«EMR-based Scaling of Batteries»

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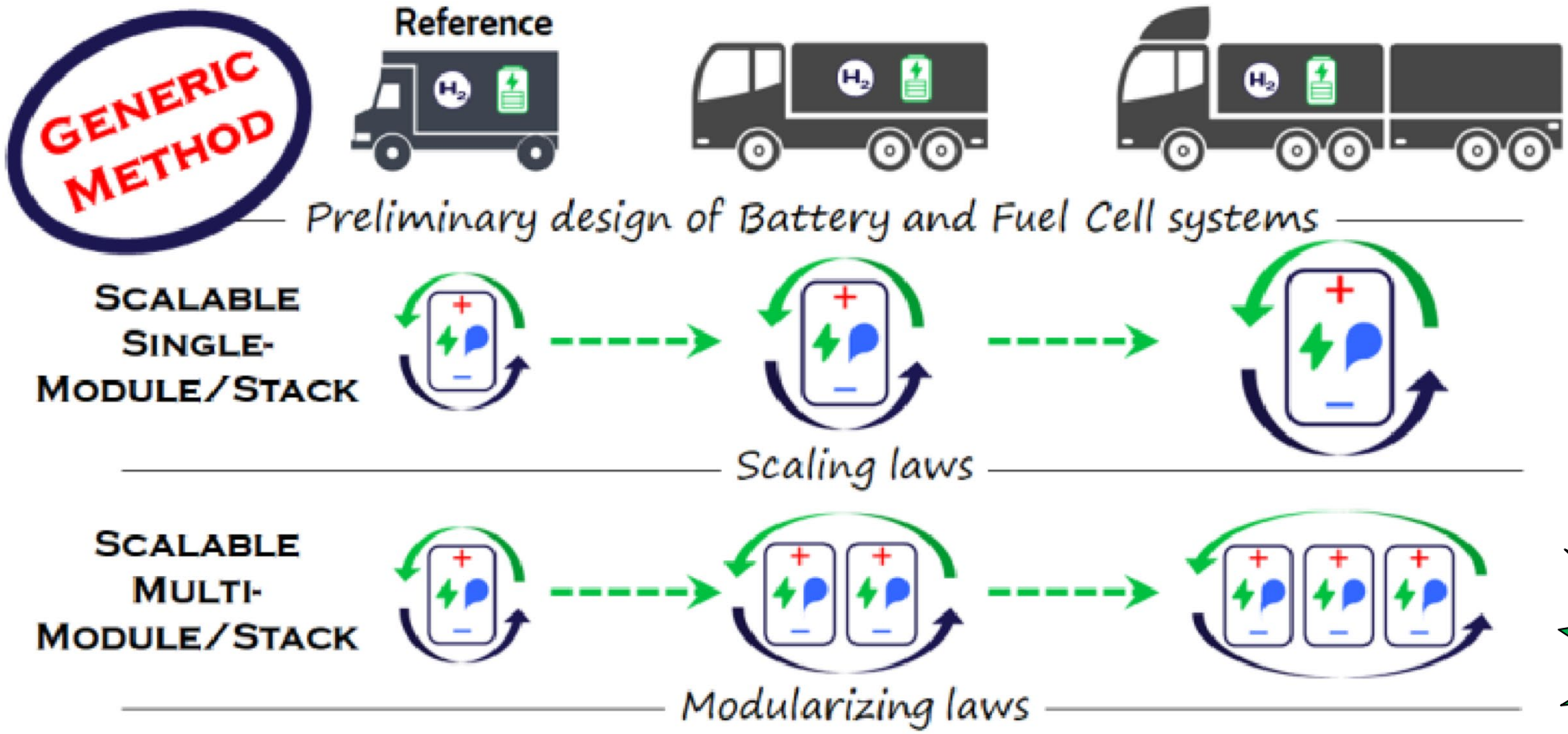
MARSHALL: develop scaling and modularizing laws for HDV batteries or FCs

My work: focus on HDV battery



Different HDV sizes

Different Cell sizes

Different Module sizes

Different Pack sizes

eco-design aspects

- Outline -

1. VECTO and EMR of Battery Heavy-duty vehicle
2. Dynamical electro-thermal model of battery cell
3. Conclusion and Perspective

EMR'25, Lille (France)

«Vehicle Energy Consumption calculation TOol (VECTO)
and
EMR of Battery Heavy-duty vehicle»

VECTO overview

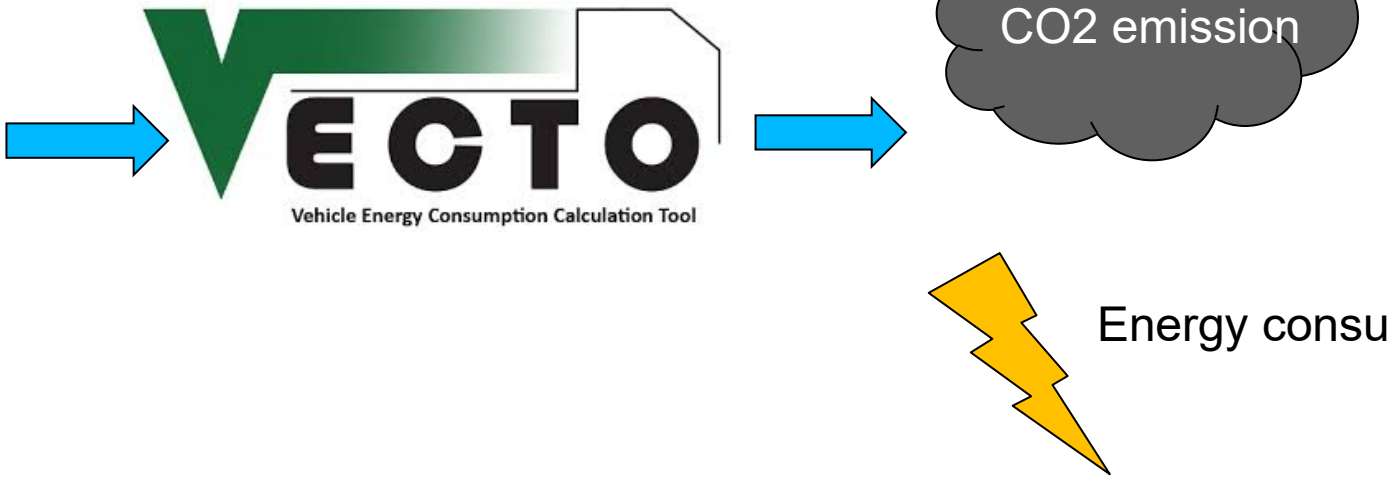
- Simulation tool deployed by the European Commission
- Used to determine CO_2 Emissions and Energy Consumption of HDV

Trucks

Coaches

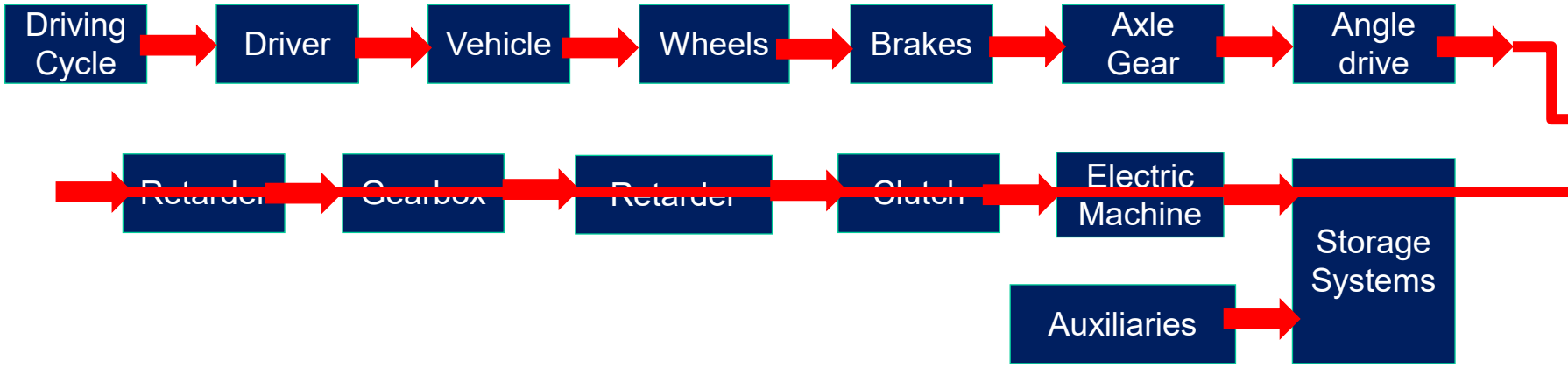
Buses

Gross Vehicle Weight > 3500 kg



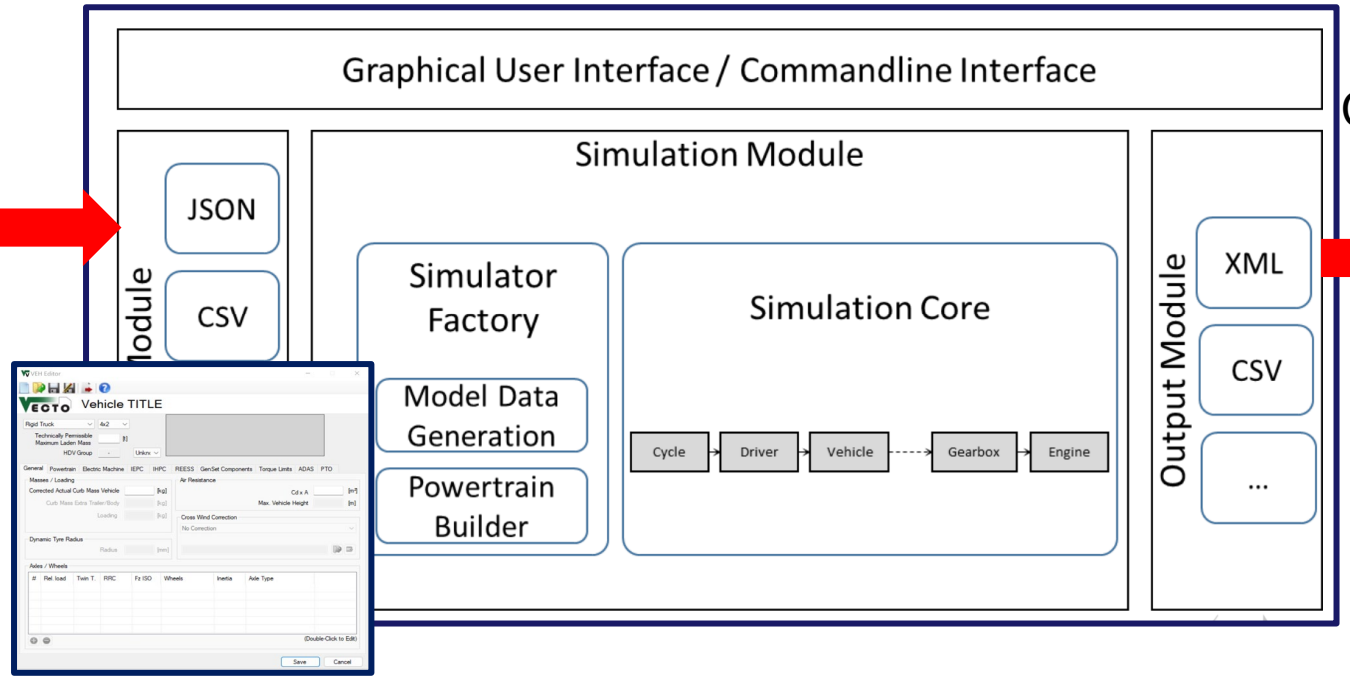
VECTO: A Backward Modeling Approach

- VECTO component model (Backward approach)

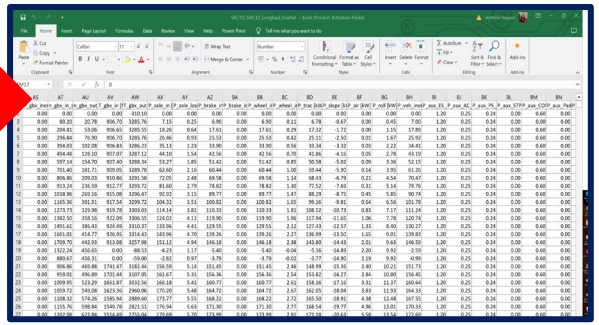


- VECTO Interface

Type of vehicle
Mission profile
Component data
Environment
Vehicle mass
Payload



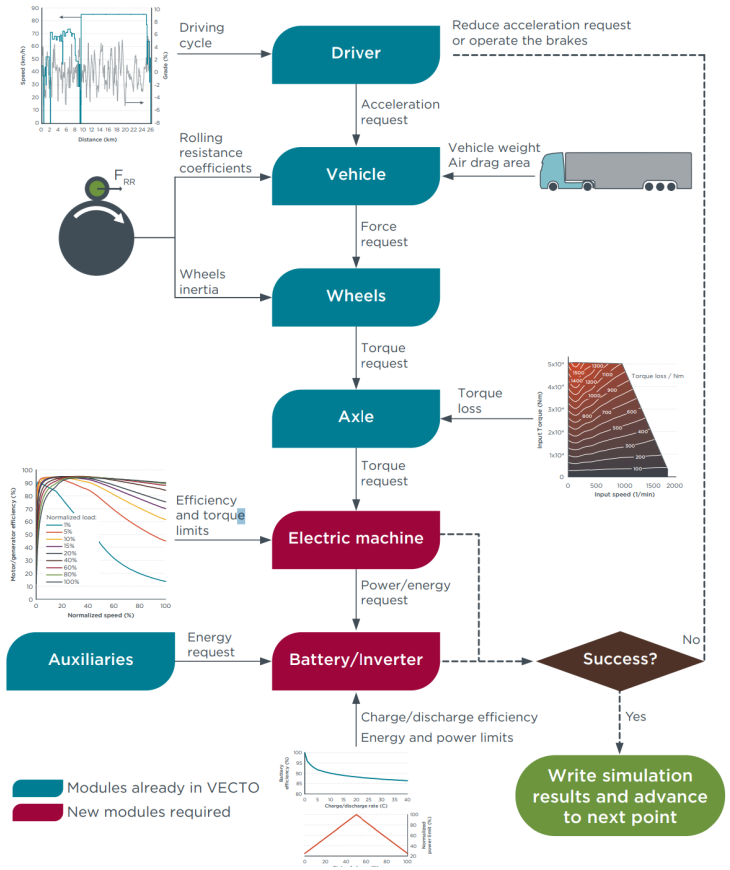
Consumption of all components



[VECTO manual 2025]

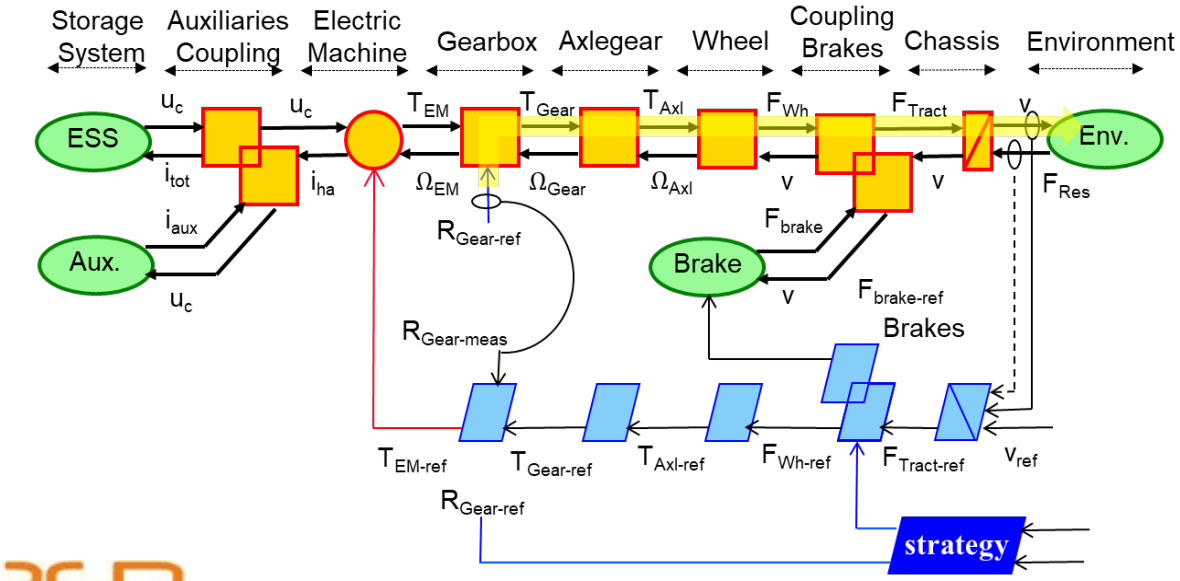
Different options to organize Battery HDV model

Backward

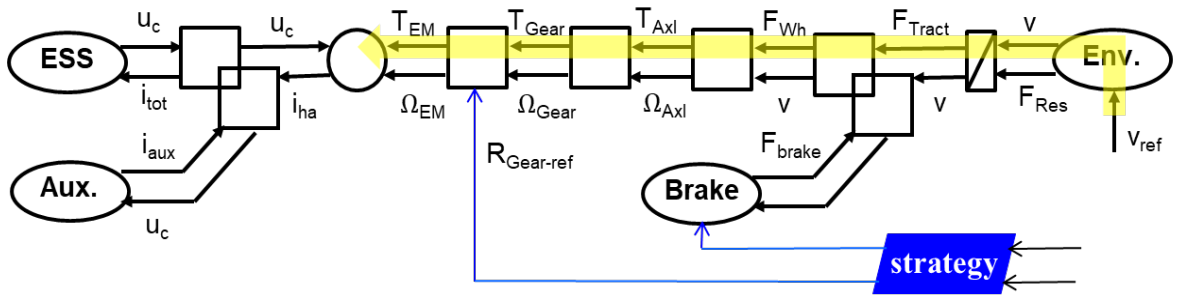


[Rodríguez 2019]

EMR: Forward description



Backward description based on EMR



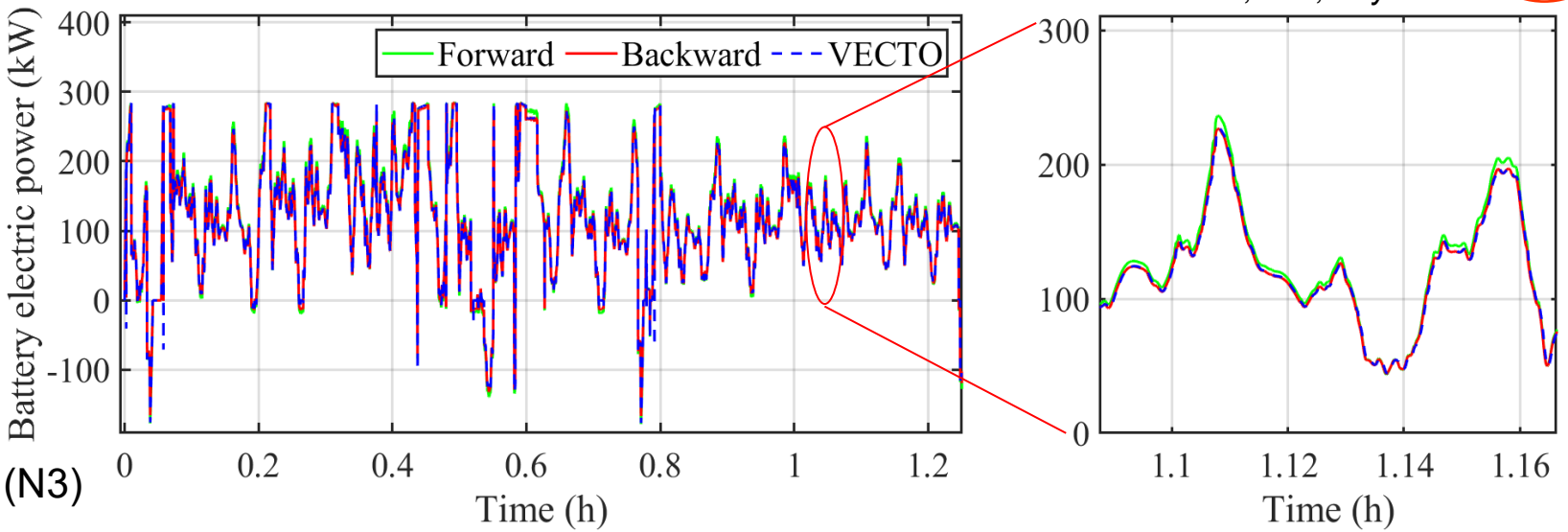
EMR-based Scaling of Batteries

Comparison of 3 representations

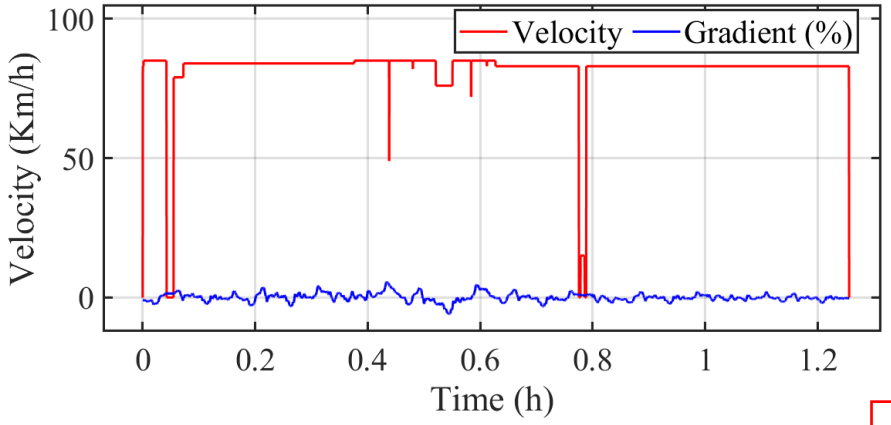
EMR

Backward

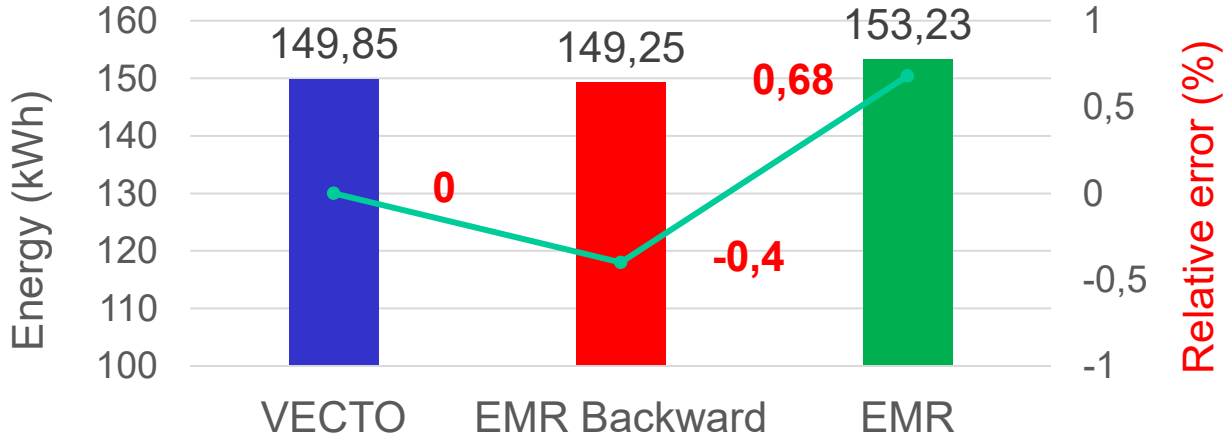
VECTO



Battery Rigid Truck Axle 4x2 (N3)



Long-haul profile mission



⇨ Similar results

⇨ Thermal model battery to be included for MARSHALL

«DYNAMICAL ELECTRO-THERMAL (E-T) MODEL OF BATTERY CELL»

[German 2020]

EMR-based Scaling of Batteries

Methodology

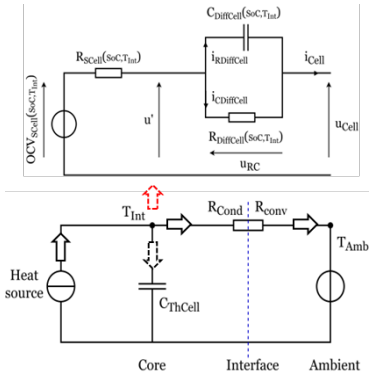
Winston cell

Model:
TSWB-LYP160AHA

Nominal Capacity:
160Ah

Operation Voltage:
2.8 – 3.8 V

Operation Temperature:
- 45°C – 85°C



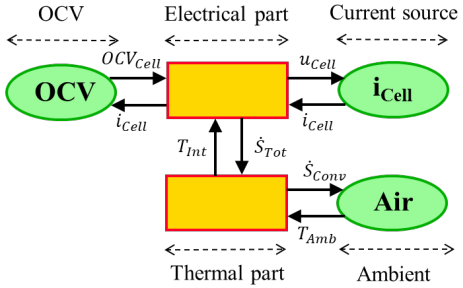
Modeling

Model type:
Equivalent Electrical Circuit (grey-box)

Electrical model:
Thevenin 1 RC

Thermal model:
Model RC

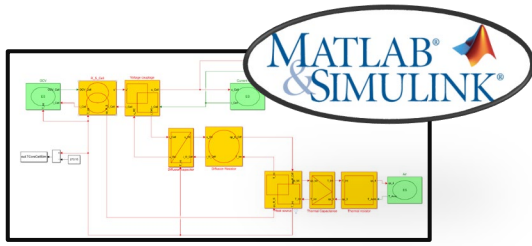
Coupling dynamical electrical - thermal model



EMR

Representation coupling dynamical electrical - thermal model

Representation electrical parameters = $f(SoC, T_{Int})$

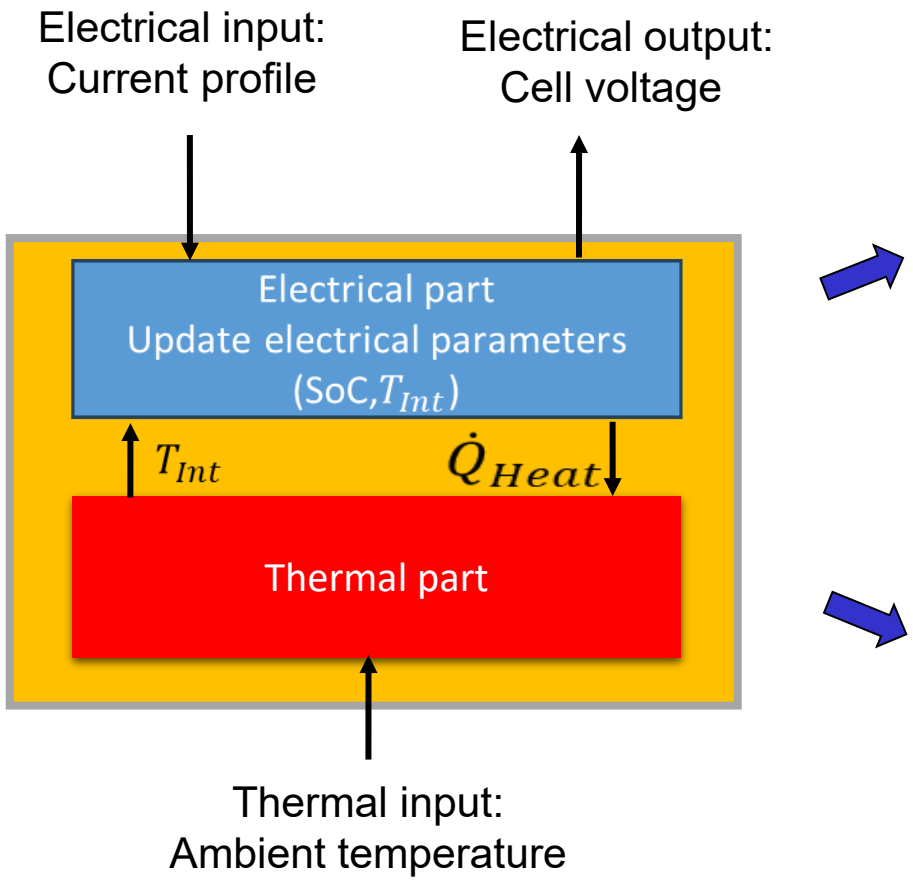


Simulation

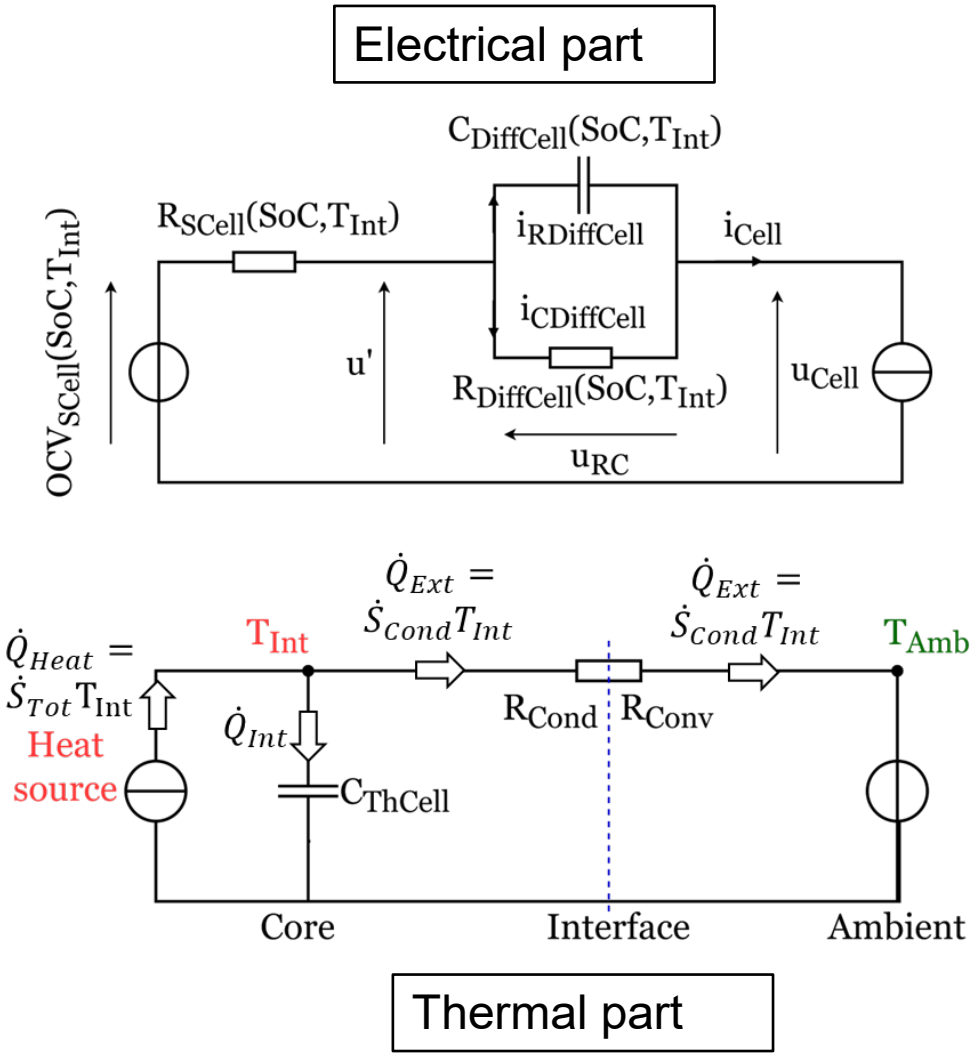
Model validation:
Using a real driving cycle and
Comparison under various temperature conditions.

winston-battery.com

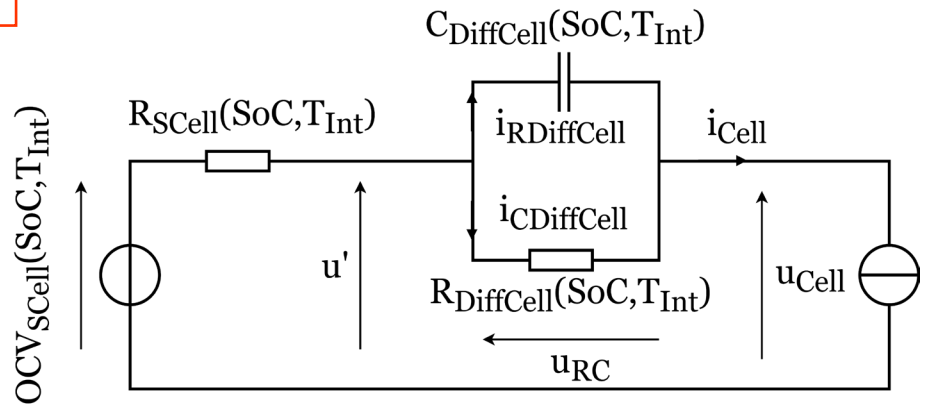
❑ Principle interaction of one cell

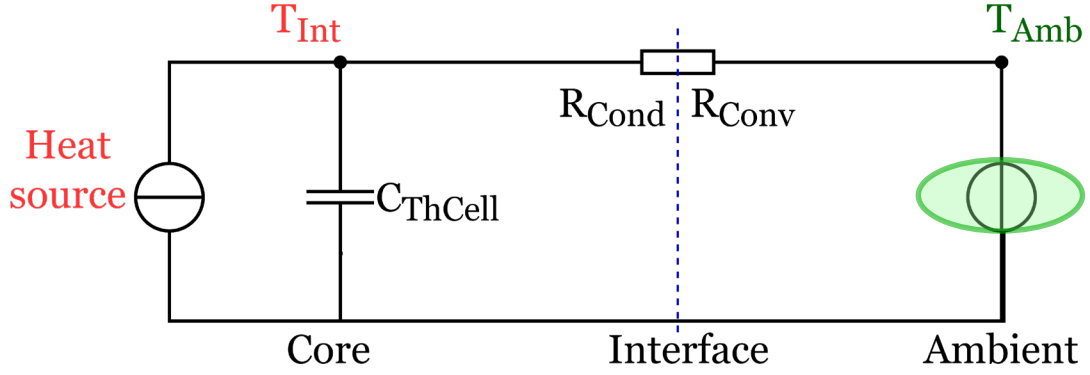


❑ Equivalent Electrical Circuit



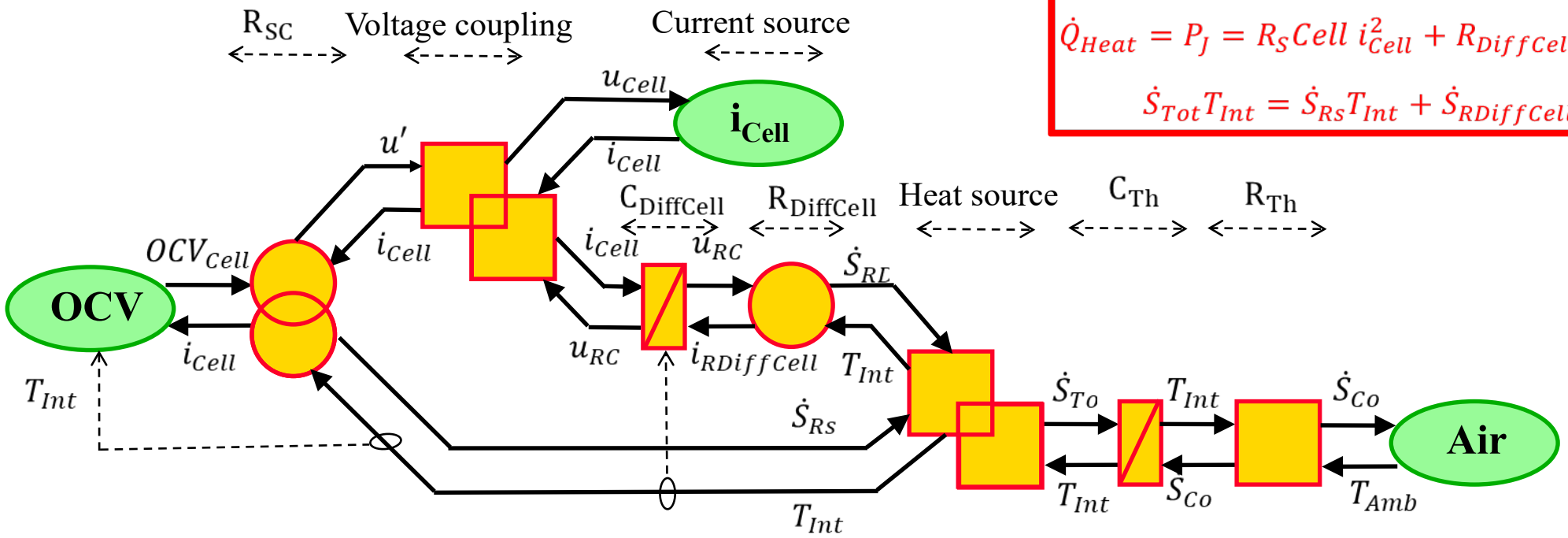
EMR of Dynamical E-T Model





$$\dot{Q}_{Heat} = P_J = R_S Cell\, i_{Cell}^2 + R_{DiffCell} i_{RDiffCell}^2$$

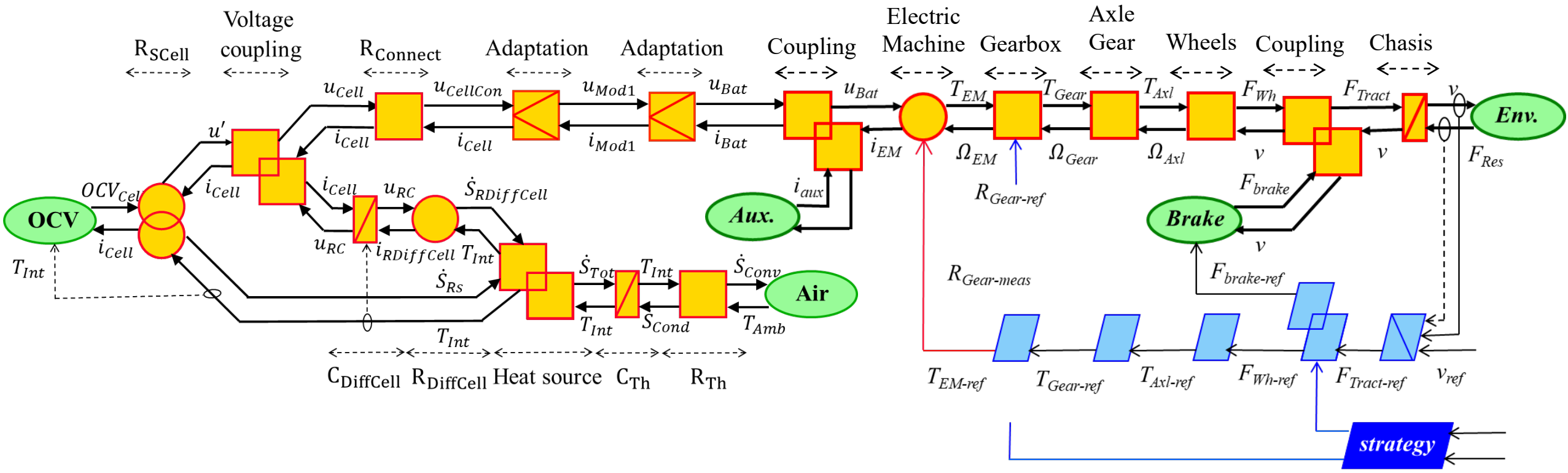
$$\dot{S}_{Tot} T_{Int} = \dot{S}_{Rs} T_{Int} + \dot{S}_{RDiffCell} T_{Int}$$



Coupling electro-thermal battery model and traction model

Integration of electro-thermal cell model into the HDV model

Cell electro-thermal model ⇨ Busbar ⇨ Module ⇨ Battery Pack ⇨ Traction electro-mechanical model of HDV model



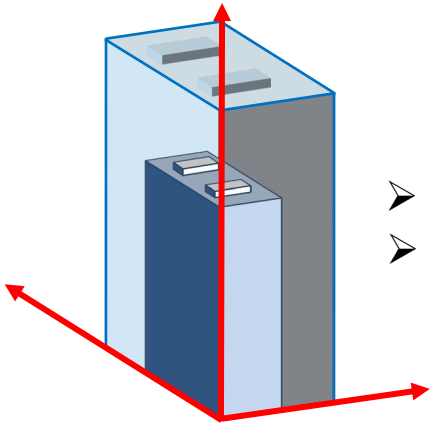
to be achieved…

« CONCLUSION AND PERSPECTIVE»

Conclusion

- Simulation and comparison of 3 representations HDV (VECTO, EMR, EMR Backward)
- EMR facilitates the representation of interconnected multi-physics for electro-thermal model
- Integration of a dynamic electro-thermal battery model into the HDV model

Scaled-up cell



Reference cell

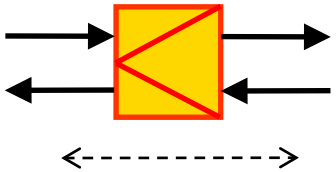
Simulation and comparison with reel cell

- Same material
- Same process product

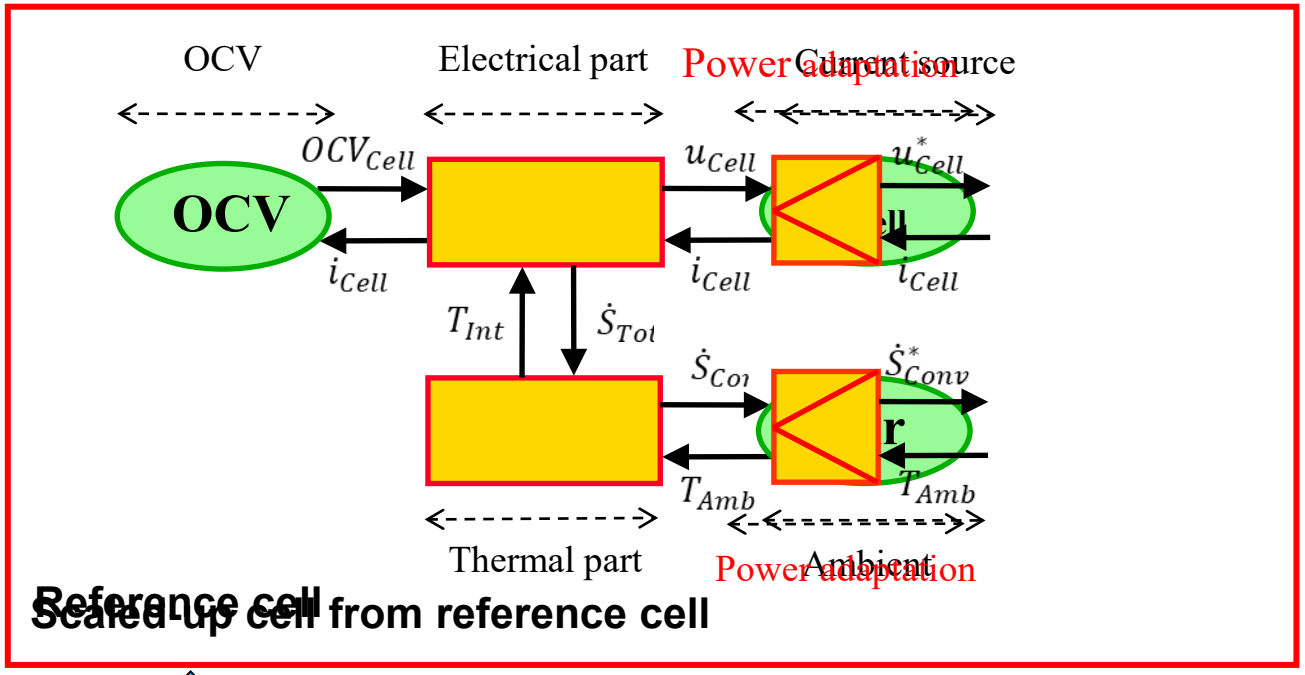
Difference tests

Scaling law

Power and Power loss scaling



Update reference cell model



« Biographies and references »

[German 2020] German, Ronan, Seima Shili, Anatole Desreveaux, Ali Sari, Pascal Venet, and Alain Bouscayrol. 2020. "Dynamical Coupling of a Battery Electro-Thermal Model and the Traction Model of an EV for Driving Range Simulation." IEEE Transactions on Vehicular Technology 69 (1): 328–37. https://doi.org/10.1109/TVT.2019.2955856.).

[Rodríguez 2019] Rodríguez, Felipe, and Oscar Delgado. 2019. "The Future of VECTO: CO2 Certification of Advanced Heavy-Duty Vehicles in the European Union." International Council on Clean Transportation, October.

[VECTO manual 2025] "VECTO Sim · Wiki · VECTO · GitLab." 2025. GitLab. June 5, 2025. https://code.europa.eu/groups/vecto/-/wikis/vecto-sim.

Thanks for your attention !