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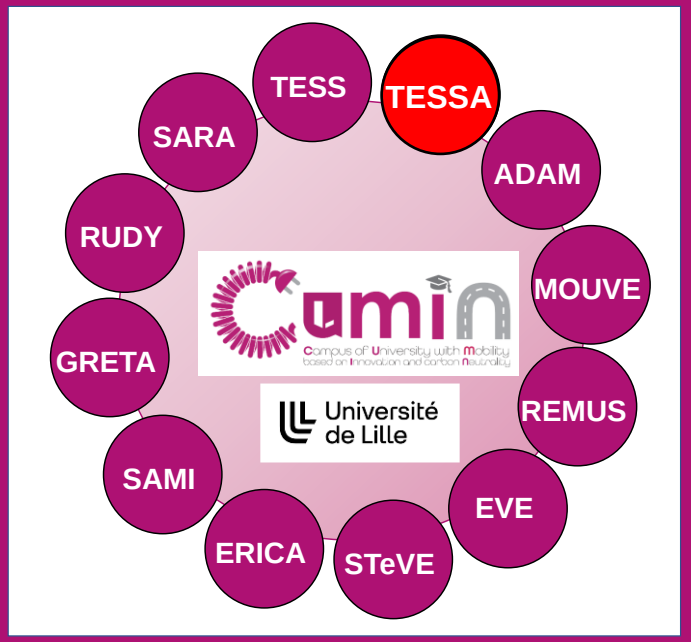


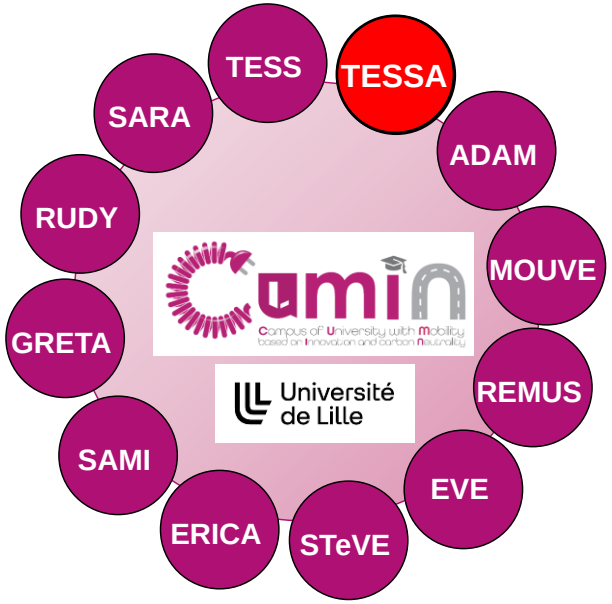
Study of an EV Driving Range Evolution Considering Battery Capacity Degradation

Martin Chaud, Ronan German, Margot Gaetani-Liseo, Clément Mayet, Alain Bouscayrol

Outline

1. Context and objective
2. Modeling of the studied EV
3. Ageing modeling
4. Simulation results and conclusion

Context and objective



TESSA: Electric Vehicle, Estimation of mobility energy for an eco-campus

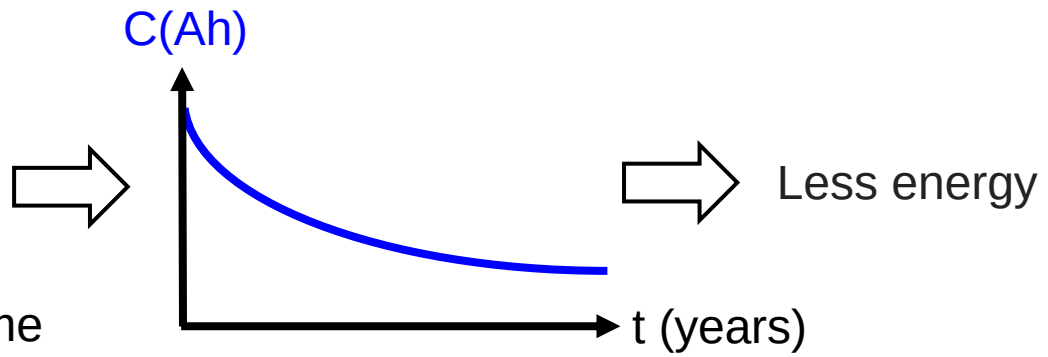
Estimate the value of second life battery for different scenarios

Methodology : Merge technical and economical models

Economically : Driving range has an impact on the battery value

We know that

- EV performance depend on the batteries
- Batteries undergo performances degradation over time



We want to quantify the impact of ageing on the driving range

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EV modeling

Studied EV

Nissan Leaf 2019: Segment C EV

Machine power:
110 kW / 150 hp

Aerodynamism
SCx: 0.77 m²

Driving range:
270 km

Mass: 1,5 tons

Energy:
40 kWh

Mass: 300 kg

Li-ion NMC battery

High sales: ~650 k units sold since 2010

60% of the EVs have NMC batteries

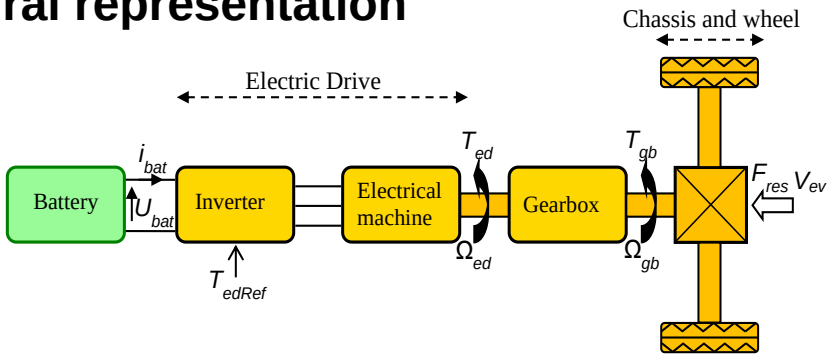
⇨ Study of an common light EV

EV modeling and validation

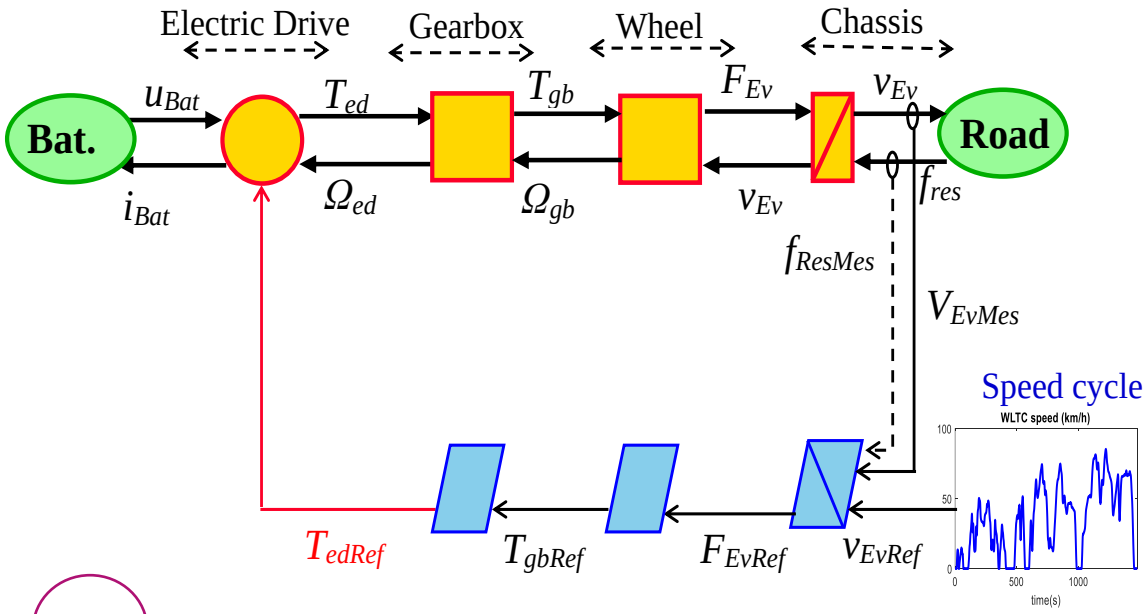
Conditions

- Nissan Leaf
- Input : Speed cycle

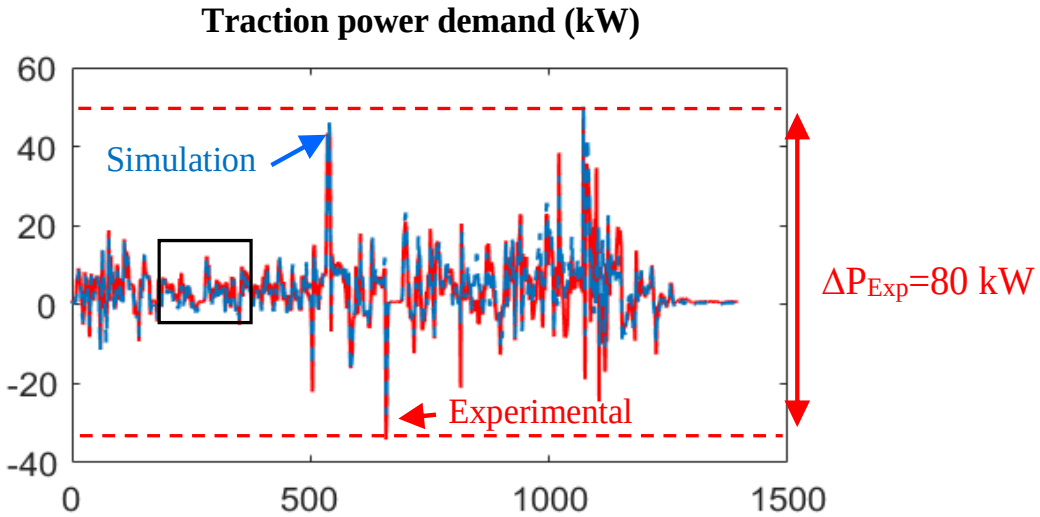
Structural representation



Description in EMR



Validation [Fadili 2022]



1,9 % error on driving range

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Ageing tests and modeling

Methodology for ageing modeling

Classic way

Mathematical model

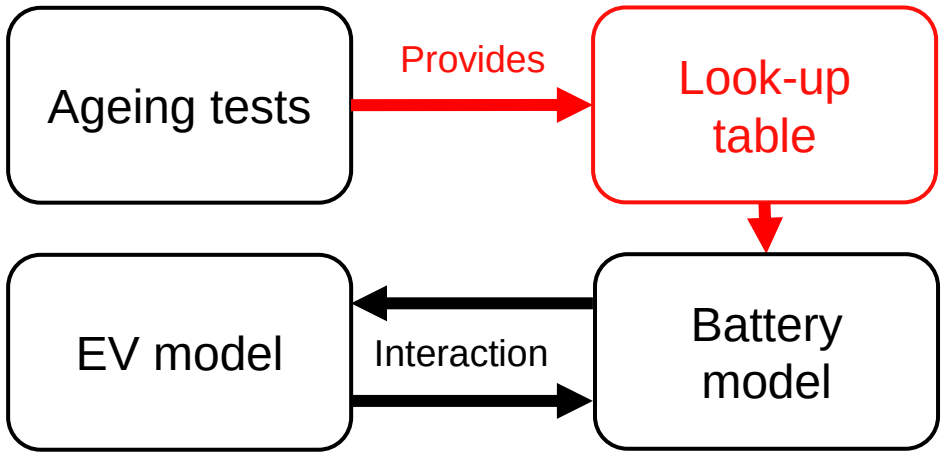
Ex: $C_{Loss} = (A + BSoC)e^{\frac{-Ea}{TK_b}}t^z$

[Ndiaye 2024]

⇨ Complex simulation

Our way

Direct use of data



⇨ The ageing tests directly provides battery parameters

⇨ **Simulation is simplified thanks to this method**

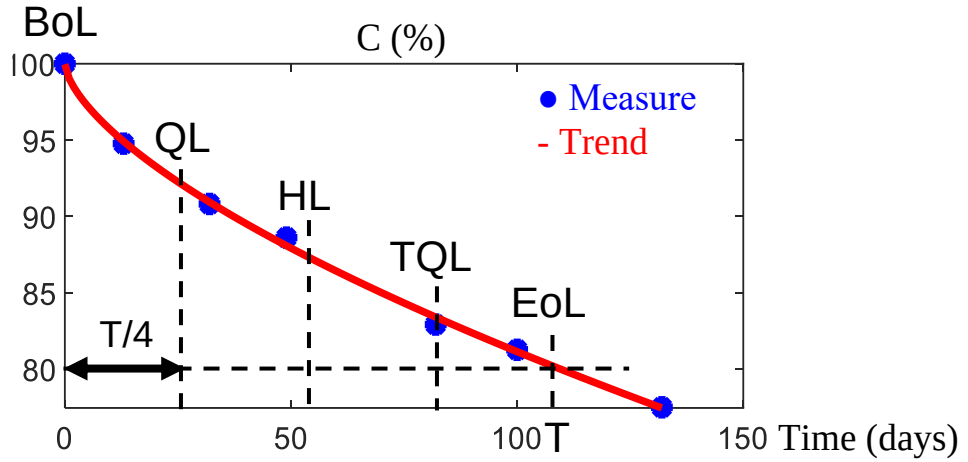
Ageing modeling

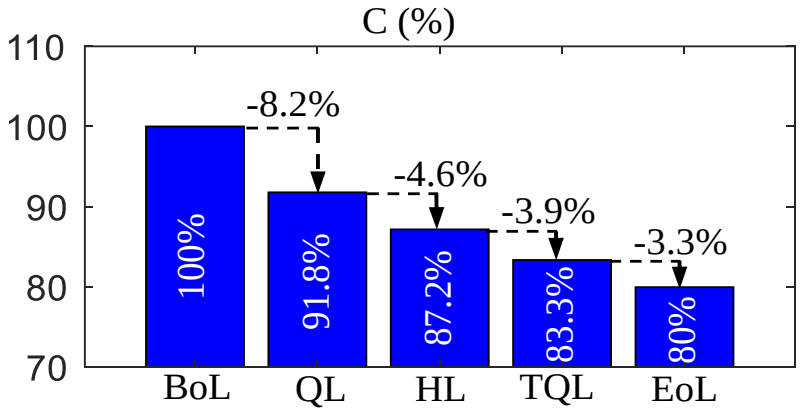
Ageing tests performed for calendar ageing @T=60°C, SoC=100%

End of Life (EoL) at 20% capacity loss

Five different ageing states are defined

Capacity loss faster at the beginning

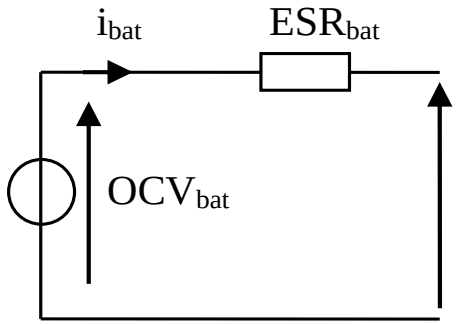




⇨ Integration of the ageing model into the battery

Battery modeling

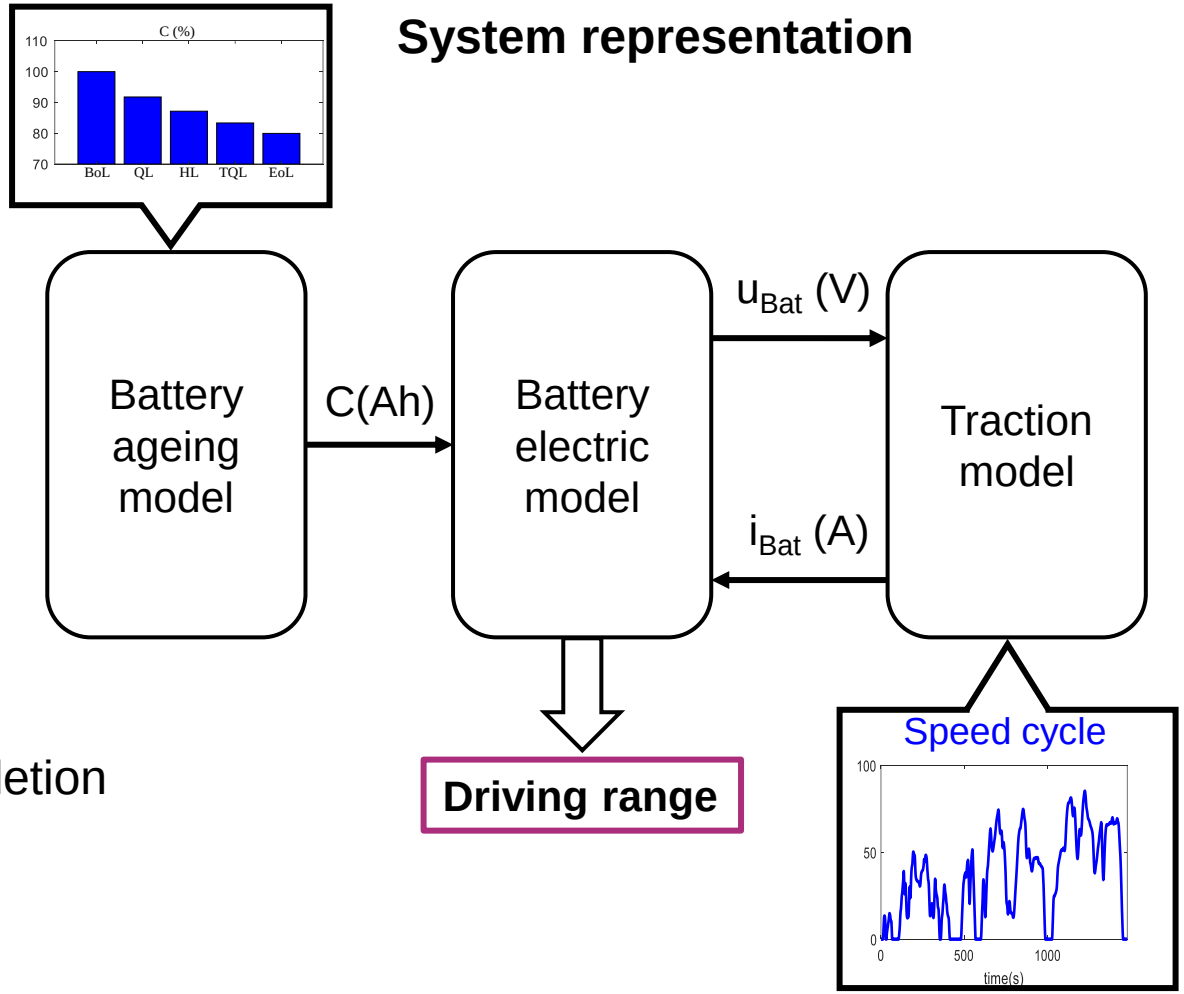
Battery electric model



[Ramsey 2020]

Constant Equivalent Series Resistance (ESR)

System representation



Simulation performed for each ageing state until energy depletion

⇨ Models interacts with each other

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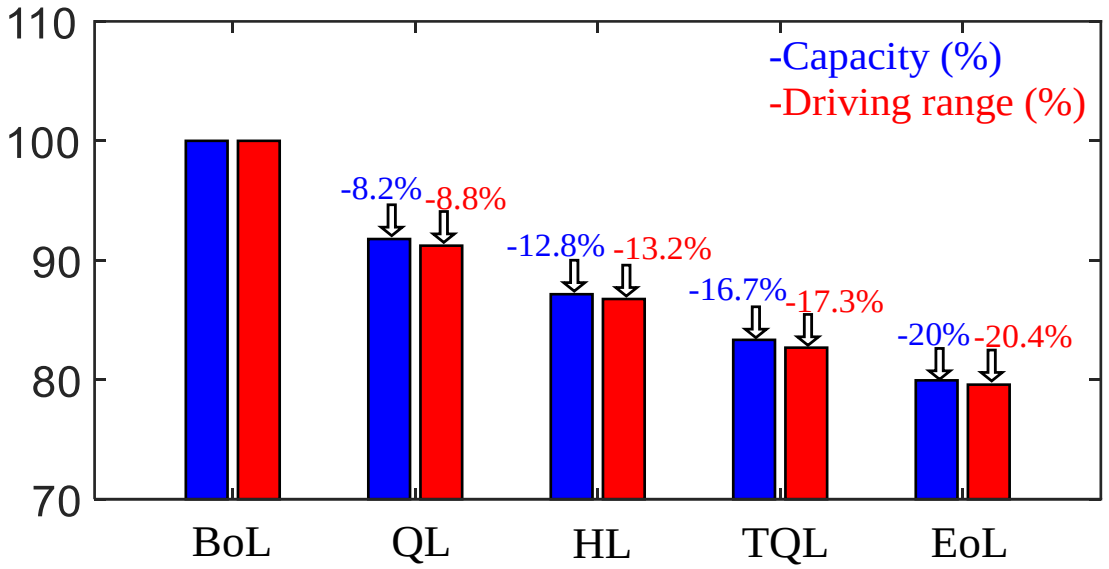
Simulation results and conclusion

Simulation results

Capacity degradation faster at the beginning of life

Driving range loss ≈ capacity degradation (2% difference)



⇨ The supplementary consumption does not cause large driving range losses

Conclusion

- Ageing tests are done for the cells of the Nissan Leaf
- The first years of use are the most detrimental for the vehicle
- Results almost shows a proportionality between capacity and driving range decrease (2% difference)

Perspectives

- Extension to other vehicles and condition (temperature, speed cycles…)
- The resistance evolution with ageing will be taken into account
- The results will be used in future work in the TESSA project

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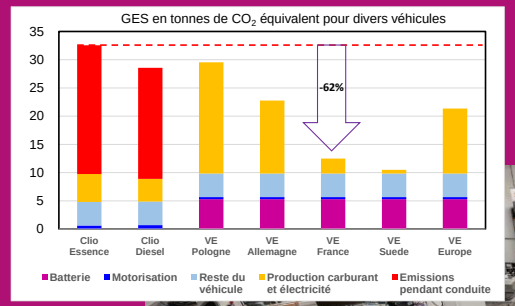

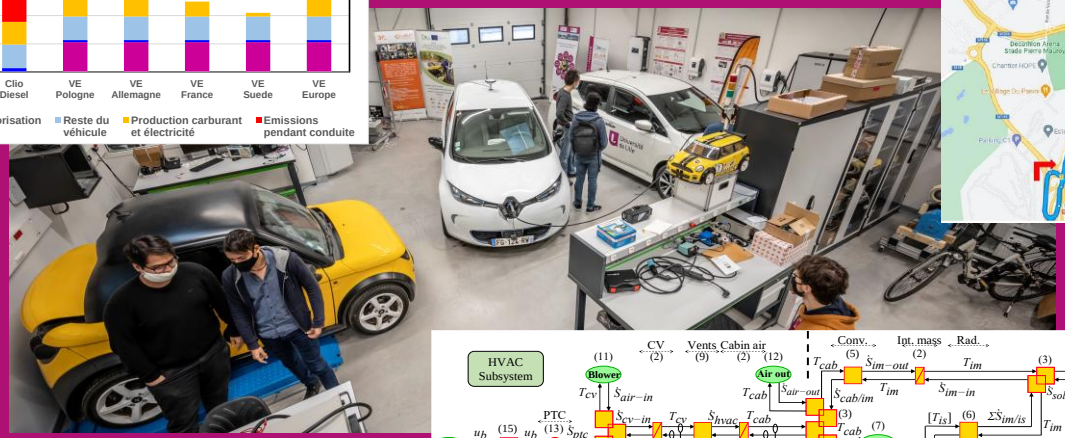

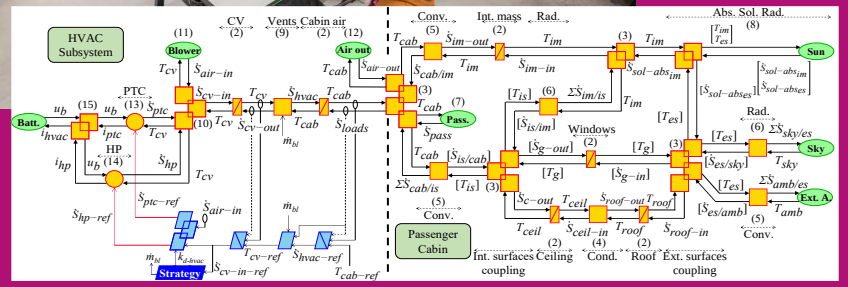

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