« EMR-based Model of a Public Rail Transports »

Dr. Clément MAYET, Prof. Alain BOUSCAYROL, Dr. Philippe DELARUE, Mr. Charles BROCART

L2EP, University of Lille, France

European Metropolis of Lille, France

- Outline -

1. Context & Objectives
2. EMR-based Models
3. Results
4. Conclusions & Perspectives

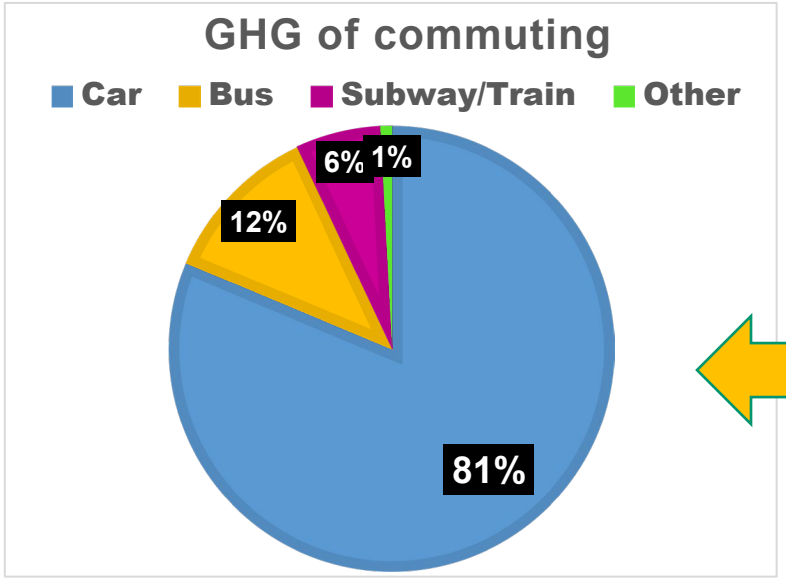
« Context & Objectives »

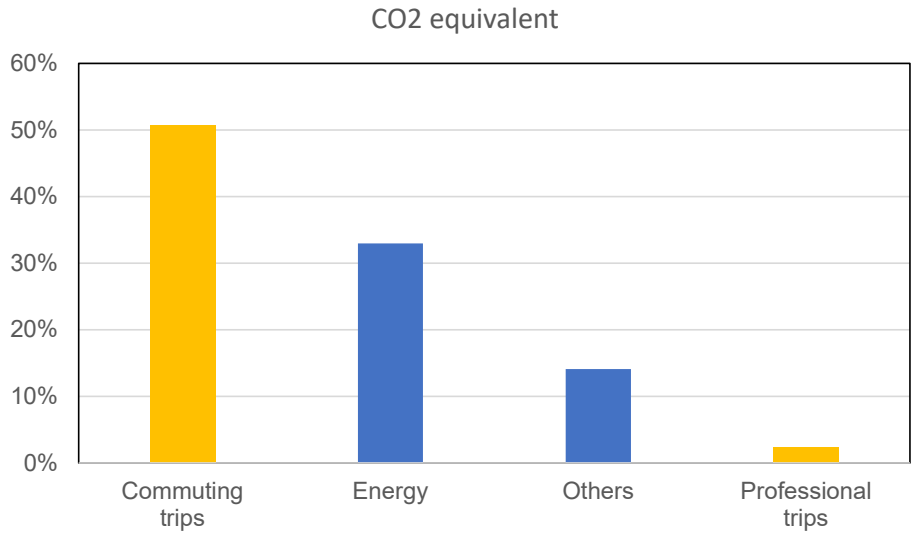
Reduce the global GHG Emission in ULille

In 2020
GHG 52 000 tons CO2eq

Université de Lille

Thus Cumin Program
Different projects focused on mobility





ICE Vehicles

- Only 24% of the km
- But 81% of GHG

REMUS – Recovery of "Metro" Braking Energy for a Sustainable University

Comparison between transportation modes

REMUS ⟷ EVE

L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

Région Hauts-de-France

MEL MÉTROPOLE EUROPÉENNE DE LILLE

Metro

R. O. BERRIEL (Ph.D.)
22/12/2023

New subway (line 1)

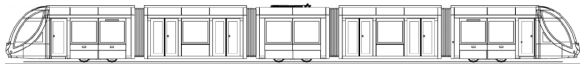
New vehicle

Actual vehicle

Tramway

MEL Internship (2024)
M2 VIE Project (2025)

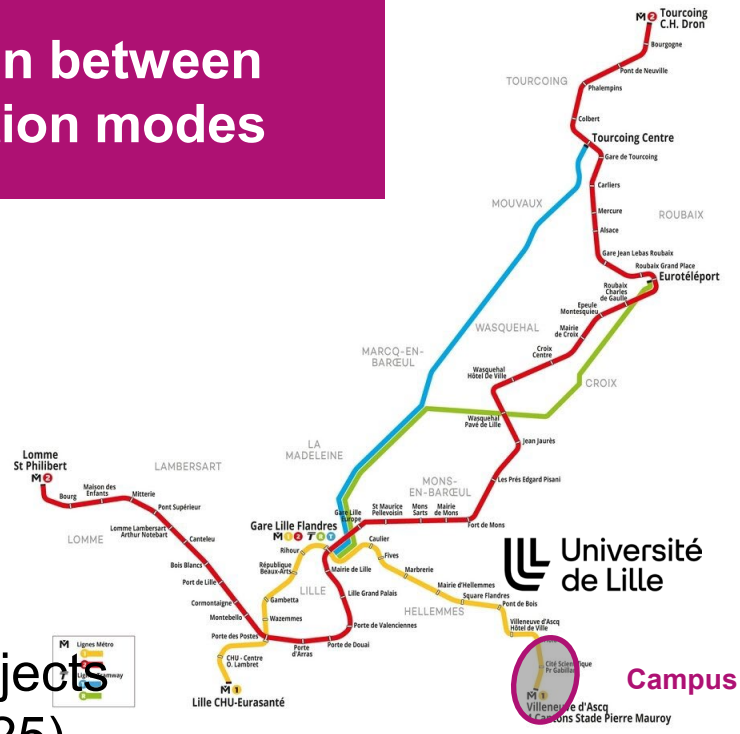
New tramway



Bus

M2 VIE Projects
(2024 & 2025)

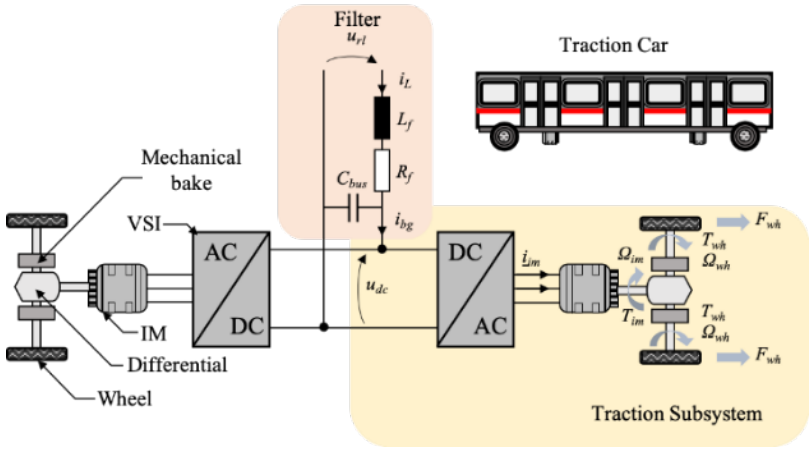
New e-bus

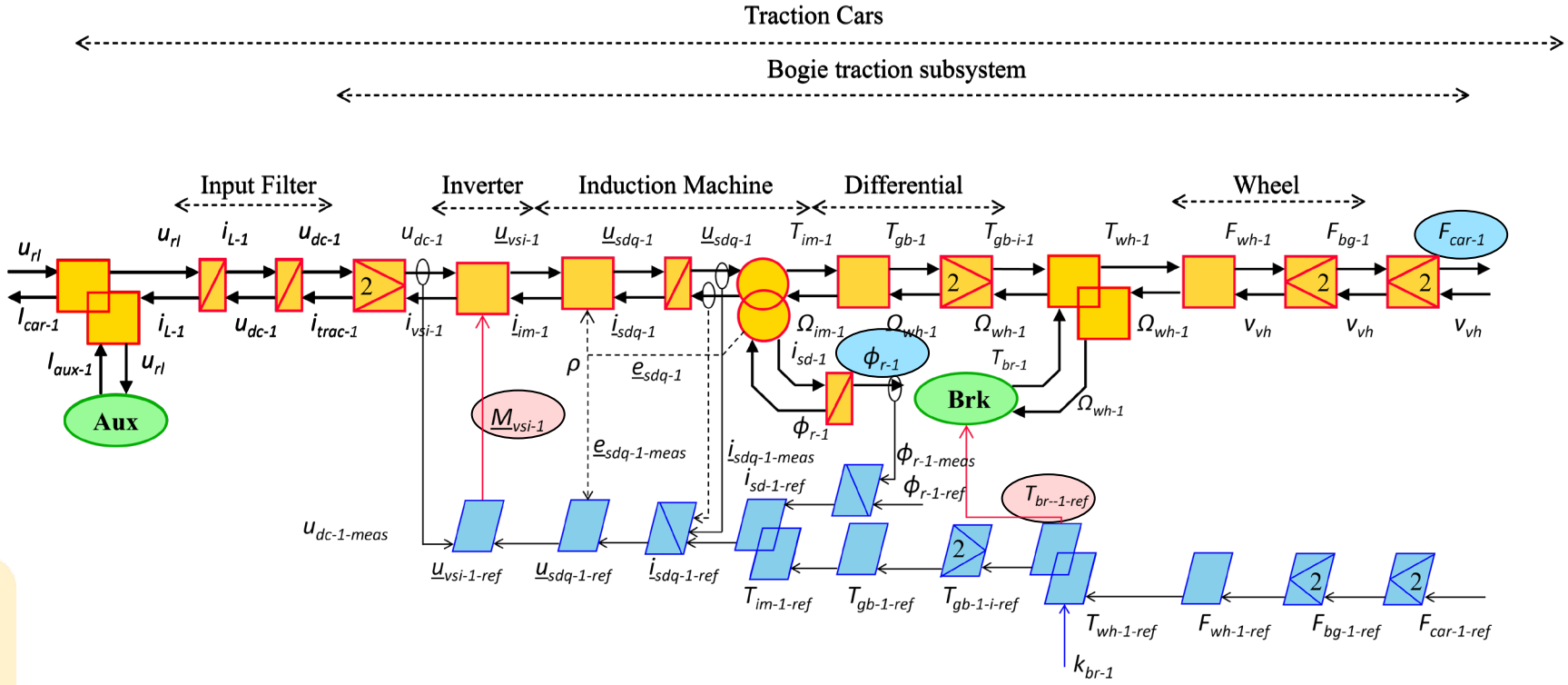


« EMR-based Models »

EMR-based model of the new subway

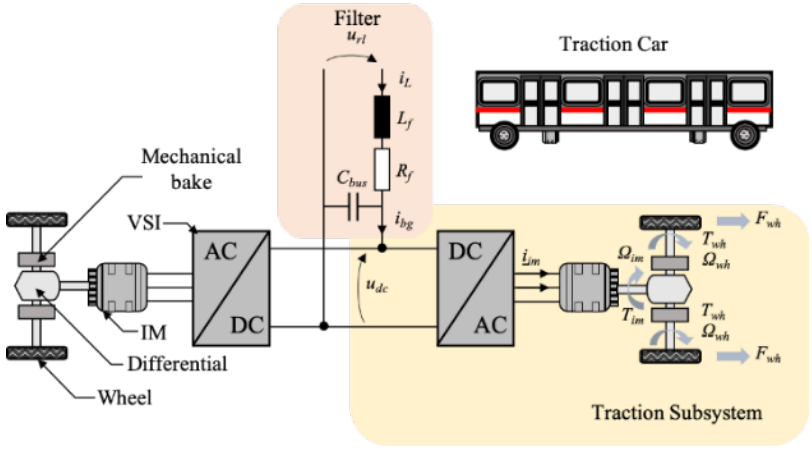
- Total of 4 cars
- 3 Traction cars (MC1, M and MC2)
- 1 non-traction car (T)

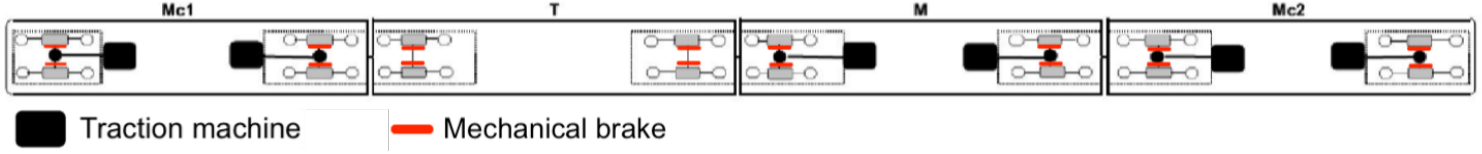


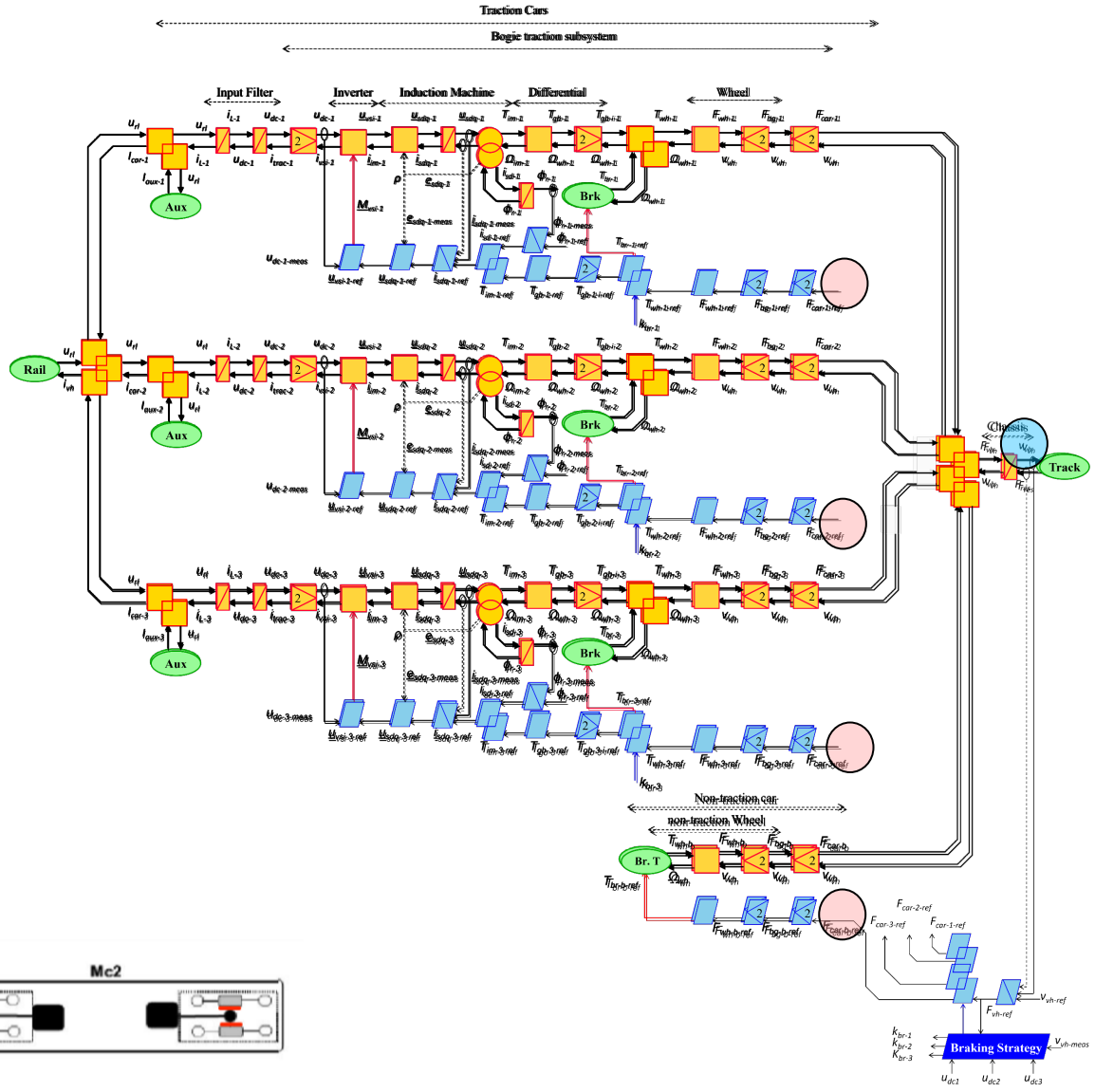


EMR-based model of the new subway

- Total of 4 cars
- 3 Traction cars
  (MC1, M and MC2)
- 1 non-traction car (T)

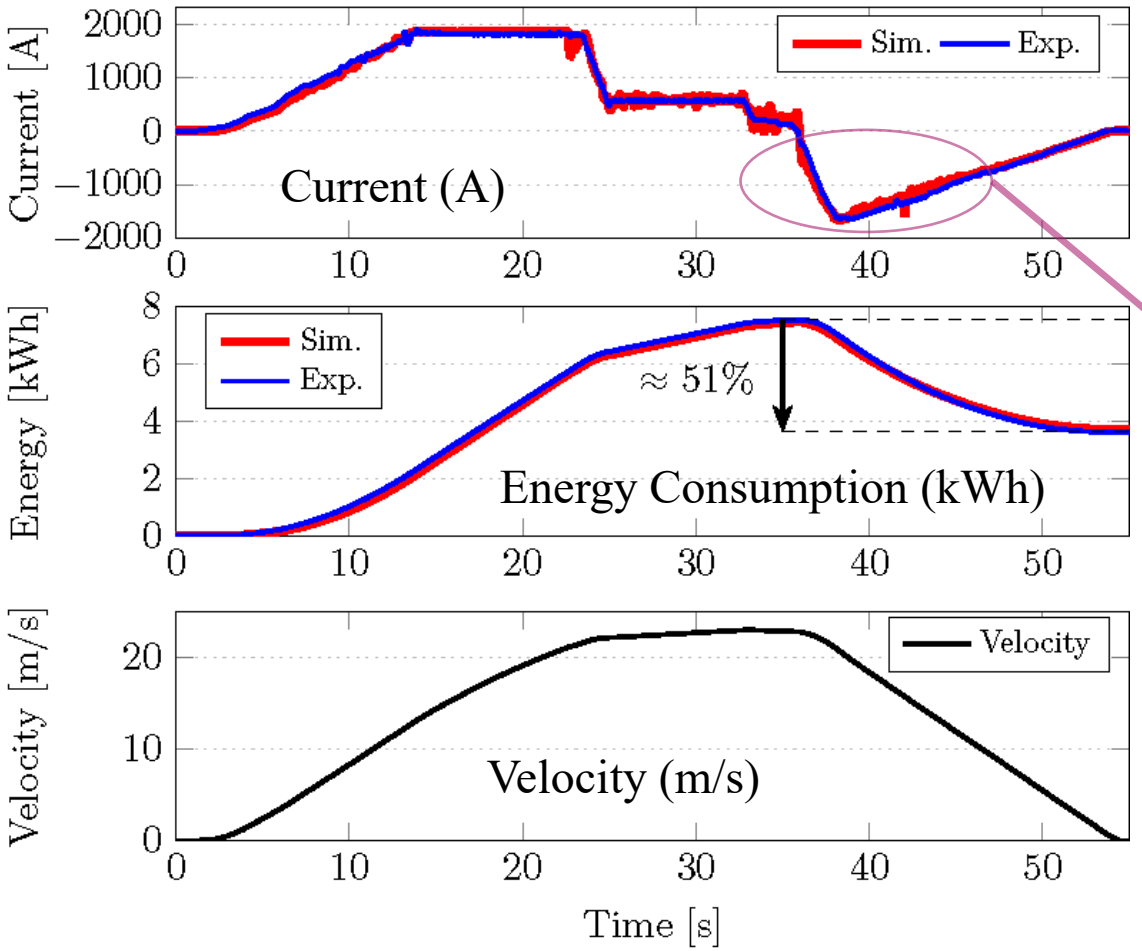


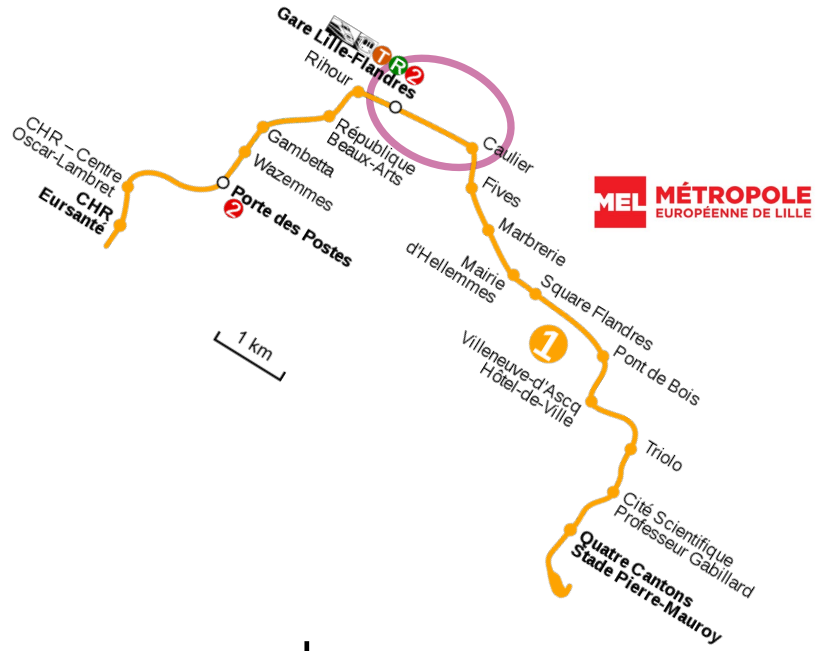




Experimental validation

Experimental
Simulation

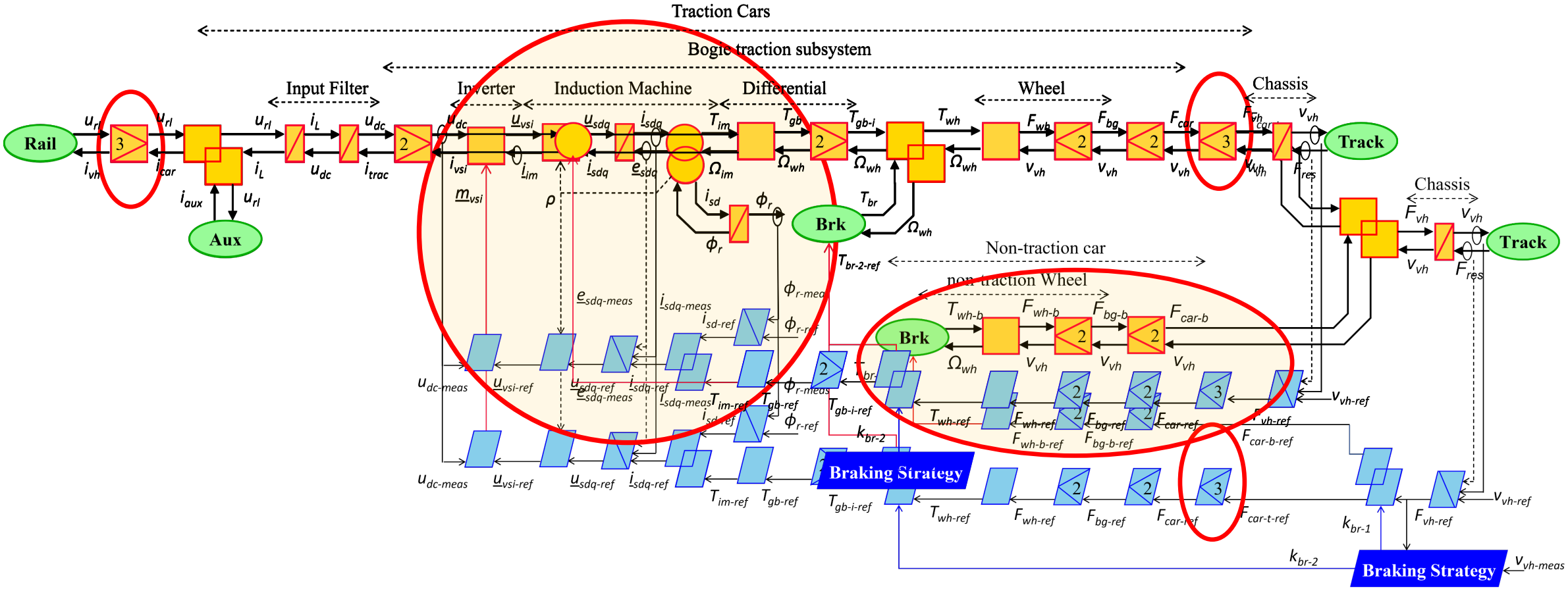




- Energy recovery phase
- 2.1% difference in energy consumption
- **Validation of the simulation tool**

Model simplification

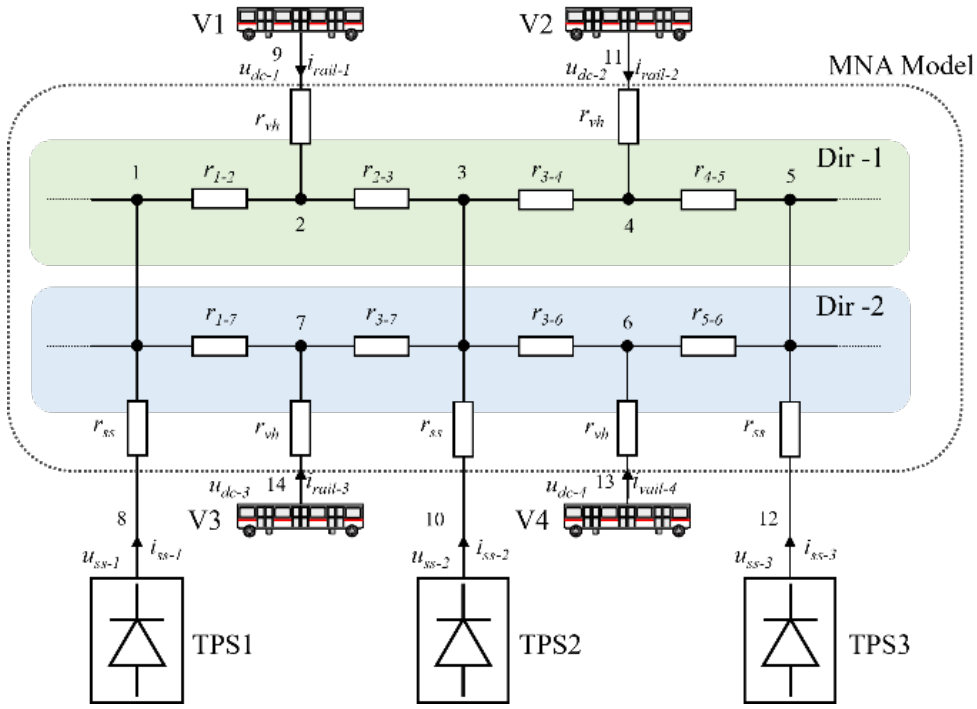
1) Same operation for all cars
2) Neglect the non-traction car
3) Neglect fast dynamics (ex: static model of the drive)



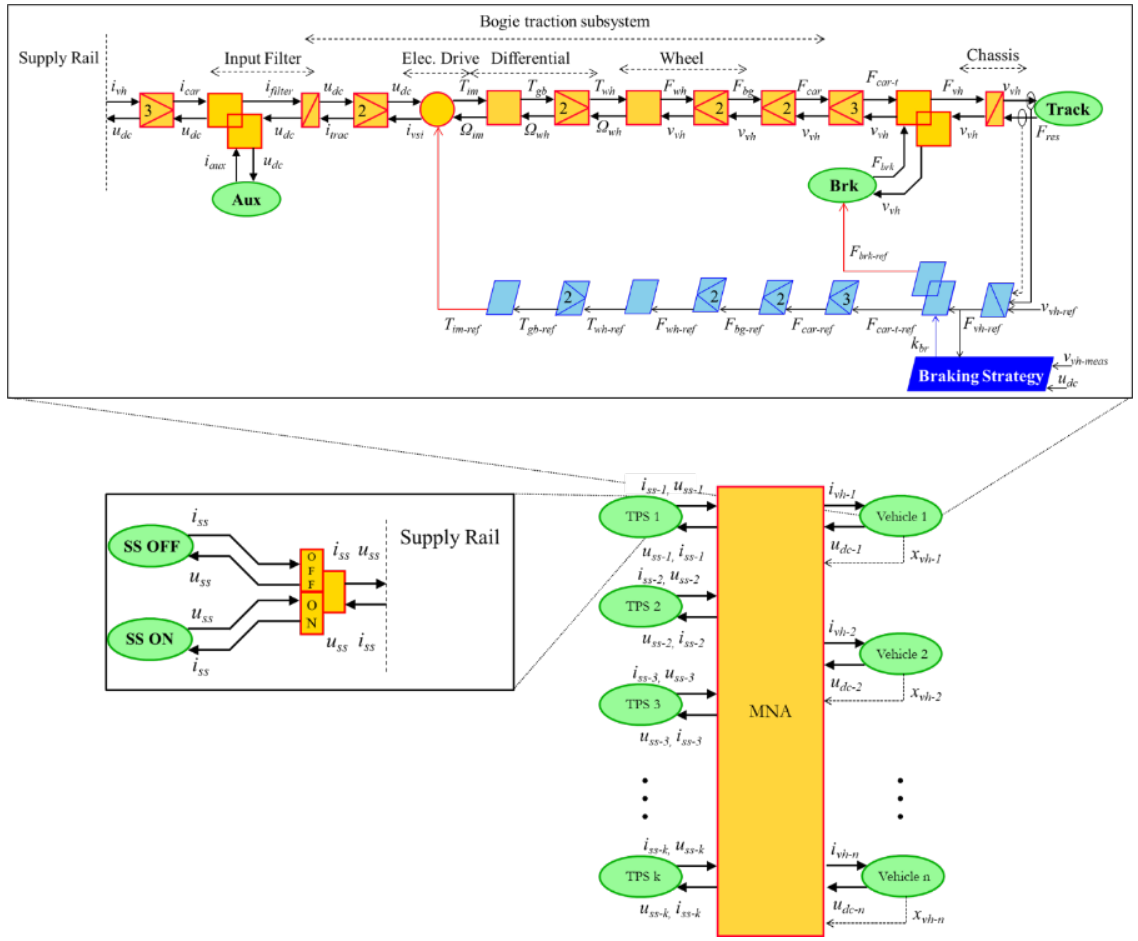
Complete model

From previous works

Estimate energy consumption for various scenarios



Energetic Macroscopic Representation (EMR)

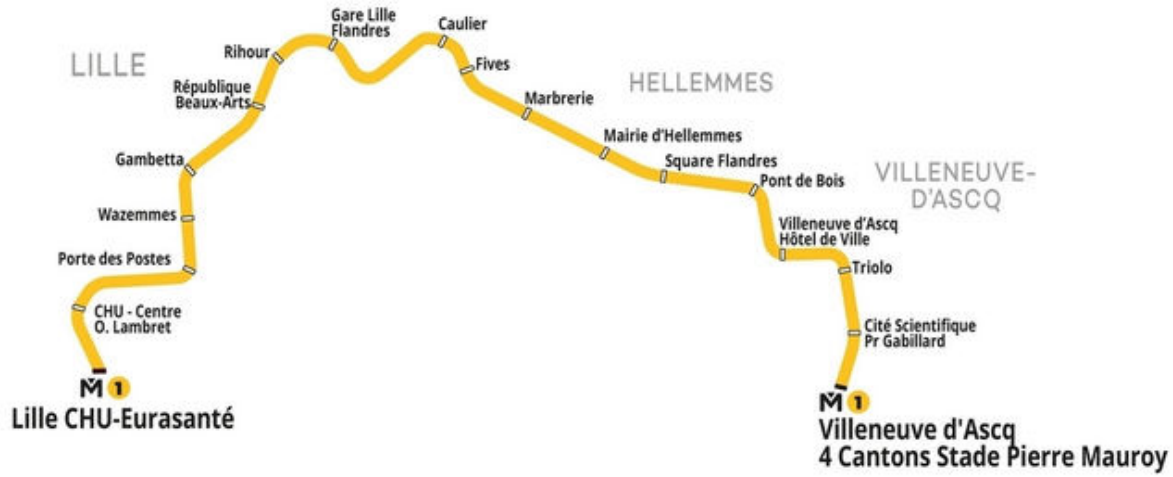


« Results »

Subway simulation

Multiple vehicles circulation
34 vehicles on peak-hours & 10 TPS

Respecting timetable
About 19h of operation

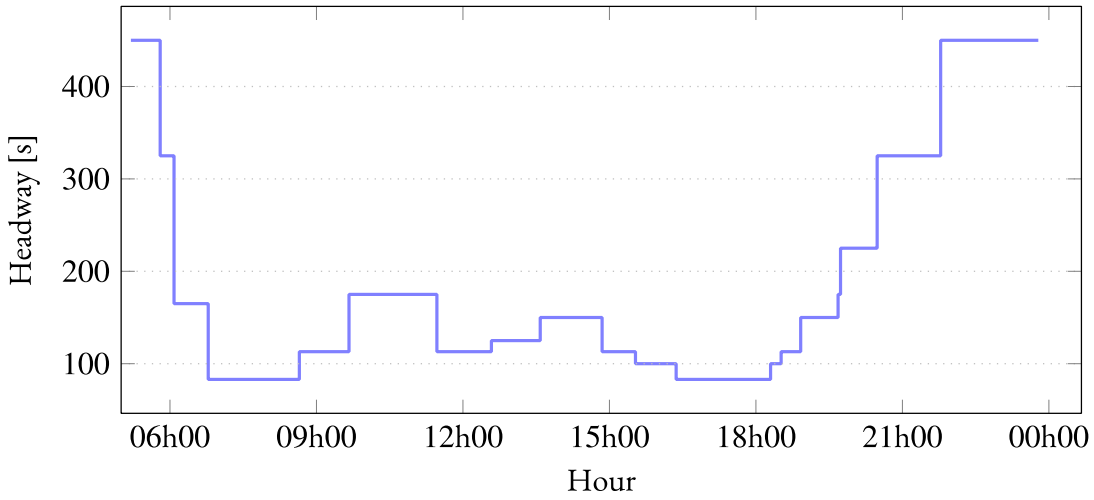


Daily key numbers:

Total energy: 82.6 MWh
Total distance: 10653.6 km
306 passengers per vehicle in average

25 Wh/pass.km

Timetable



Public Rail Transports

Daily indicators per person

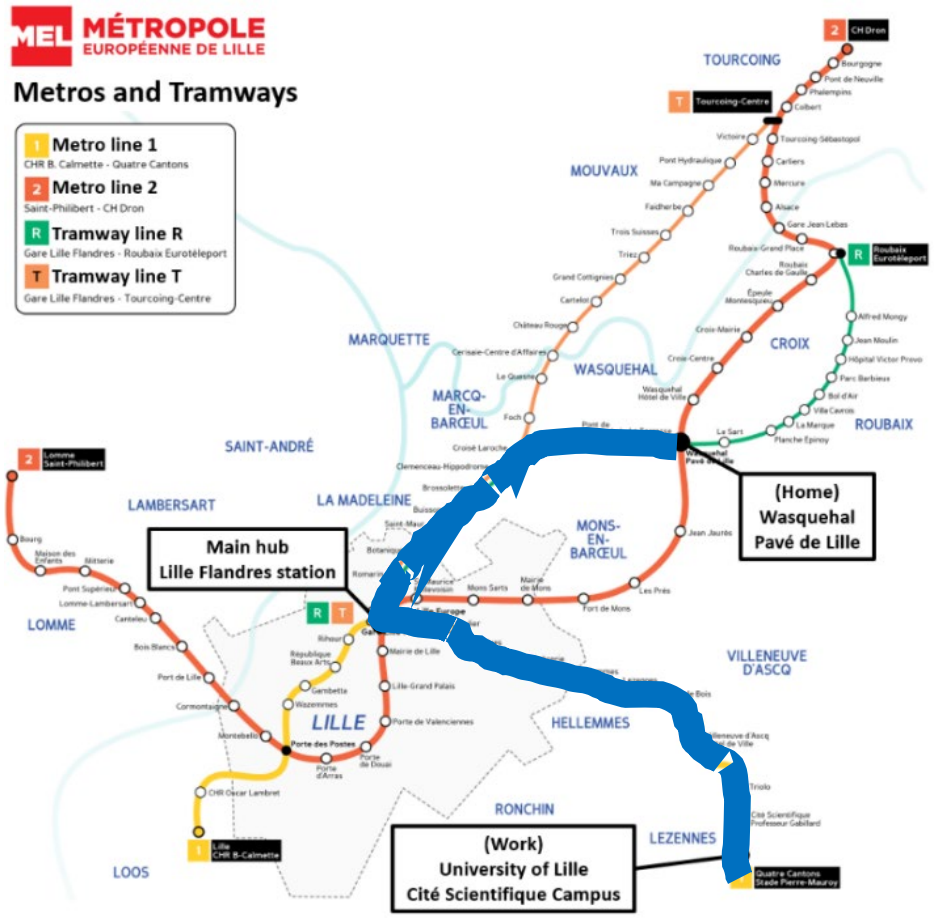
Transport	Distance	Energy	CO2eq
Tramway	8.8 km	233.2 Wh	7.5 g
Subway	15.2 km	384.6 Wh	12.3 g
Total	**24 km**	**617.8 Wh**	**19.8 g**

32 gCO2eq/kWh (RTE, 2023)

Well-to-Tank (WTT 100%) → Tank-to-Wheel (TTW 0%)

Other daily indicators per person:

- 72 min round trip
- 1.45 € per day (annual pass)



« Conclusions & Perspectives »

Conclusions

- EMR for better organization of the entire complex model
- Simulation of the future public rail transport (new metro + new tramway)
- Estimation of several daily indicators (GHG, energy, journey time, cost, etc.)
- Comparison with gasoline cars

Indicators	Gazoline car	VS	Rail public transport
GHG	2459.8 g CO2eq	÷ 124	19.8 g CO2eq
Travel time	30 min	× 2.4	72 min
Direct personal costs	1.76 €	÷ 1.2	1.45 €

Perspectives

- Consideration of other transport systems (buses, electric bicycles, etc.)
- Complete life cycle analysis (LCA) to refine environmental comparisons
- Estimation of other indicators (cost to society, stress factor, human factor, etc.)

Thanks for your attention !

Personal car (gasoline)

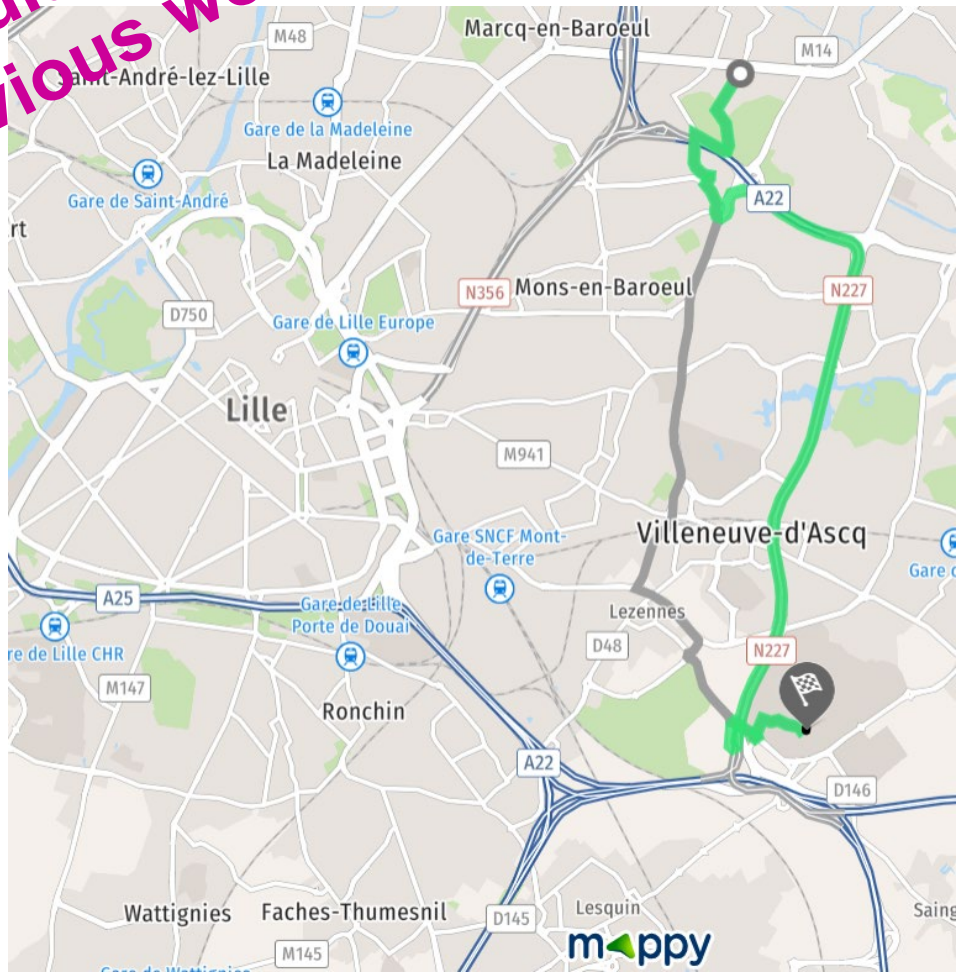
Results from previous work

Daily indicators per person

Transport	Distance	Gasoline	CO2eq
Car	19.6 km	0.94 L	2459.8 g

14.5 gCO2eq/L — Well-to-Tank (WTT 11.5%)

111 gCO2eq/L — Tank-to-Wheel (TTW 88.5%)



Other daily indicators per person:

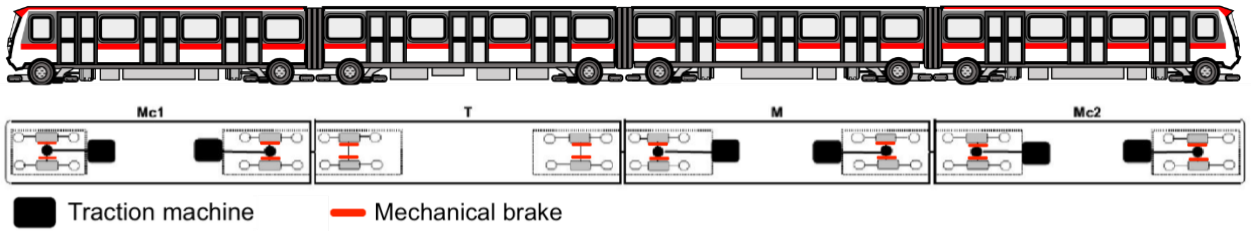
- 30 min round trip
- 1.76 € per day (1.88 €/L in 2023)

New public rail transports in MEL

New subways

Val 208 (Siemens)

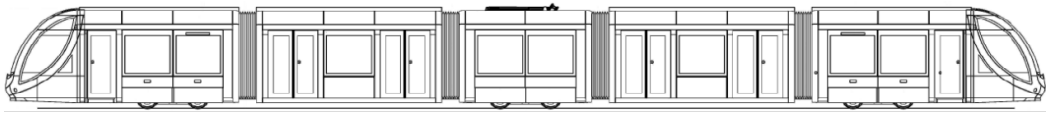
NMR (Alstom)



New Tramways

Old BREDA tram

CITADIS X03 tram (Alstom)



Motorized bogie **Carrying bogie** **Motorized bogie**

Evaluate the impact of these new rail public transports