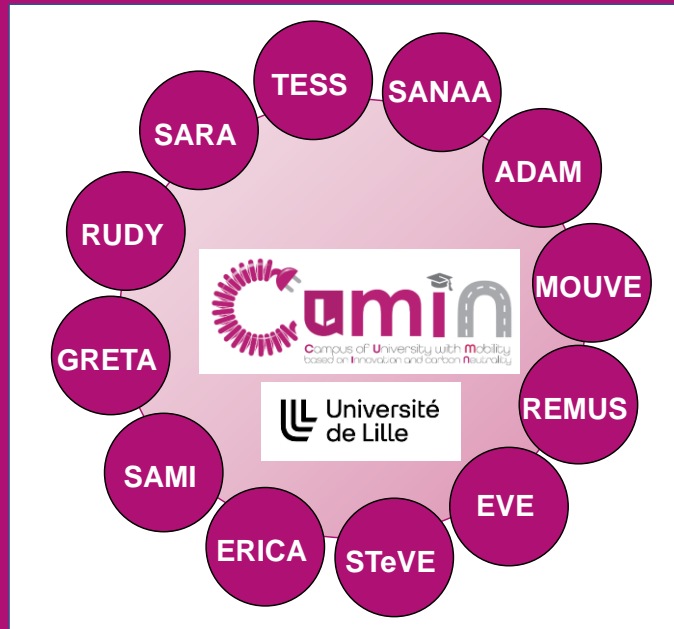https://cumin.univ-lille.fr/

Université de Lille — FRANCE 2030

Evolution of the performance of an electric vehicle

depending on the health of the battery

Authors
Alhelou Serge Antonio
Fall Mouhamadane

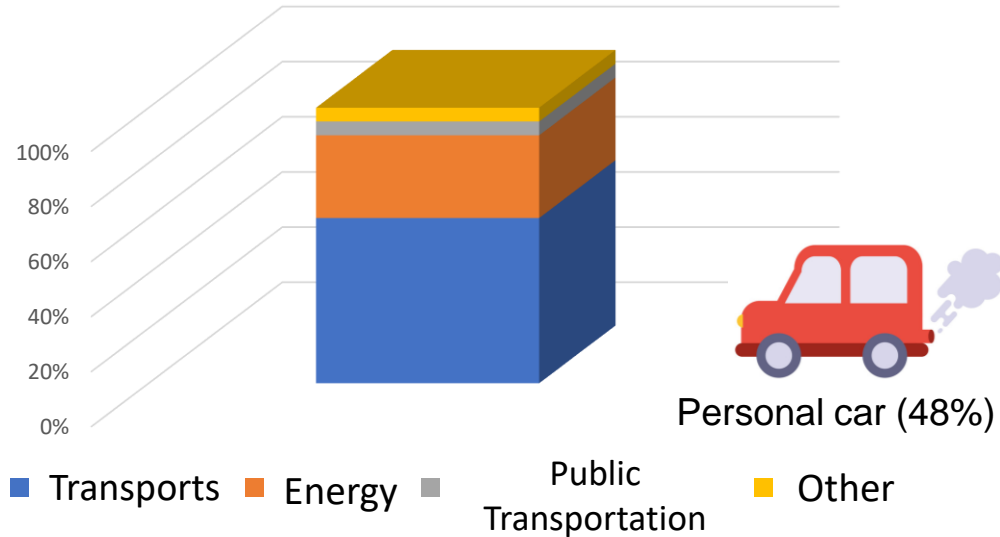Supervisor
German Ronan
Gaetani-liseo Margot

Plan

1 **Context and objective**

2 **Basic concepts and definitions**

3 **Test results document**

4 **Simulation and results**

5 **Conclusion**

General context

Université de Lille

2020 GHG 52,000 tonnes CO_2 eq

CO2 Emissions

Personal car (48%)

- ■ Transports
- ■ Energy
- ■ Public Transportation
- ■ Other

⚠ Personal cars are transitioning to electrification
EVs make up 18% of the total vehicle market in 2023 [IEA 23]

CUMIN study : Electric Vehicles

~15 T CO_2 eq

- ■ Energy
- ■ Chassis
- ■ Motor
- ■ Battery

[Desreveaux 2023]
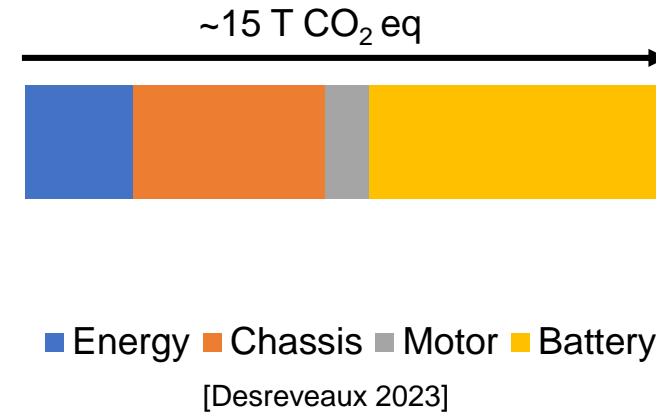
~ 40% of the total GHG emissions from EVs are due to battery production

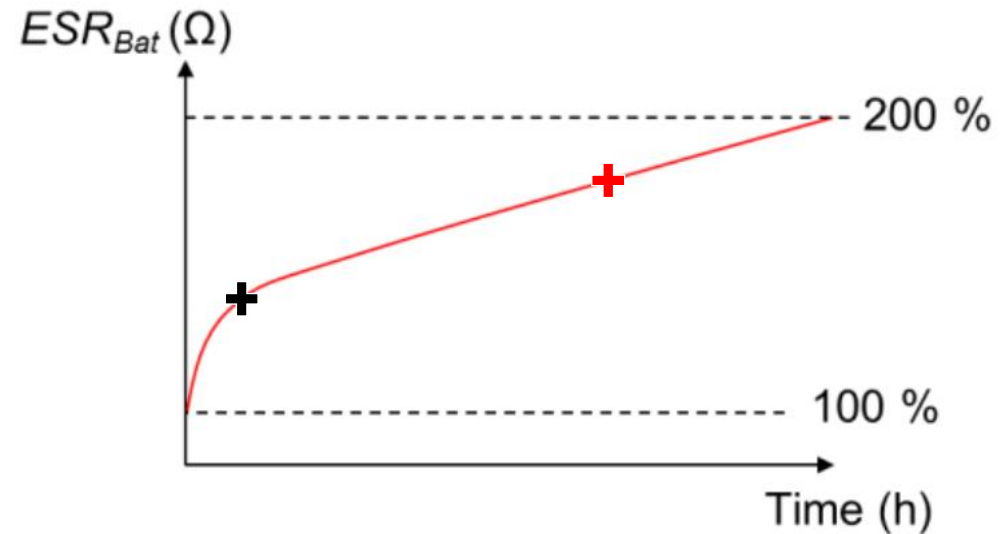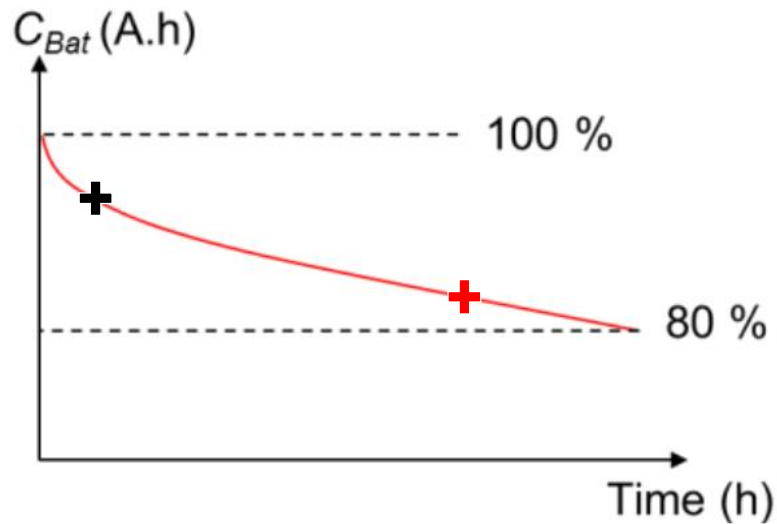https://www.iea.org/energy-system/transport/electric-vehicles

➡ Studying battery aging is interesting

Objective of the project

Objective: Study the vehicle's driving range based on the health status of its battery
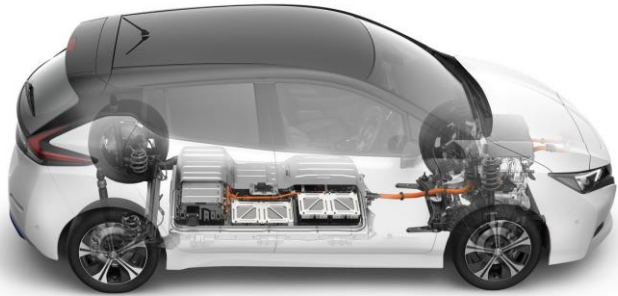
Example: Effects of battery aging

C_{Bat} (A.h)

100 %

80 %

Time (h)

ESR_{Bat} (Ω)

200 %

100 %

Time (h)

- Capacity decreases, so energy decreases

- ESR (Equivalent Series Resistance) increases, so losses increase

Driving range decreases with aging

Inputs and outputs of the project

Complete test report

Vehicle simulation with multiple health states

Results of aging tests by Alla Ndiaye

Our project

Driving range study according to the scenario

Basic concepts and definitions

Cell: It is the smallest unit of the battery

Module

Battery

ESR_cell

I_cell
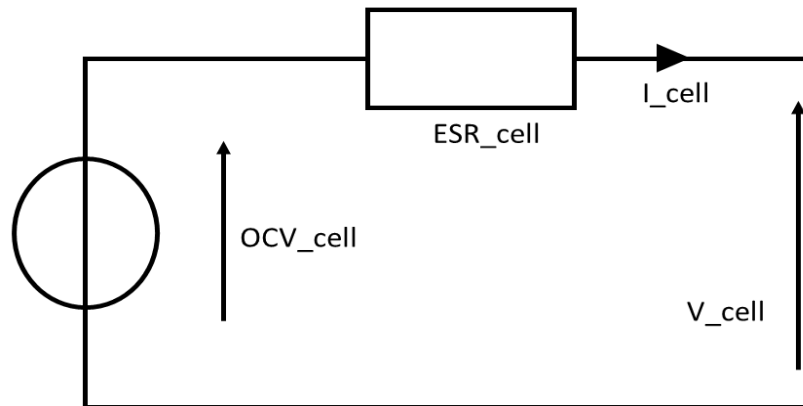
OCV_cell

V_cell

Equivalent electrical circuit
of a lithium-ion battery cell

OCV_cell: Open Circuit Voltage of the cell

ESR_cell: Equivalent Series Resistance of the cell

ESR is defined as presented in the works of [Ramsey 2023]

Assumption we consider all the cells the same in the battery

Presentation of the Nissan LEAF battery pack

Np=2
Ns=4

1 cell

Sample

U pack

1 module

×24 modules

module
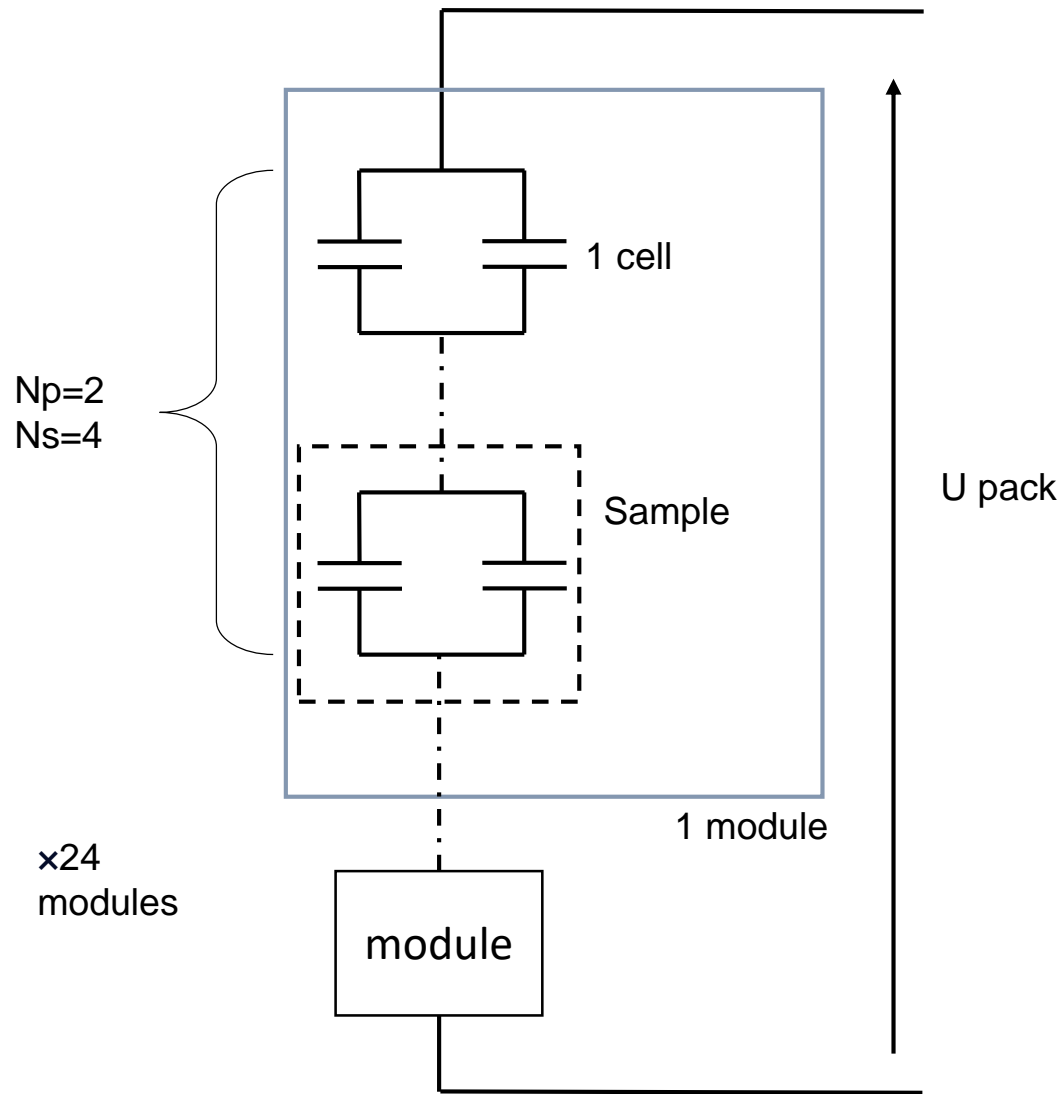
Structural diagram of the Nissan LEAF battery pack

A photo of a Nissan LEAF battery from the L2EP lab

Battery pack characteristics:
- Nominal voltage 350,4 V
- Energy 40 kWh -> 270 km of range (for a brand-new vehicle)
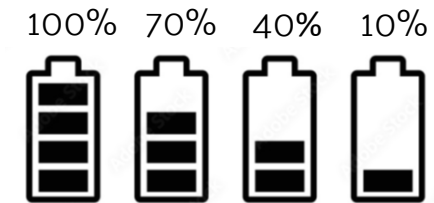
Presentation of aging tests

Laboratory AMPERE Lyon
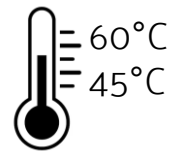*Thesis by Alla NDIAYE*

Modules from a LEAF battery

Modules tested
under different experimental conditions

Accelerated aging tests at fixed temperature and fixed state of charge

100% 70% 40% 10%
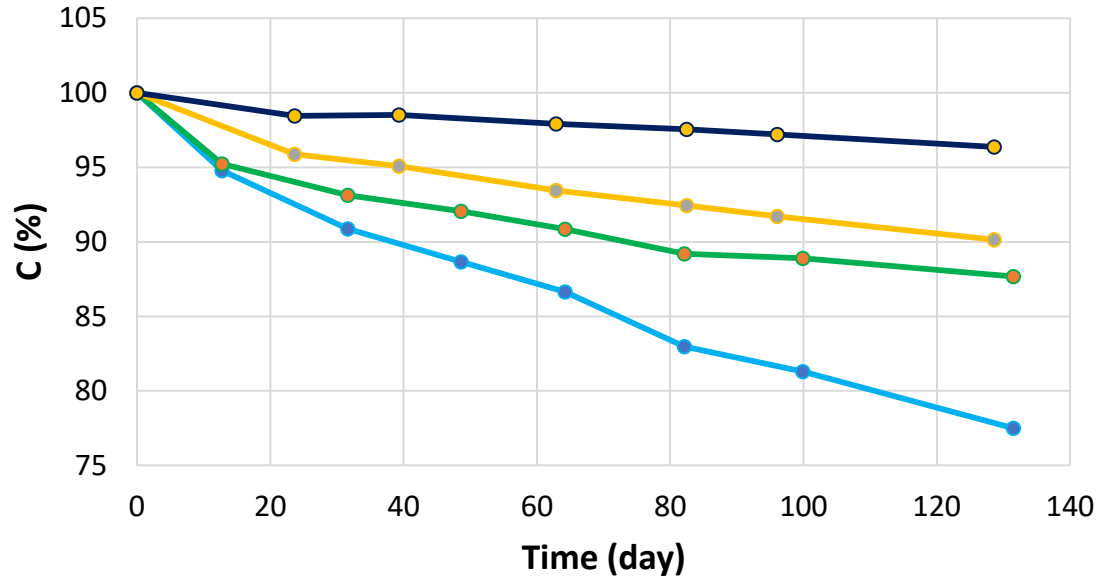
SOC: State of Charge
of the battery

60°C
45°C

Temperature

➡ To have pairs (ESR_bat, C_bat)

Presentation of the experimental results

Capacity $_{T60°C}$

Resistance $_{T60-R\_100\%}$

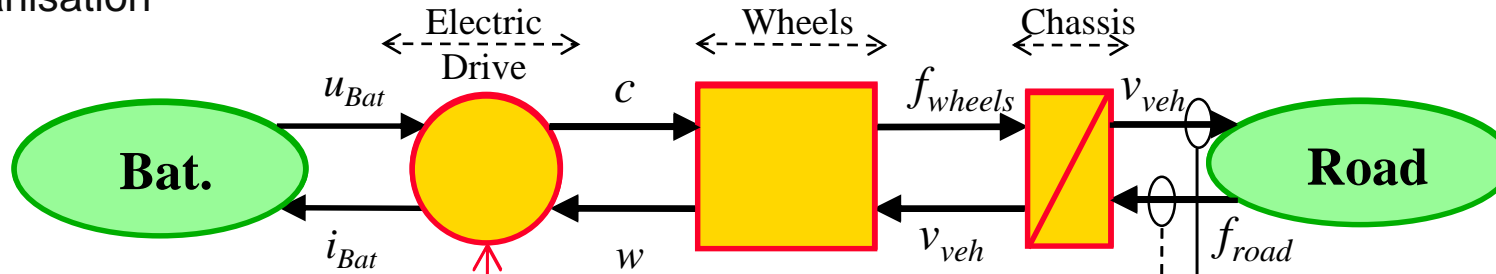Capacity decreases over time
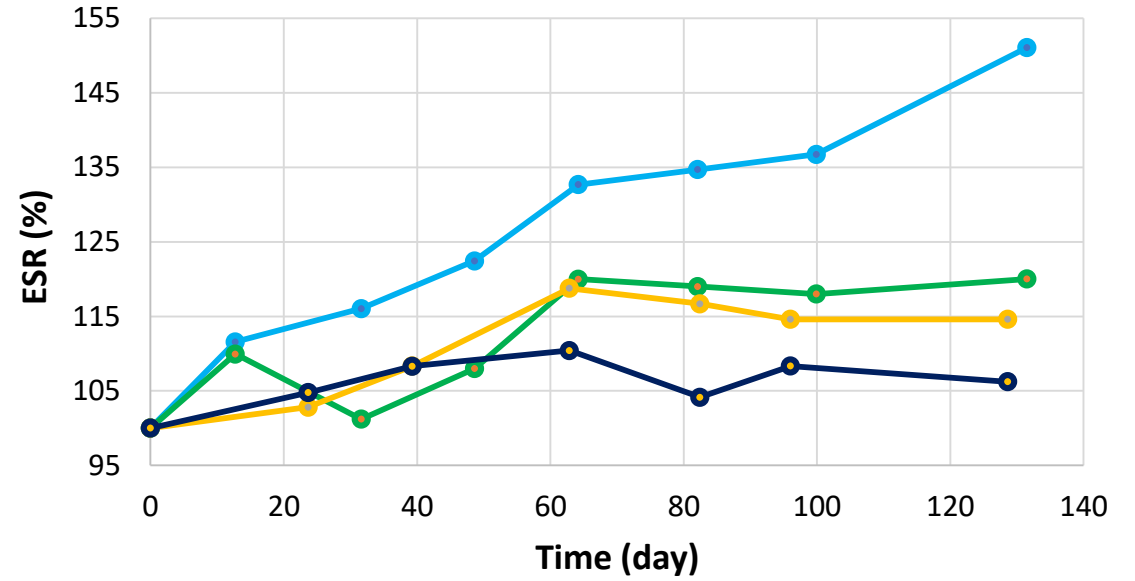
Resistance increases over time

➡ Faster aging when the state of charge is higher
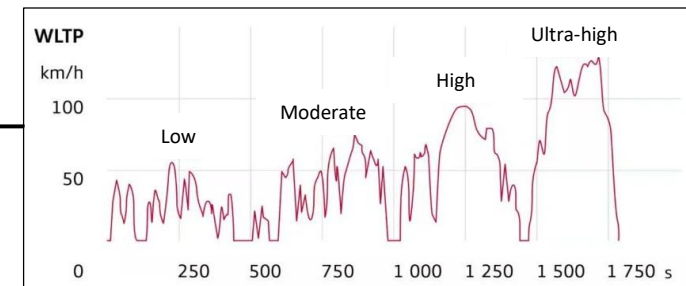
Same for the temperature

Vehicle modeling

EMR: for organisation

Considered Vehicle Characteristics	
Energy	40 KWh
Machine Power	110 KW
Diameter of wheels	406,4 mm
Mass	1505+75
S_{Cx}	0.77 m²
F0	186 N

Electric Drive

u_{Bat} c Wheels f_{wheels} Chassis v_{veh}

Bat. Road

i_{Bat} w v_{veh} f_{road}

f_{road_mes}

v_{veh_mes}

Speed cycle

c_{ref} f_{wheels_ref} v_{ref}

WLTP
km/h

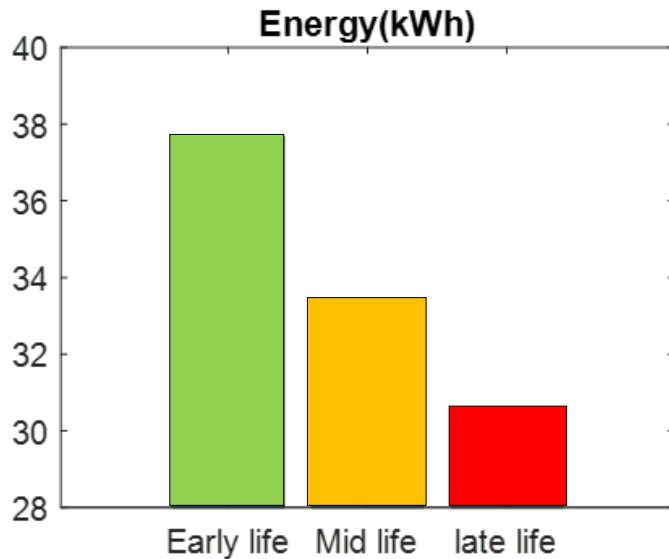100 Moderate High Ultra-high
Low
50

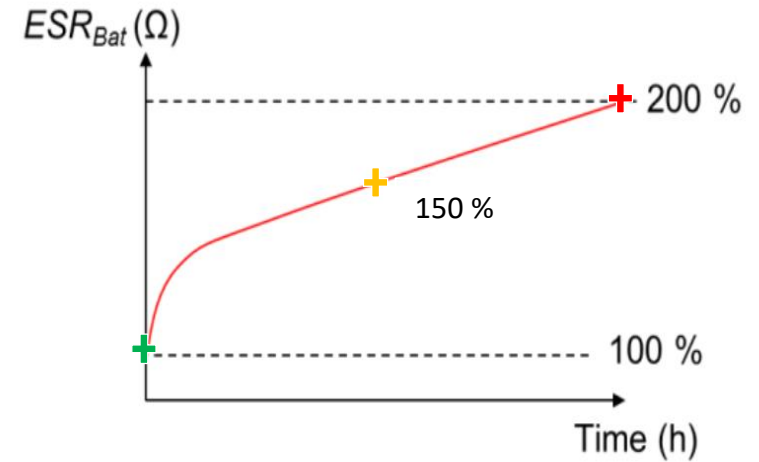0 250 500 750 1 000 1 250 1 500 1 750 s
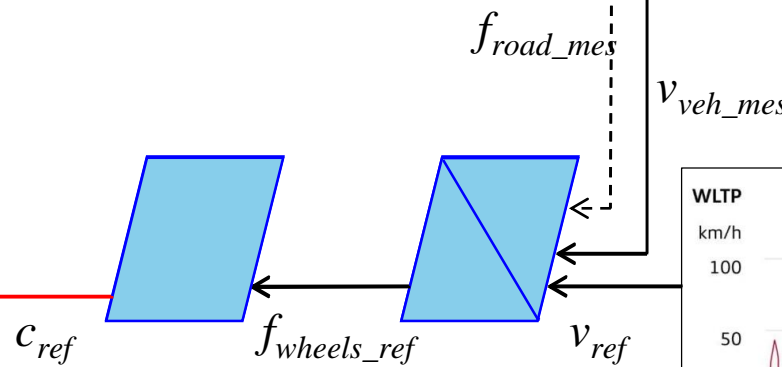
Cycle duration 30mins

Distance 23km

Average speed 46.5 km/h

Simulation results

3 scenarios
- Early life
- Mid life
- Late life

C_{Bat} (A.h) — 100 %, 90 %, 80 %, Time (h)

ESR_{Bat} (Ω) — 200 %, 150 %, 100 %, Time (h)

Energy(kWh) — Early life, Mid life, late life

Driving range(km) — Early life, Mid life, late life
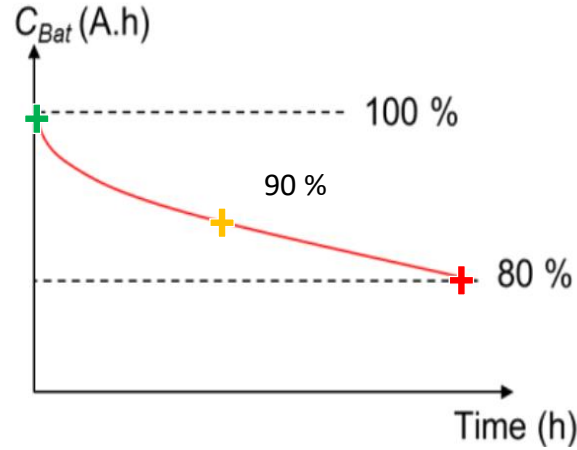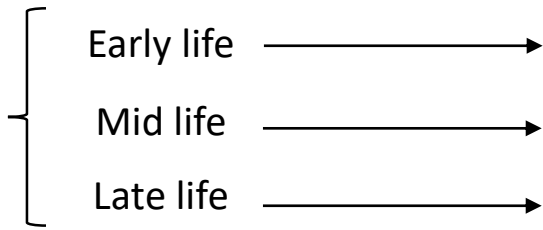
Energy decreases 19%
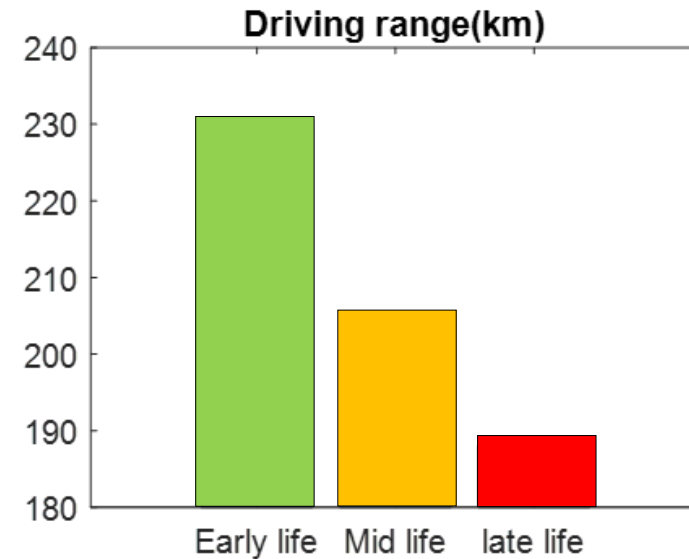
Driving range decreases 21%

Driving range decreases 10% more than energy

Conclusion and perspectives
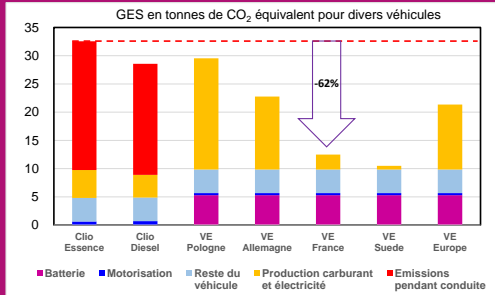
Simulation results

- Extraction of couples ESR/C

- Simulation of the complete vehicle under three health states

- Driving range decreases more than energy because of ESR effect

Perspectives

- Simulation of the complete vehicule under different scenarios

- Making a consumption study

https://cumin.univ-lille.fr/
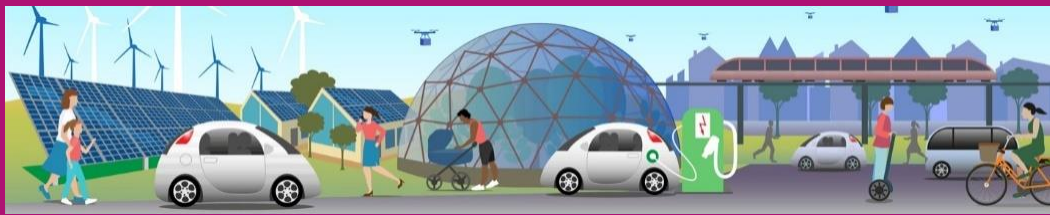
Our university as an exciting living lab towards eco-cities through an innovative transdisciplinary framework !