DESIGN OF COMPLEX THERMAL MANAGEMENT SYSTEMS USING A CUSTOMER USER INTERFACE

Thermal Management Expo Europe 2024

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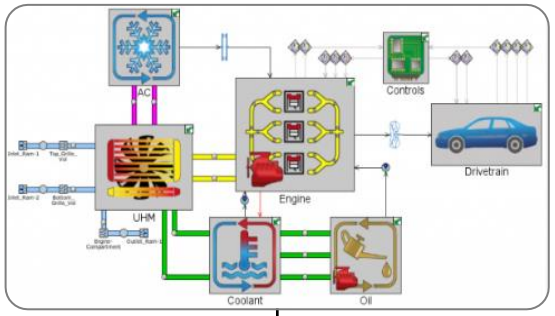
GENERAL APPROACH

Thermal System Architecture for Powertrain & HVAC

- Conceptual design of coolant and refrigerant systems
- Analysis of energy flow in powertrain cooling and passenger compartment

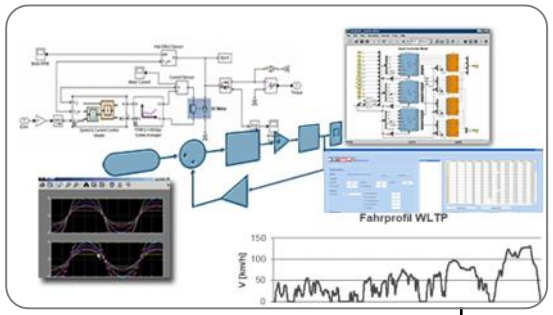
▶ 1D - System Simulation



Thermal Management Operating Strategies

- Optimized operating strategy leads to high efficiency
- Well adjusted control leads to stable temperature gradients

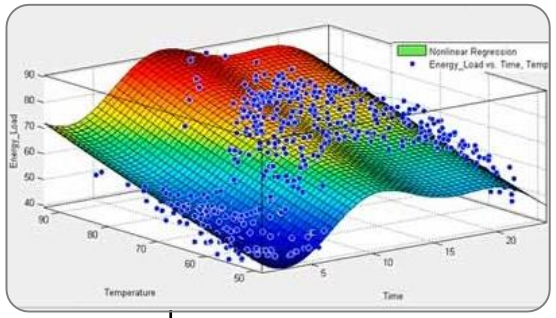
▶ Control Unit - Simulation



Dimensioning of Heat Exchanger

- Demand-oriented and targeted component design
- Creation of heat exchanger maps and geometries

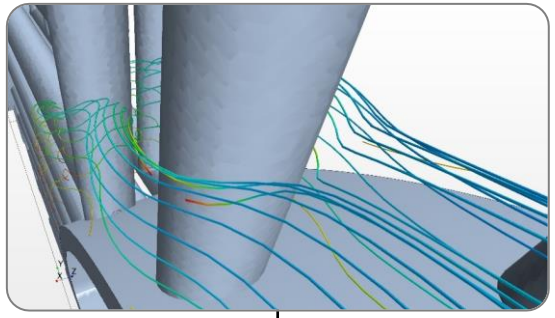
▶ 0D-Simulation - Performance Design



Optimization of Heat Exchanger

- Determination of pressure loss and heat transfer
- Consideration of packaging constraints given by the customer

▶ 3D CFD - Geometry Optimization



THERMO-ENGINEERING

EUROPEAN RESEARCH PROJECT INNOTHERMS

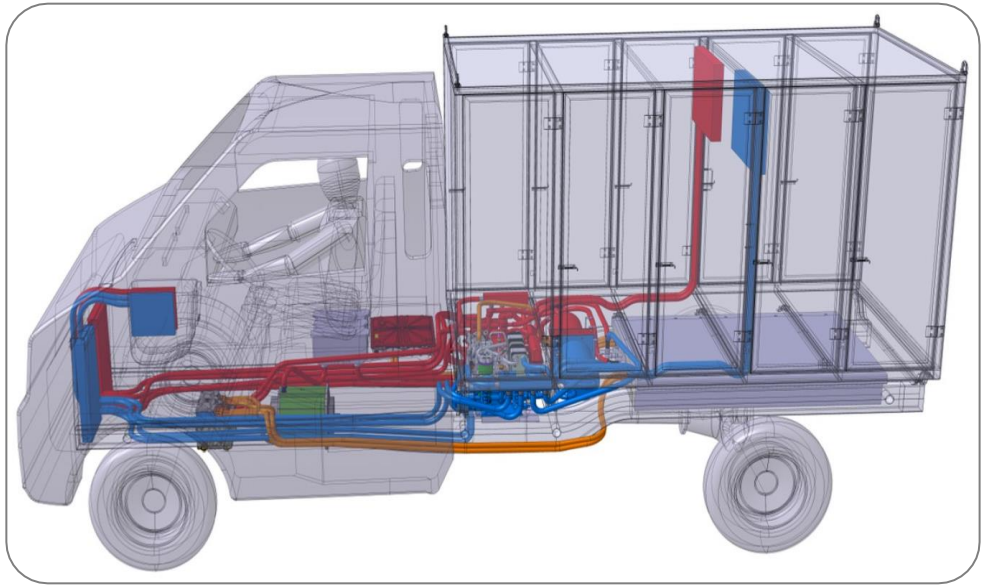
MOTIVATION

- Increasing demand for deliveries of prepared and fresh food
- Challenges for the thermal management to ensure thermal comfort for passenger, vehicle components and transport goods (warm and cold)

Idea: Innovative electric delivery vehicle with an optimized thermal management system

AIMS OF THE PROJECT

- Higher efficiency and driving range compared to a reference vehicle with common technologies (air conditioning system and auxiliary heaters)
- Temperature control of hot and cold transport goods within the respective thermal limit ranges
- Development of a method to simplify the application of the complete vehicle simulation



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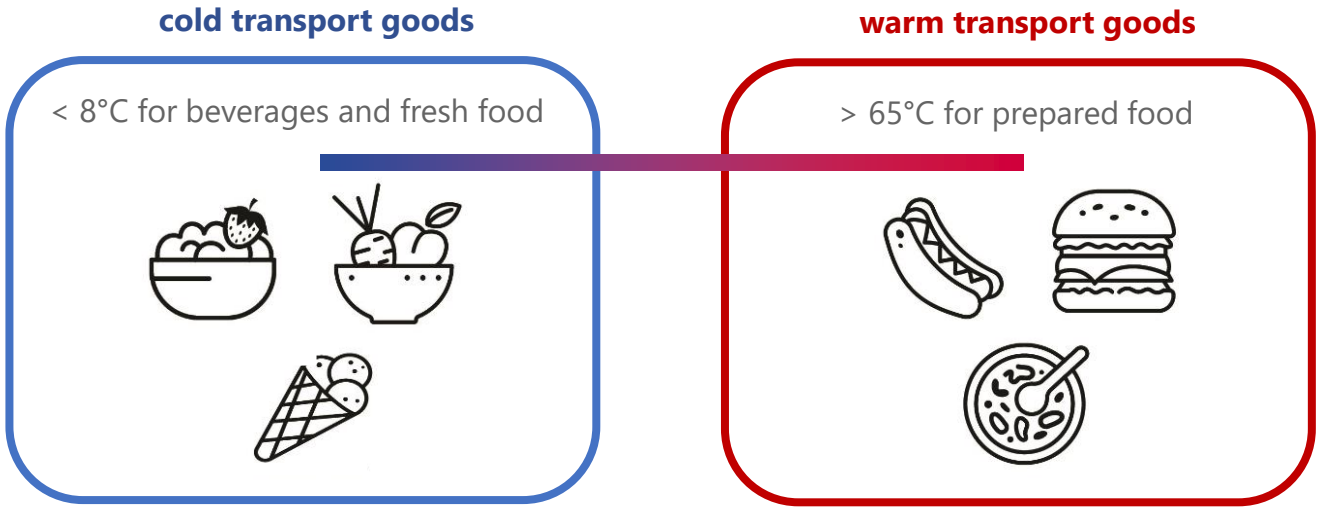
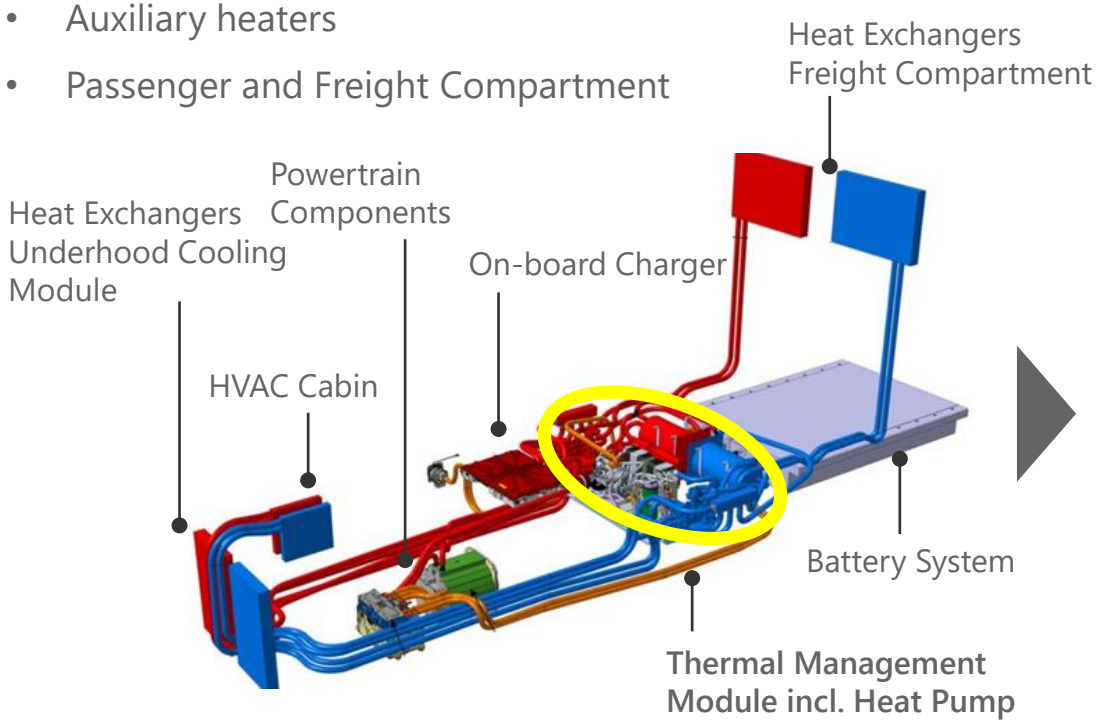


INNOVATIVE THERMAL MANAGEMENT SYSTEM

DESIGN

- High and low temperature coolant circuits
- Heat pump system, coupled to the High Temperature and low temperature circuit via a shell-and-tube heat exchanger
- Thermal storage units (Hot and Cold)
- Auxiliary heaters
- Passenger and Freight Compartment



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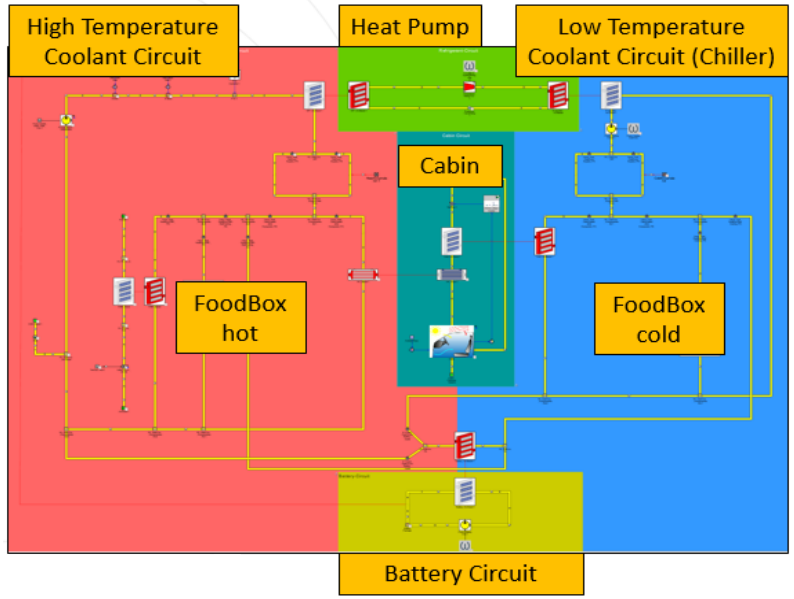
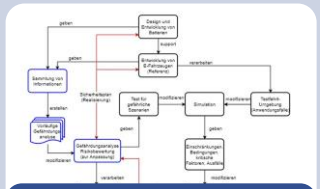
BASIC FUNCTION

- Ensure the heat/ cooling demand of all thermal customers
- High temperature coolant circuit is heated by a heat pump with a subsequent heat storage unit and auxiliary heater. Heat flows generated by the drive are also used to heat the circuit
- Low temperature coolant circuit is cooled by the cold side of the heat pump and supported by the cold thermal storage unit
- Coolant valves are used to meet the heating or cooling requirements of all thermal customers

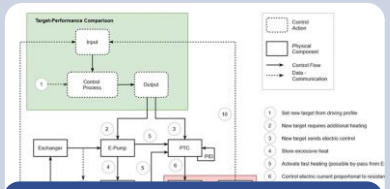
Transfer to a 1D-Model



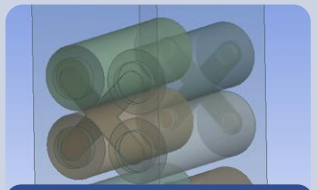
MODULAR CO-SIMULATION ARCHITECTURE



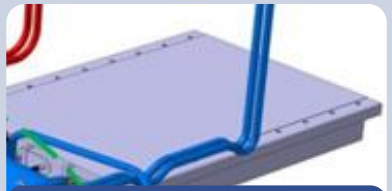
Functional Safety
C-Code



Battery Mgmt. System
C-Code

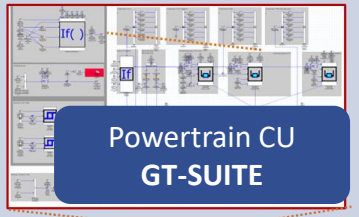


Battery Cells
Matlab

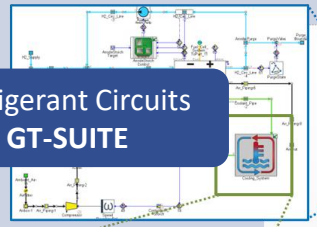


Battery Pack
FMU (Simscape)

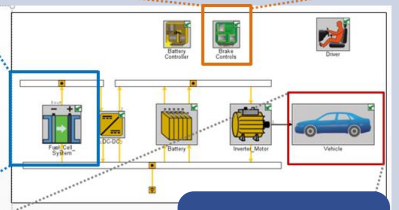
Master Model
GT-SUITE



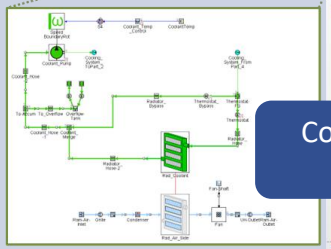
Powertrain CU
GT-SUITE

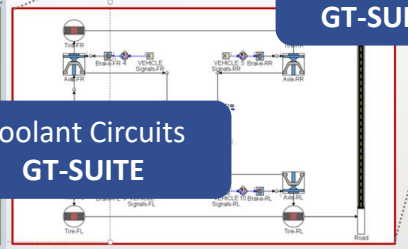


Refrigerant Circuits
GT-SUITE

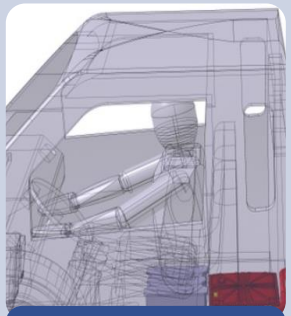


HVAC CU
GT-SUITE

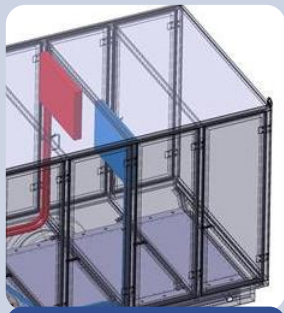




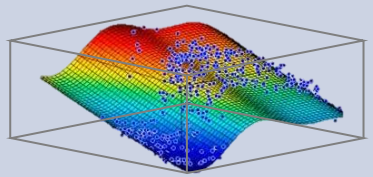
Coolant Circuits
GT-SUITE



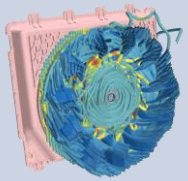
Passenger Cabin
DLL (Simulink)



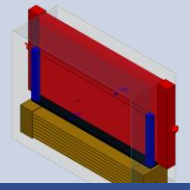
Freight Comp.
DLL (Simulink)



Heat Exchanger Design
0D (TheSim)



Underhood Cooling Module
CFD (StarCCM+)



Underhood Cooling Module
GT-COOL3D

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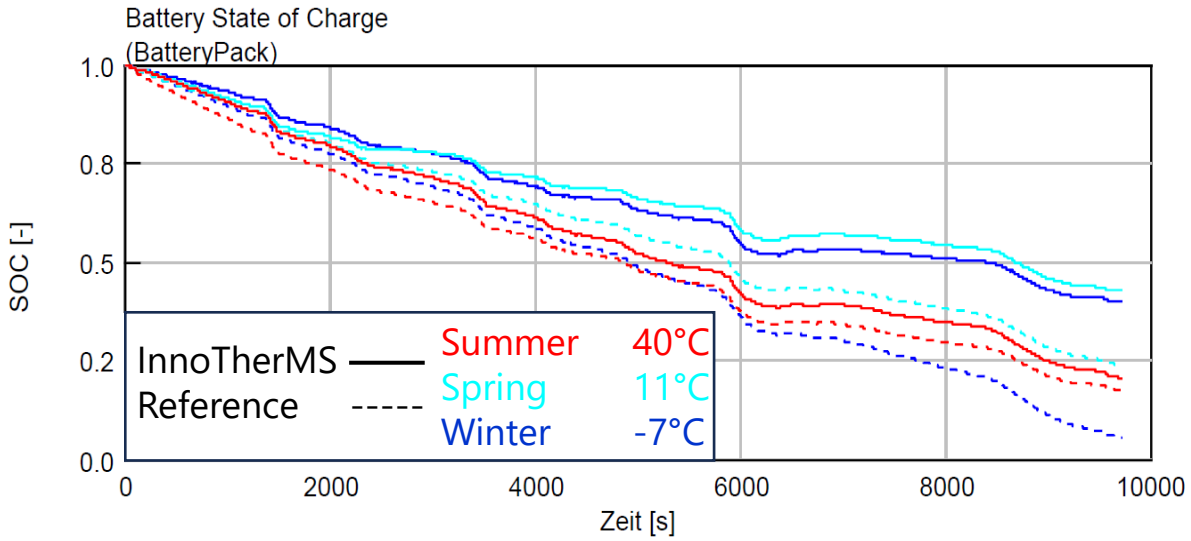
SUMMARY AND OUTLOOK

OVERALL SIMULATIONS RESULTS:

- Reduction of energy consumption approx. +13%
- Increase of electric range by approx. 10%
- Proof of concept for the thermal management system

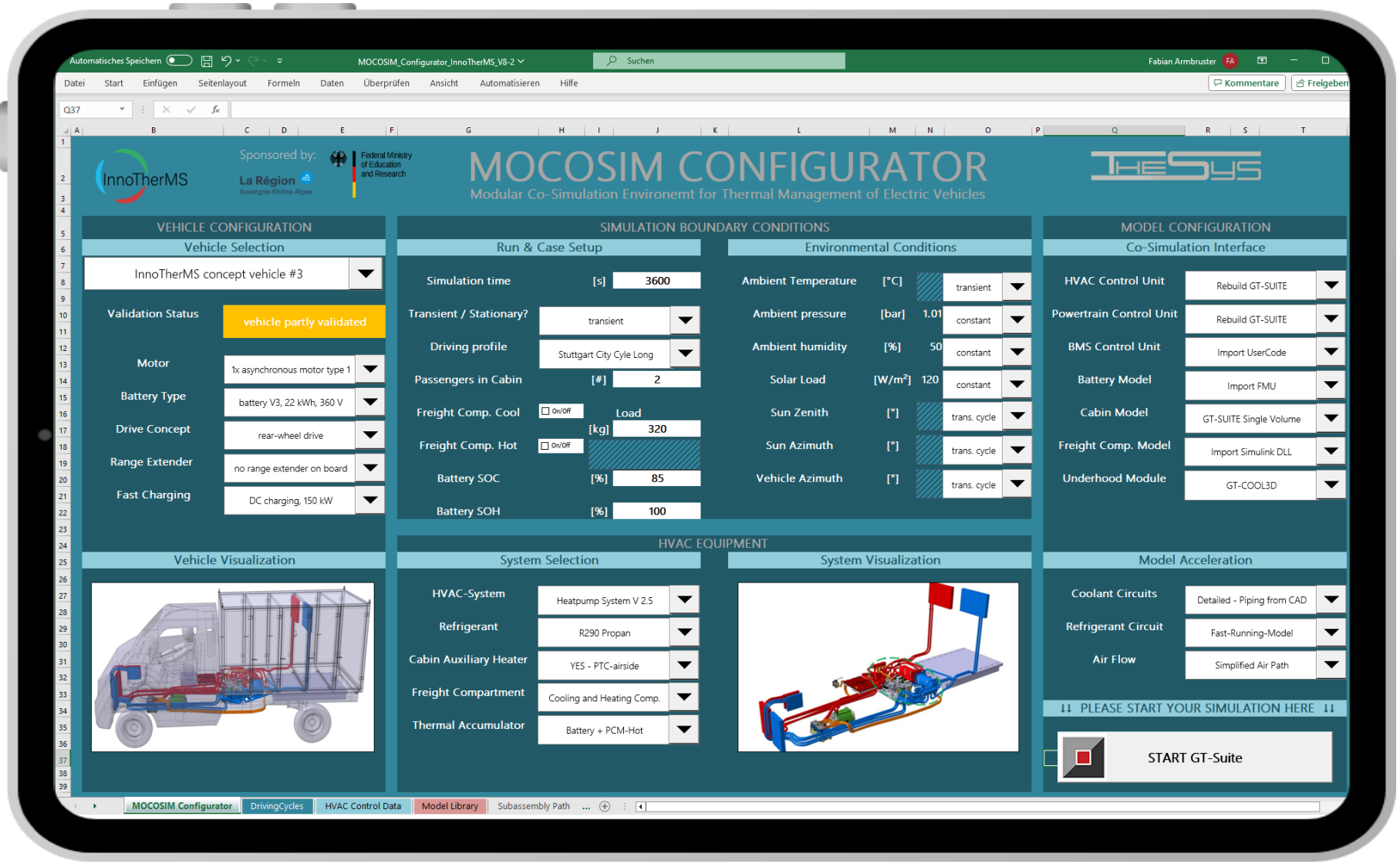


	InnoTherMS vehicle	Reference vehicle	Range difference
Summer	30,0 kWh/100km	30,2 kWh/100km	+ 1%
Spring	22,1 kWh/100km	27,5 kWh/100km	+25%
Winter	28,9 kWh/100km	34,3 kWh/100km	+19%

SUMMARY AND OUTLOOK

RESULT OF THE METHODOLOGY

- **EXCEL USER INTERFACE FOR CASE AND MODUL SETUP „MOCOSIM“:**
  - Vehicle Selection
  - System Selection
  - Run- and Case-Setup
  - Environmental Conditions
  - Co-Simulation Interface
  - Model Acceleration



CONTACT