Two-Session-Clustering Workshop

17.02.2021 | SESSION 1: Thermal management control system to be implemented in a demo car which will maximize energy efficiency

Presenter:
Bernd THIERINGER

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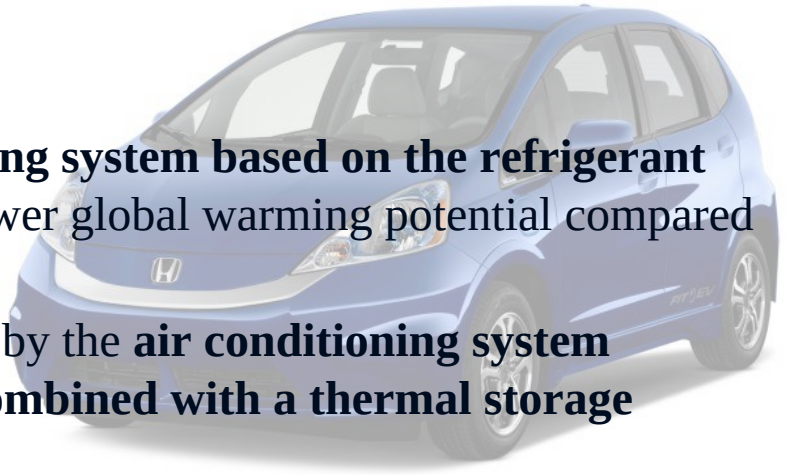
Thermal management control system to maximize energy efficiency
OBJECTIVES

- Implementing an **innovative air conditioning system based on the refrigerant R290 (propane)**, that has a significantly lower global warming potential compared to the standard refrigerant R134a
- The heating of the vehicle can also be done by the **air conditioning system working in heat pump operation mode combined with a thermal storage system**.
- **Infrared heating panels** in the near field of the passengers enhance thermal comfort and reduce heat-up times, and therefore the energy consumption, while having little mass.



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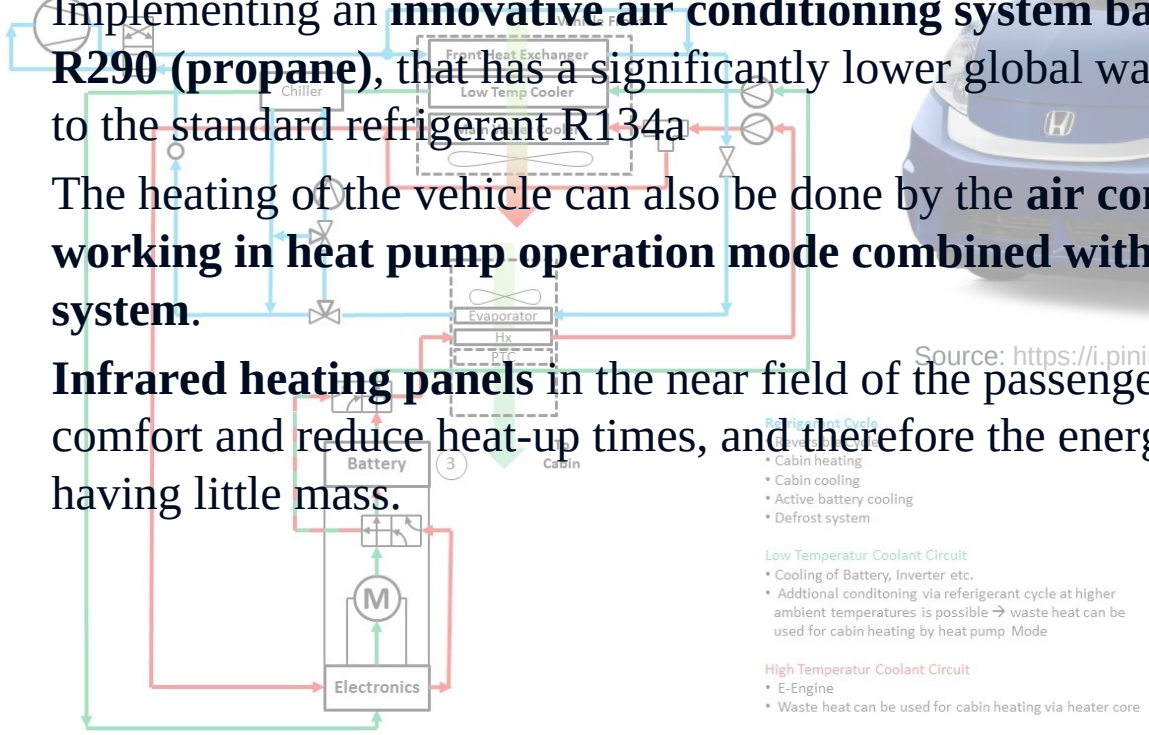

Source: AVL Thermal & HVAC

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OBJECTIVES

- Comparison refrigerants, why R290?

Parameter	R134a | 1234yf	R290
GWP	1430 | 4	3
AC-Power	☺	☺
HP-Power	😐	☺
Efficiency (COP/EER)	😐	☺
Flameable	☺	☹

R290: (Propane) is a strong and environmentally friendly refrigerant, but flameable;
targets: using a small amount (app. 150 g)
adopt a safety concept
R134a: in Europe it is prohibited for new vehicles since 2017
1234yf: ongoing discussions (flameable, TFA, trifluoracetic acid, found in drinking water)

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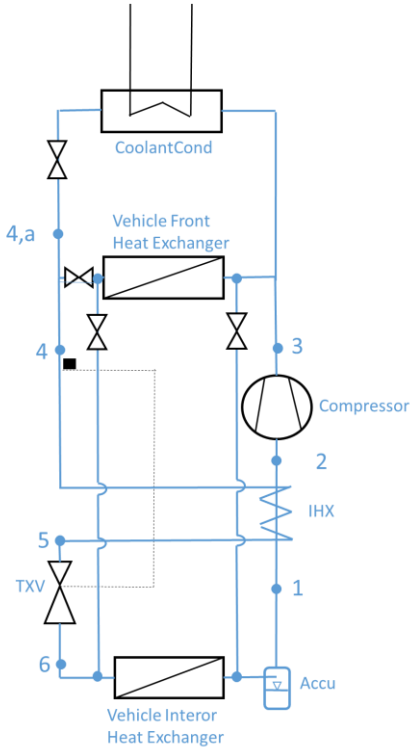
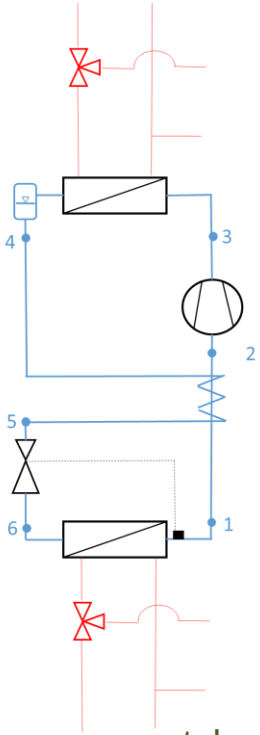
Thermal management control system to maximize energy efficiency
OBJECTIVES

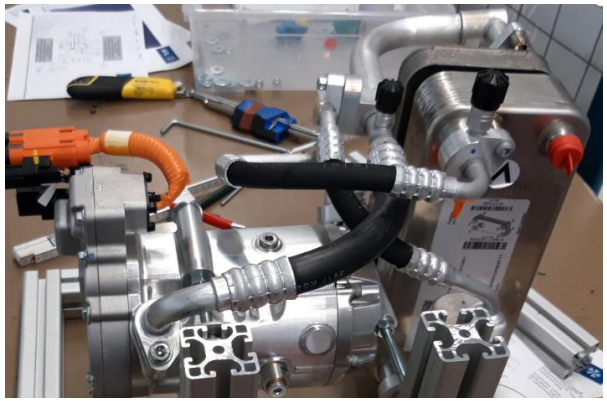
- Reversible AC cycle for heatpump operation

Internally switchable



externally switchable





☺Very compact, low amount of refrigerant
☺ Safety issues (only water in HVAC unit)
☹ Temperature levels

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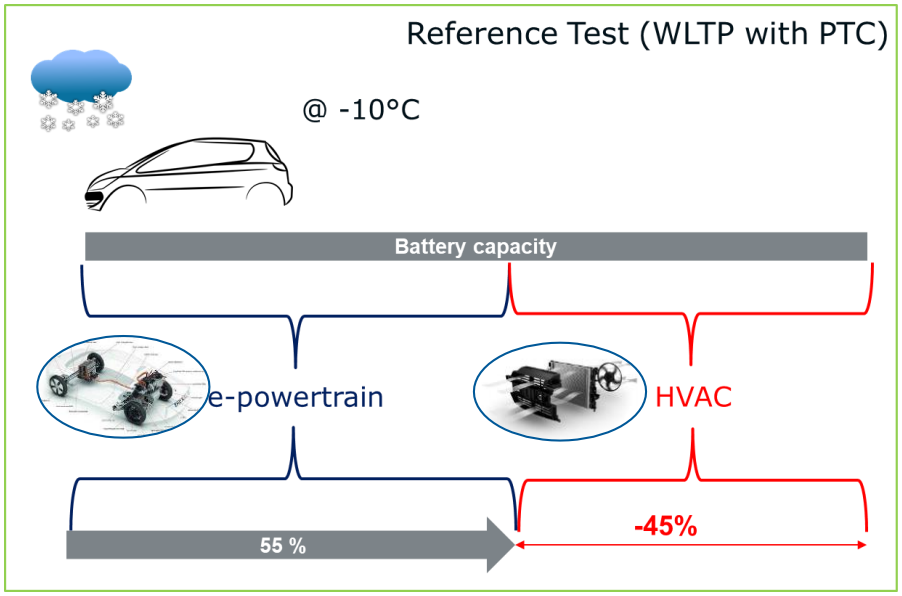
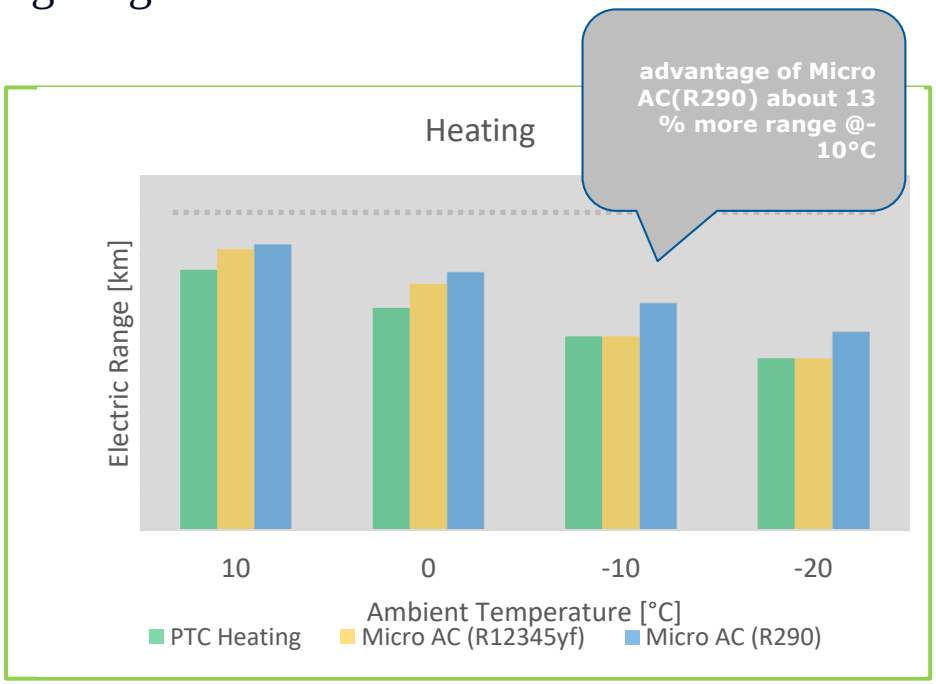
Thermal management control system to maximize energy efficiency
OBJECTIVES

- First assumption of the influence on driving range





Achievable range increase due to 290 heat pump technology compared to the Mainstream case @ -10° C ambient temperature is **about 20%**

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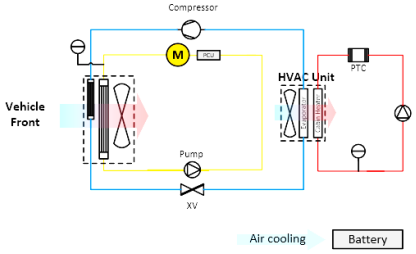
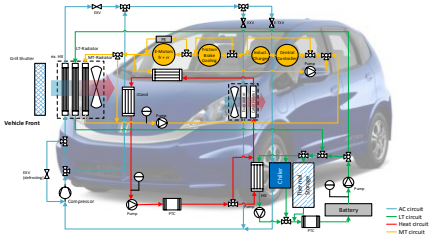
Thermal management control system to maximize energy efficiency

APPROACH

- From the Status Quo VTMS to the Future VTMS





DEFINITION OF TARGETS

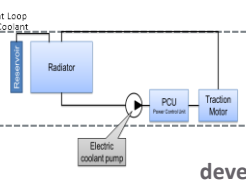
CONFIRMATION OF TARGETS

System Design

System Validation

Vehicle level

Concept development

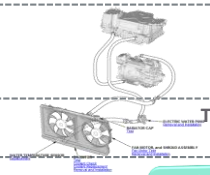


- VTMS Test

System level

Development of subsystems

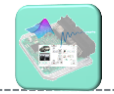
Thermal component specification



- AC-Tests

Component level

Thermal management control strategy



- Compressor tests

Define Requirements Specifications

Test & Integration

* detailed performance assessment of the state of the Honda FIT EV
* Definition of the system layout for a heat pump operated with R290
* Selection of components for the new VTMS with 1D simulation tools
* Geometrical Integration into the vehicle

system level tests on the bench; define control strategy

vehicle build → prepare for vehicle tests

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Thermal management control system to maximize energy efficiency

APPROACH

- Design of the future VTMS

Powertrain Circuit
- Containing EM and PCU
- Cooling with radiator and IHX

→ Switching between these modes via valve 1

- Electric pump controllable via PWM signal
- Containing first accumulator

Heating Circuit
- Containing PTC, condenser and heater core
- Heat for the heater core from heat pump (condenser) and/or PTC
- Take away heat from refrigerant cycle to environmnent via main radiator

→ Switching between these modes via valve 4

- Containing second accumulator
-

Refrigerant Circuit
- Watercooled heat exchanger

→ Chiller replaces an evaporator

→ Icond replaces an (air) condenser

- EXV is used instead of a TXV (Superheat 5 K)
- IHX is used to improve efficiency
- Complexity is "outsourced" to the water circuits

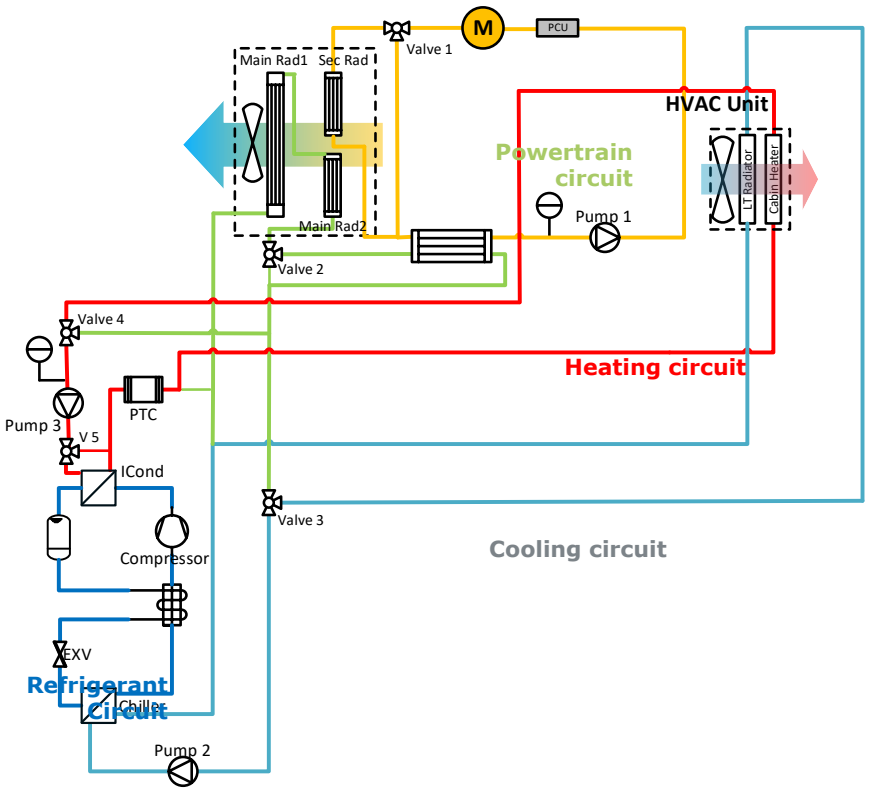
Cooling Circuit
- Containing chiller and LTR
- Indirect cooling of the cabin air via LTR

→ 1 reason is safety (propane)

- In heat pump mode "heat" is taken from environment via main radiator

→ Switching between these modes via valve 3

→ Partly opened valve allows reheat mode



- Operation modes

heating	cooling	reheating
Heating with waste heat	Deicing	PTC heating

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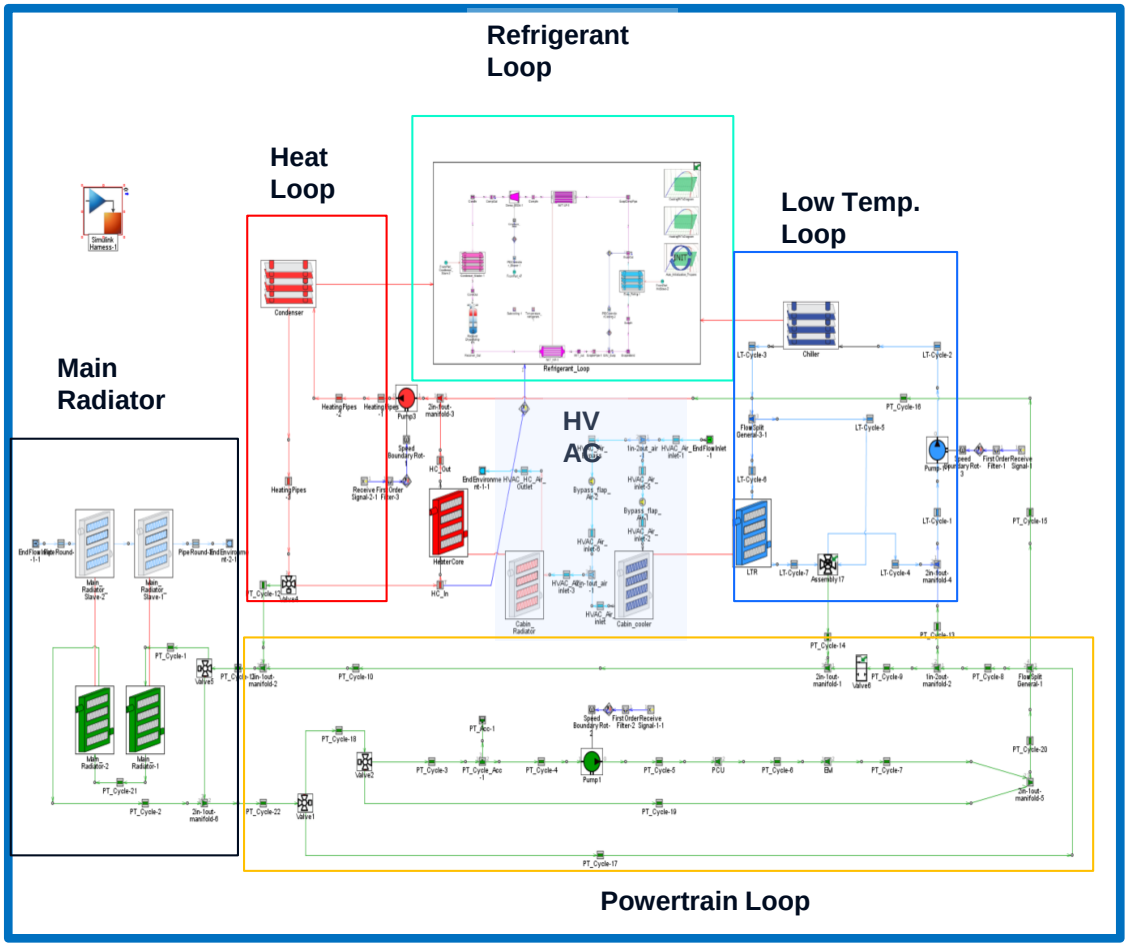
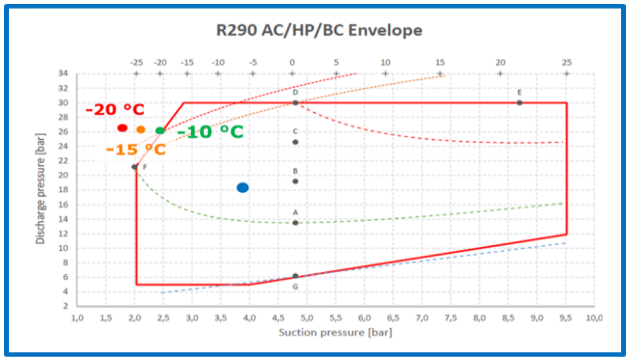
APPROACH

- Simulation of the future VTMS: 1D simulation using GT-suite

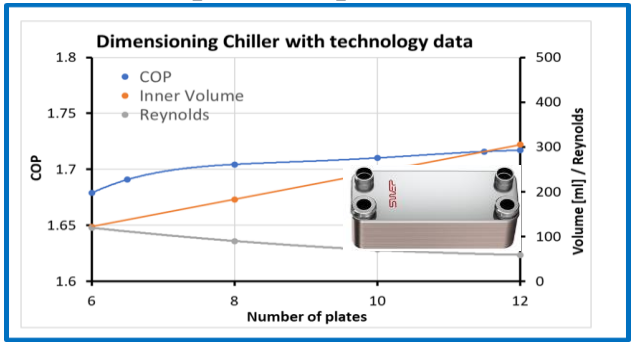


implement component data



Conclusion:
- Based on the envelop of the compressor for low ambient temperatures additional heat input from the PTC is required to operate Micro AC at lower high pressures

define component specifications



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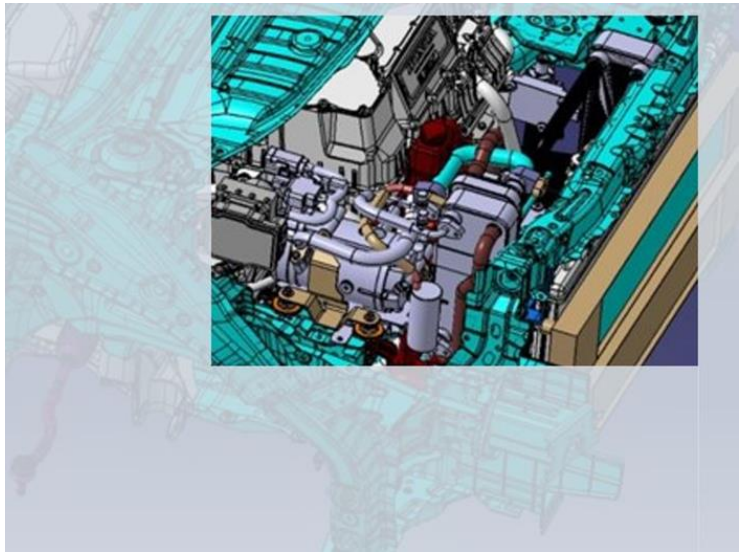
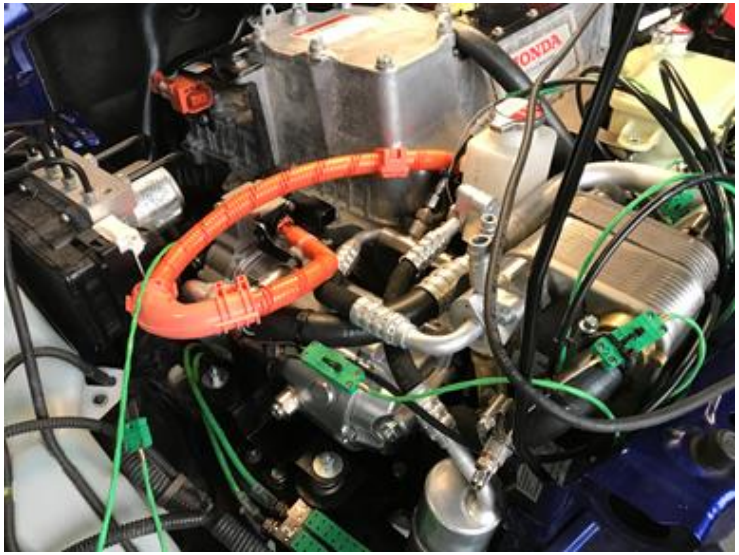
Thermal management control system to maximize energy efficiency
IMPLEMENTATION

- Packaging of the future QUIET VTMS into the vehicle



- Purchasing of water valves, water pumps, shaped hoses, heat exchangers and AC lines according to the new design

- System installation including sensors (temperatures, pressure, volumetric flow)



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Thermal management control system to maximize energy efficiency
IMPLEMENTATION

- Safety concept:
  - low filling amount
  - Compact installation in the vehicle front
  - No R290 in the cabin
  - Pressure relief valve from Ventrex

- Replacing the evaporator in the HVAC unit by a water radiator

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Thermal management control system to maximize energy efficiency
IMPLEMENTATION

- 2 additional heat exchangers in front of the main radiator to increase heat exchange surface for the heat pump

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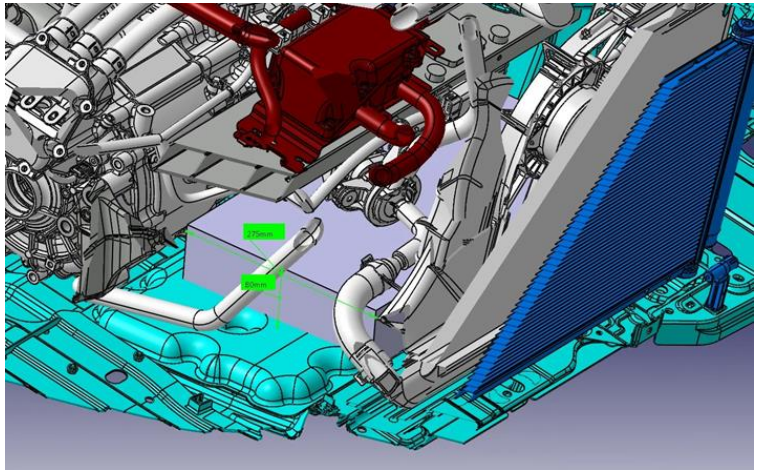
Thermal management control system to maximize energy efficiency
IMPLEMENTATION

- Definition of the max. dimensions for the PCM heat storage tank



- PCM heat storage tank from Rubitherm integrated in the system

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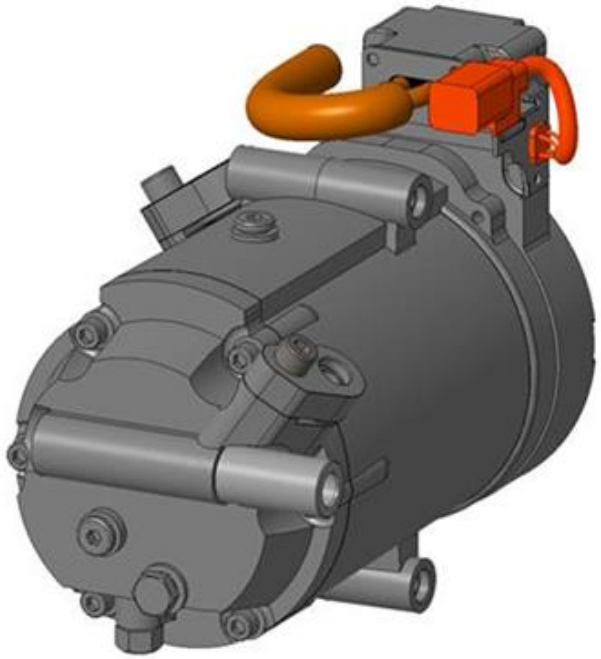
Thermal management control system to maximize energy efficiency
IMPLEMENTATION

- Integration of the 48V DCDC converter into the HV system. This is the power supply for the infrared heating panels from ATT

- The R290 AC compressor from Obrist



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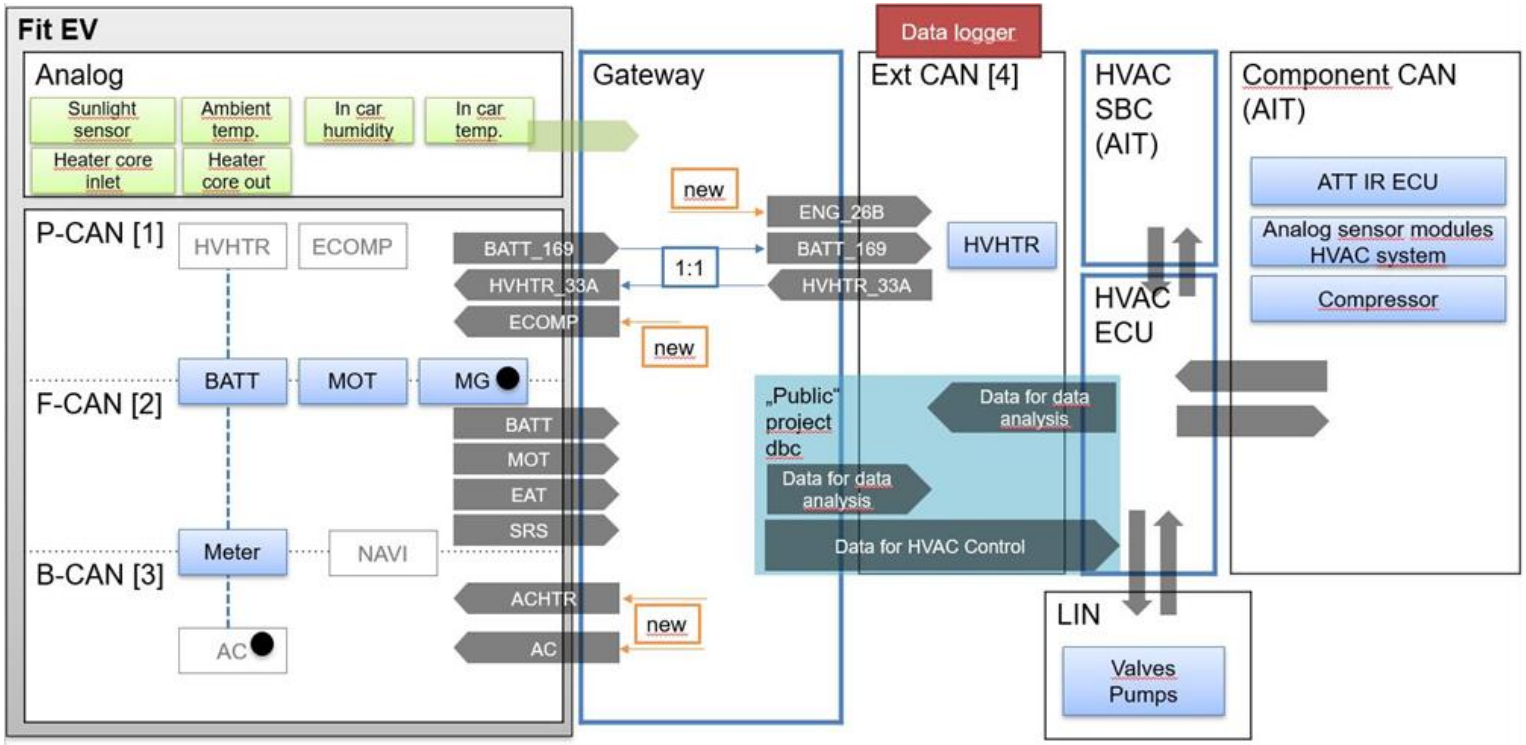
Thermal management control system to maximize energy efficiency
HIGHLIGHTS

- Despite this very complex system architecture of the VTMS control the system is running in the vehicle



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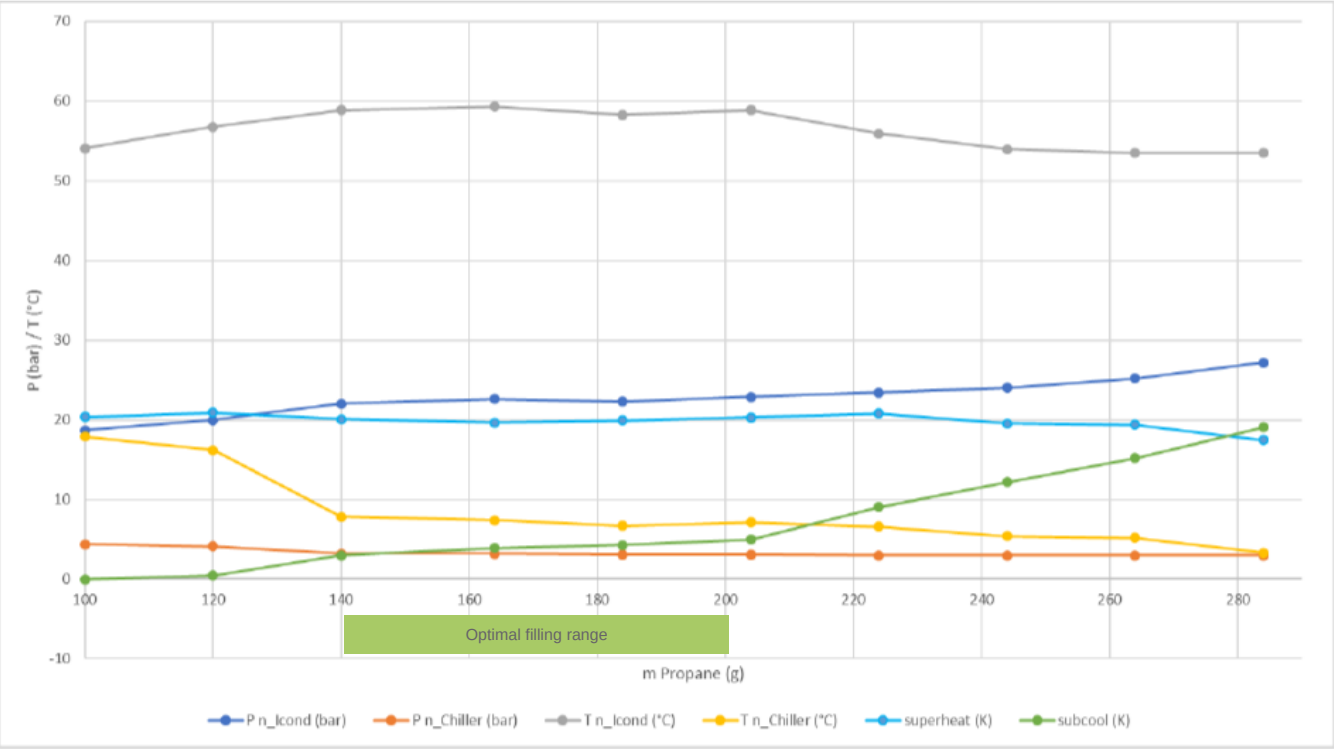
Thermal management control system to maximize energy efficiency
HIGHLIGHTS

- Filling amount determination of the refrigerant cycle nearly confirmed our target:
- The system is now operated with 160 grams R290



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Thermal management control system to maximize energy efficiency
OUTLOOK

- The commissioning of the vehicle and its very complex VTMS system with its control took some time. Also due to the Corona lockdowns and travel restrictions the cooperation between the project partners in Austria, Germany, Croatia and Italy caused some delay in the project.

- We are now looking forward to start the evaluation of the vehicle with all its technical improvements, hopefully to confirm the targets concerning the increase of the driving range at similar thermal comfort.

- Thanks to the whole team and good luck for the vehicle tests!

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Get in touch with the QUIET consortium!

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