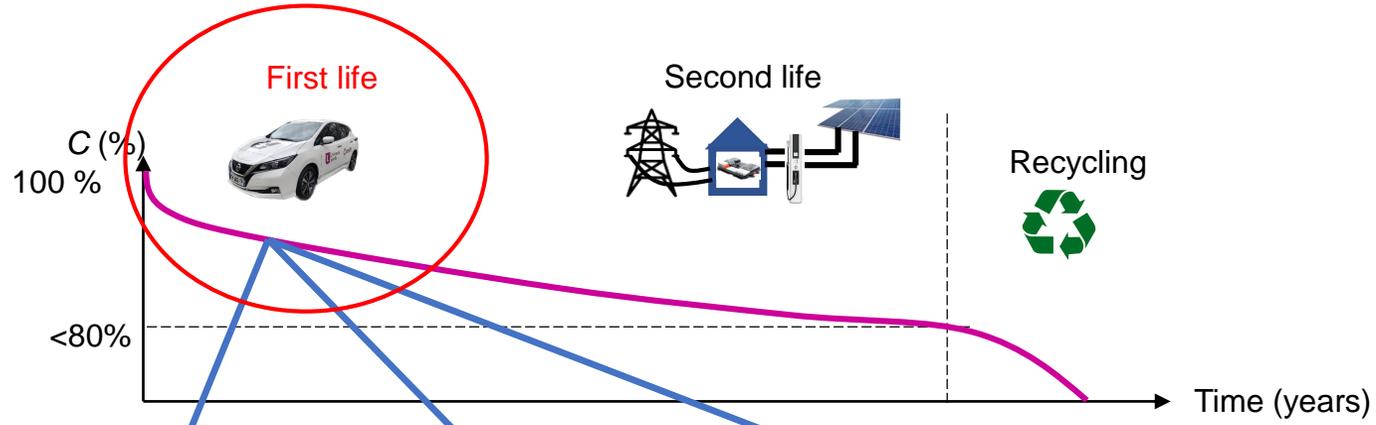


→ My work focus on the battery's first life



Objective of the study

EV battery first life aging → 3 modes



1. Charging



2. Driving



3. Rest



} → 3 modes

Definitions :

Operation ($i \neq 0$)

Rest ($i = 0$)

} → 2 phases

Objective: understand first-life battery aging to enable second-life use



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Vehicle and battery model

Important definitions



Nissan Leaf

- Cell : Battery elementary component



x8



- Module



x24



- Battery pack



- State of Charge SoC (%) → Remaining energy

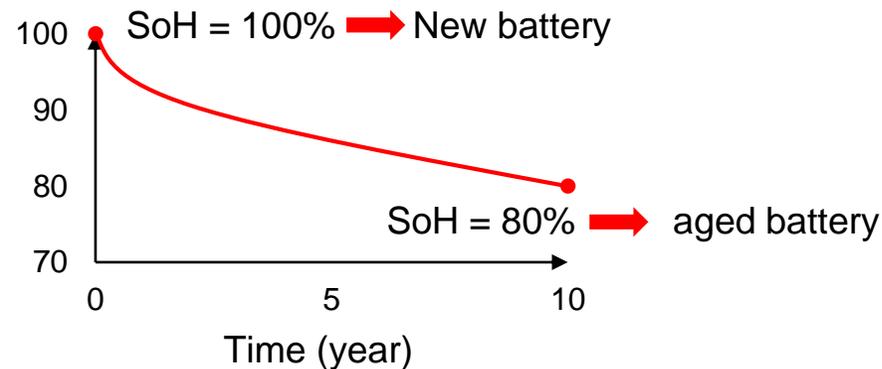
SoC = 0% → Battery empty



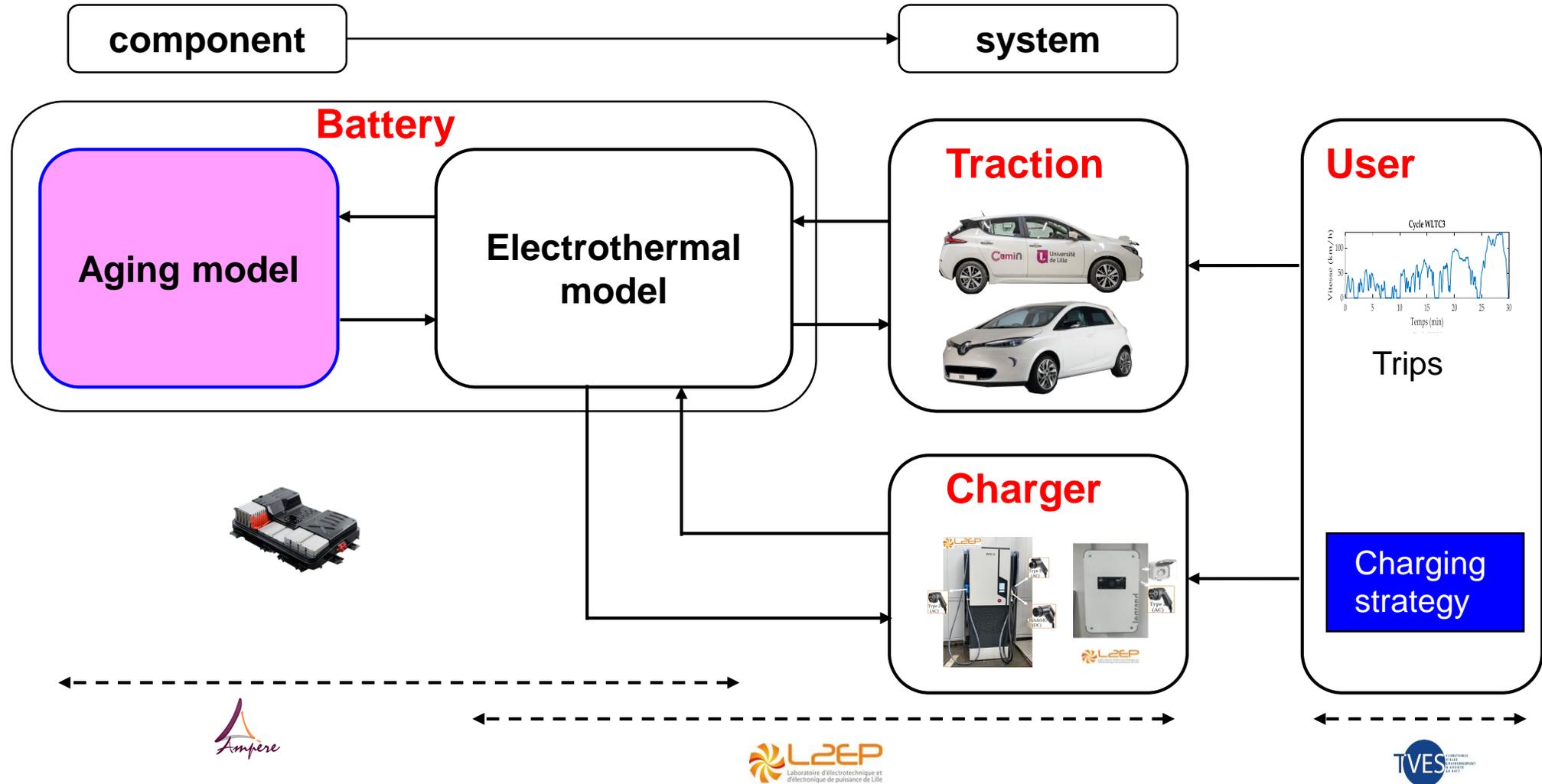
SoC = 100% → Battery fully charged



- State of Health SoH (%) → Degradation level



Multi-scale and multi-domain approach



How to connect all the models for a multi-year study?

Nissan Leaf modelling

❑ Traction model

❖ CUMIN program

Nissan Leaf 2018



Battery Modules (x24)



8 modules acquired for characterization



Instrumented to acquire data (SoC, battery current, ...)



Traction model

❑ Chargers



EV-box Charger



Recording charges

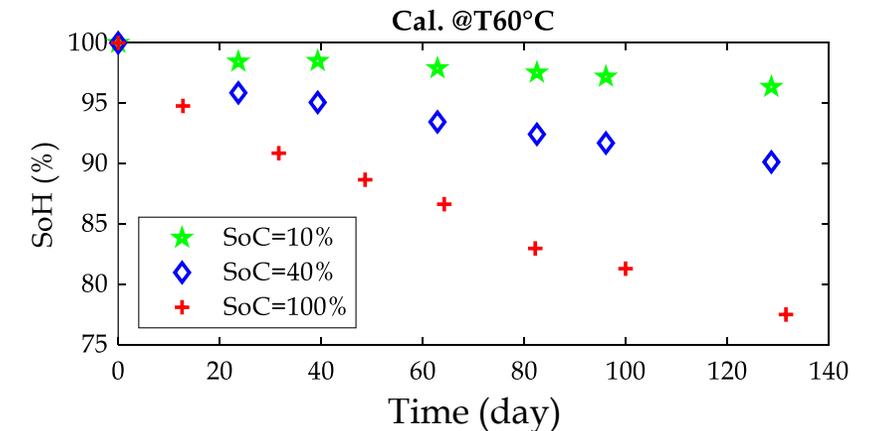
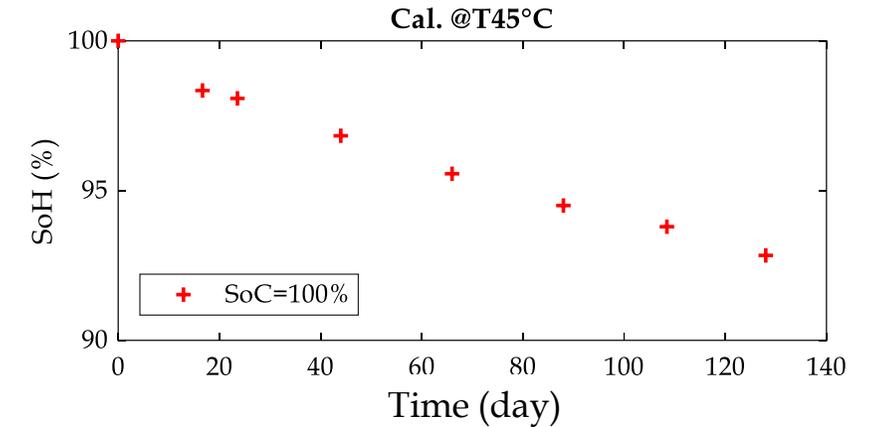


Modeling the charger

❑ Battery ageing characterization



High SoC/high T accelerate aging



Battery aging model

$$dC_{\text{loss}t \rightarrow t+dt} = d \left[(A + B\text{SoC}) e^{\frac{-Ea}{k_B T_{\text{Bat}}}} t^z + k_{\text{FEC}} \text{FEC}^\alpha \right]$$



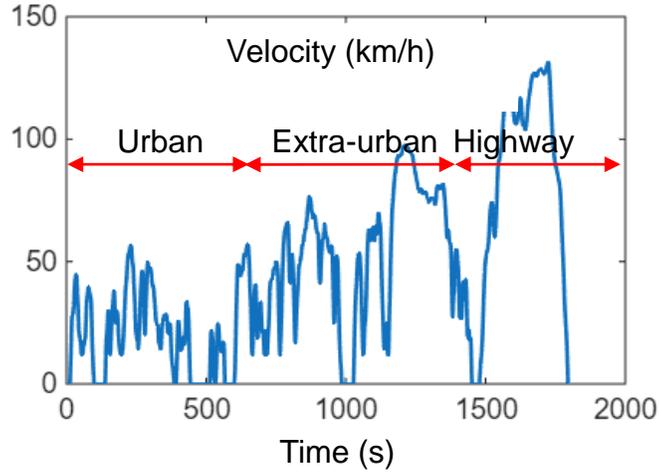
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Impact of user charging habits on EV Batterie aging

Study of the impact of charging habits

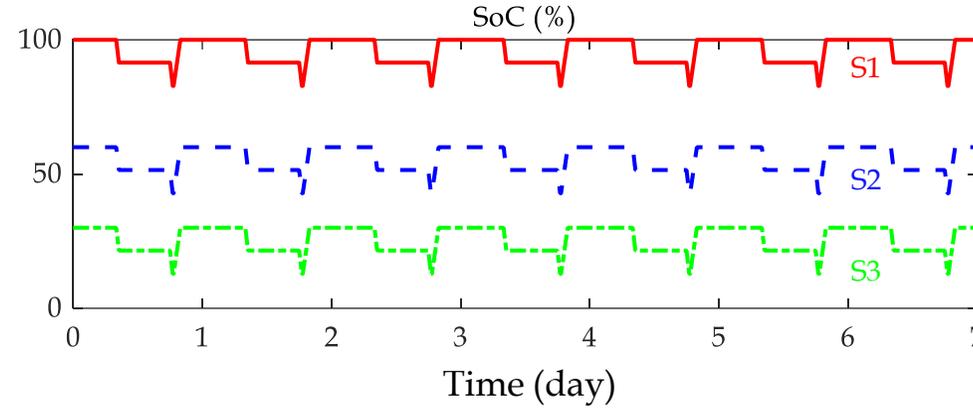


Speed cycle: WLTC



Charging scenarios

S1, S2, S3 → Daily charge



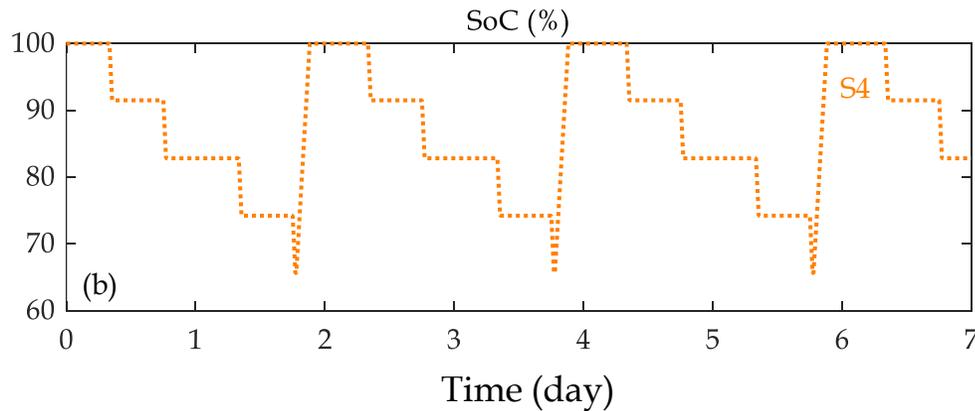
Initial SoC

S1 : 100 %

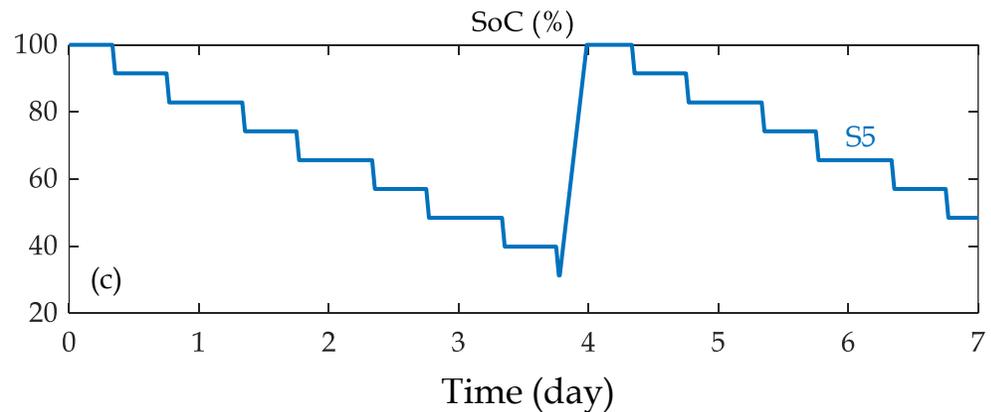
S2 : 60 %

S3 : 30 %

S4 → Charge every 2 days

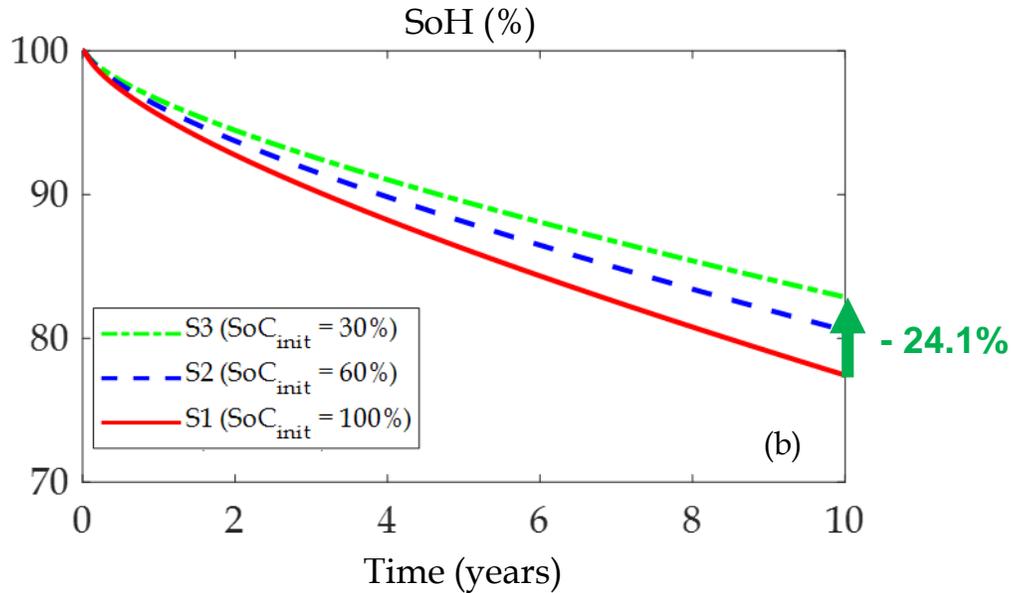


S5 → Charge every 4 days



Study of the impact of charging habits

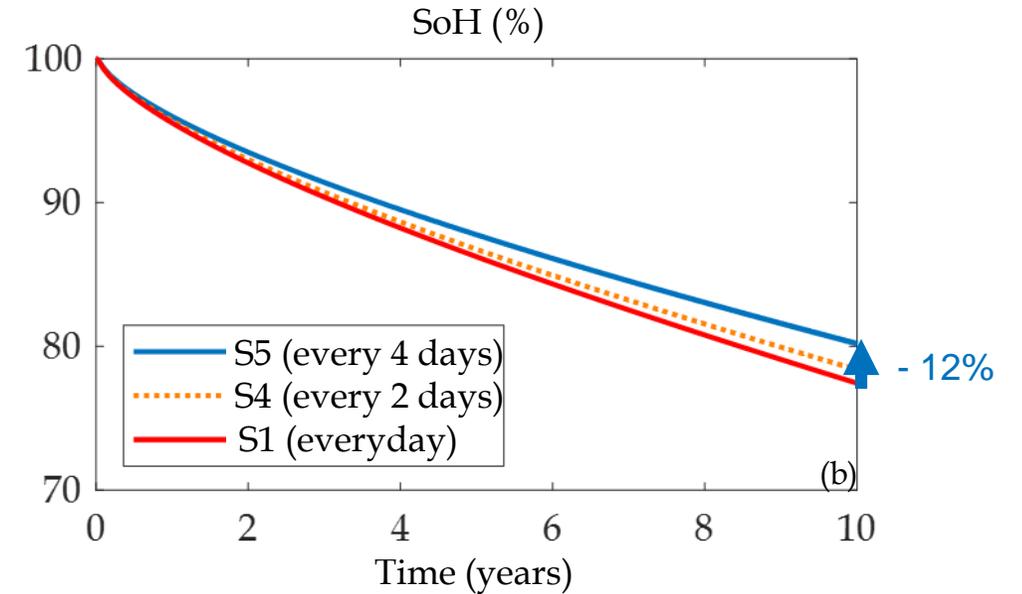
Daily charging scenarios over 10 years



Up to - 24.1% degradation

➡ Lower SoC helps to extend the battery's lifespan

Scenarios with various charging intervals over 10 years



Up to - 12% degradation

➡ Spacing out recharges helps reduce battery aging

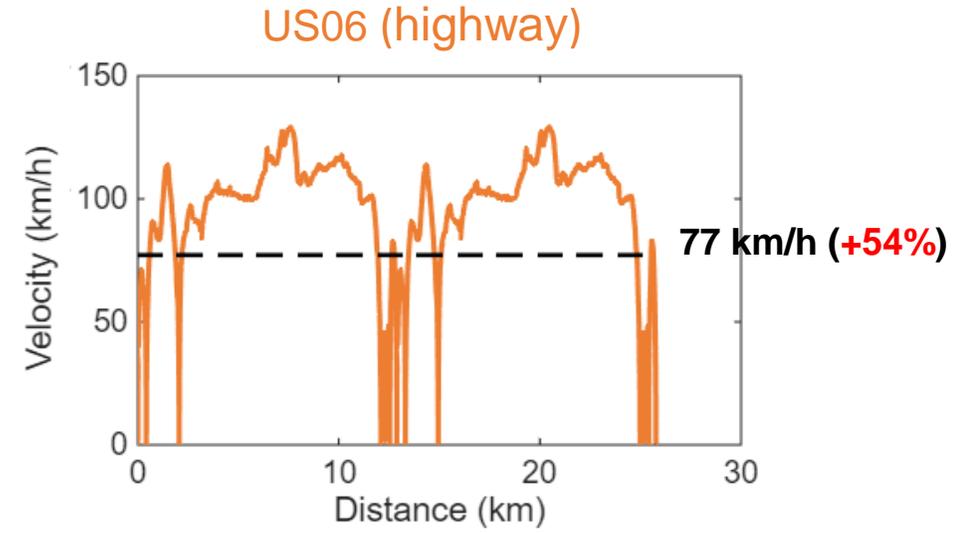
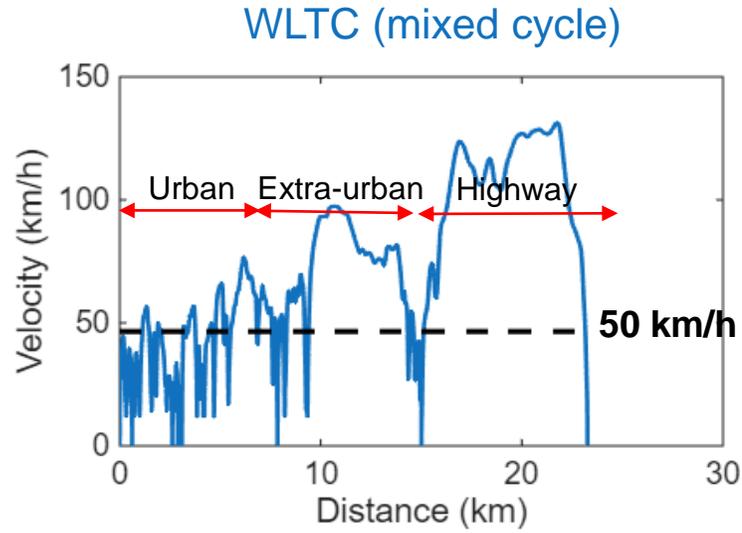


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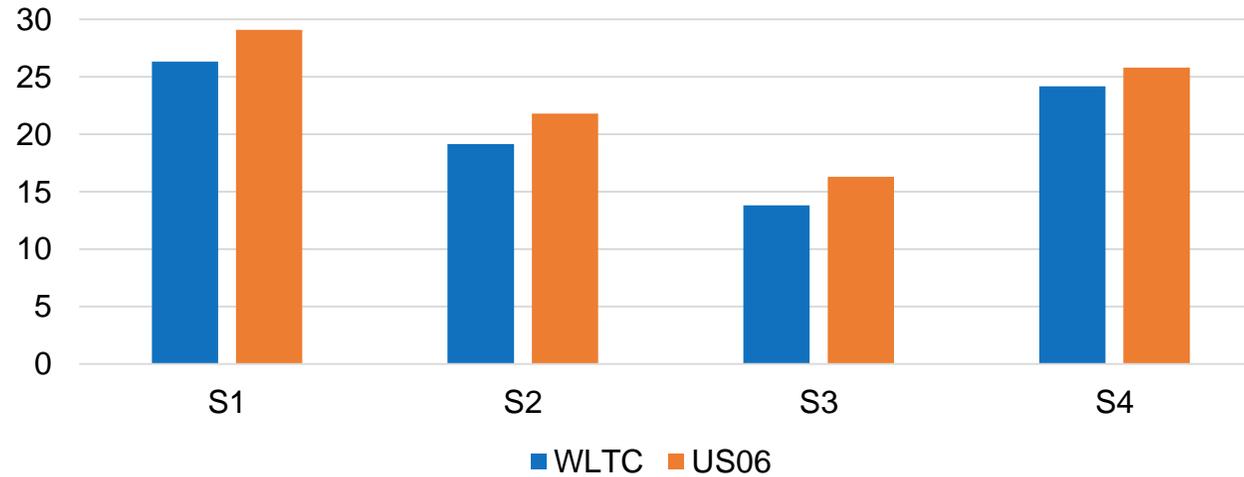
Study of the impact of usage on EV battery aging



Influence of the type of trip: mixed and highway



Capacity loss (%)



Highway
↓
+11% degradation on average

Highway use of an electric vehicle → Accelerated battery aging

Conclusion

✓ **Modeling:**

1. Vehicle and battery model and EMR
2. Integration of the battery model into the vehicle

✓ **Practical recommendation:** Adapt charging habits to reduce battery degradation

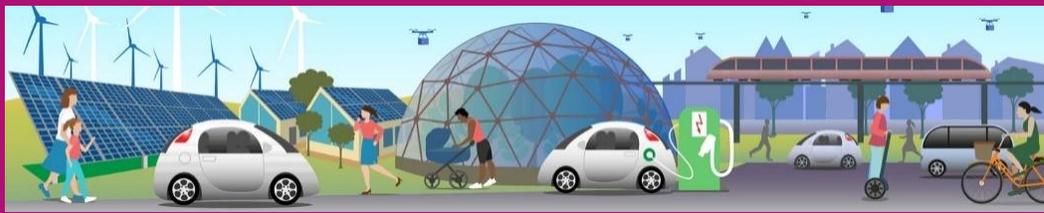
1. Reduce the average State of Charge (SoC)

➡ **Do not fully charge for long rest time (e.g. vacation)**

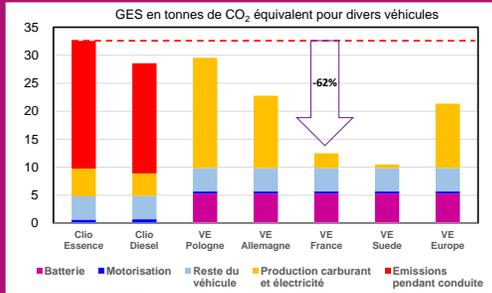
2. Space out recharges

➡ **Do not charge every day**

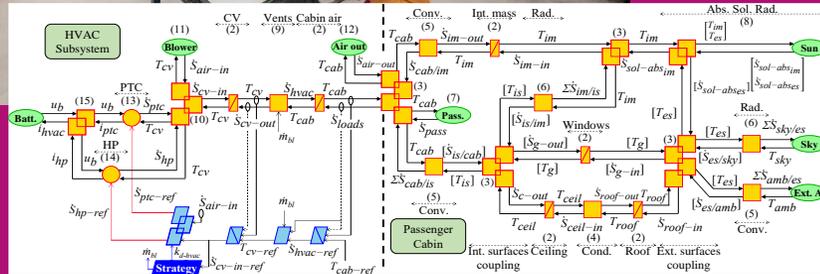
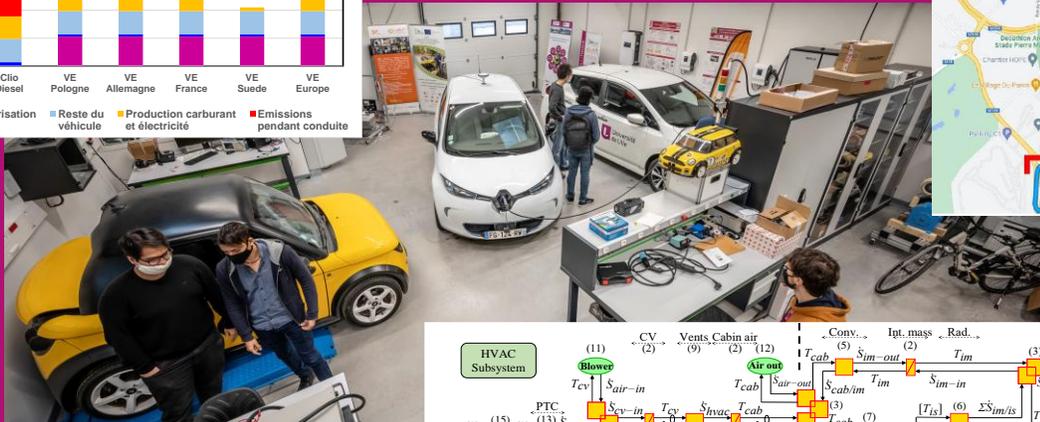
3. Highway driving cycles ➡ Accelerated aging



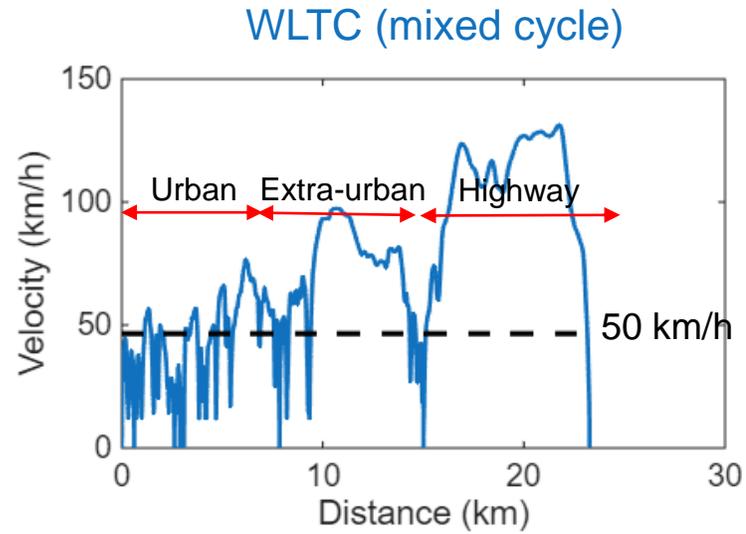
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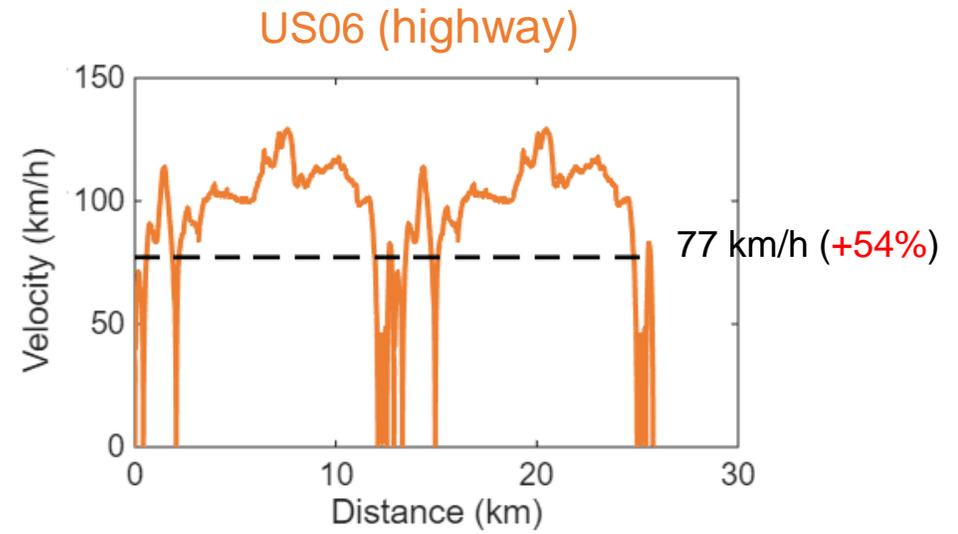
Our university as an exciting living lab towards eco-cities through an innovative transdisciplinary framework !



Influence of the type of trip: mixed and highway



23,3 km/trip
17.010 km/year



25 km/trip
18.250 km/year
+7 %