Simulation for product development

Application to thermal management field

Volvo Group

Volvo Group Trucks Technology | Vehicle Engineering & Chassis & Vehicle Dynamics Engineering | Powertrain Installation | Kamilia Barthoux

27/06/2024

Summury

Volvo Group presentation

Thermal management system

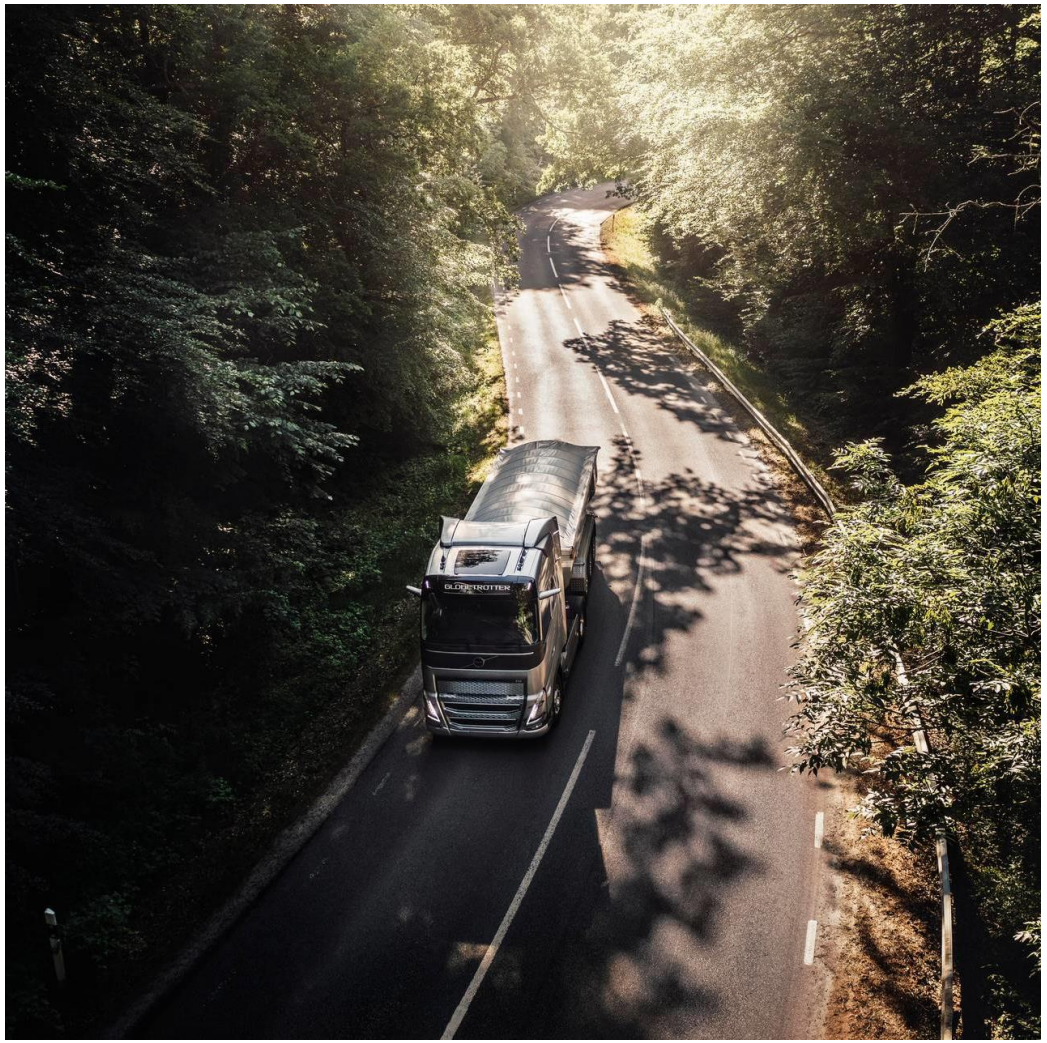
1D simulation for ICE cooling system optimization

1D simulations for BEV cooling system development

1D simulation for cab heating optimization

Real word data integration

Conclusion



What we do

Volvo Group offers trucks, buses, construction equipment, power solutions for marine and industrial applications, financing and services that increase our customers' uptime and productivity.

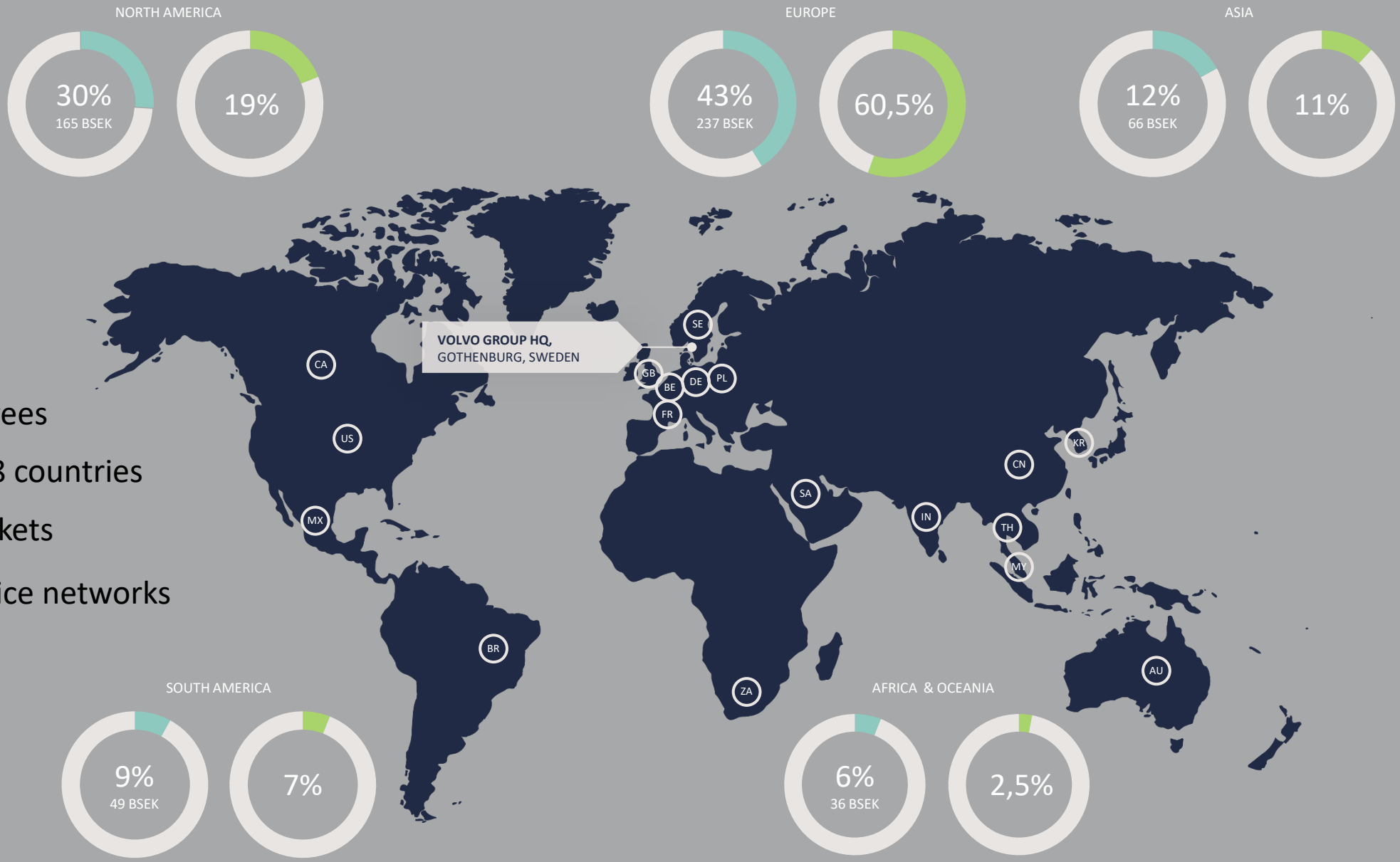
We develop and offer electrified and autonomous solutions for the benefit of customers, society and for the environment.

Our brands

Volvo Group's brand portfolio consists of several distinct brands, targeting a variety of customers and segments.

Global presence

- 104,000 employees
- Production in 18 countries
- Almost 190 markets
- Worldwide service networks and dealerships



VOLVO

100% fossil free Volvo Group vehicles from 2040

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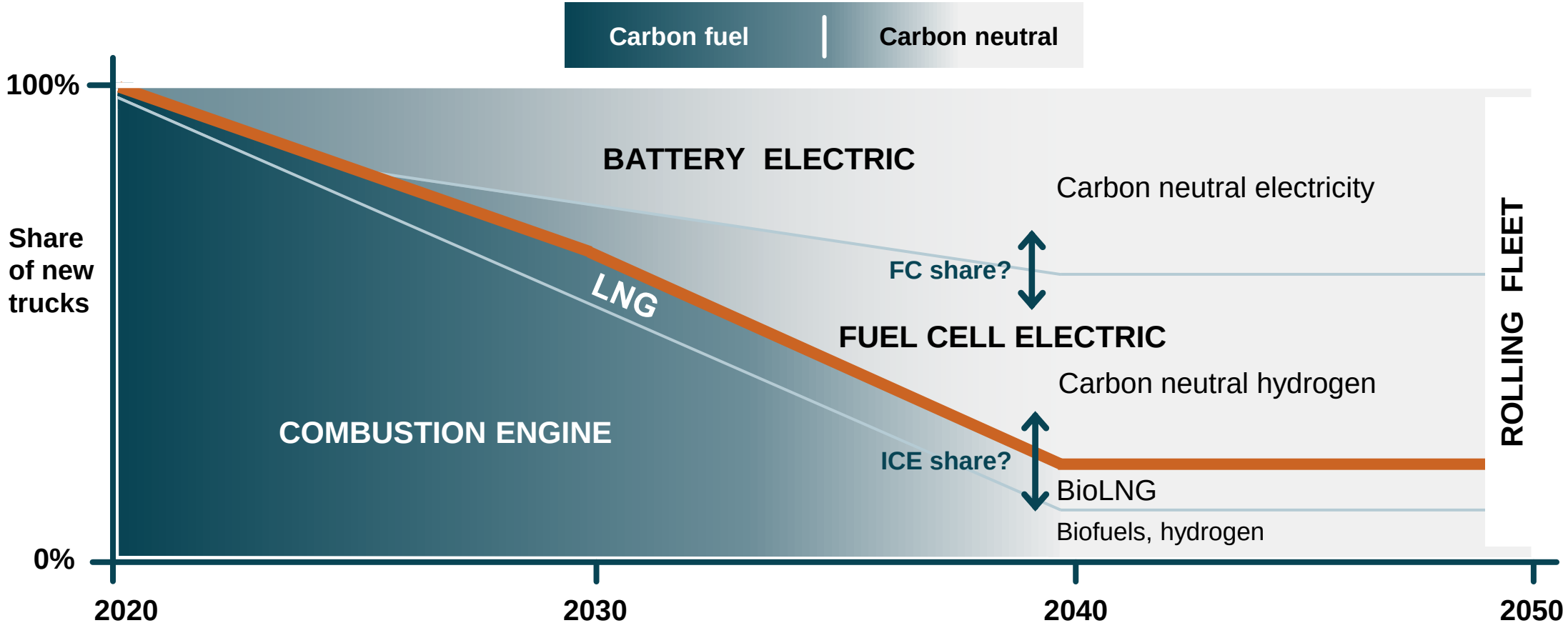
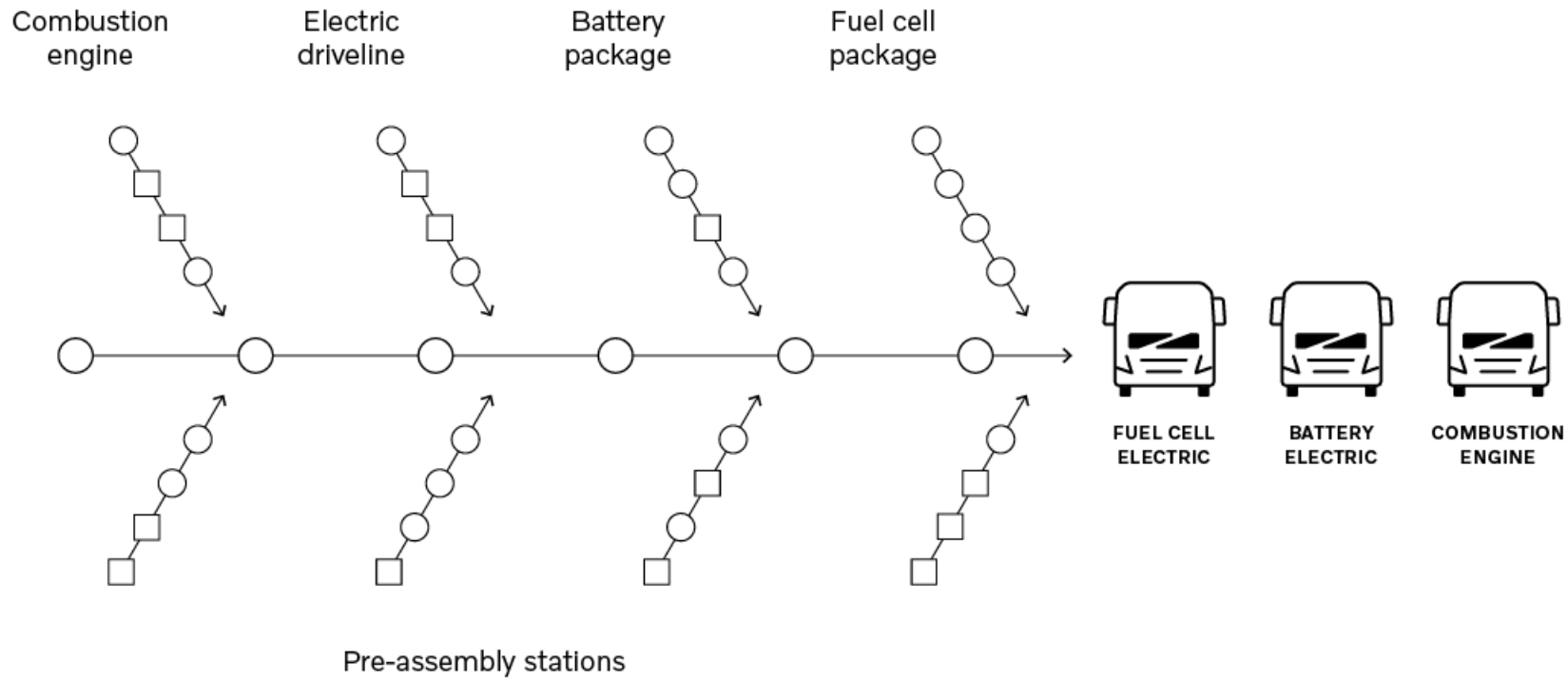


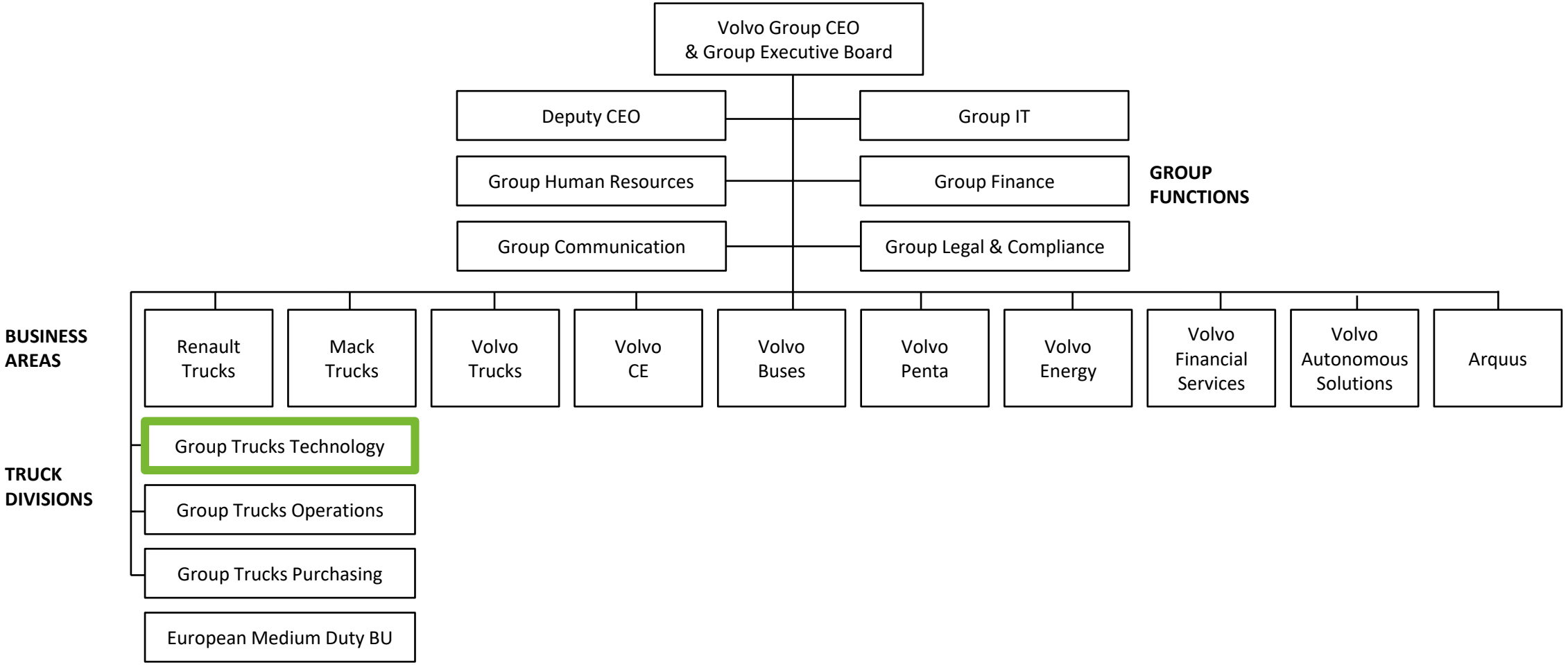
Mixed model assembly

Volvo produces electric trucks on the same lines as its conventional trucks, which gives high production flexibility and efficiency gains.



Complete solutions

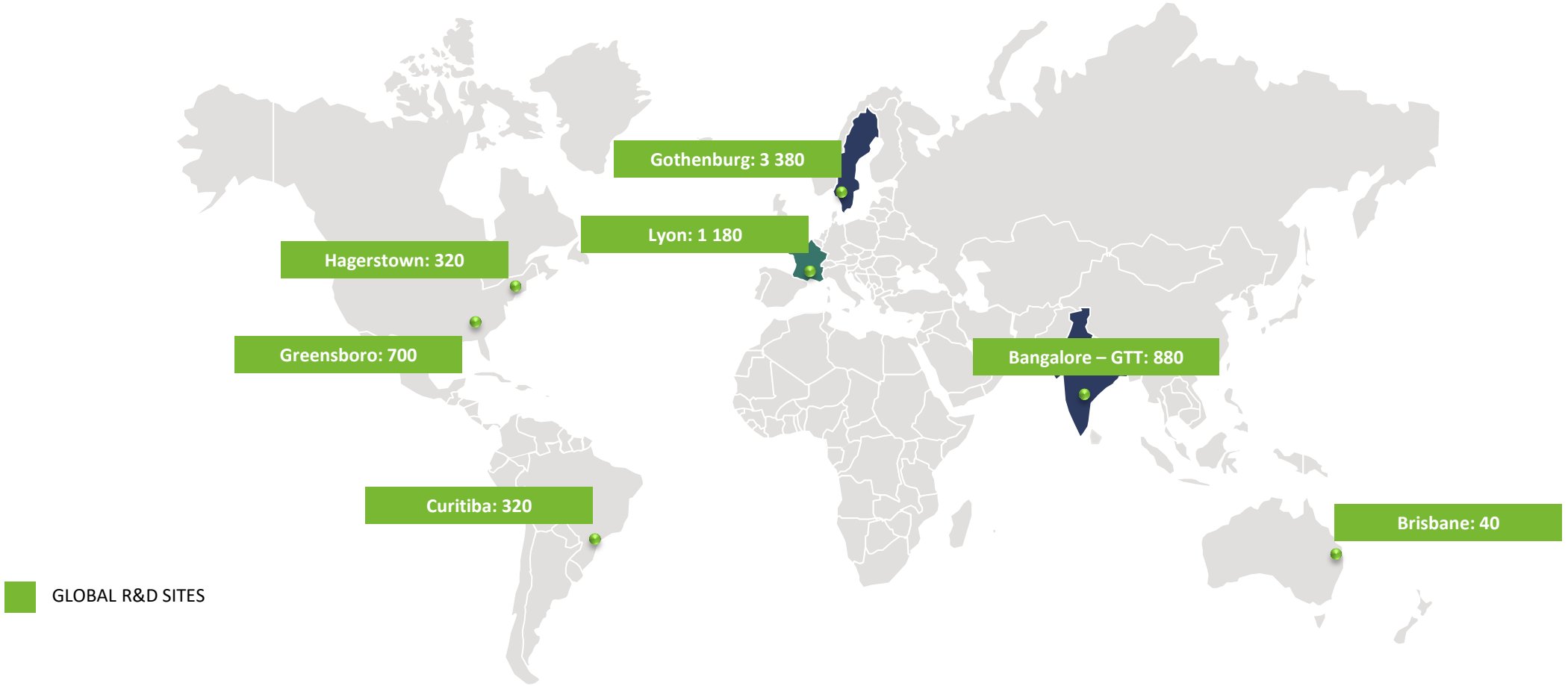
Volvo Group organization



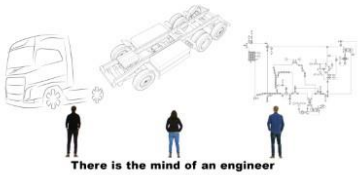
Volvo Group Trucks Technology

Global cooperation in our R&D system

6,820 GTT PROFESSIONALS



GTT’s main organizations



VEHICLE ENGINEERING

Vehicle Engineering are responsible for the integration and development of technologies into a complete truck for all brands within the Volvo Group.

We offer integrated solutions to our customers, and we are dedicated to high quality and competitive time to market.

VEHICLE TECHNOLOGY

Vehicle Technology provide innovative, safe and driver friendly solutions.

Our solutions are based on optimized mechanics, electronics & software, exceeding our customers’ expectations regarding vehicle behavior, uptime, energy consumption and productivity.

POWERTRAIN ENGINEERING

Powertrain Engineering is developing and maintaining products and product components of the complete driveline.

Powertrain Engineering also include Group Truck Technology’s center of development and expertise for Hydrogen solutions.

COMPLETE VEHICLE

Complete Vehicle translate the soul of the brand to a product message, design the products and services, deliver all truck and component builds, develop niche products and aftermarket solutions and verify and validate the products and services.

ELECTROMOBILITY

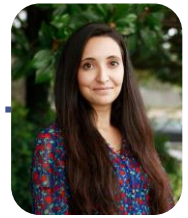
Electromobility are developing the complete electric propulsion system for all Volvo Group truck brands, Volvo Buses, Volvo Construction Equipment and Volvo Penta.

PPSO

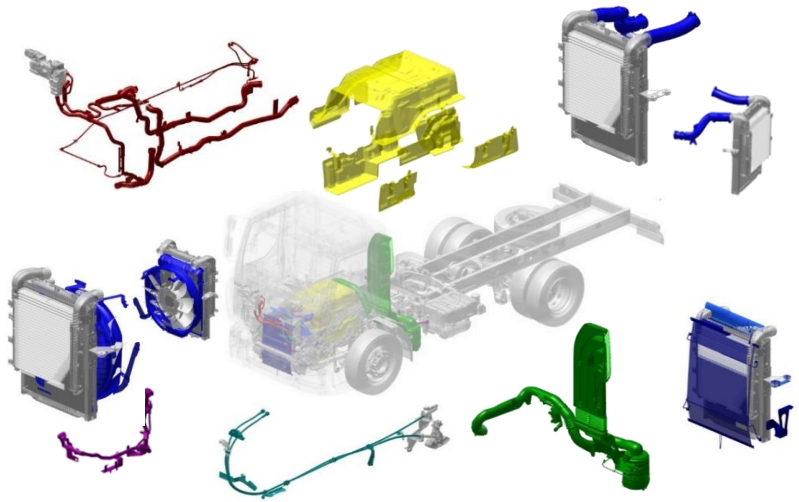
Project & Product Strategy Office (PPSO) are responsible for technology strategies and strategic product planning for the Volvo Group as well as for project management of product change introductions (Intro Blocks).

GTT – Vehicle ENGINEERING – CHASSIS POWERTRAIN INSTALLATION LYON

Components
& PM & Systems
(9 people)

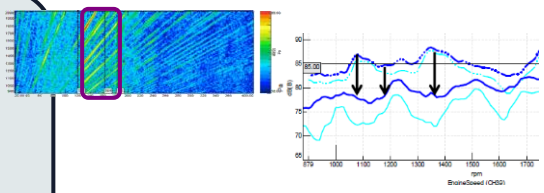


Kamilia BARTHOUX
Group Manager
Powertrain Installation



ACOUSTIC

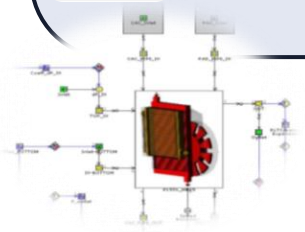
Florence BREFORT
Lead noise analyst



1D

Guillaume BALLET
Lead 1D analyst

Laurent GALDEANO
1D analyst

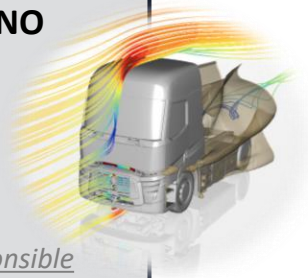


Simulation & Verification
(8 people)

3D CFD

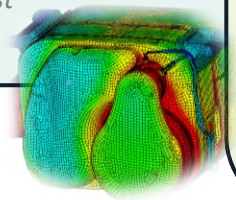
Alexandre CANO
Expert CFD
& 1D analyst

Alain PARET
Verification responsible
& CFD

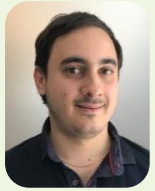


3D HOTSPOTS

David CHAROLLAIS
Expert Hotspots
& 1D analyst



PHYCICAL TESTING



Natan LECLERCQ
Test engineer

Jean-Marie GUEGAN
Test engineer

RENAULT TRUCKS HD

ARQUUS

VOLVO

THERMAL MANAGEMENT SIMULATIONS

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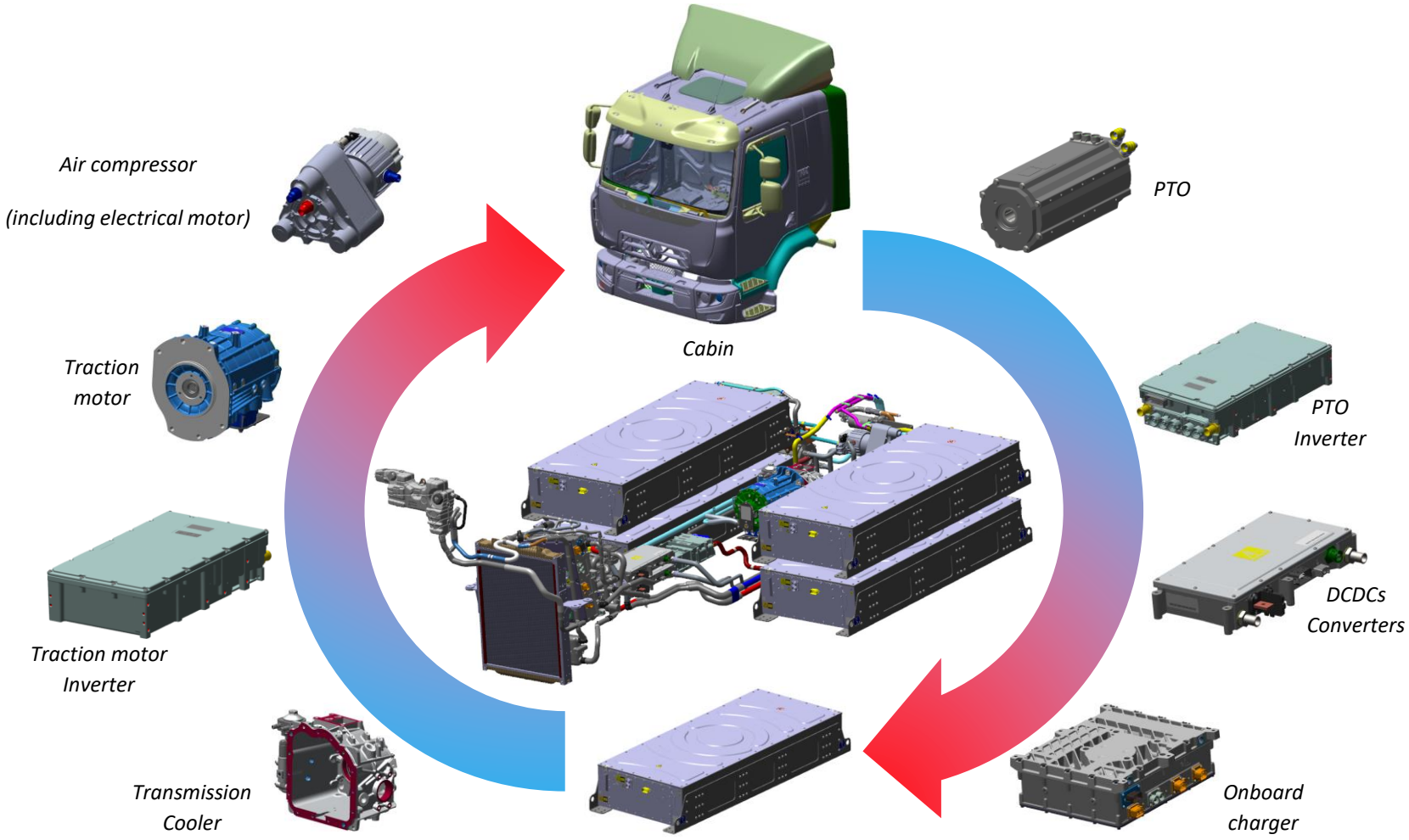
27/06/2024

THERMAL MANAGEMENT SCOPE

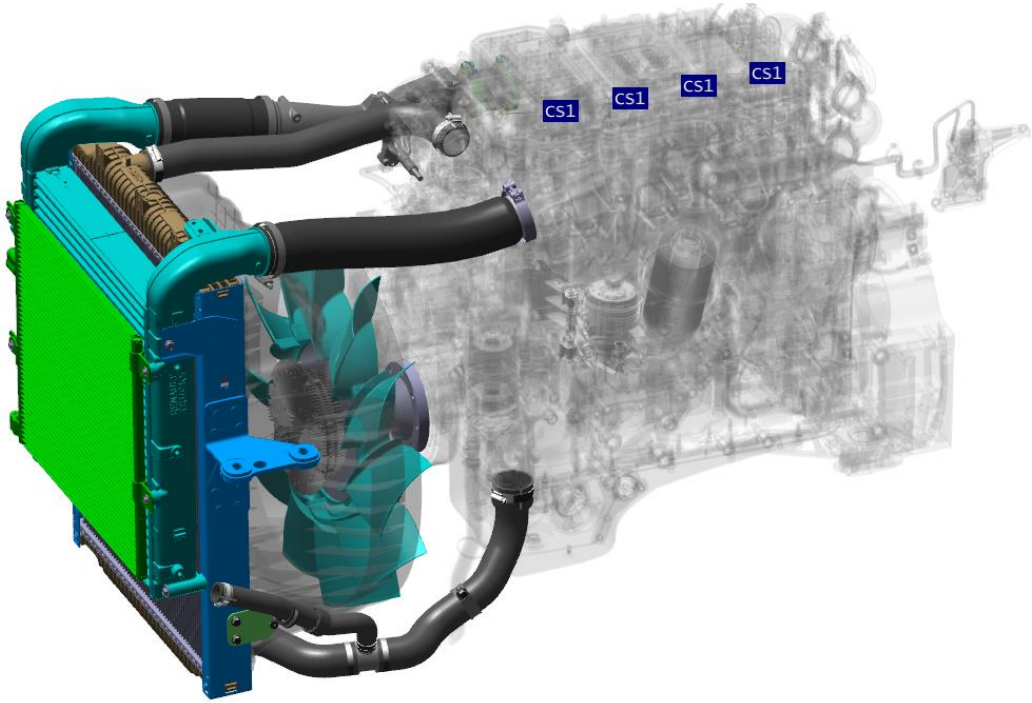
- A complex thermal system !

- That needs heating & cooling
  - Cabin (A/C & Cab heating)
  - ESS

- With various requirements
  - Minimum coolant flowrate
  - Maximum coolant pressure
  - Components & coolant temperature



ICE cooling system optimization



Study objective :

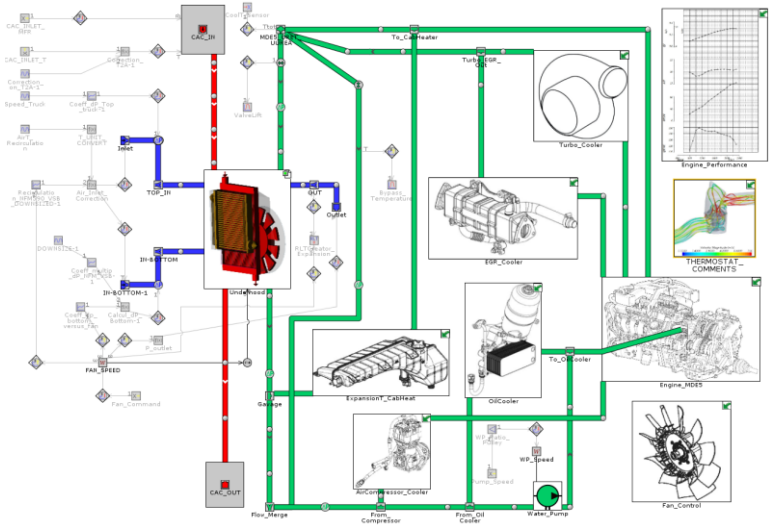
Optimize radiator, fan , charge air cooler sizing

Why ?

- Lower weight for competitors
- Most of our customers with light needs

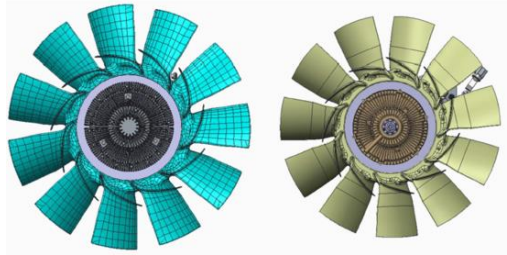
1st application

Renault Trucks D

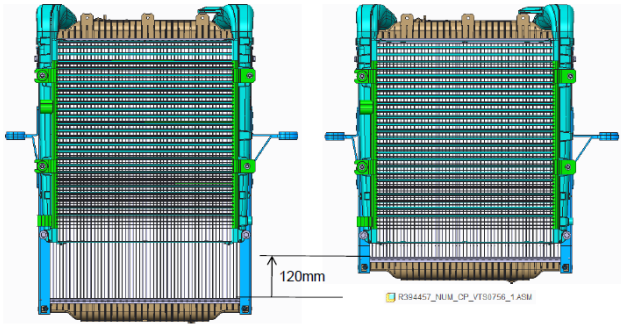


Ice cooling system optimization

- Several parameters investigated :
  - Radiator size
  - Charge air cooler size
  - Fan shroud
  - Fan

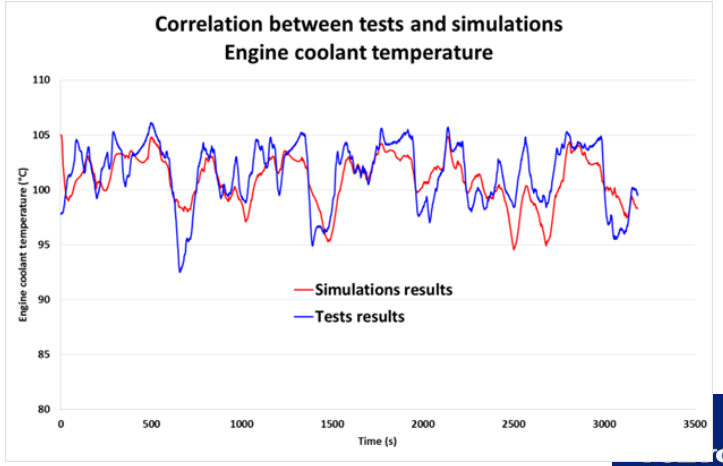


- Based on correlated original model, GT-SUITE's component scaling option was used to test all potential solutions in steady state



- The final concept was chosen, based on the GT-SUITE, prototyped and tested successfully

- Final verification with physical tests + transient simulations well correlated



- During severe tests in Spain, no risk on engine was observed even after a high reduction of the cooling package size (3 kg + 3 kg fan / 35 euros saved)

APPROVED

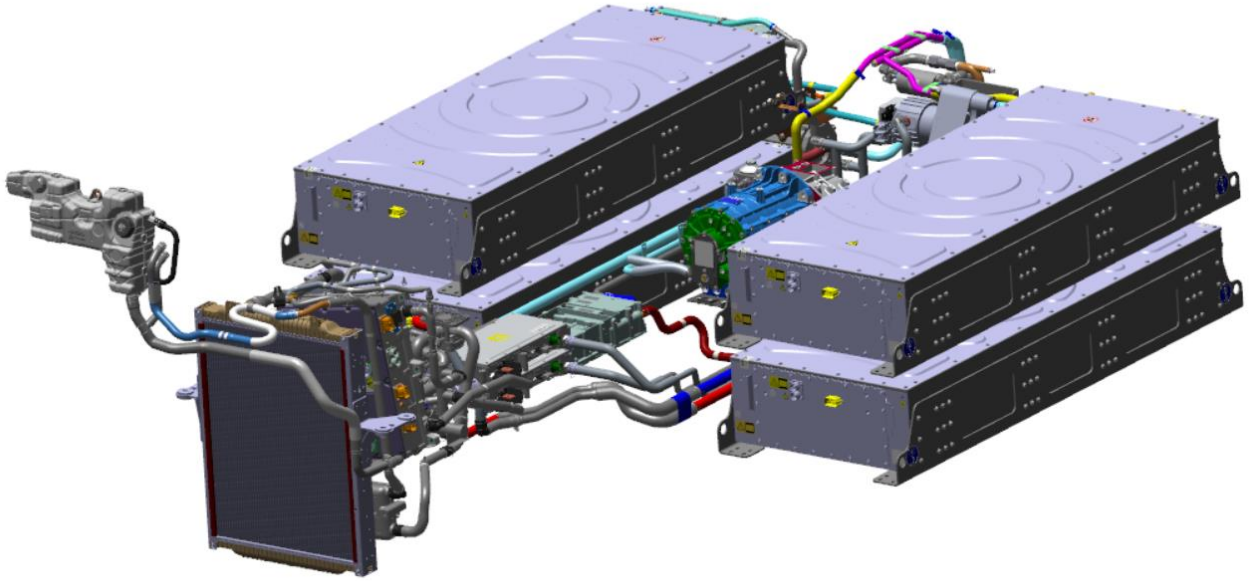
BEV thermal management Optimization

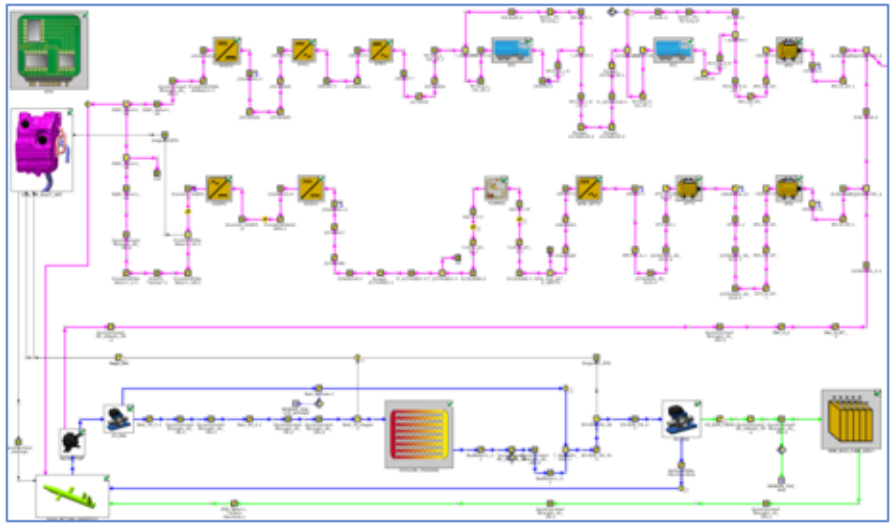
- **Study objective :**
  - Determine battery temperature & electronical component temperatures
  - Flow and pressure rate study for this complex system

- **Why ?**
  - Cab heating and cooling performance
  - ESS ageing
  - Thermal system power consumption
  - Necessary for agreement with suppliers

- **1st application**

Renault Trucks Medium Duty BEV





BEV thermal management Optimization

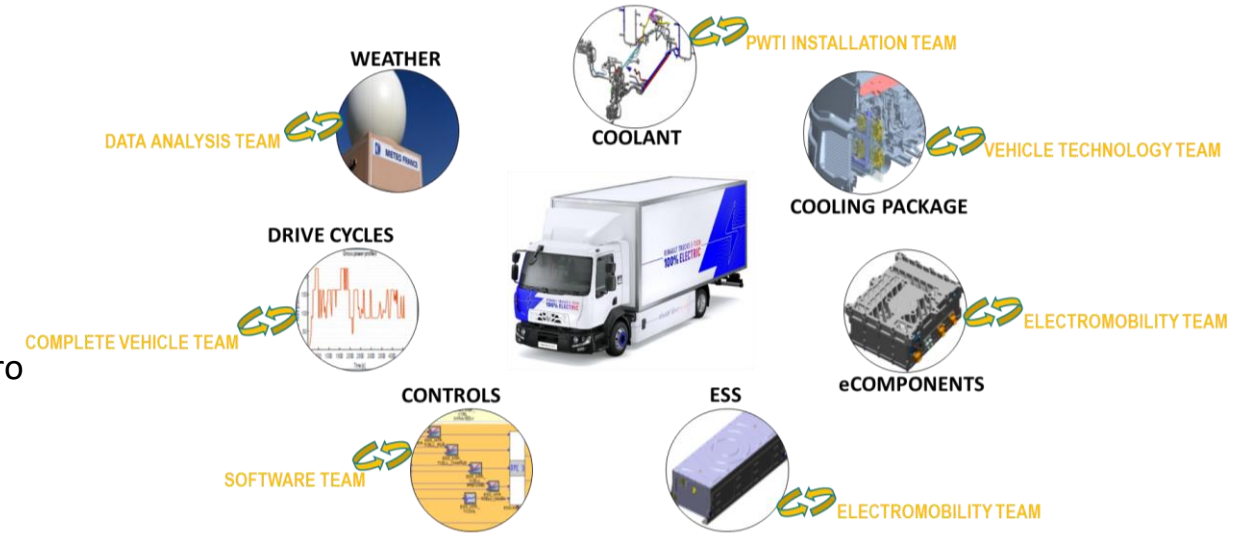
- Complex 1D GT model with input data from several teams

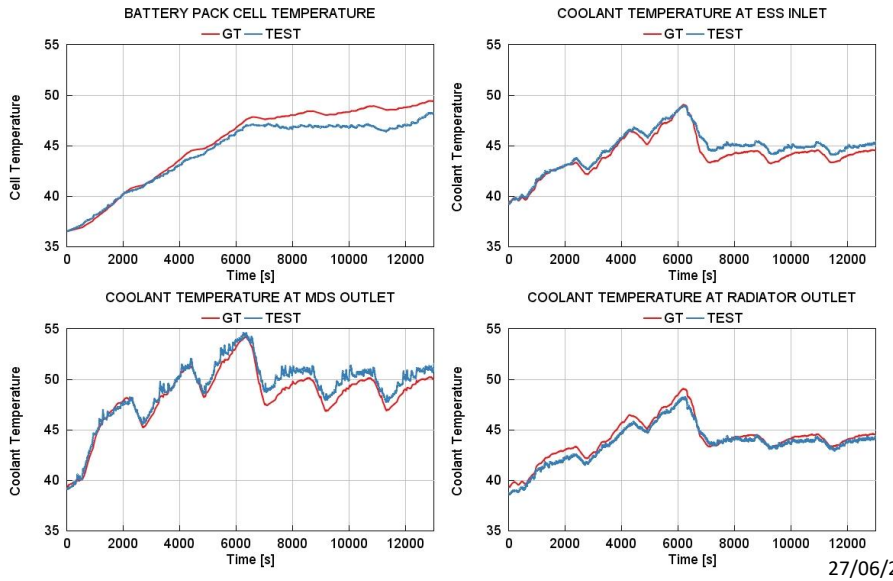
Results from other 1D simulation models (ex : battery behaviour with electro chemical modelling in GT Autolion)

- Performed simulations :
  - Dynamic tests performed from 0°C to 40°C
  - Specific drive cycle with 24 hours patterns

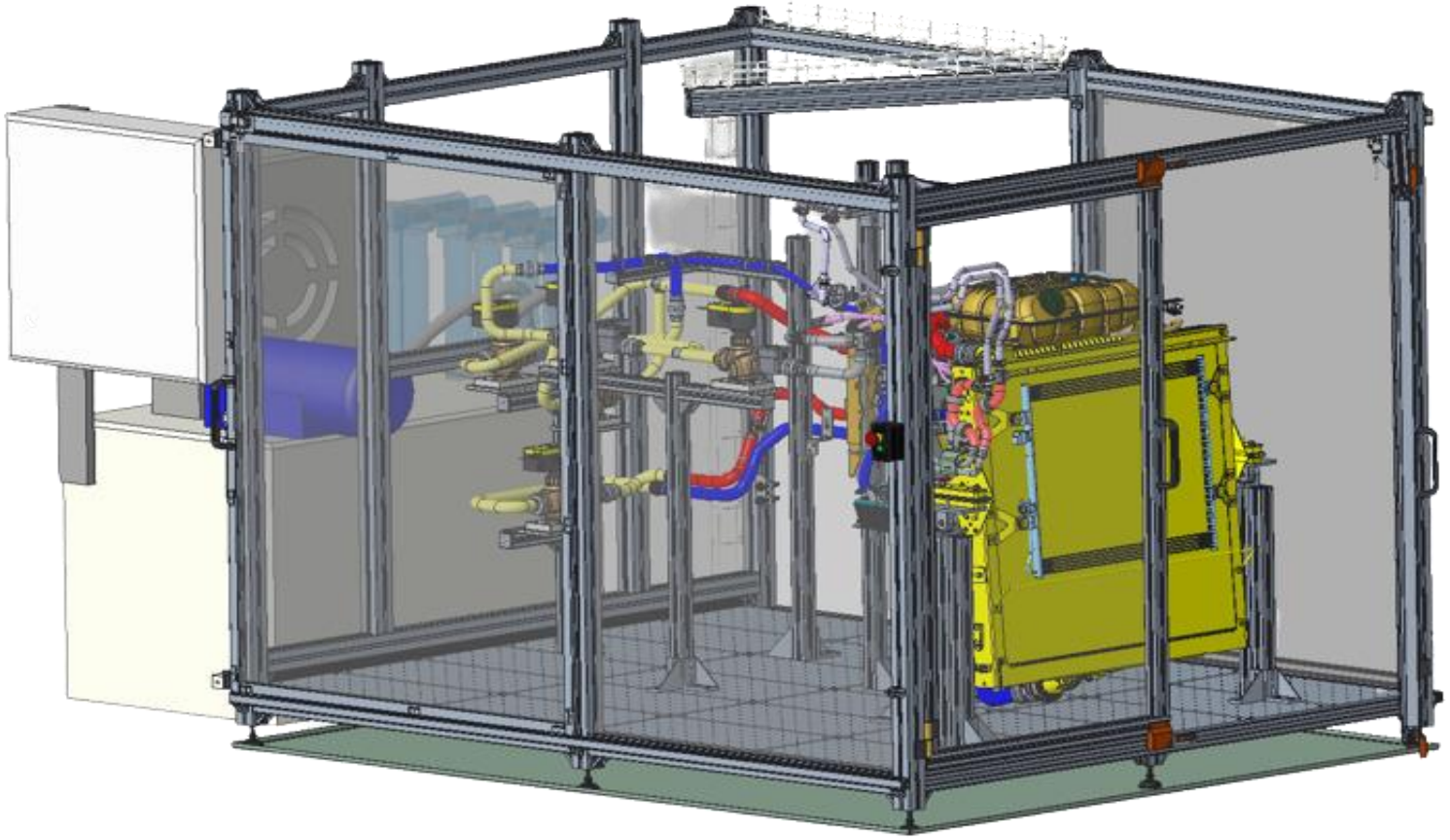
- Results : extraction of temperatures at multiple locations
  - **Cell temperature** at battery pack level
  - **Coolant temperature** at multiple locations
  - **Good correlations** between tests and simulations : Global trends are well captured by model

- For very more accurate results : real weather data necessary





BEV thermal management Optimization



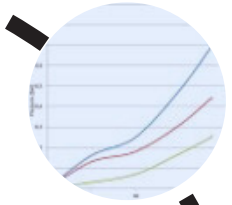
VOLVO

Why building this test bench ?

CONTROL

Debug & optimize control

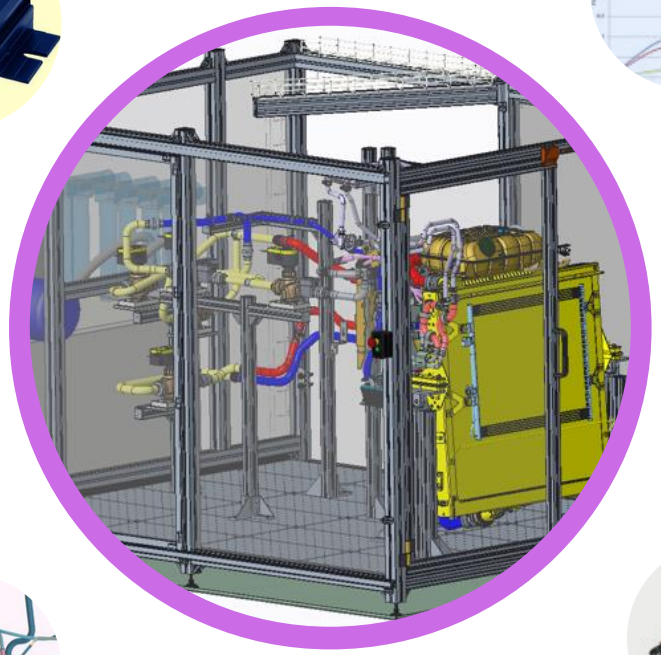
CHARACTERIZE



flow , pressure , multiple operating points for different components

CALIBRATE

Simulation models

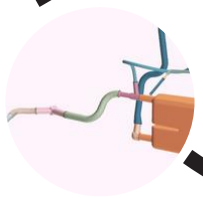


TEST

Complex hydraulic system

IMPROVE

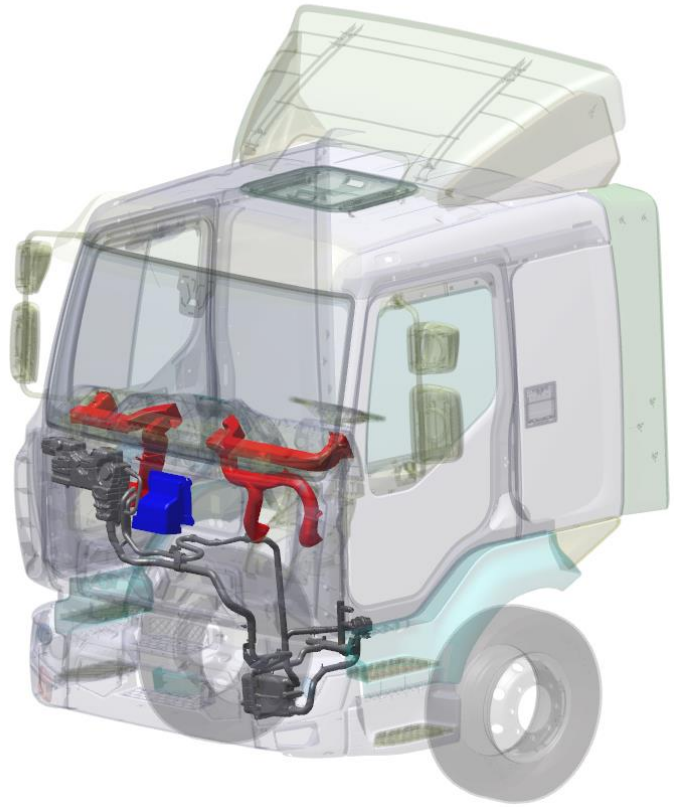
Knowledge on dearation



DESIGN

Work on geometry issues
Optimize design possibilities

BEV cab heating system optimization



Study objective :

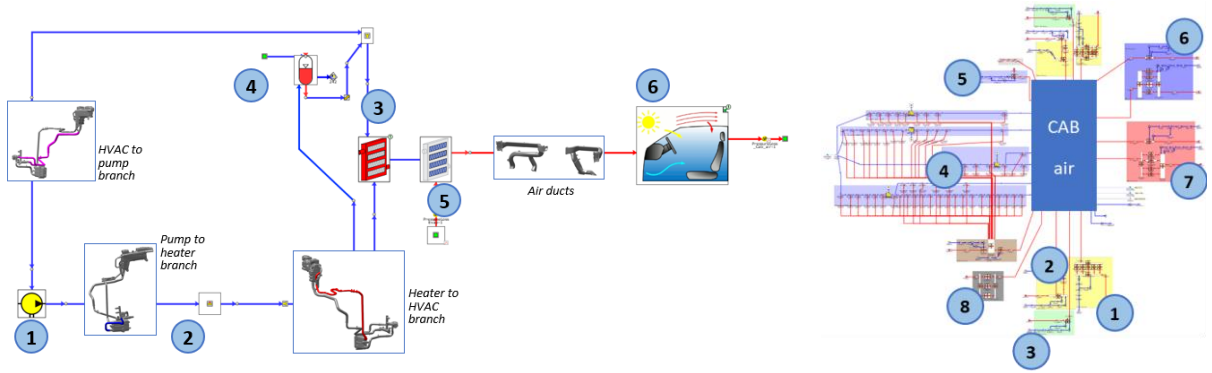
- Quantify & optimize the amount of energy :
- Taken from the batteries to feed the heater
- Lost in the coolant circuit / the cabin faces /HVAC and cabin

Why ?

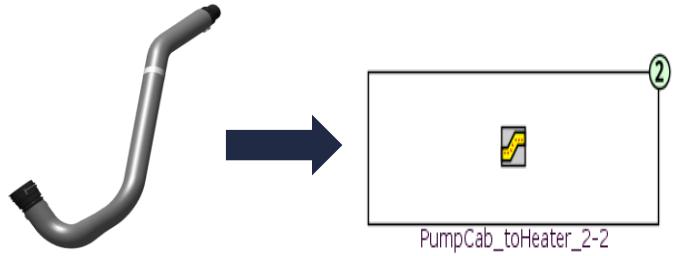
- Heat is not « free » anymore, it’s taken from the batteries
- Up to 25% less autonomy in winter

1st application

Renault Trucks Medium Duty BEV



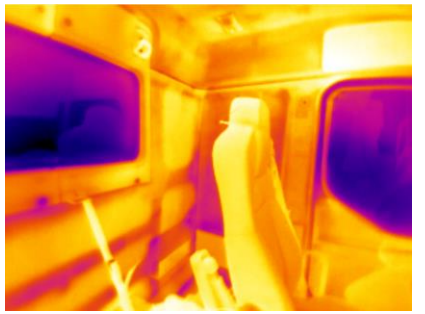
BEV cab heating system optimization

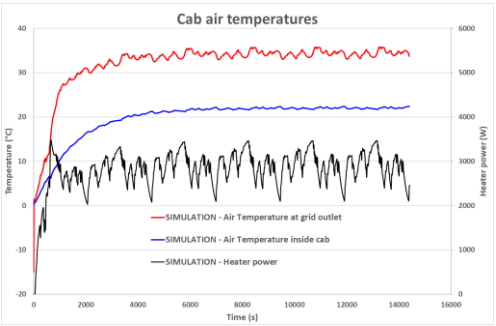


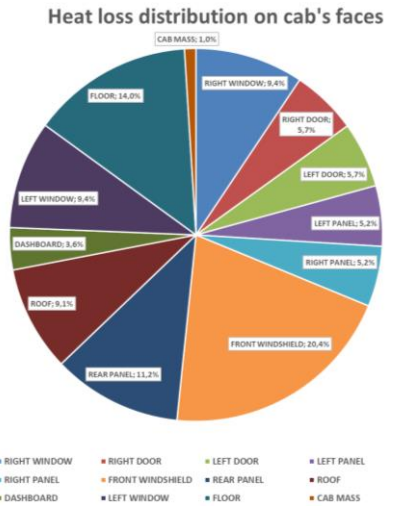
- 2 models: coolant + cabine
  - Coolant model : all components modelled by GT-suite + modelled performance for the main ones (Pumps , HVAC, Fan)
  - Cab model : air temperature inside cab evolution

- Performed Simulations :
  - climatic chamber, at -15°C / Standstill truck / Cab heating with 5 kW / 7,5 kW / 10 kW => well correlated to tests
  - Transient haulages at any ambient temperature to estimate heater power to maintain 22°C inside cab

- Simulation output :
  - Heat budget from ESS to driver
  - main component consumers => possible to compare several technical solutions
  - Heat Loss distribution on cab faces







INTEGRATION OF REAL-WORLD WEATHER DATA

- Historical standard methodology for thermal simulations
  - Most severe conditions

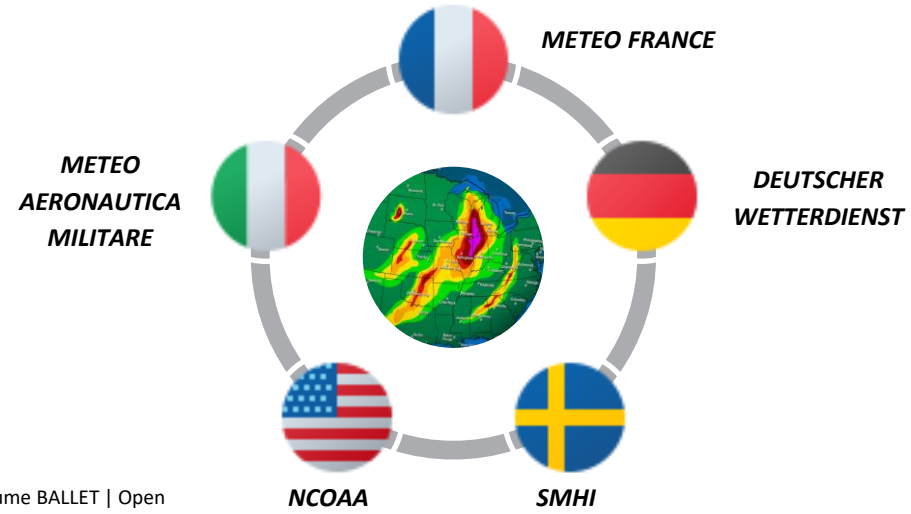
45°C

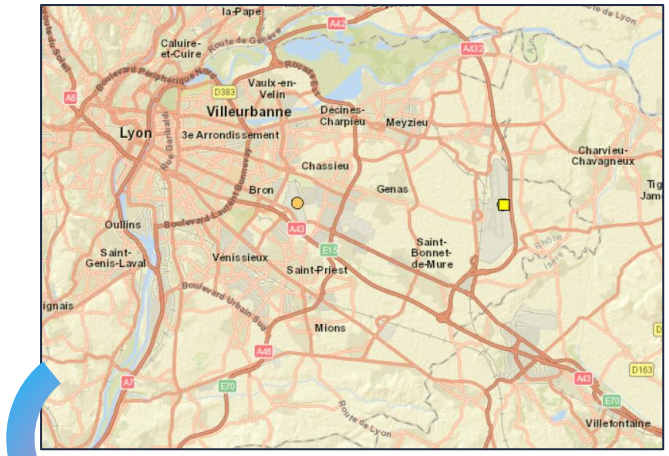
-25°C

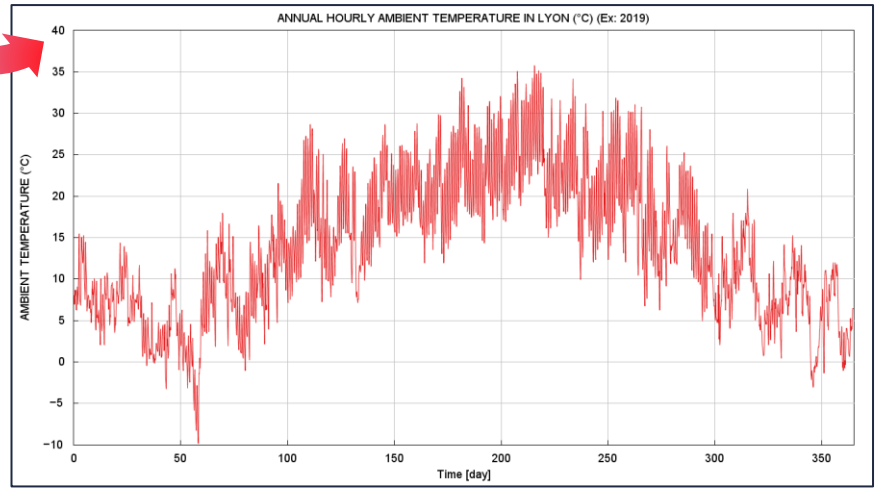
- Mandatory but not efficient for real-world use case !

INTEGRATION OF REAL-WORLD WEATHER DATA

- How can weather data support our activity ?
- Direct impact on thermal management system performance
  - Cab heating and cooling performance
  - Temperature distribution over electrical components
  - ESS ageing
  - Thermal system power consumption..
- Lots of observational data available…








ELECTRIC
ELECTRIC
ELECTRIC


Volvo 7900


MACK
MACK
MACK
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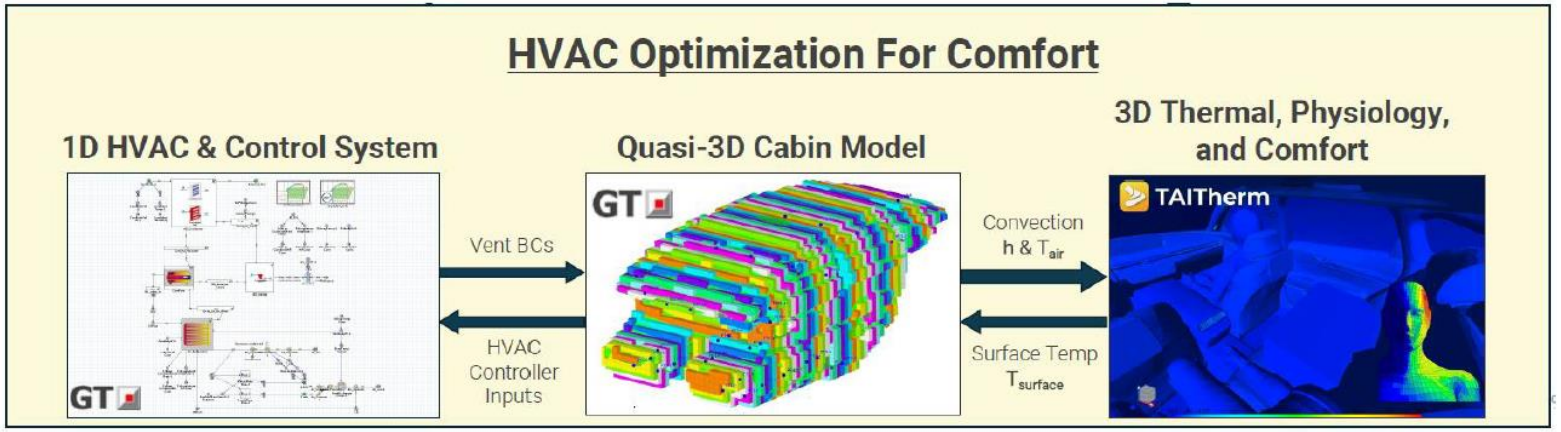
VOLVO

Other potential activities : human comfort

✓ 3D models coupling : GT-suite (1-D) / Star CCM+ (3-D fluid) / TAITherm (3-D thermal)



Manequin to estimate comfort, additionally to temperatures

=> possibility to reduced temperature inside cab, and deliver heat locally

✓ A/C system simulation with solar load