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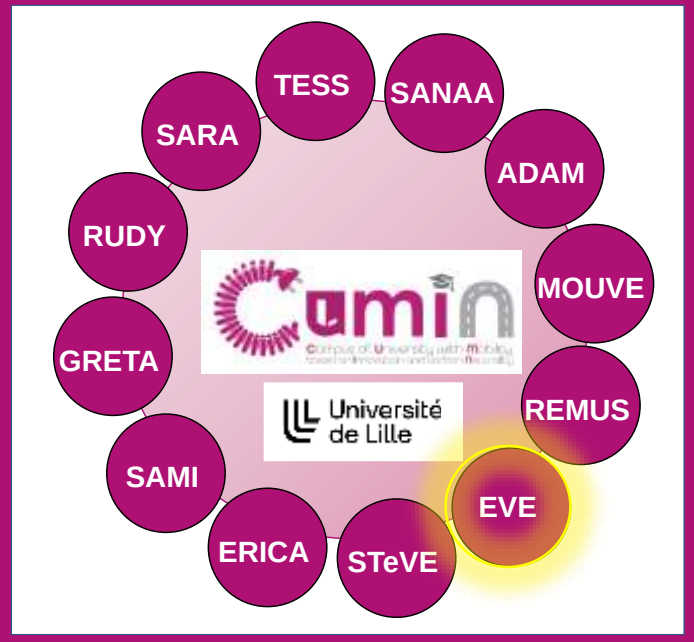

CUMIN - EVE

Electric Bus Consumption

Master 2 VIE

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Supervised by:
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Outline

1. Context and Objective of the Project
2. Simulation of the bus
3. Model validation
4. Conclusion and Perspectives

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1. Context & objective

Context and Objective

CUMIN: Campus of **U**niversity with **M**obility based on **I**nnovation and carbon **N**eutral

EVE : Energy consumption estimation of various electrified vehicles.

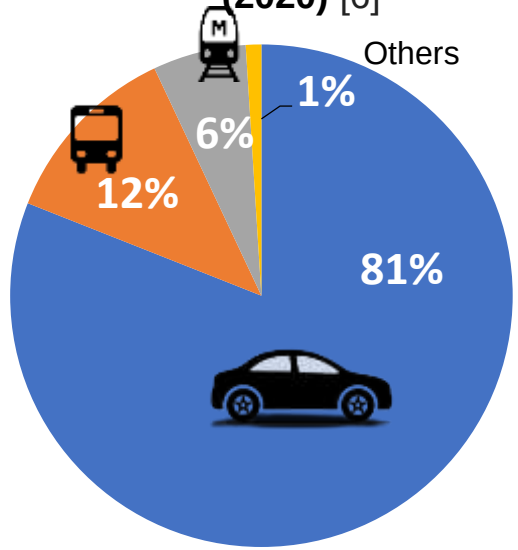
In Partnership With MEL MÉTROPOLE EUROPÉENNE DE LILLE

Objective: Study the Energy Consumption of an Electric Bus under varying meteorological conditions.

Ilévia bus of MEL

Reference route 8 C10A

GHG Emissions in the university of Lille (2020) [6]



➡ 12% of GHG come from buses.

Position of the MEL bus

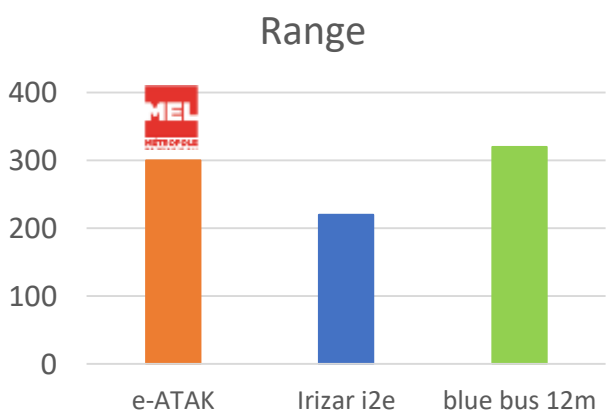
Preselection

KARSAN e-ATAK

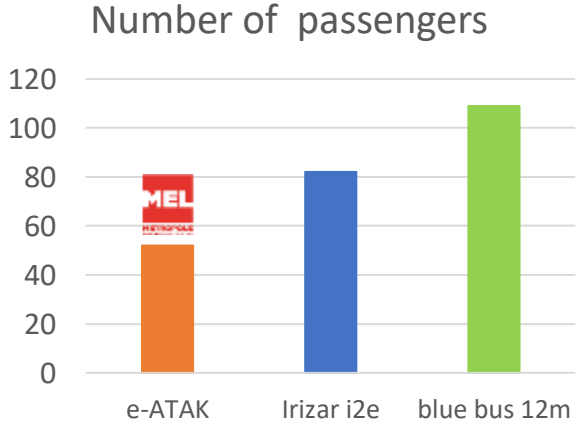
Bluebus 12M

Irizar i2e

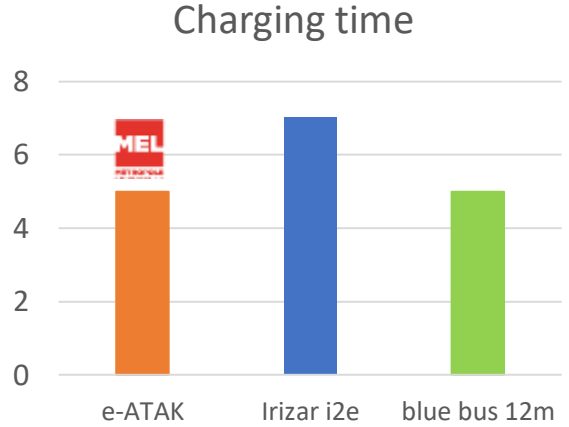
Comparison



A range of 300 km



Maximal capacity of 52



5 hours

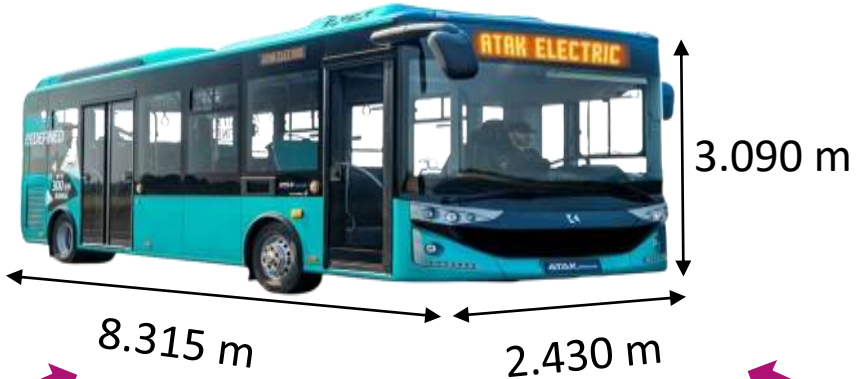
➡ MEL bus has a reduced size with standard range and fewer passengers

Presentation of the MEL bus parameters

Machine parameters
- Type : PMSM
- Power : 230 kW
- **Average efficiency: 90%** [1]

Battery parameters
- Type Li-ion
- **Energy: 220 kWh**
- Voltage: 352.3 V
- Capacity: 120 Ah

Weight: 11500 Kg



Confort system
- **Air conditioning: 22 kW**
- **Heating: 26kW**

Friction parameters
- Frontal area: 7.50 m²
- Drag Coefficient Cx: 0.73
- Rolling resistance: ~0.015 m/s²

➡ MEL parameters are used in the model

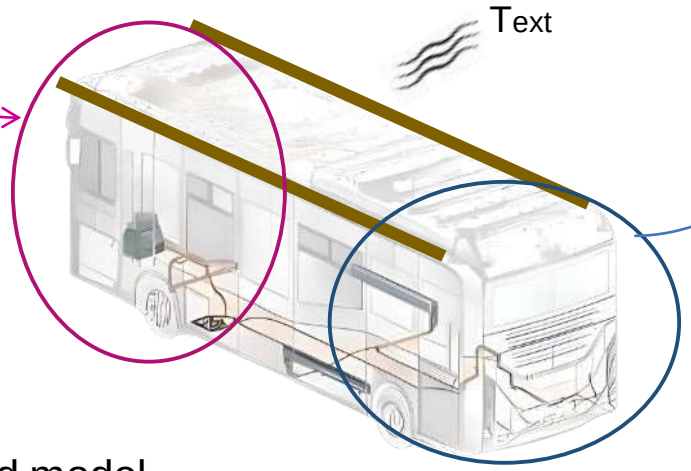
Characteristics of thermal comfort

Driving area

Heating:
- Water circulation heating system
- P=11 kW

Air conditioning:
- P=4 kW

2 Areas



Passenger area

Thermal conditioning :
- P= 15 KW heating, Text > 0°C
- P=18kW Air conditioning

Heating for special conditions
- P= 12.4 kW, Text < 0°C

➡ Searching for a simplified model

Estimation of MEL

total thermal comfort energy consumption of 0.27 kWh/km **MEL[23]**

- d=9.36 km
- t=31 minutes

⟶ $P_{th.regulation}$=4.88kW

➡ Assumption: this power corresponds to a thermal regulation of +/- 5°C.

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2. Simulation of the bus

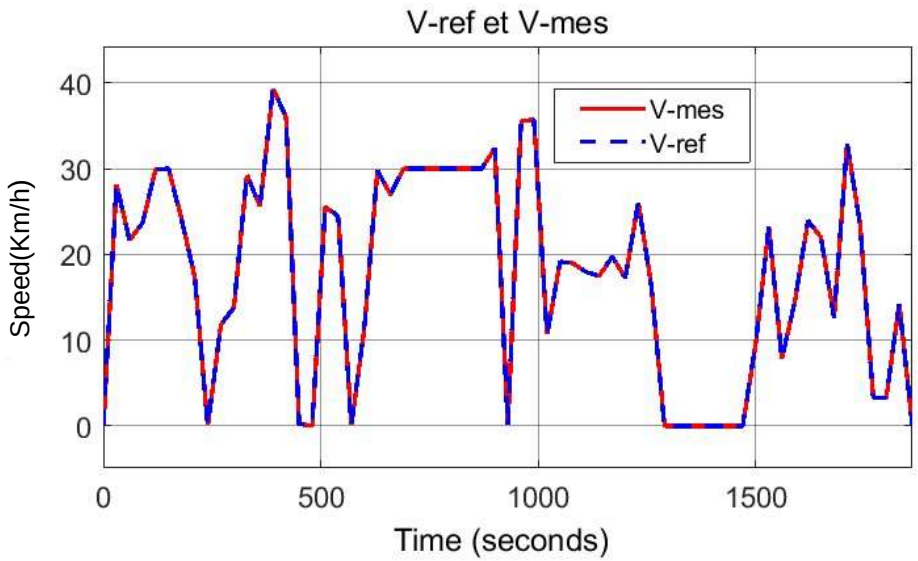
(Matlab/Simulink ©)

Presentation of MEL records

Reference route [7] : Line C10 Ilévia C10A

Geographic map of the C10 bus route

Speed (km/h) vs Time



Sampling time 30s

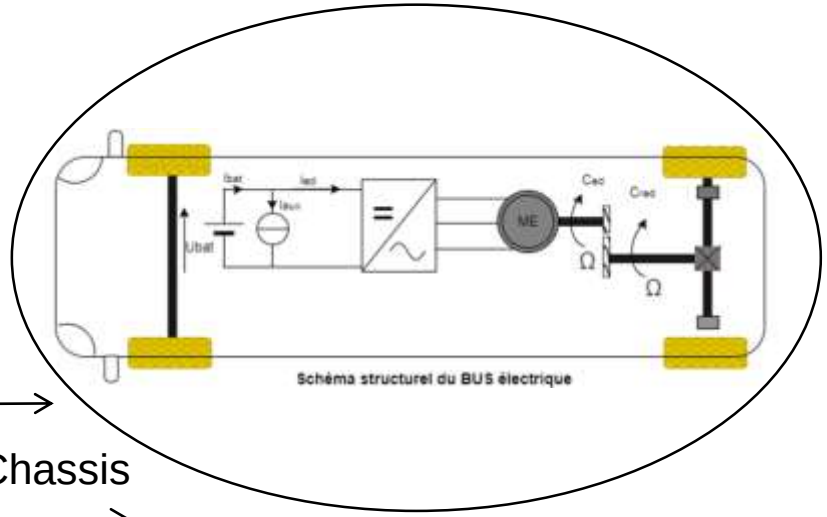
Slope close to a flat road

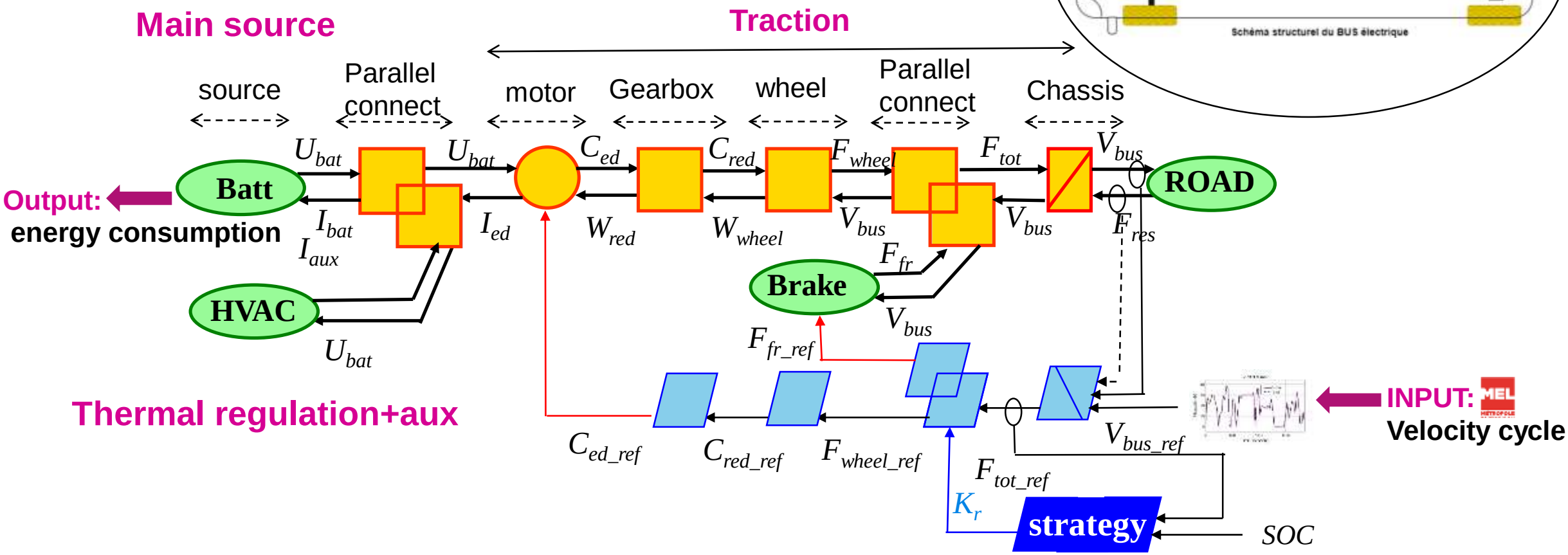
slope = 0.4% ≈ 0

➡ Integrate the data into the simulation

Bus model organization

Using the Energetic Macroscopic Representation formalism





Hypothesis: 30% electrical braking, 70% mechanical braking

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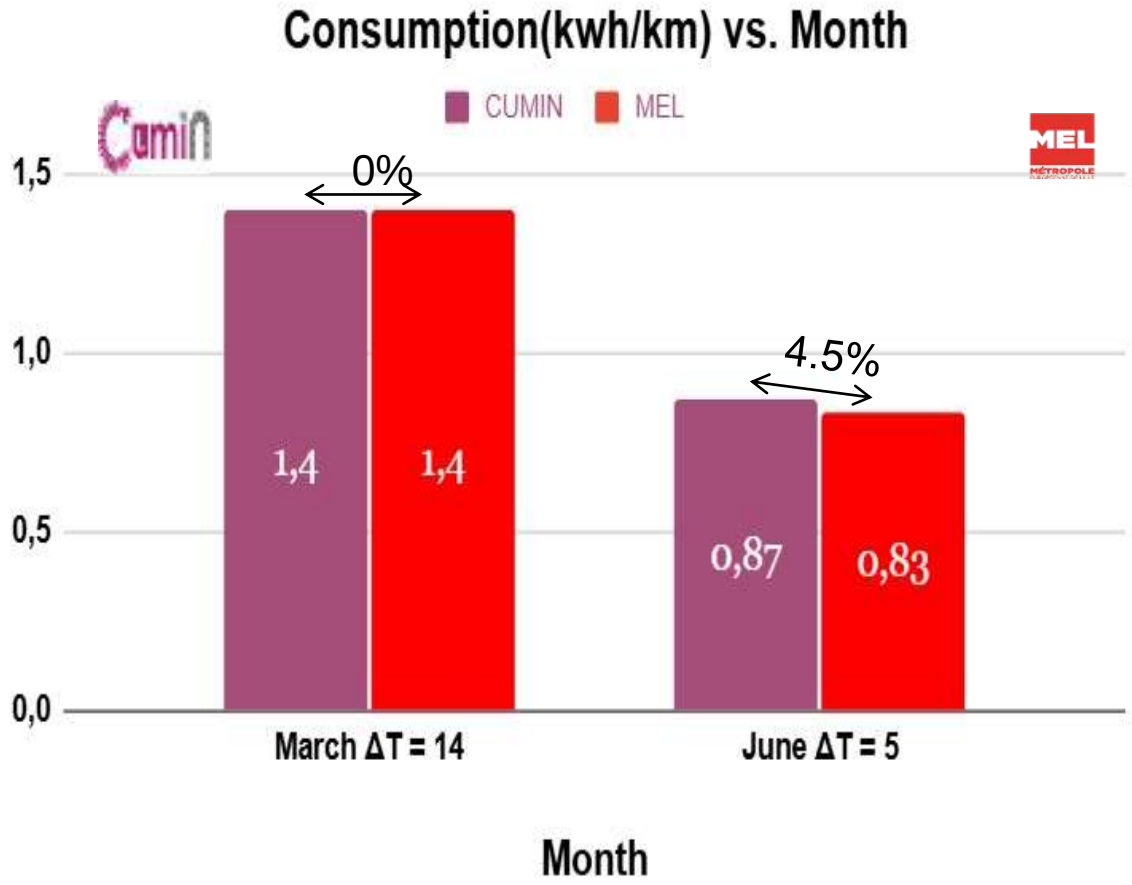
2.Model validation

Model Validation

Conditions

Speed cycle
BUS mass with driver = 11.6 t

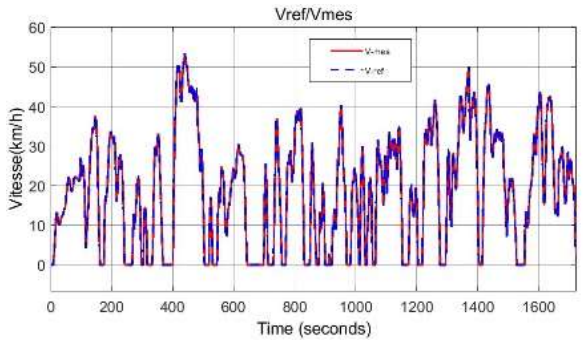
Scenario / Parameters	01 June 2024	01 March 2024
T_{int}	19°C	19°C
$\Delta T = T_{int} - T_{ext}$	5.54 kW	14.54 kW
Auxiliary power	5°C	14°C



➡ The model is validated for two external temperature

The Impact of seasonal changes on the energy consumption of a bus

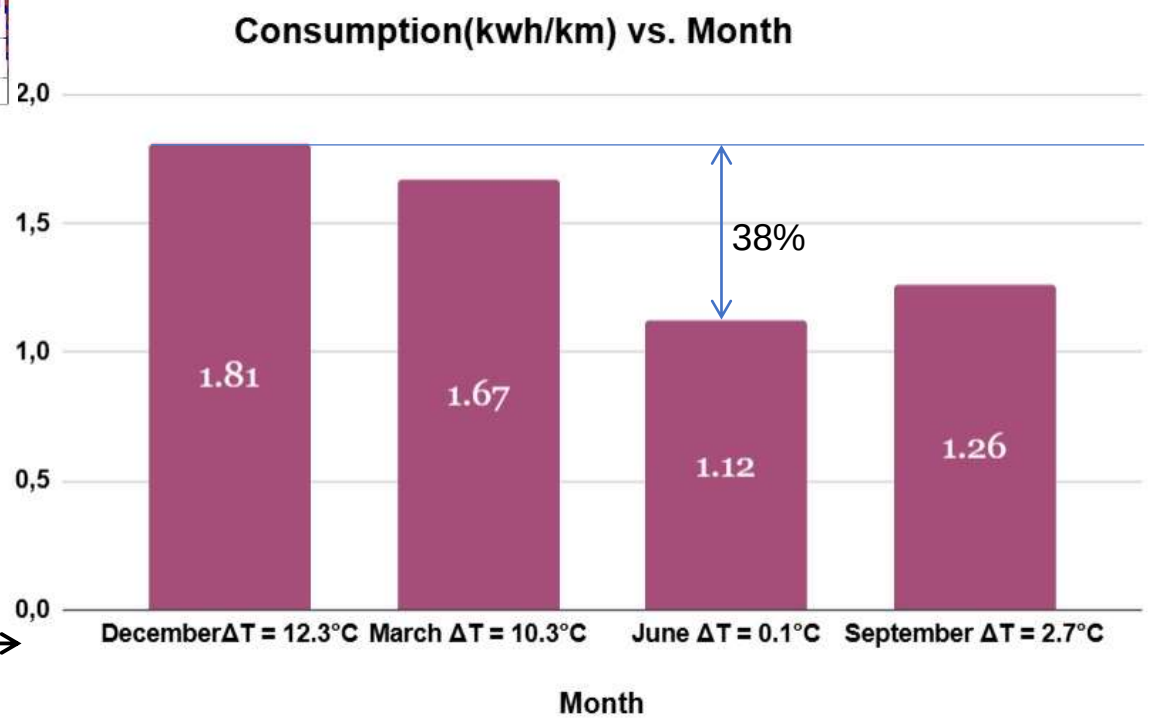
Recording a new cycle / sampling time 1s



Fixed Parameters:

- Speed cycle
- **Bus half charged m=13.55 tonnes**
- T_{int} = 19°C

Variable Parameters



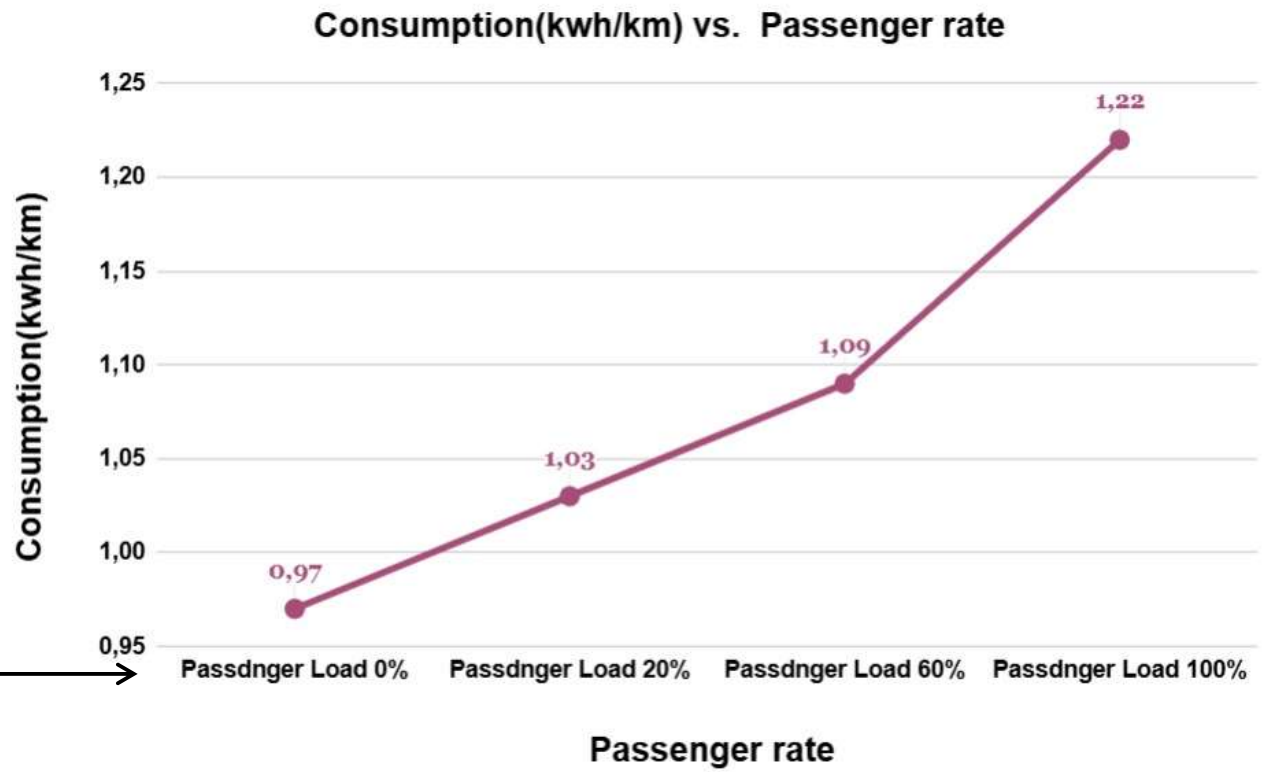
Seasonal impact on energy consumption reaches up to 38%

The Impact of passengers on the energy consumption

Fixed Parameters:

Month: June
Auxiliary Power: 0.64 kW
ΔT = 0.1°C
Speed Cycle Camin

Variable Parameters →



➡ Maximal impact of passenger rate is 25%

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4.Conclusion

Conclusion and perspectives

Conclusion

- Used data for bus modeling.
- Validated the model using MEL real driving cycles.
- Analyzed the impact of the passengers and seasons on energy consumption.

Perspectives

- Obtain more detailed data for better precision
- Use real HVAC data to evaluate heating and cooling impact.

Bibliography

[1] Le Hen Ortega, Bruno, Ronan German ,Alain Bouscayrol, et Loic Boulon. « Merging control for the hybrid energy storage subsystem of a Fuel-Cell Vehicle ». In *2021 23rd European Conference on Power Electronics and Applications (EPE'21 ECCE Europe)*, 1-8, 2021.

[2] Kammuang-lue, Niti, et Jirawat Boonjun. « Simulation and Comparison on Energy Consumption between Electric and Diesel Buses: Feasibility Study on Electric Rubber-Tire Bus Potential in Chiang Mai ». In *2019 IEEE 10th International Conference on Mechanical and Aerospace Engineering (ICMAE)*, 490-96, 2019.

[3] HCI OFFRE. Extrait de l'offre HDI : Acquisition de véhicules de transport en commun. 2021. [Document interne, confidentiel, non publié].

[4] METROPOLE EUROPEENNE DE LILLE, CCTP – Annexe 1 : Simulations du véhicule électrique, 2021, [Document interne, confidentiel, non publié].

[5] https://cdn.karsan.com/Delivery/Public/File/e-ATAK_Brochure_FR.pdf .

[6] Bilan carbone de l'Université de Lille en 2020, rapport interne, 2020.

[7] https://urlr.me/sY4j3c