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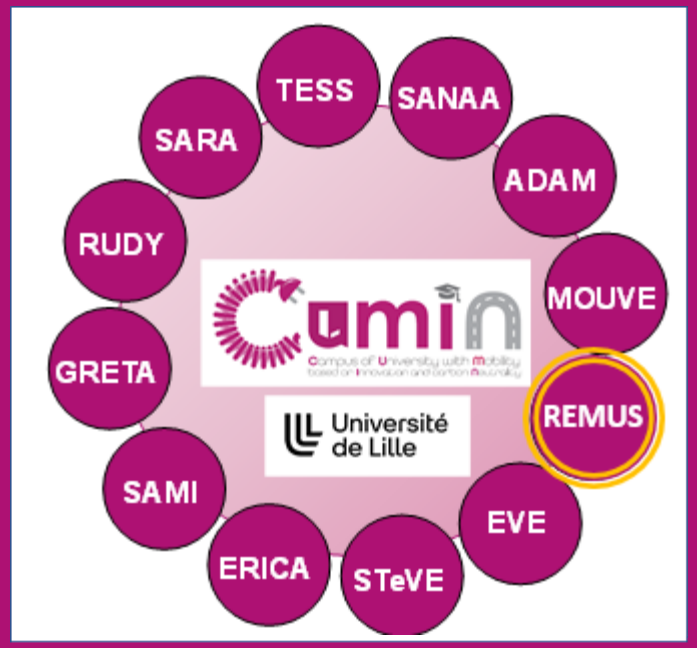

CUMIN - REMUS

Tramway energy consumption

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Outline

1. Objective
2. Studied tramway (CITADIS X03)
3. Model organization of the tramway system
4. Validation and simulation results
5. Conclusion and perspectives

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1. Objective

Objective

- **Estimation of the energy consumption of the new tramway line and the recoverable braking energy**
- **Collaboration between MEL and L2EP (University of Lille)**
- **Replacement of old tramways (BREDA) by new tramways (CITADIS)**

Old BREDA tram

CITADIS X03 tram

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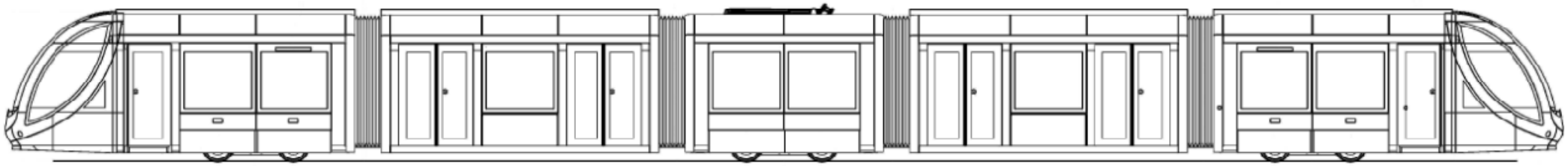
2. Studied tramway (CITADIS X03)

Characteristics of the CITADIS X03 tramway



Characteristics of the CITADIS X03 Tramway	
Empty weight in working order	45,52 t
Normal load weight	59,30 t
Maximum speed	70 km/h
Diameter of new wheels	580 mm

Energy and mechanical characteristics	
Maximum power at the rim	880 kW
Supply voltage	750 V
Average acceleration (from 0 to 40 km/h)	1,15 m/s²
Auxiliary power supply	75,4 kW
Number of motorized bogies	2
Number of carrying bogies	1
Number of motors per bogie	2

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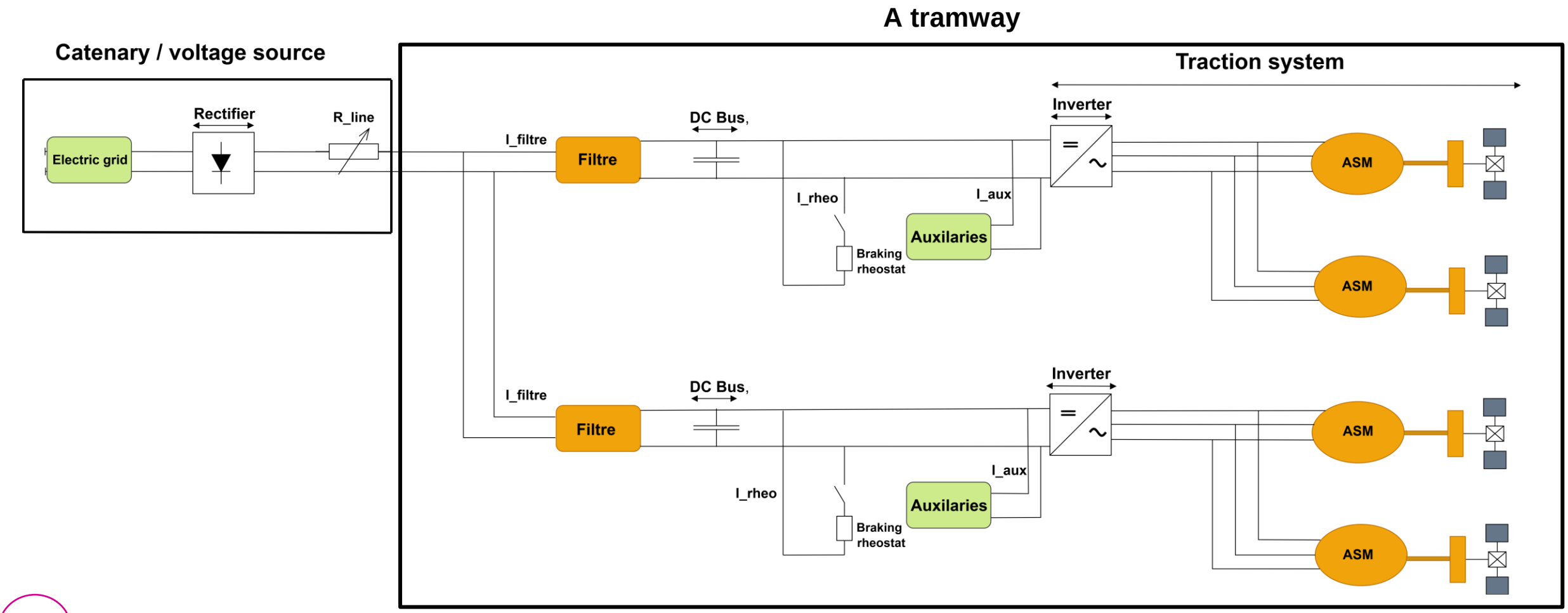
Structural diagram

Modeling of a simplified line: 1 tramway powered by a grid system + rectifier + line resistance



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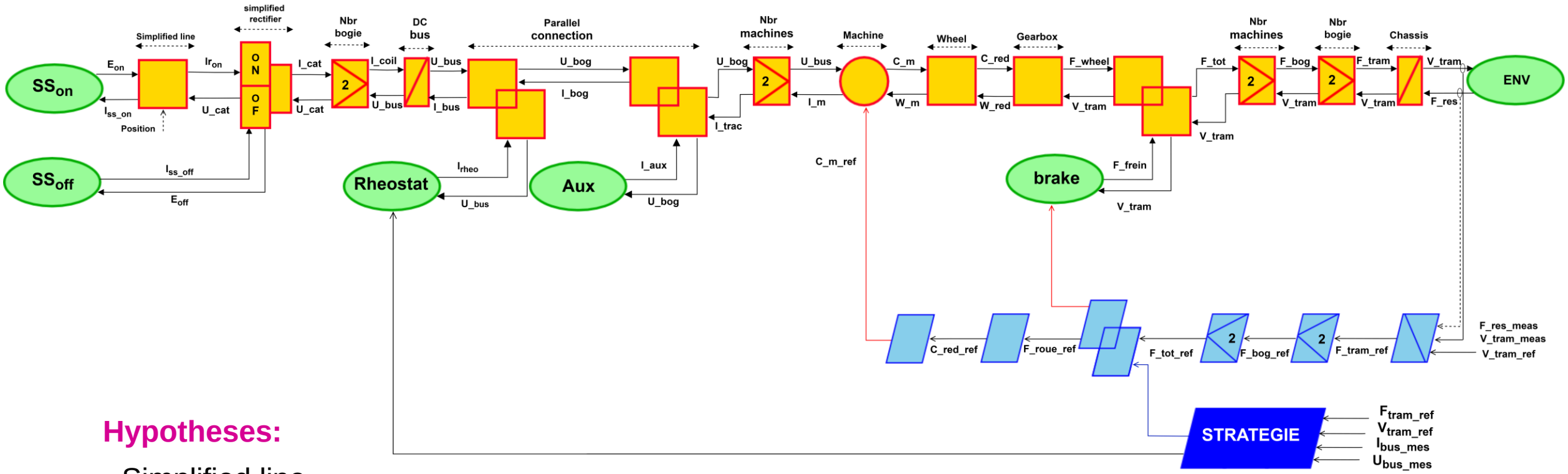
3. Model organization of the tramway system

Model organization of the tramway system

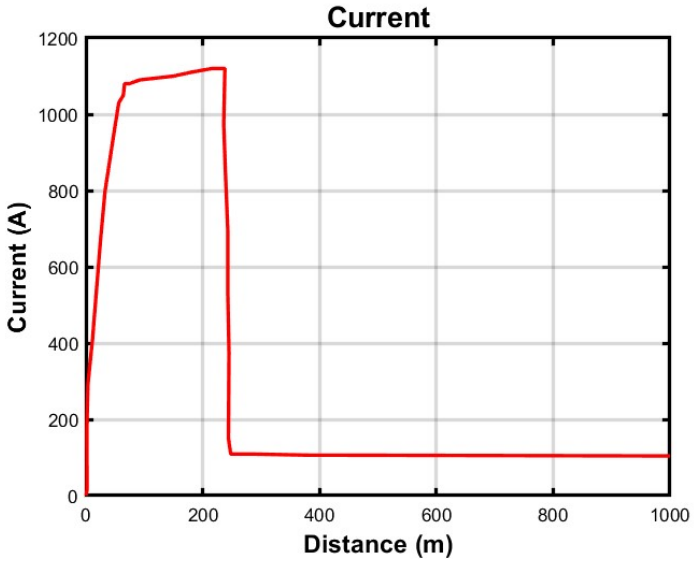


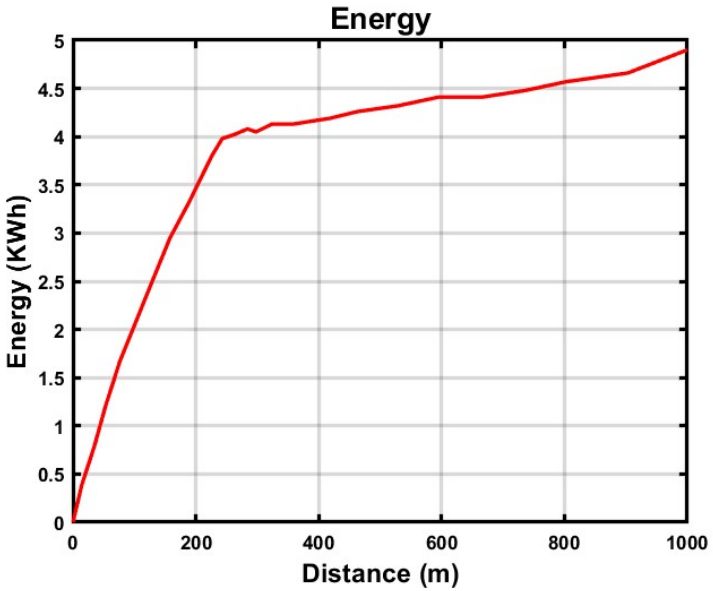
Hypotheses:

- Simplified line
- Quasi-static model
- Straight-line rolling
- Slope and wind speed are neglected

Validation

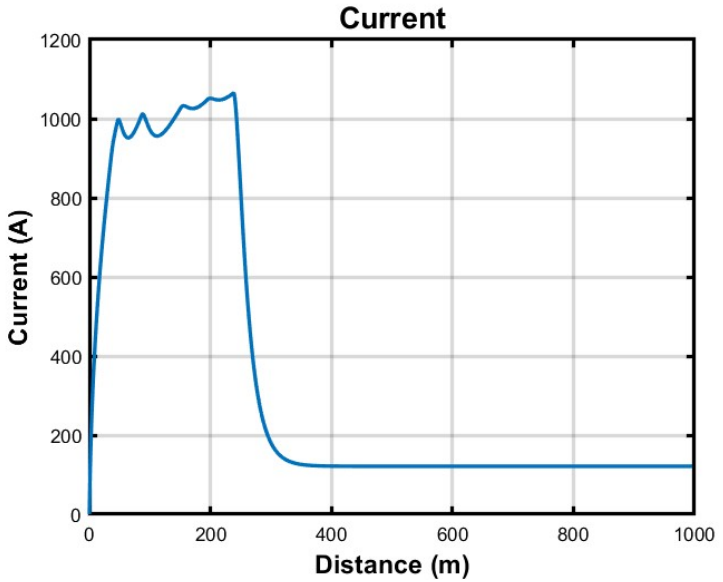
❑ *Reference results*

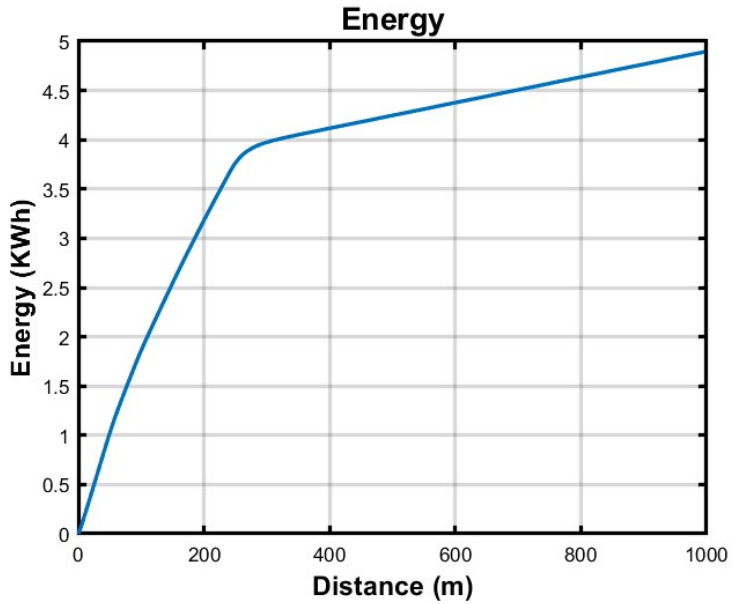




Only a 2% error on the energy consumption of the model vs. theoretical

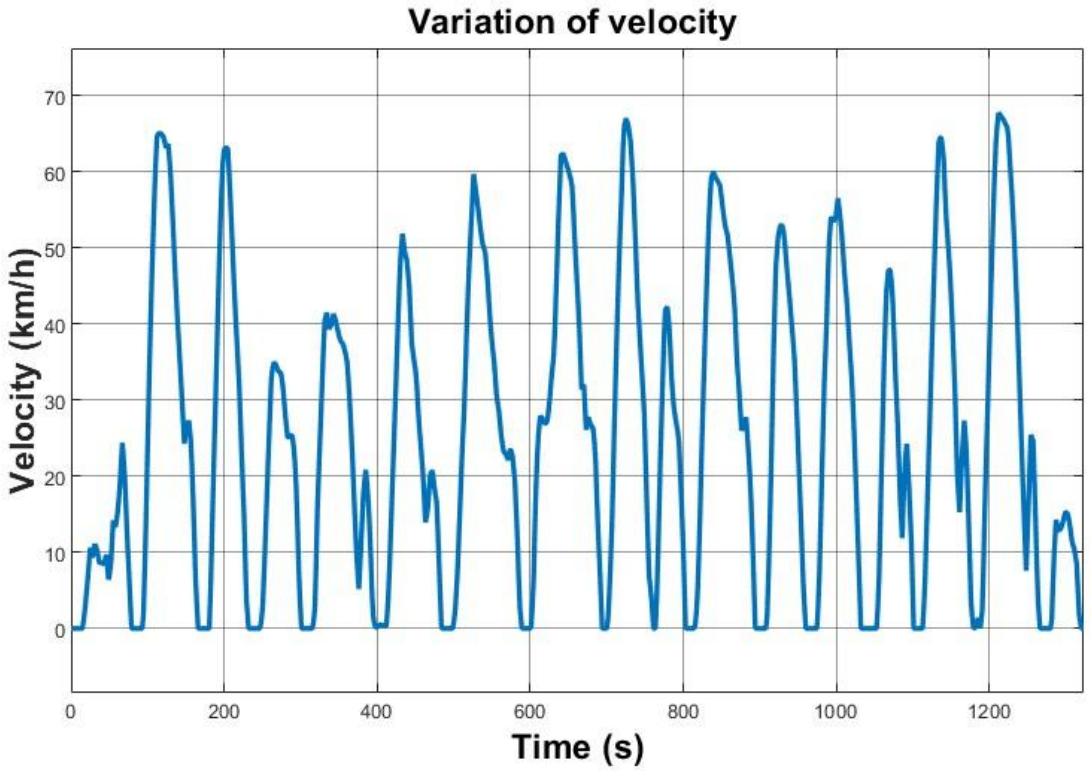
❑ *Simulation results*

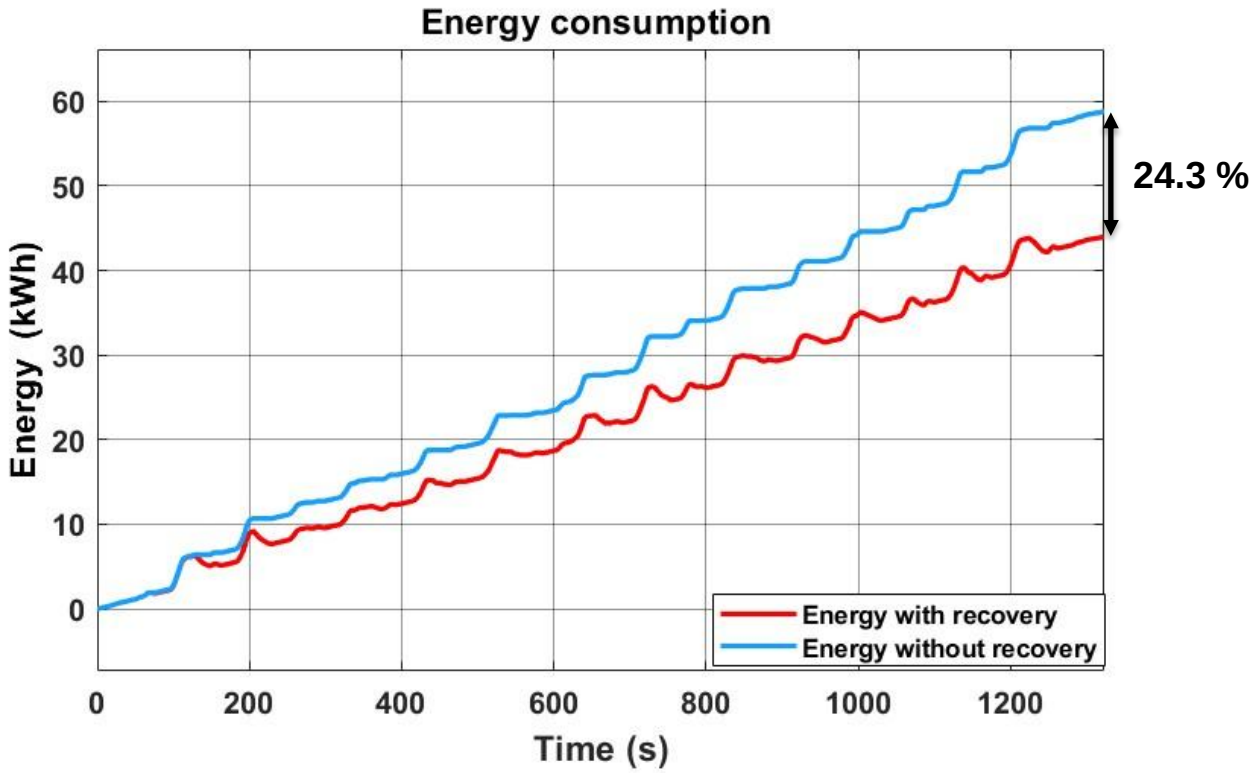




Results and Interpretation

- *Speed and Energy Results of the Simulation with and without Reversibility*
- *1 tramway on the line, real cycle*

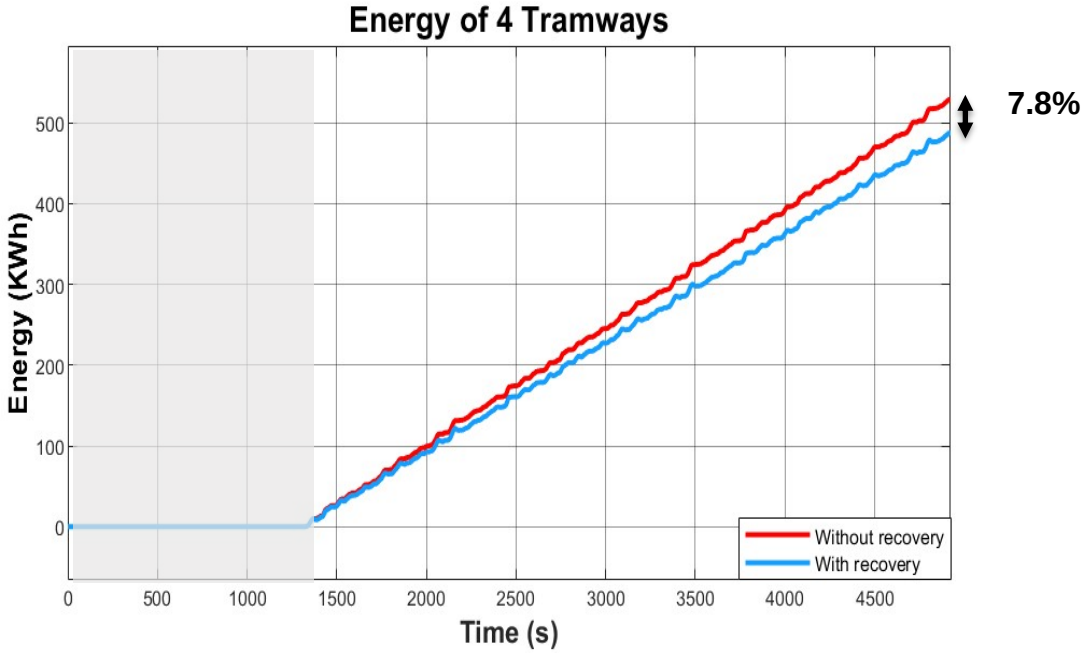


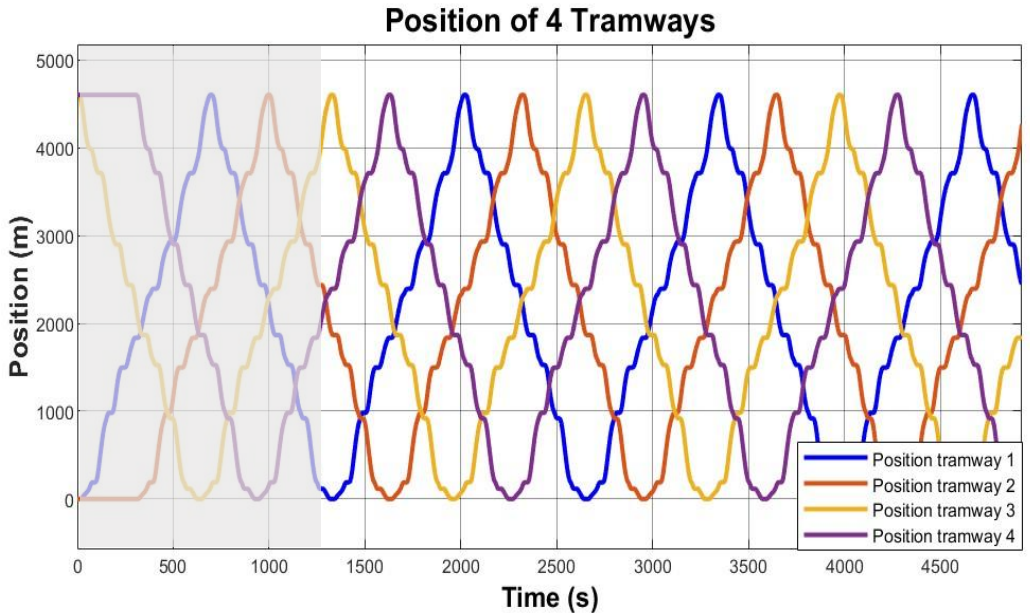


Analysis and Interpretation of Simulation Results

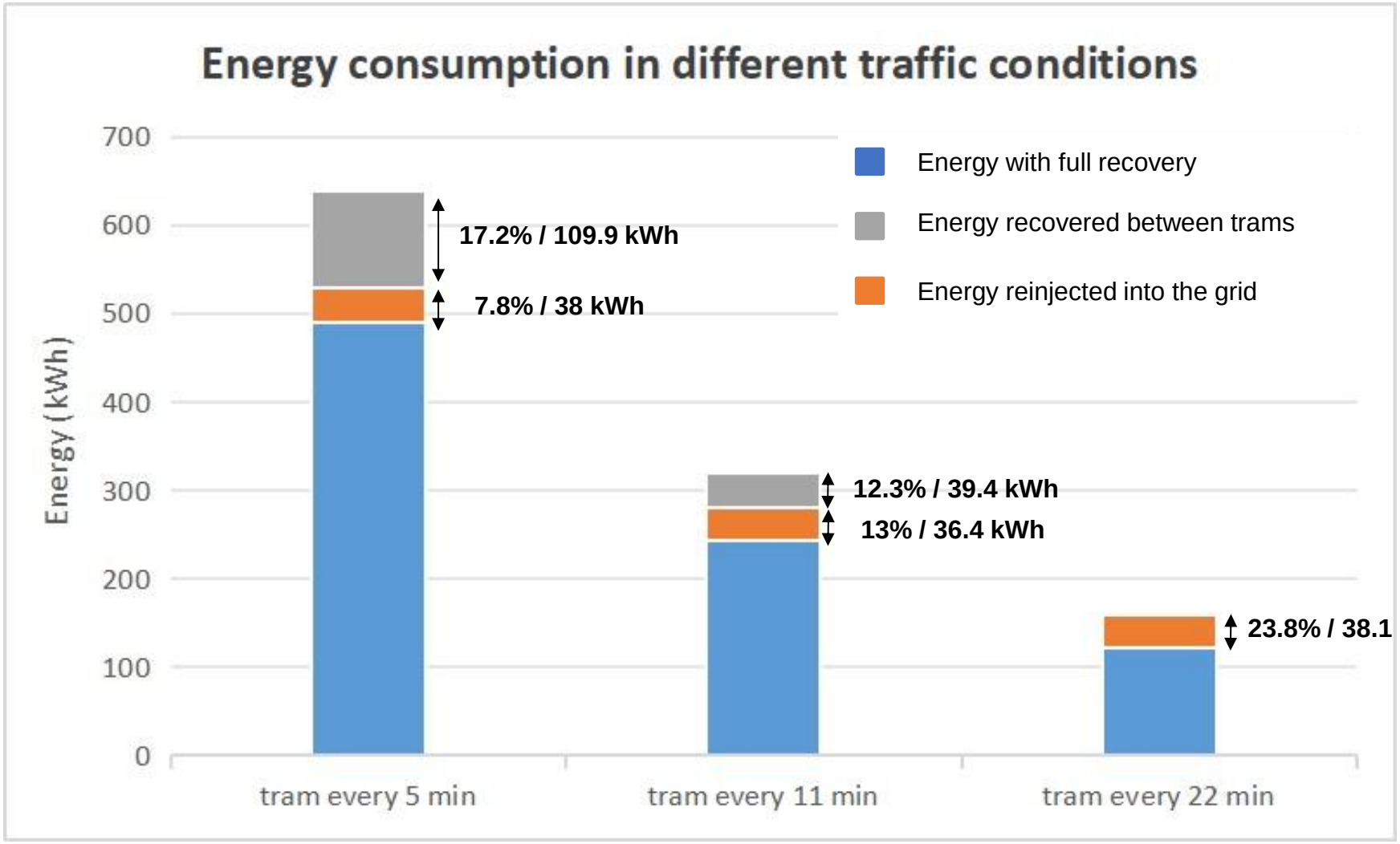
Hypotheses:

- *Average efficiency is assumed to model the different resistances.*
- *Route from Station Romarin to Station Clemenceau Hippodrome (4,9km)*
- *Headway : 5 minutes (4 Tramways)*
- *Simulation time: 1 hour*





Energy consumption in different traffic



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4. Conclusion and perspectives

Conclusion

Conclusion :

- The recovery of braking energy represents a significant energy potential.
- The dissipated braking energy can be stored or reintroduced into the electrical grid.

Perspectives:

- Gain a deeper understanding of DC power supply (topology, line resistances of conductors, etc.)
- Improve the modeling of the line
- Use energy storage systems

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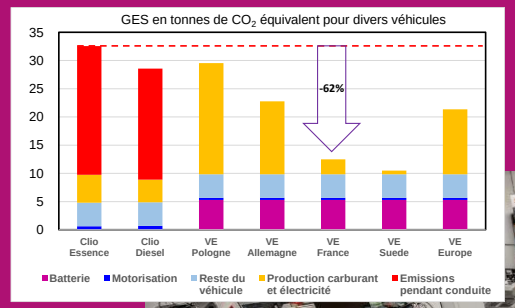

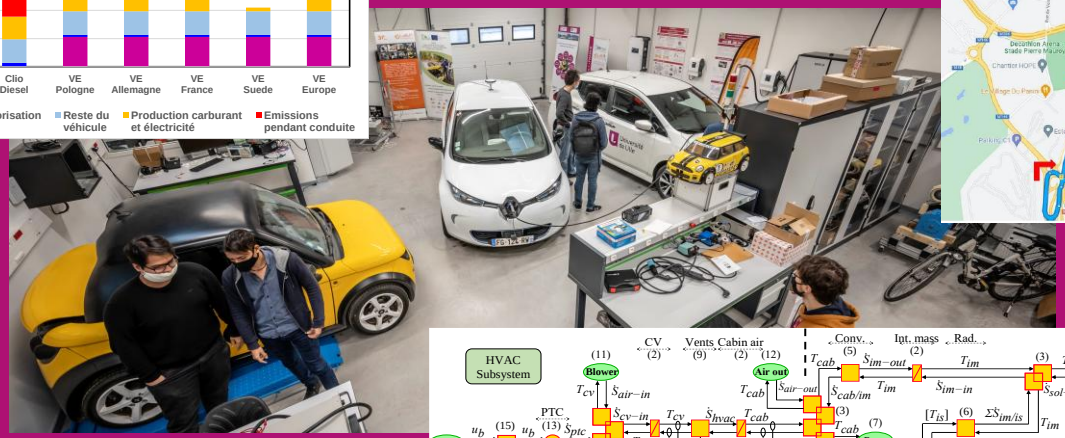

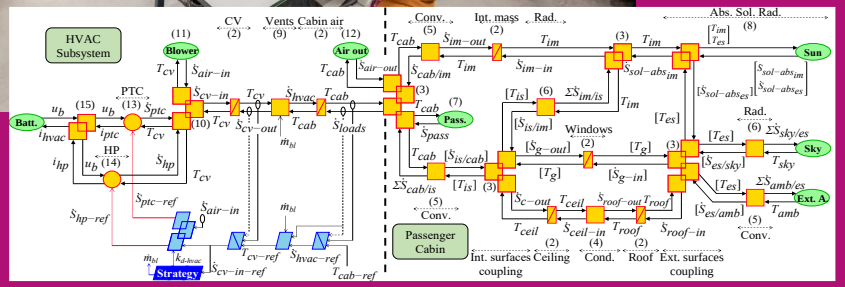

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