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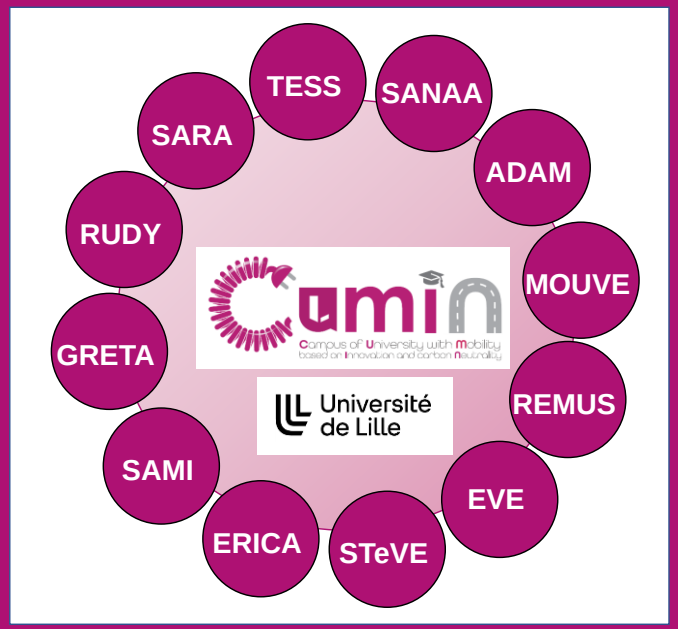
Scalable simulation framework for electric vehicles



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L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille · TVES · LaMCUBE Laboratoire de mécanique, multiphysique, multiéchelle · CLERSÉ · LILLE · Gériico · MEL MÉTROPOLE EUROPÉENNE DE LILLE

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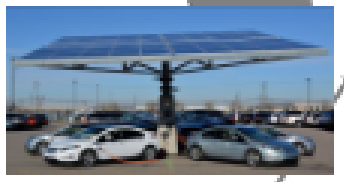
Outline

1. Context
2. Scalable simulation tool for different EV based-on EMR
3. Conclusion

Scalable electrified powertrains for eco-campus

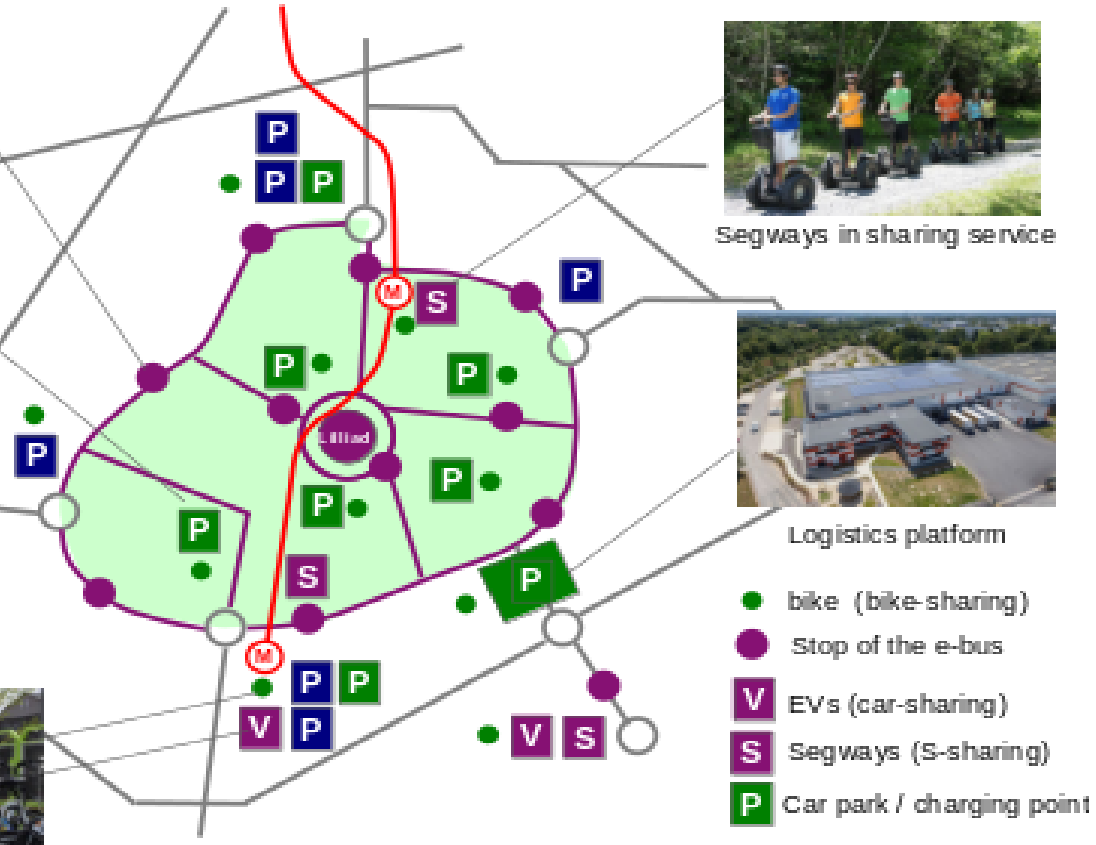
- Need for fast energy consumption assessment of different solutions

autonomous electric bus



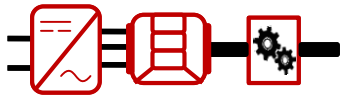
Car park with PV charging stations

Light EVs, e-bikes, bikes, In sharing service

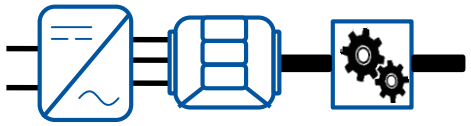


Segways in sharing service

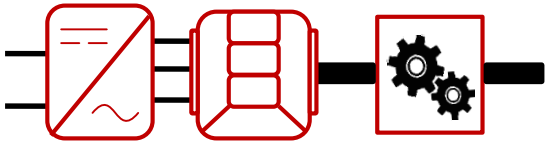
Logistics platform



Downscaling



Reference electric axle



Upscaling

- Objective: Develop a simulation tool for transferring/scaling the design solutions of a reference component to promptly derive others

Case study: scaling of an e-axle of a passenger car

Affordable version
Limited performances

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Sporty version
Improved performances

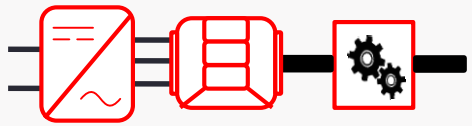
Downscaling

54 kW

Top speed
Acceleration time 0-100 km/h

Reference e-axle

80 kW

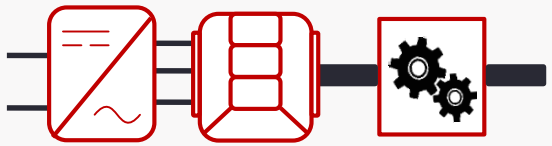


Top speed : 144 km/h

Acceleration time 0-100 km/h: 9.9 s

Upscaling

110 kW

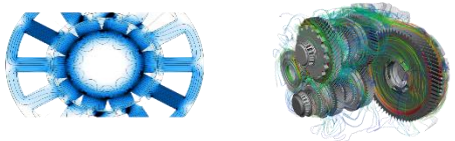


Top speed
Acceleration time 0-100 km/h

Power scaling: 0.67

Power scaling: 1.33

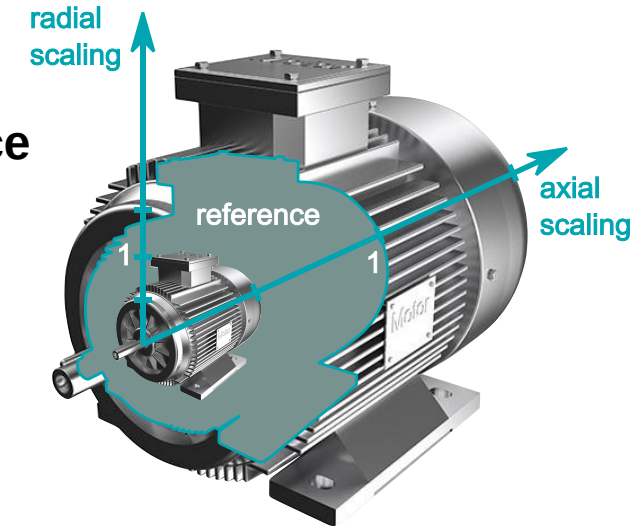
How to achieve this?



Numerical models
Testing results

Data of a reference component

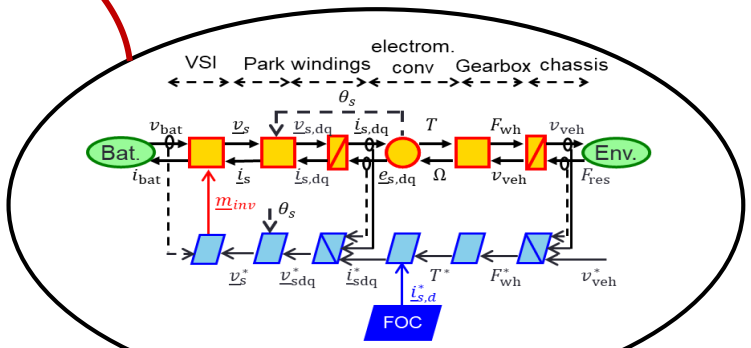
Scaling laws

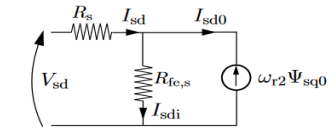


Scaled Data

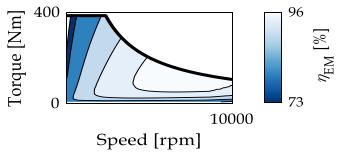
Distinct geometries
Different power rating

System-level simulation
Vehicle model



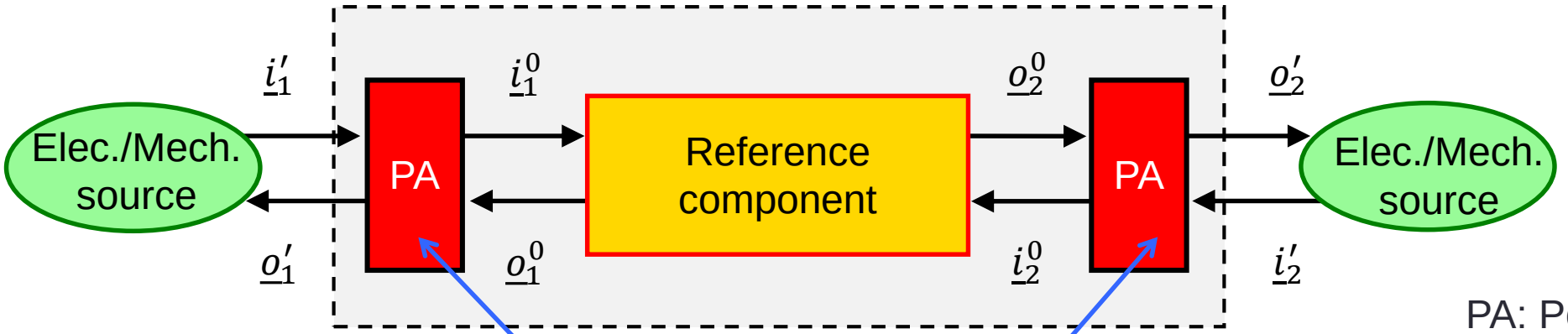


Analytical models



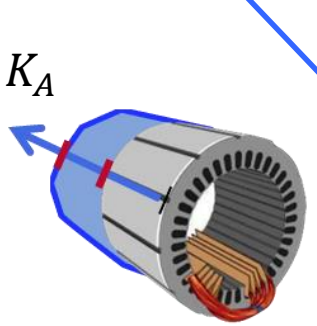
Mapping-based models

New structuration of the scaled components based on scaling laws

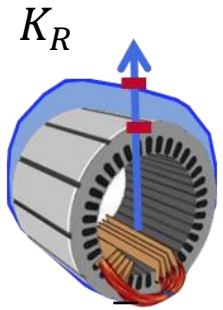


PA: Power Adaptation

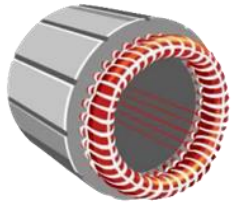
Electric machine scaling



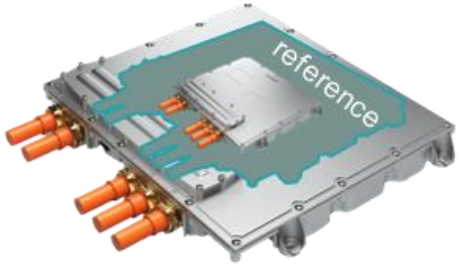
- Axial scaling



- Radial scaling

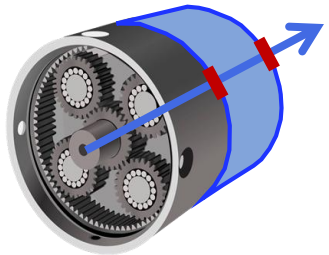


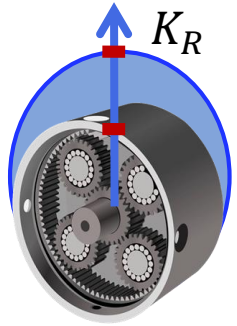
- Rewinding



Inverter scaling

Gearbox scaling

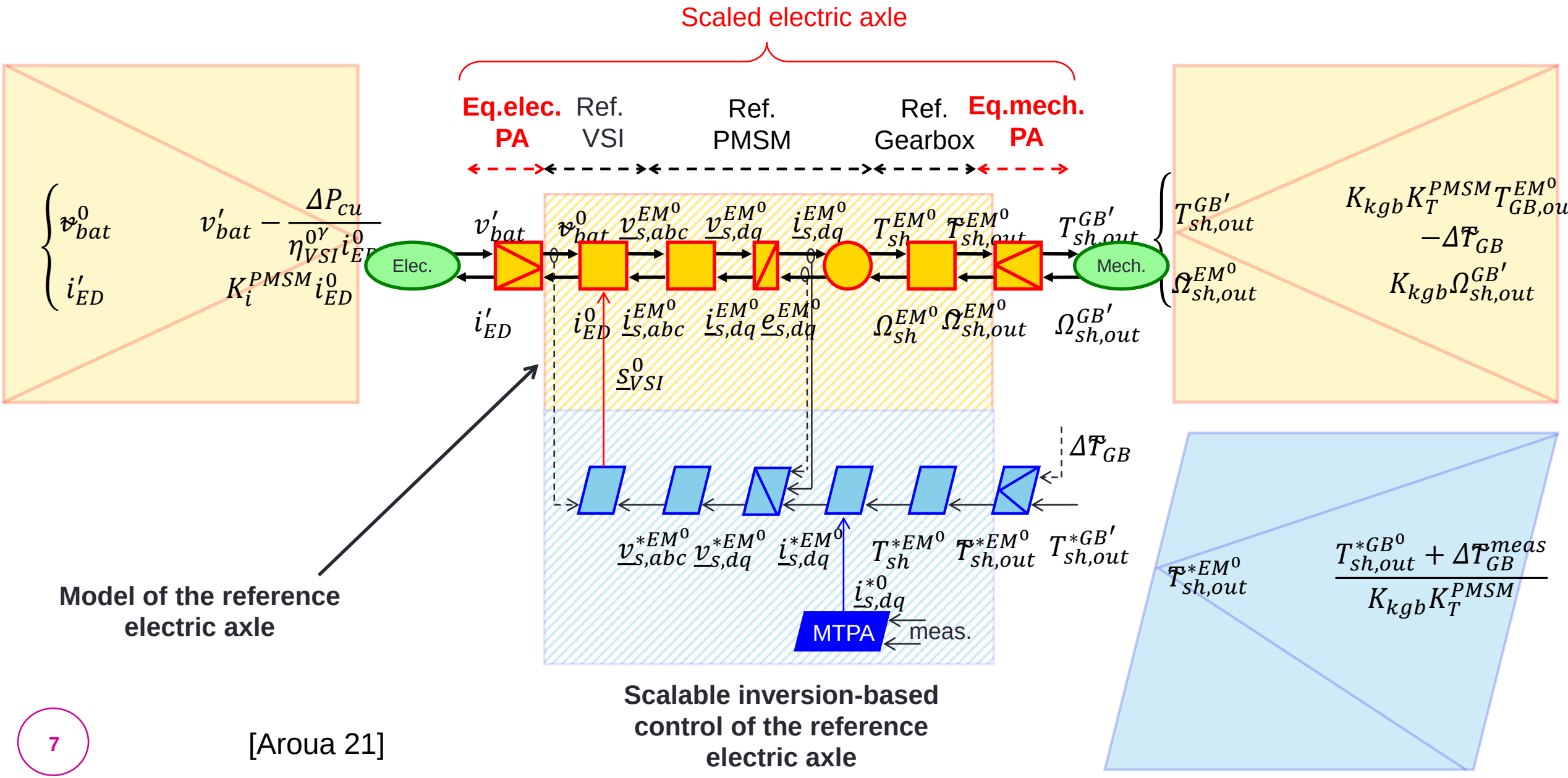




-Gear ratio scaling

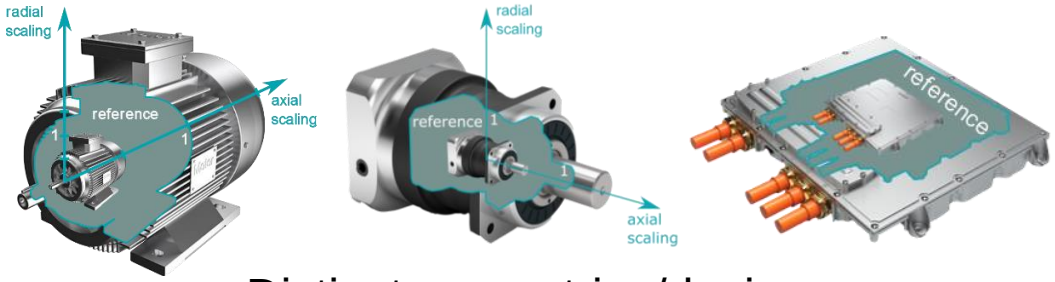
[Lhomme 20]

EMR-based scaling laws of electric axle



[Aroua 21]

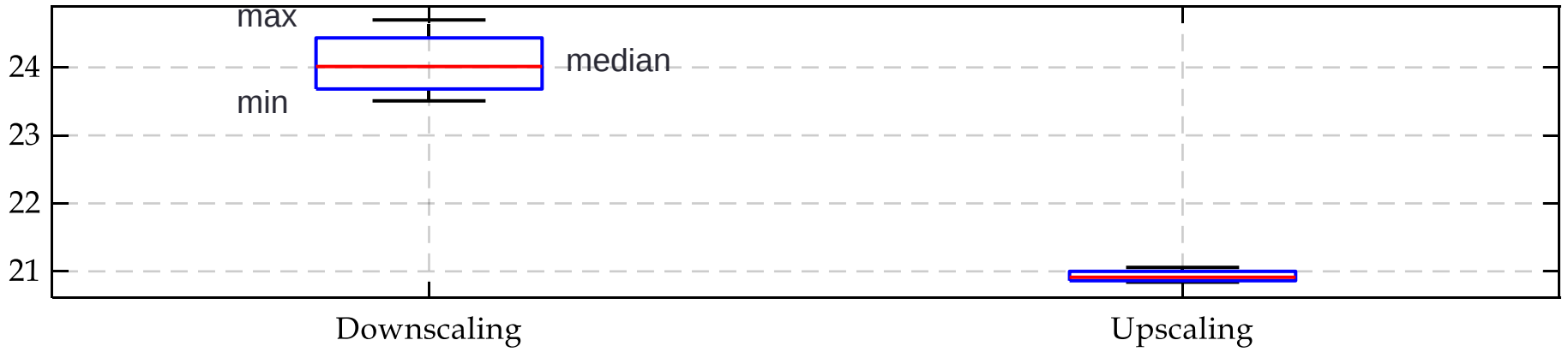
Energy consumption assessment



Distinct geometries/designs

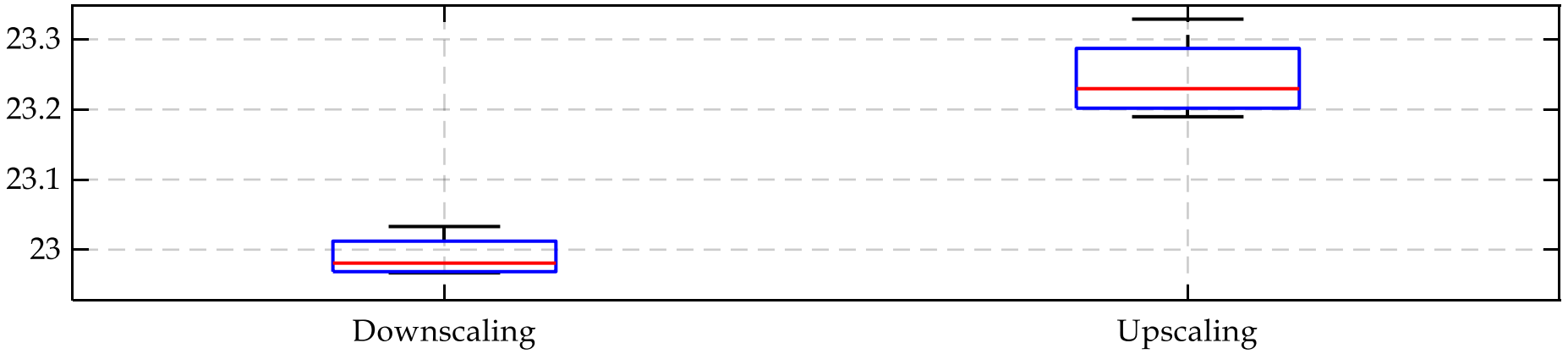
[kWh/100km]

NYCC urban driving cycle



[kWh/100km]

Artemis highway driving cycle



Conclusion

- Scalable simulation framework to analyze the performance of a broad range of EV
- New organization of the scaling laws
- Ease of incorporation of scalability to speed up the system-level simulations

➢ Perspectives:

  - Investigation of the impact of light and lower-power rated vehicles on the energy consumption

References

[Aroua 21]: Aroua, A., Lhomme, W., Verbelen, F., Bouscayrol, A., & Stockman, K. (2021, October). Inversion-based Control of Scaled PMSM for Battery Electric Vehicles. In *2021 IEEE Vehicle Power and Propulsion Conference (VPPC)* (pp. 1-6). IEEE.

[Lhomme 20]: Lhomme, W., Verbelen, F., Ibrahim, M. N., & Stockman, K. (2020, November). Energetic macroscopic representation of scalable PMSM for electric vehicles. In *2020 IEEE Vehicle Power and Propulsion Conference (VPPC)* (pp. 1-6). IEEE.

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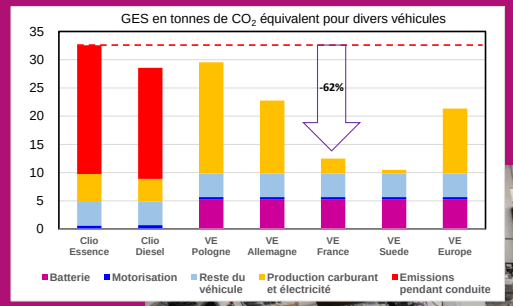

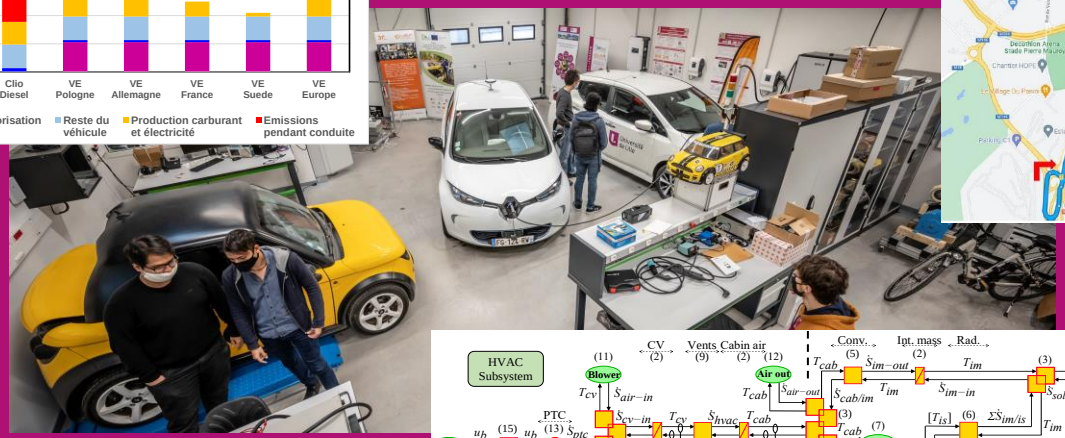

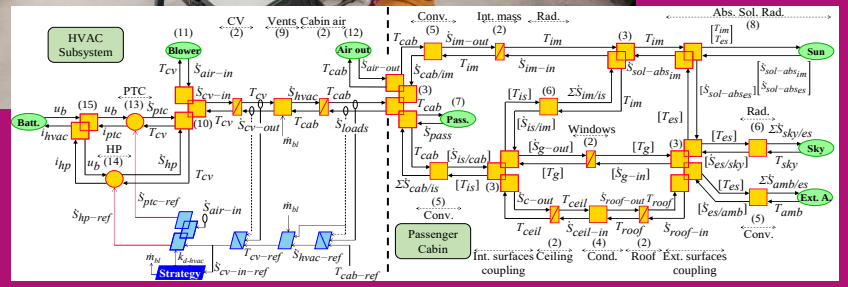

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