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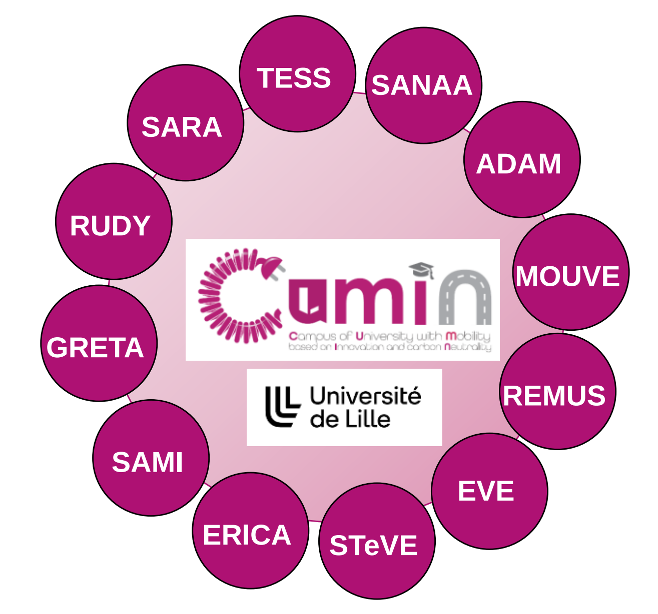

CUMIN - TESSA

Techno-Economic Study of Second-life battery for Affordable e-mobilty campus

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L2EP · TVES · LaMcube Laboratoire de mécanique, multiphysique, multiéchelle · CLERSÉ · Lille · Gériico · MEL MÉTROPOLE EUROPÉENNE DE LILLE

TESSA brings together different streams of research

Technology research at L2EP on EVs and batteries

Social science research at TVES on transport needs and behaviors

Techno-economic and financial modeling approaches to understand alternatives

The CUMIN-TESSA project comes from our experience in the earlier CUMIN-TESS research

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MEL MÉTROPOLE EUROPÉENNE DE LILLE

I-SITE UNIVERSITÉ LILLE NORD-EUROPE

coupling technical and economical models

University

User

Sustainable Urban Mobility Plan (coupling to MOUVE)

First roadmap of campus electrification

?

More detailed roadmap?
Extension to RIT campus?

Battery 2nd life (TESSA)

- Optimal usage
- When to replace
- Availability

- Awareness
- Preferences

(coupling to ERICA)

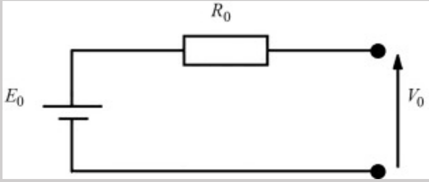
French case (5 years):
e-car TCO > diesel car TCO

?

extension to US case?
extension to other vehicles?

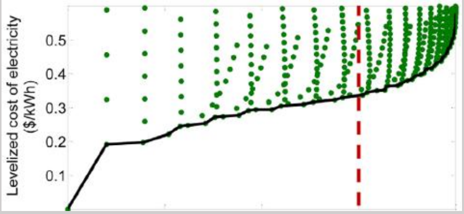
1. How should second-life EV batteries be operated to balance their economic and environmental benefits?

Technical Models



Battery performance = f(operation)
Battery lifetime = f(operation)

Economic Models



Economic value = f(operation, performance, lifetime, preferences)

Environmental Assessment

Grid emissions effects = f(operation, performance)
Embodied emissions = f(lifetime)

Driver Behavior and Preferences

Integrated Framework

Economic value = f(operation, preferences)

Net emissions effect = f(operation)

2. If electric vehicle batteries have a useful second life, when should drivers replace them?

Traditional Approach

EV battery replacement defined by pre-defined cutoff (80% of original capacity)

Discarded

Recycling or scrapping

Improved Approach

EV battery replacement defined by pre-defined cutoff (80% of original capacity)

Discarded

Second life uses discarded batteries for economic or environmental benefits

TESSA Approach

EV battery replacement defined by EV owner needs & behavior

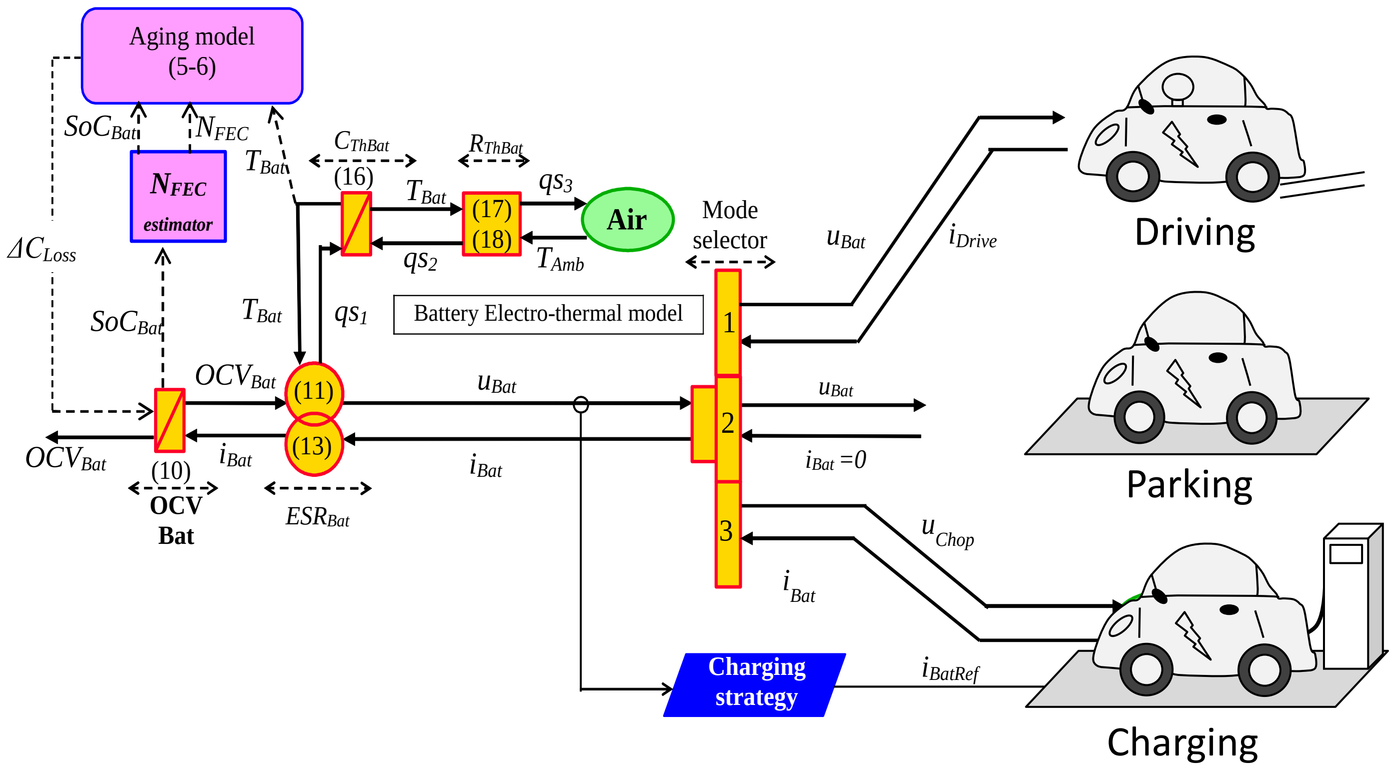
Value of second life affects EV battery replacement

Second life uses discarded batteries for economic or environmental benefits

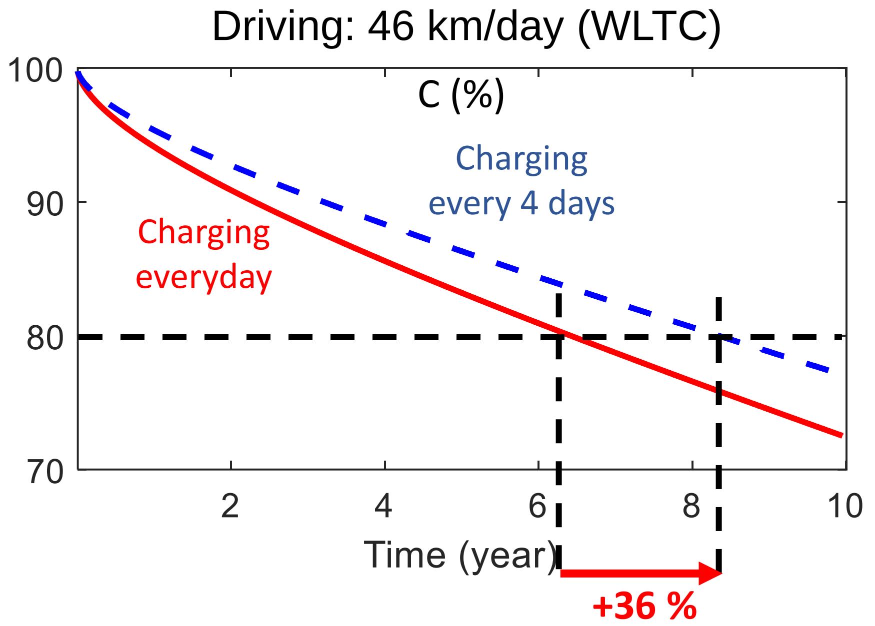
How does this change in perspective affect EV battery design and replacement?

TESSA uses models and platforms from CUMIN MOUVE and EVE projects

Development of a battery aging model ⟺ Interaction with an EV model



Charging strategy has significant effect on lifetime

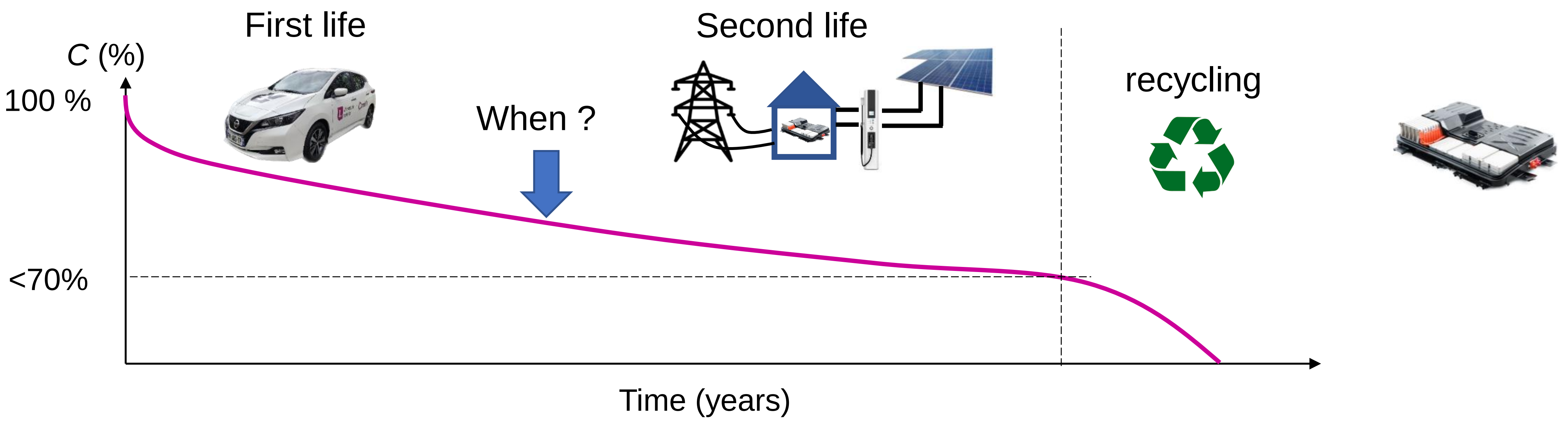


Lifetime extension by 36% for the same driving

BUT…

- How can we include user preference/behavior with the battery degradation?
- How can we integrate the second life into a cohesive framework?

One core element to TESSA is a detailed battery aging model



Consequences of battery aging:

- Acceleration is reduced
- Driving range decreases
- Losses increase

⇨ Lower driver satisfaction

⇨ Higher cost per km (consumption/recharge)

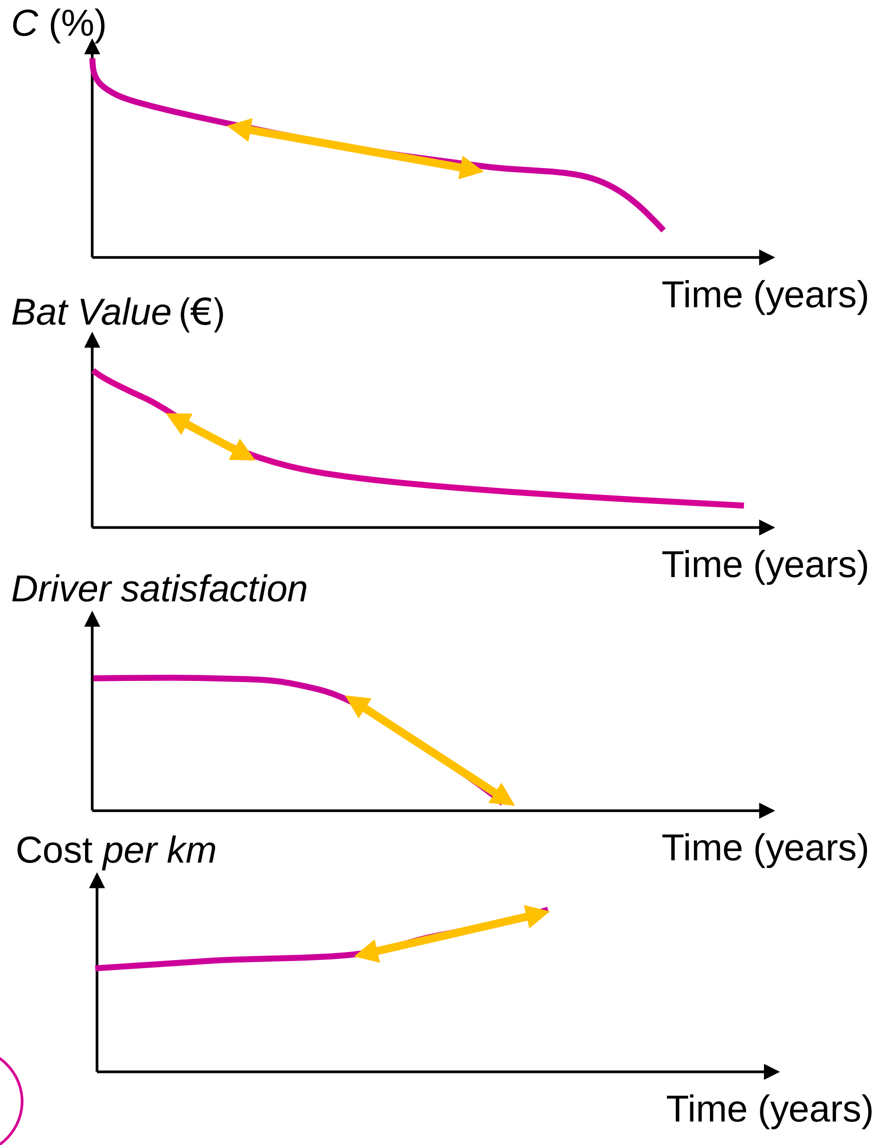
Similar phenomenon for mobile phone

Less autonomy

More frequent recharges

⇨ **Grid applications are generally less demanding on batteries than EVs. But can the economics of second-life batteries work?**

The second core element is a framework to integrate technical, environmental, and behavioral/preference elements



Important elements

- Construct the curves (data inputs)
- Account for variations across drivers, locations, battery types, etc.
- Account for seasonal cycles (winter, summer)
- Integrate environmental effects (using a life-cycle analysis approach)

The second core element is a framework to integrate technical, environmental, and behavioral/preference elements

Engineering

Environment

Driver

$$\text{Second Life Value (SLV)} = C_{alternative} - C_{reengineering} - C_{replace} + B_{environmental} + V_{range} + V_{lifetime} + V_{efficiency}$$

The market value of a used EV battery is equal to the cost of providing the same service from a new battery (using “Levelized Cost of Storage”)

There are fixed costs for preparing a used EV battery for second life.

The EV (perhaps) gets a new battery

Environmental benefits are attributable to reduced/delayed need for new battery production

New EV battery extends both range and lifetime, which drivers value

New EV battery improves cycling efficiency, saving energy costs

A simple example for the 2nd life value of 100,000 mile EV batteries over time

Model Input	Value
Round-trip efficiency	85%
Stationary application cycling	1 cycle/day
Financial discount rate	8%
Social discount rate (DICE)	4.5%
Social discount rate (SCC Explorer)	2%
Cost of make-up electricity	$0.15/kWh

Year	New battery cost ($/kWh)	LCOS ($/kWh)	Second-life battery price ($/kWh)	Present value of env. damages of new battery ($/kWh)	Present value of env. damages when delaying new battery ($/kWh)	Environmental benefit of SLB ($/kWh)	Second Life Value ($/kWh)
2025	$139	$0.10	$56.46	$17.64	$12.94	$4.70	$61.16
2030	$98	$0.08	$39.88	$18.18	$12.04	$6.14	$46.02
2035	$69	$0.07	$28.17	$16.92	$10.84	$6.07	$34.24
2040	$49	$0.06	$19.90	$15.23	$8.52	$6.71	$26.61

TESSA has an interdisciplinary challenge (and opportunity)

TESSA brings together different streams of researches

Technology research at L2EP on EVs, batteries

Economic and financial modeling approaches to understand alternatives

Social science research at TVES on transport needs and behaviors

Instrumented e-vehicles and PV-based charging stations

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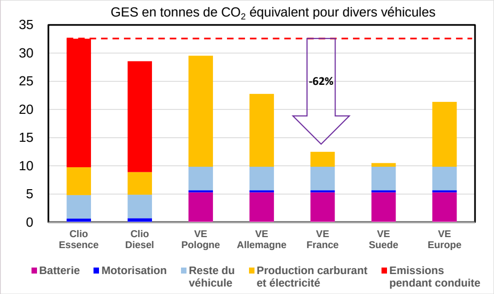

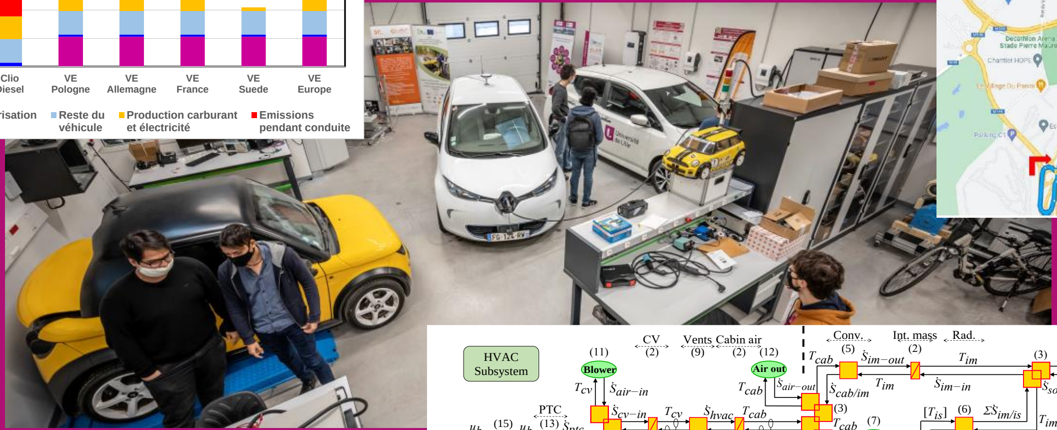

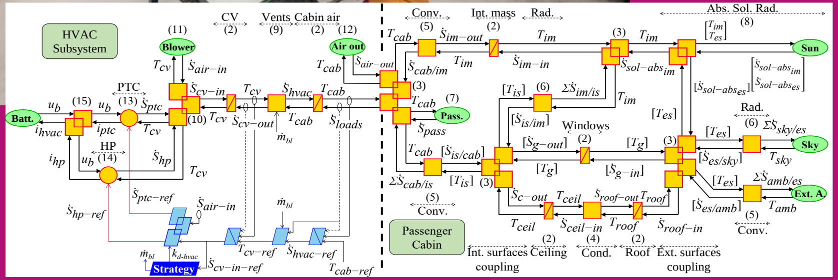

Our university as an exciting living lab towards eco-cities through an innovative transdisciplinary framework !