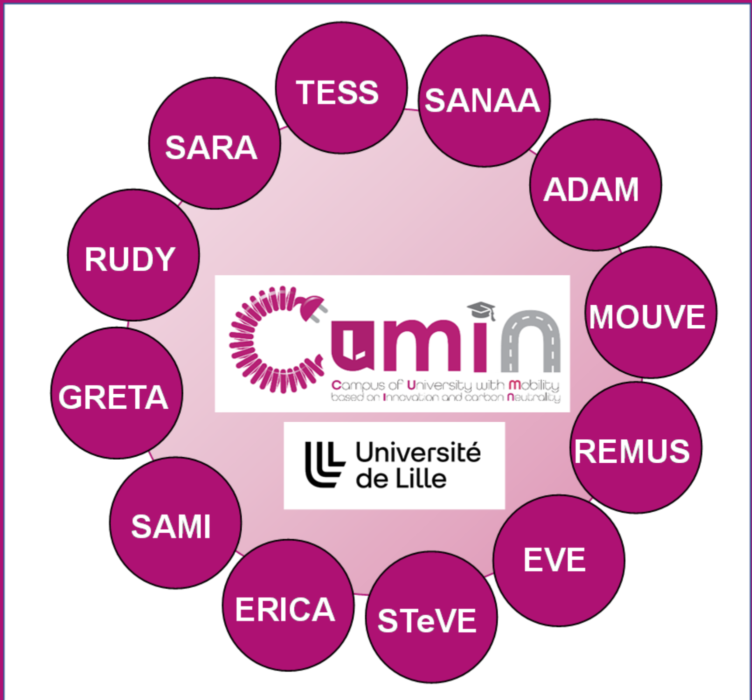
https://cumin.univ-lille.fr/



"Master projects on CUMIN: example of energy consumption of Plug-in Hybrid Electric Vehicle"

R. GERMAN (L2EP), A. ZAOUAK (L2EP), A. BOUSCAYROL (L2EP)

Implication of Master students in CUMIN program

As everybody knows :

interdisciplinary program

→ Master students are involved through different degrees

- Example: **Master on Intelligent and Electric Vehicles** (M2 VIE)

- This year, 6 final projects (over 7) have been dedicated to CUMIN → Strong involvement

→ This presentation gives an overview on these projects

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

CUMIN-SARA

« Development of a supervision interface for the Nissan Leaf»

Master students:

Tarik ATTAR

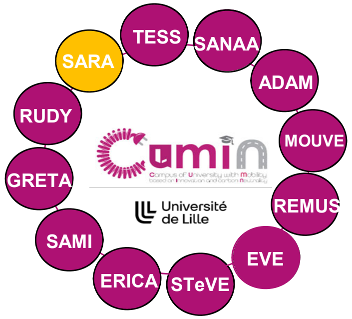
Fadhlerrahmane HOUMEUR

Lylia IDIR

Supervisor: Eduard AGUIRRE

Université de Lille

Position and objective



Position in CUMIN

- SARA, Social Acceptances of electric vehicle in Restricted Area
- Needs of measurements of commuting trips of different campus users

Context

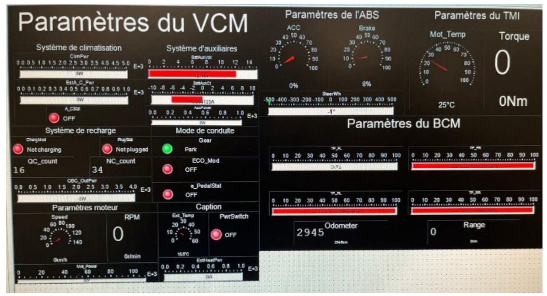
A Nissan leaf has been bought in 2019 at the L2EP Laboratory

Real time computer can be connected to the CAR communication port (OBD)

Acronyms

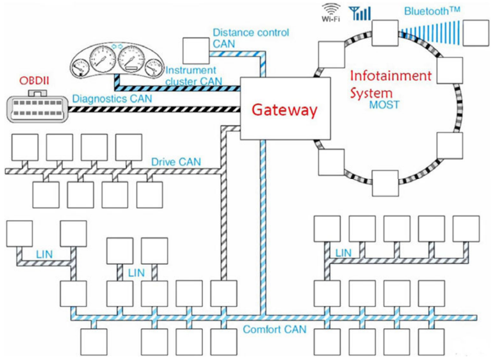
- OBD : On Board Diagnosis
- VCM : Vehicle Control Monitoring

Objective: real-time display to monitor the car important variables

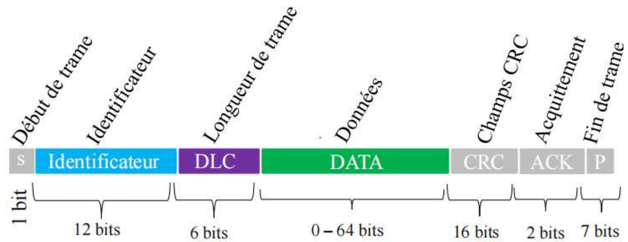


Developments and results

The L2EP Nissan Leaf is the reference vehicle

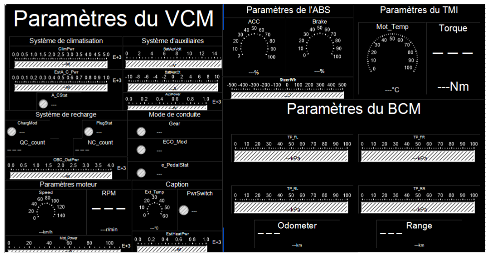


It is connected to the Real time computer via OBD 2 plug

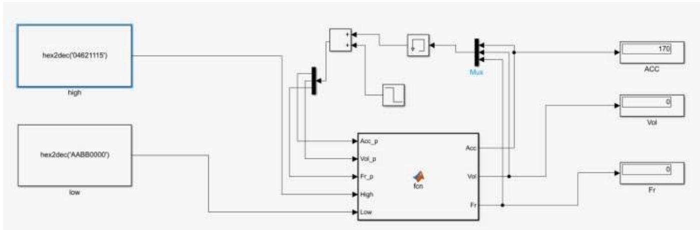


The CAN communication norm is used

CAN: Controller Area Network



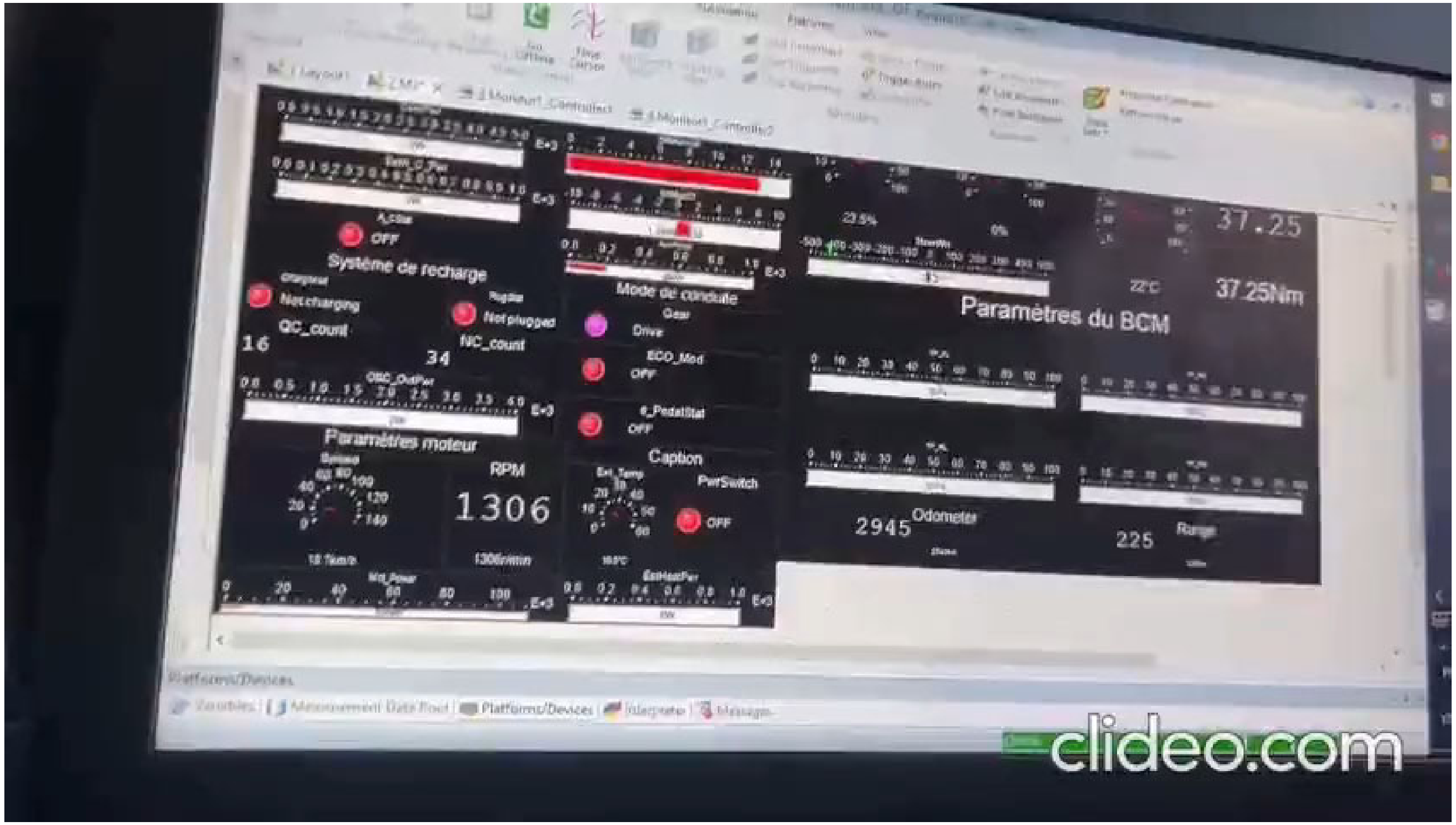
The display is achieved in real-time



The program is splitting the CAN variables

The objective is reached

Demonstration video



➡ It works!

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

CUMIN-STeVE

« Simulator for the performance analysis of electric cars »

Master Students:

Hassan BABAOUSMAIL

Yinfqi ZHANG

Yassir MAALBI

Supervisor: Walter LHOMME

Université de Lille

Position and objective

Position in CUMIN

- STeVE, Scalability of powerTrain for electrified Vehicles of an Eco-campus
- Achieved in the Laboratory of Electrical engineering and Power Electronics

Context

Today : many categories for EVs

Small

Medium

Large/ SUV

➡ various parameters

- Weight
- Power
- Aerodynamics
- Battery size

➡ Those parameters impact the driving range

➡ Objective: Build a rapid simulation tool with vehicle input parameters based on scaling laws

Developments and results

- 3 SUVs

- 3 medium Vehicles

- 3 smaller vehicles

A database of EVs is achieved

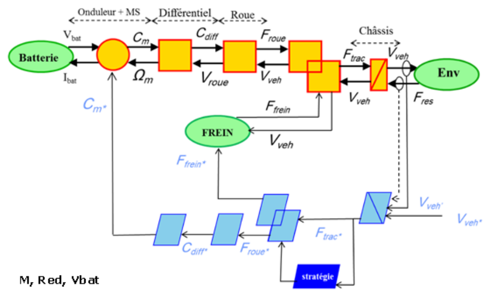
- Weight
- Power
- Aerodynamics
- Battery size

Cbat	Vbat	Masse	Rayon	S_Cx	P	Cm	W_base	Vmax	A0-100	
0,99	0,23	0,84	0,85	0,72	0,82	0,52	0,51	0,74	-0,45	Auto
	0,27	0,84	0,83	0,74	0,83	0,50	0,56	0,72	-0,48	Cbat
		0,44	0,27	0,12	0,57	0,33	0,67	0,50	-0,64	Vbat
			0,86	0,81	0,97	0,83	0,50	0,93	-0,75	Masse
				0,66	0,80	0,57	0,48	0,83	-0,45	Rayon
					0,76	0,57	0,48	0,54	-0,43	S_Cx
						0,75	0,66	0,90	-0,83	P
							0,03	0,88	-0,69	Cm
								0,34	-0,58	W_base
									-0,77	Vmax

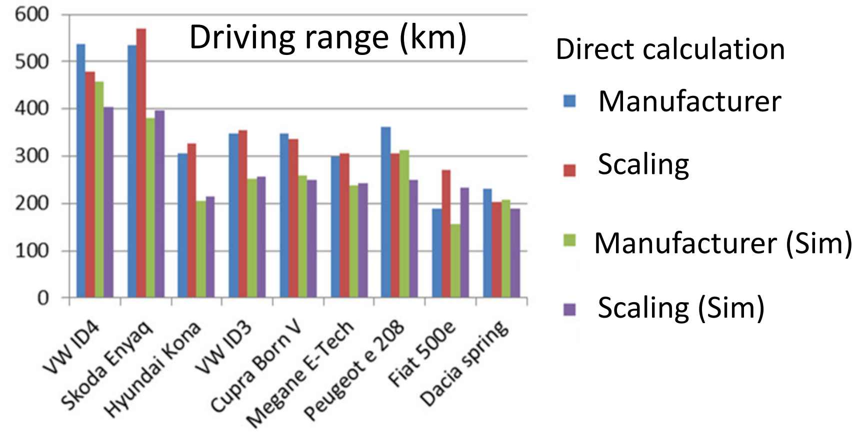
Pearson correlation achieved between parameters

$$Cbat\ [kWh] = 0.0365\,M - 13.8838$$
$$Auto\ [km] = 0.1967\,M + 4.5258$$
$$r\ [m] = 1.3727 * 10^{-5}\,M + 0.283$$
$$SCx = 4.0439 * 10^{-5}\,M + 0.6831$$
$$V_{max}\ [km/h] = 0.0451\,M + 77.913$$
$$P_{max}\ [kW] = 0.1313\,M - 98.9786$$

Scaling laws achieved



General vehicle model used



Validation with the data base

Scaling law can be used for other vehicles

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

CUMIN-MOUVE

« Bidirectionnal on-board charger for Evs »

Master Students:

Samy Anis BEY

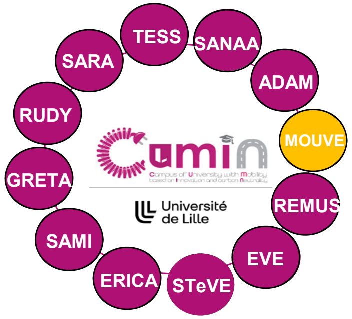
Azeddine ZIBANI

Supervisor: Philippe DELARUE

Université de Lille

Cumin

Position and objective

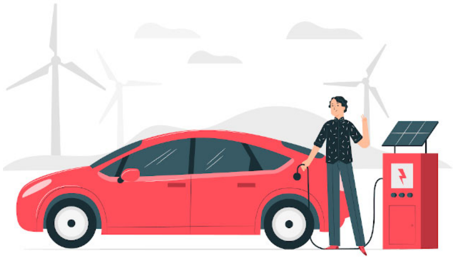


Position in CUMIN

- MOUVE - MObility and Use of electric VEhicles based on dedicated charging infrastructure
- Achieved in the Laboratory of Electrical engineering and Power Electronics

Context

Today most of battery chargers from AC are mono-directional



AC charging station

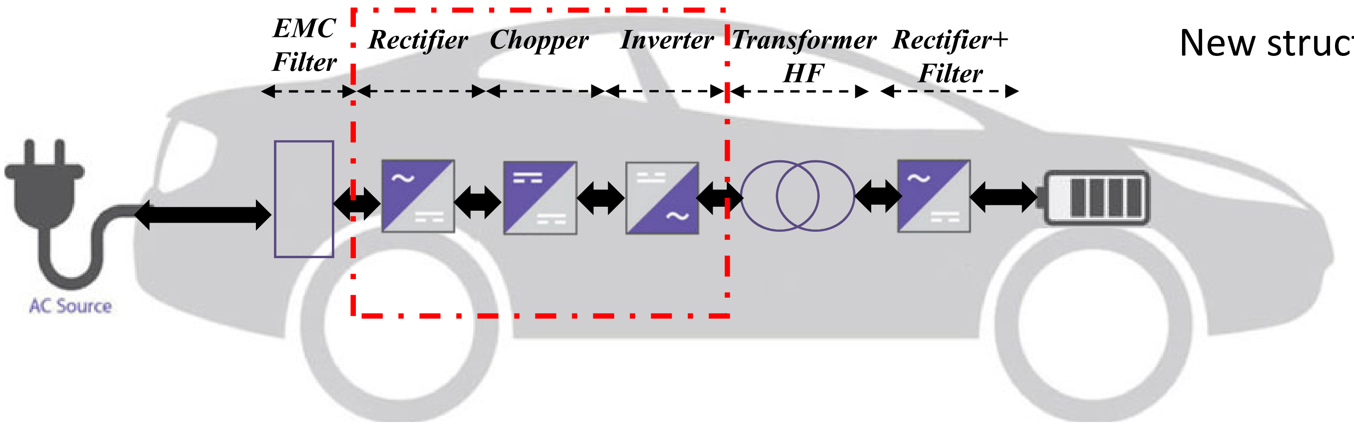
DC conversion in the car

➡ Vehicle batteries cannot be used to supply a building (No V2G)

V2G : vehicle to grid

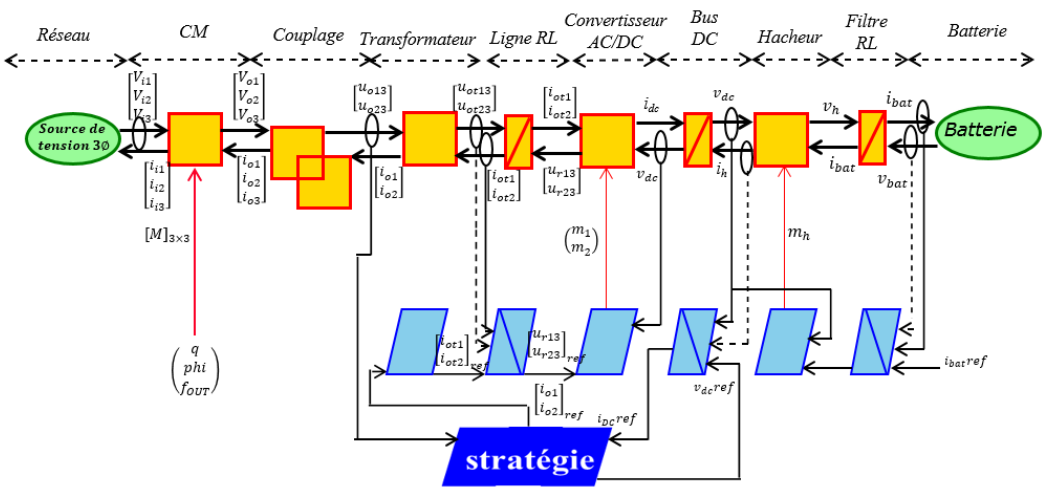
➡ Objective : Control a new bidirectional AC/DC converter structure inside the car

Developments and results

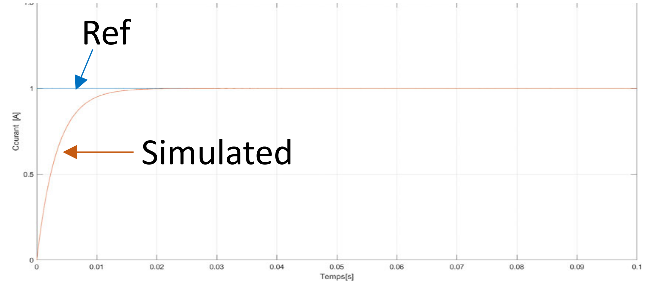


New structure for AC/DC conversion (advantages)

- High power density
- Based on switch matrix
- No capacitor implied (more reliable)
- Bidirectional



Model and control structure by EMR



➡ Control of the battery current achieved

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

CUMIN-EVE

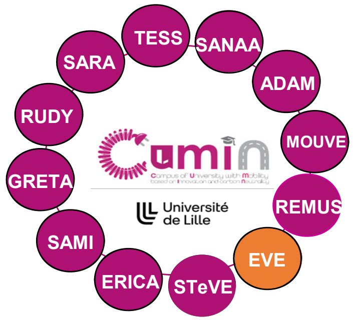
« Study of the recharge of a bus at the end of the line »

Master student:

Ayman KIBAL

Supervisor: Ronan GERMAN

Position and objective



Position in CUMIN

- EVE - Electric Vehicle, Estimation of mobility for an eco-campus
- Achieved in the Laboratory of Electrical engineering and Power Electronics in collaboration with MEL

Context

Bus can be recharged in many ways (once a day or more often)

End of line charging studied

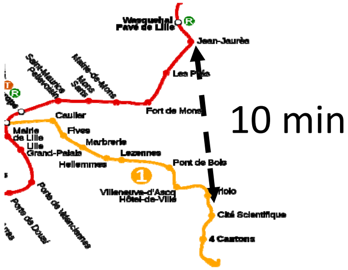
Only 10 minutes to recharge

➡ Quick time : high charging power needed !

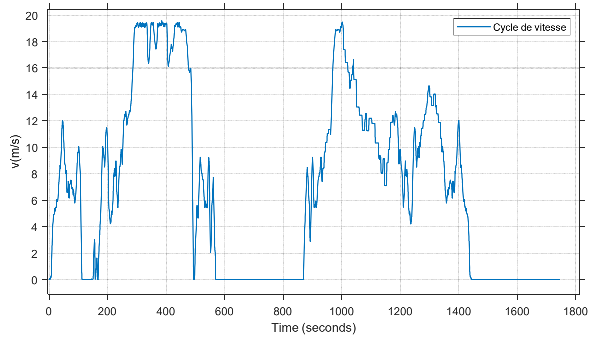
➡ Objective : Quantify the charging power needed for end of line recharge

Developments and results

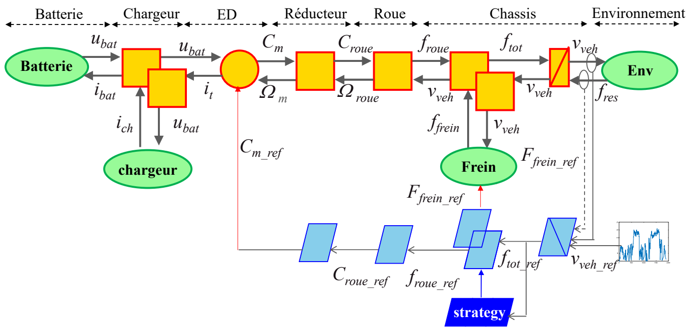
A bus is selected (BYD K9 12m)



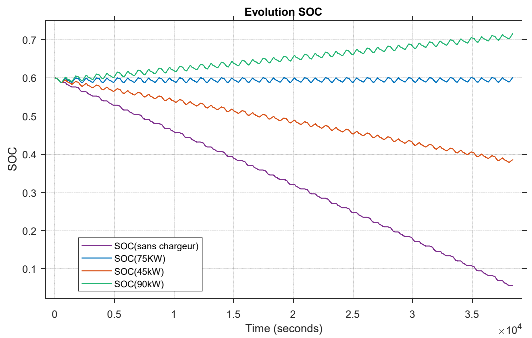
A trip is selected



Speed cycle is recorded



Model and control structure by EMR



Try in simulation different charging power

75 kW: constant SoC

<75 kW: too low

➡ 75 kW is enough to keep the bus battery at constant State of Charge

CUMIN-REMUS

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

« On-board braking energy recovery in a tramway »

Master Students:

Hatim BIAZ

Dyaa CHARAK

Sami SAIGH

Supervisor: Ryan O. BERRIEL

Université de Lille

Position and objective

Position in CUMIN

- REMUS - Recovery of Energy from Metros in University based on sustainability of an eco-campus
- Achieved in the Laboratory of Electrical engineering and Power Electronics in collaboration with MEL

Context

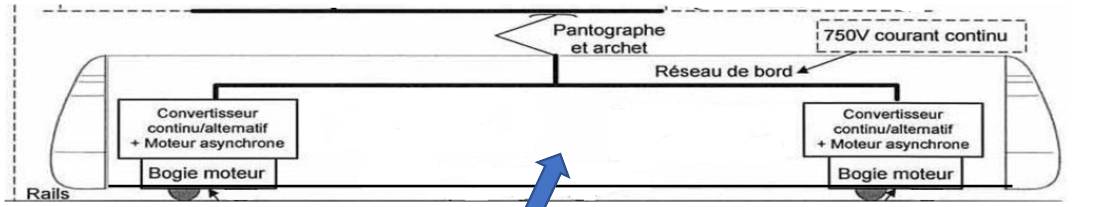
Today the tramway line supply is mono-directional

No energy recovery can be achieved

Braking energy is "burned" inside resistors

Objective : develop an onboard system with super capacitors to recover braking energy

Developments and results

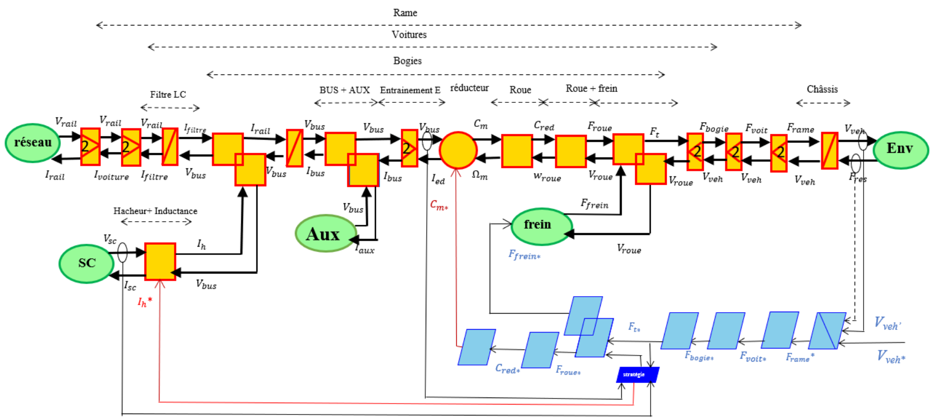


Supercapacitor packs are inserted inside the tram

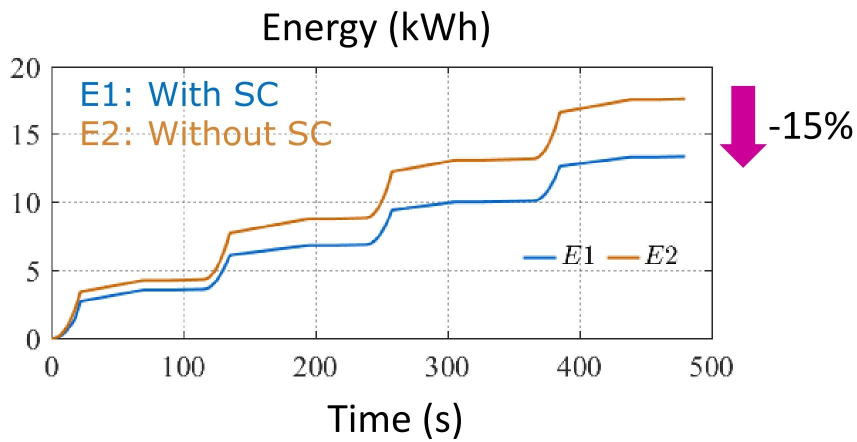
- High power density

Good system for braking energy recovery

60 F, 500 V (2 kWh)



Model and control structure by EMR



Comparison in simulation of the consumption (-15% with SCs)

CUMIN-EVE

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

« Energy consumption of a plug-in hybrid vehicle »

Master Students:

Safia SAIDJ

Abdelkader ZAOUAK

Mohamed-Said ZIBAR

Supervisor: Alain BOUSCAYROL

Université de Lille

Cumin

Outline

1. Context and objective
2. Studied vehicle
3. Consumption for different cycles
4. Energy requirements and charging time

Source: https://www.stickpng.com/fr/img/transport/voitures/toyota/toyota-prius

Context and objective

CUMIN is a multidisciplinary program. There are different axes such as the estimation of the consumption of electric vehicles, electric vehicles charging…

Demonstrator campus

carbon neutral

Objective: estimation of the charging needs of a P-HEV in full electrical mode

Studied vehicle

- **Toyota Prius III**

Battery capacity: 4,4 kWh
Mass: 1370 kg

Source : https://www.fiches-auto.fr/

Vehicle characteristics

- Thermal Engine

Power (kW)	73 at 5200 rpm
Torque (Nm)	142

- Electric Motor 1

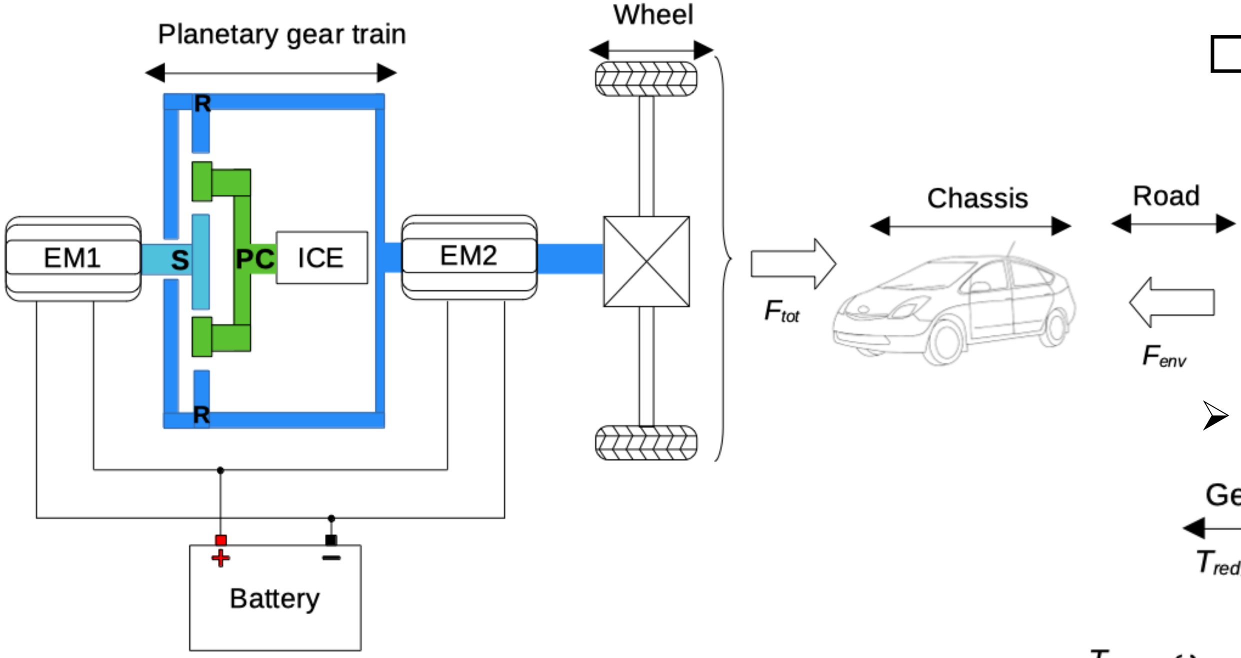
Power (kW)	40
Torque (Nm)	150

- Electric Motor 2

Power (kW)	60
Torque (Nm)	207

Structural representation of the vehicle

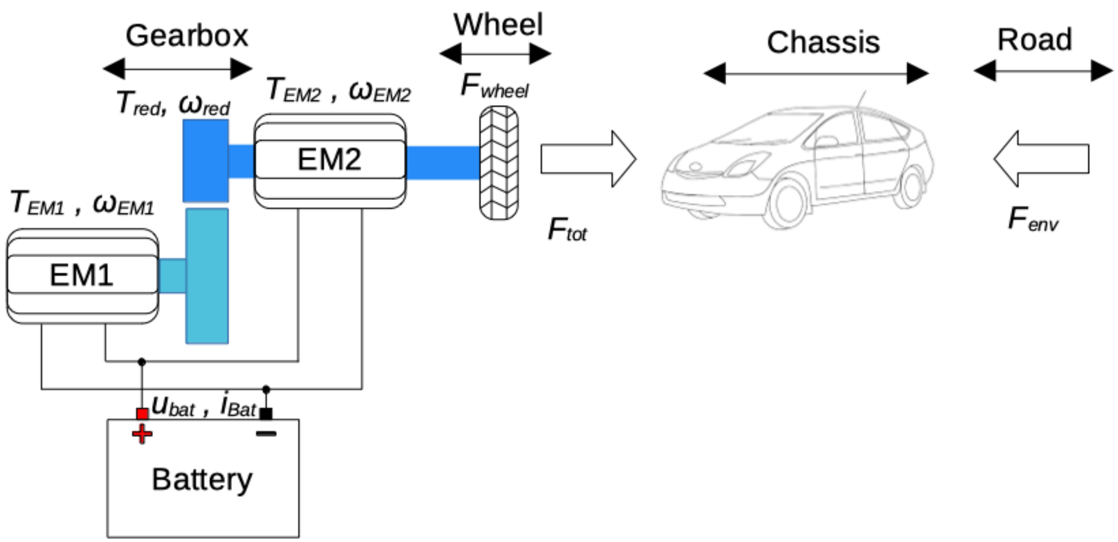
➢ Hybrid mode :



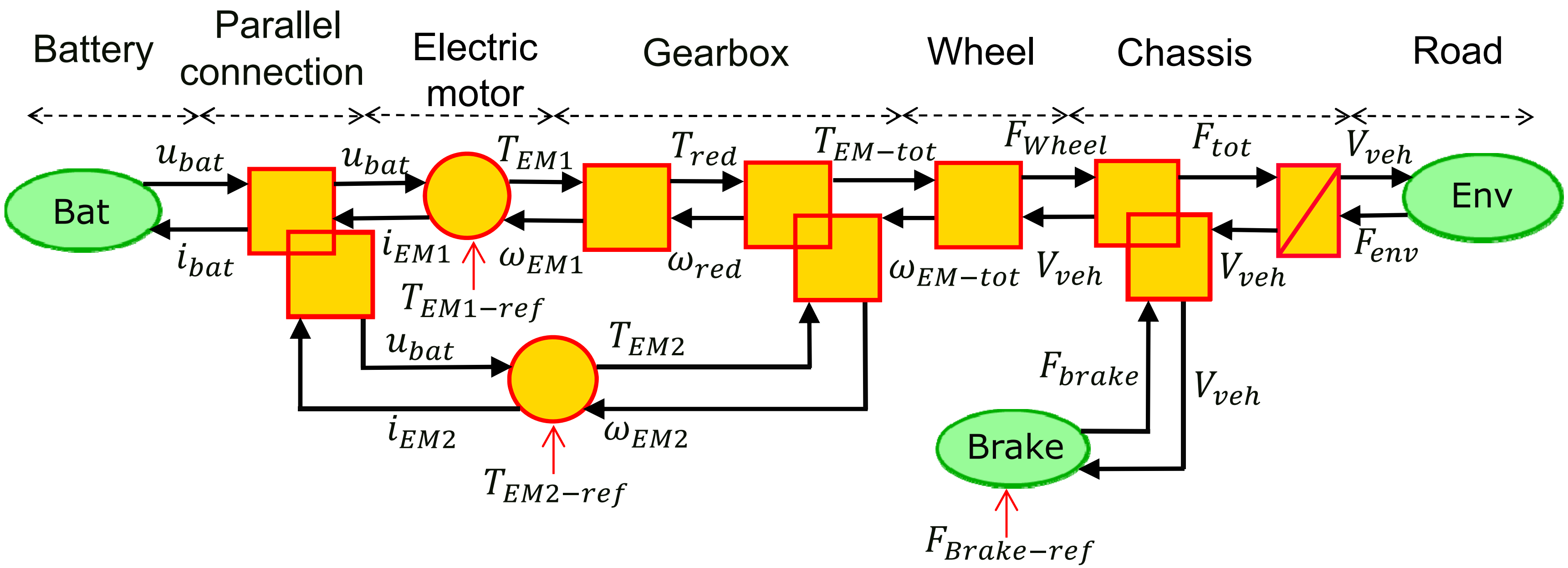
Assumptions :

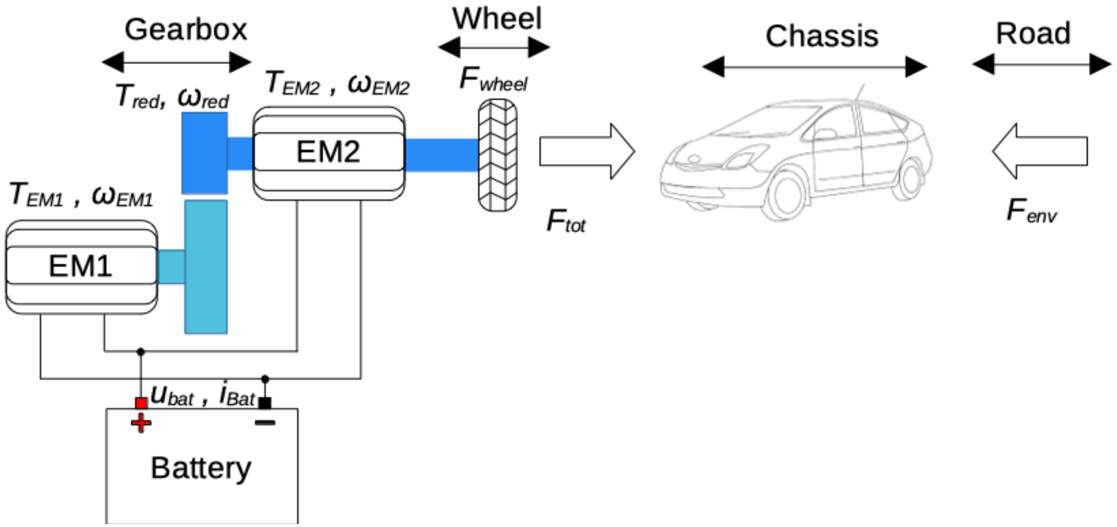
- Thermal engine not taken into account
- Epicyclic gear train assimilated to a gearbox
- Electric drive (Motor + inverter + control)
- Equivalent wheel

➢ Full electric mode :

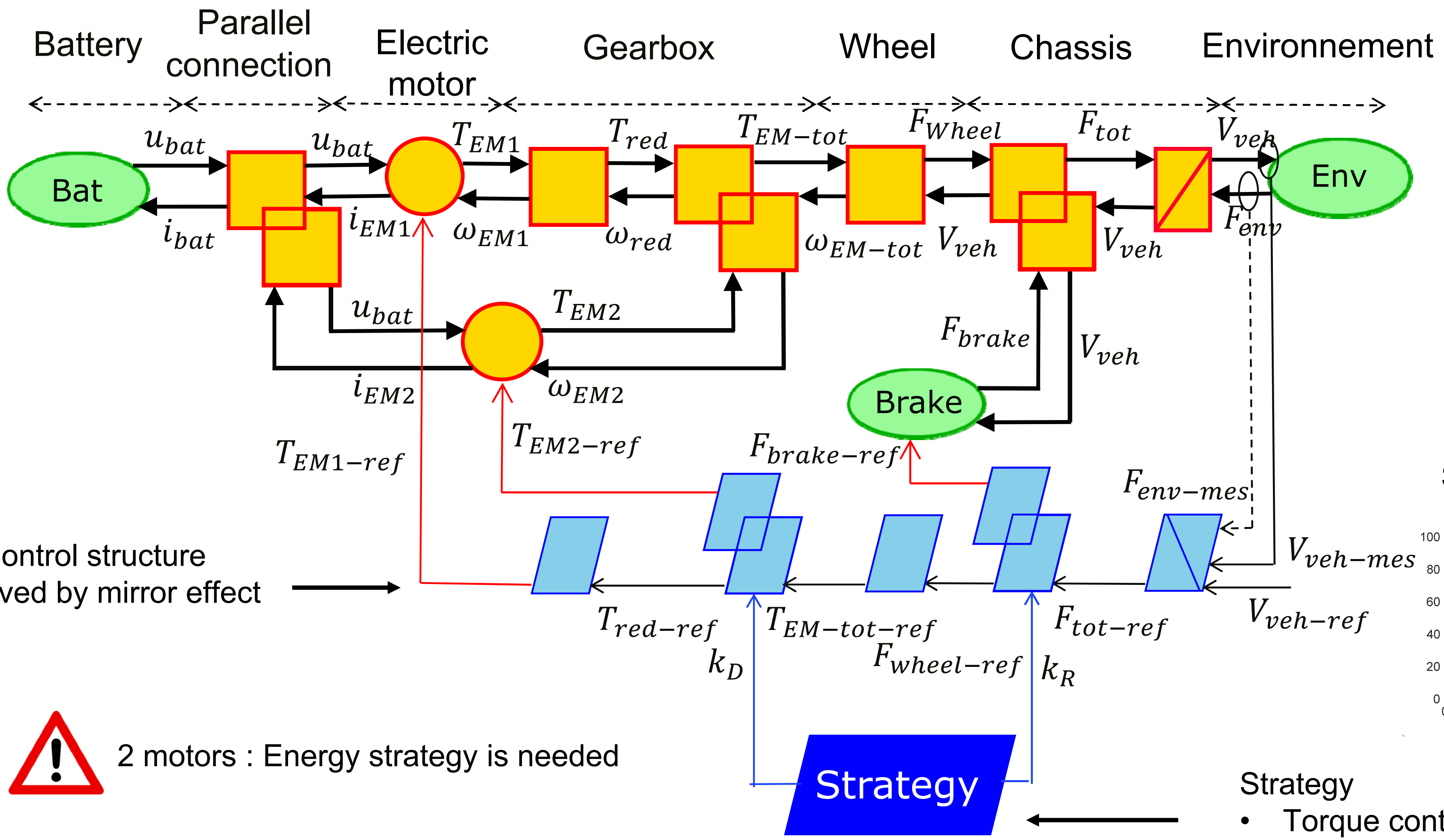


Energetic Macroscopic Representation (EMR)



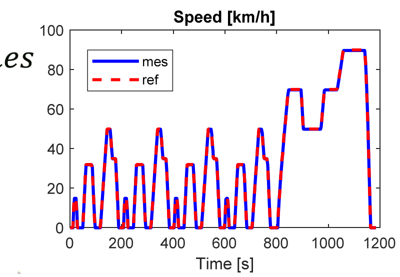


SMC of the vehicle in electric mode



Control structure achieved by mirror effect

Speed is the input



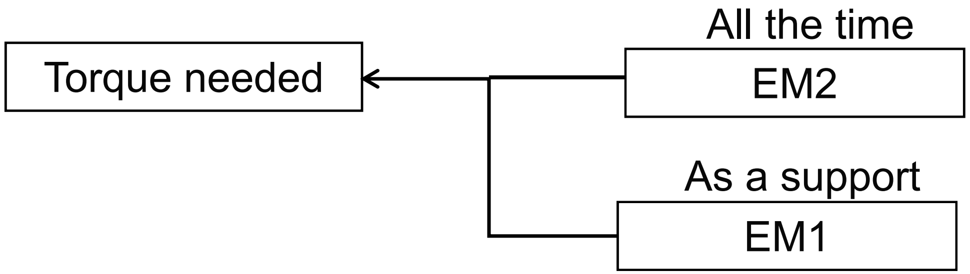
⚠ 2 motors : Energy strategy is needed

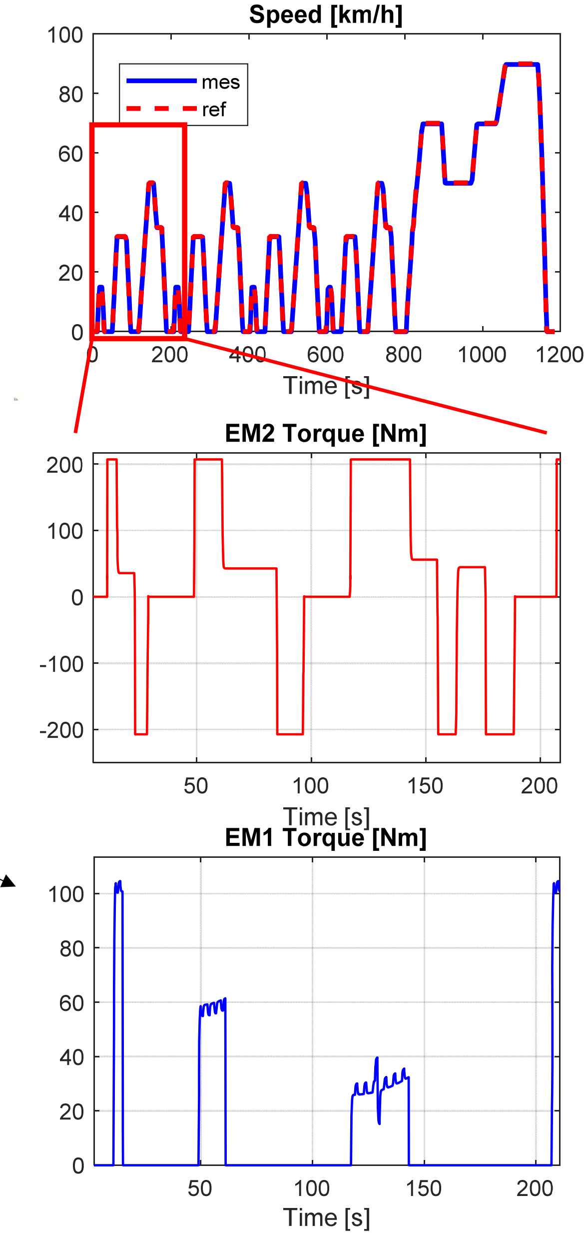
Strategy
- Torque control (motors)
- Braking energy recovery (60%)

Model validation with mixed cycle

Reference speed cycle : NEDC

Torque strategy





Comparison between model and man. data

ZEV mode, manufacturer: 0,198 kWh/km

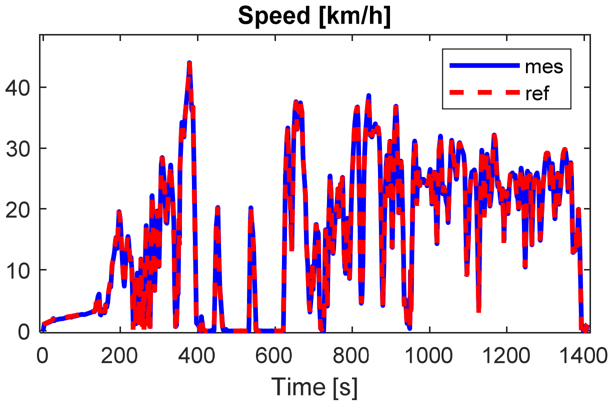
ZEV mode, simulation: 0,191 kWh/km

difference : 4%

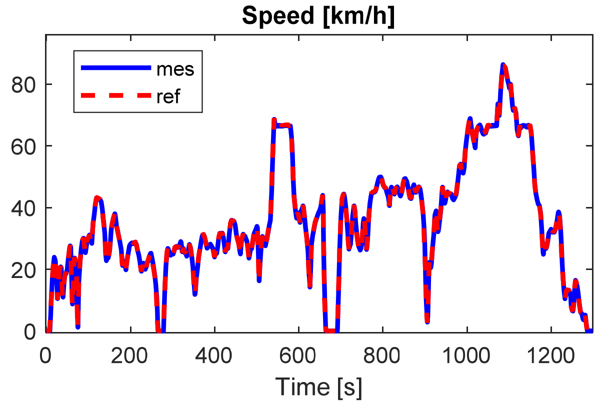
The vehicle model is validated

Simulation study of different cycles

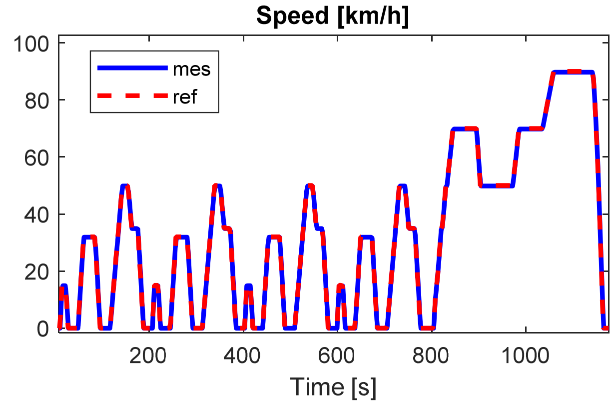
Urban cycle



Extra-Urban cycle



Mixed cycle



	Urban	Extra-Urban	Mixed
Maximal speed [km/h]	45	88	90
Distance [km]	5.6	12.6	10.58
Energy [kWh]	1.2	2.5	2.02

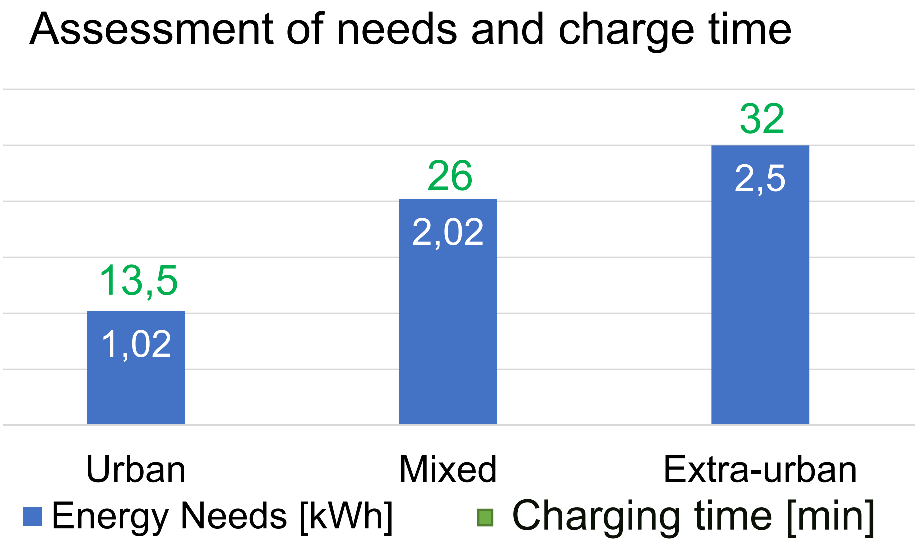
- ➢ Different charging needs depending on the trip

Energy requirements and charging time

Estimation the charging time as a function of the cycle

Available charging station Université de Lille

Charging station *GREEN'UP* (P = 4,6 kW)
Studied Vehicle: 4,4k Wh
Full charge< 1 h

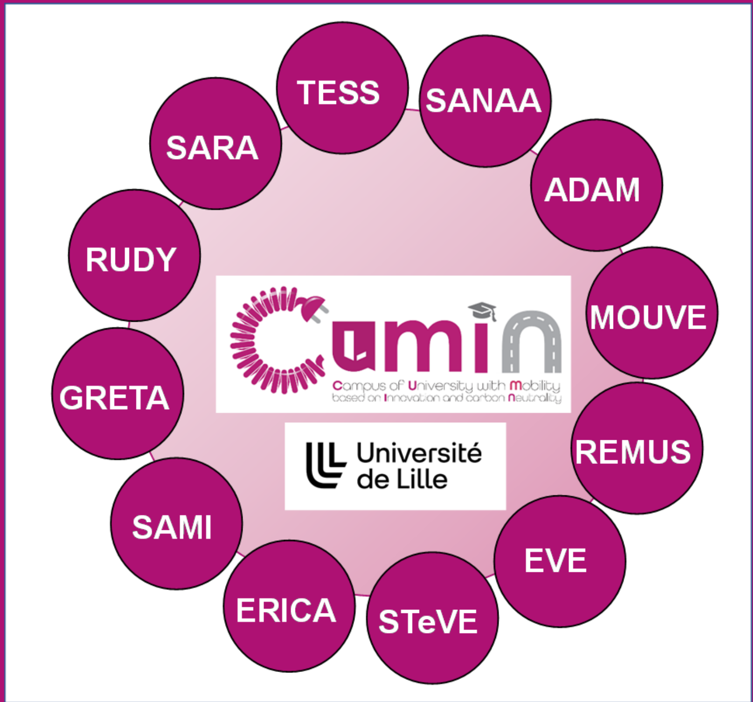


Conclusion

- Work:
  - ✓ Vehicle modelling and control
  - ✓ Strategy of torque distribution
  - ✓ Validation of the simulation model
  - ✓ Charging time for different cycles

- Perspective :
  - ✓ Validation by real vehicle tests
  - ✓ Efficiency maps of electrical machines
  - ✓ Simulation of different commuting trips

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



CUMIN programme

Our campus as
an exciting living lab
towards eco-cities!