



1

Kigali Amendment



UN
environment
programme

- Global agreement to phase down HFCs
- Reduce climate impact and meet global goals
- Driving transition to low-GWP, sustainable refrigerant alternatives

2

India's Transition



- Kigali phase-down implementation from 2028
- Growing automotive sector and rapid EV adoption
- MAC sector to become a major HFC emission contributor
- Need for low-GWP, scalable solutions for Indian conditions (e.g. high ambient temperatures)

3

UNIDO Initiatives in India



Capacity Building
Train-the-Trainer (TtT) programme with SIAM for MAC service sector



Technology Demonstration
R-290 refrigerant substitution project under CCAC – UNIDO

4

R-290 Demonstration Project



CCAC – UNIDO R-290 Demonstration Project

- Develop R-290 based EV HVAC system
- Demonstrate technical feasibility
- Develop safety strategy and guidelines
- Generate knowledge for future deployment

5

Tata Motors Leading the Demonstration



TATA MOTORS
Connecting Aspirations



Passenger Vehicle
Punch EV
India's No. 1
micro-SUV in FY2025

Commercial Vehicle
Intra EV
Last-mile logistics
1.0 – 1.3 Ton class

Towards a low-GWP, safe and scalable future for India's mobile air conditioning sector

Pilot Project of R-290 Refrigerant Substitution Technology for Electric Vehicles

CCAC – UNIDO – TATA MOTORS DEMONSTRATION PROJECT

ATMOSPHERE MAC SUMMIT 2026 X TU BERLIN

 Brussels

29 September 2026

Sunny Kumar (Tata Motors Passenger Vehicles Ltd.)



Why This Project Matters

2028

India enters Kigali phase-down implementation



MAC

MAC sector expected to become a major HFC emission contributor



EV

Rapid growth of EVs and automotive cooling demand



HIGH AMBIENT

Need for low-GWP alternatives suitable for high ambient climates



Key Message: India requires environment friendly low GWP, sustainable and scalable alternatives to high gwp HFC-134a.

R-290: Why Consider Propane?

GWP ≈ 3

~500x lower GWP than R134a

Near-zero ODP

Excellent thermodynamics

R-290

PROPANE

No PFAS / TFA concern

Natural refrigerant

Future-ready mobility

R-290 Value Proposition

Superior cooling

- Highest latent heat of vaporization:
 - R290 ->> 384 kJ/kg
 - R1234yf >>217
 - R134a >> 247
- Excellent thermal conductivity
 - (0.12 W/m ·K) >> improves heat transfer

Higher efficiency

- Better thermodynamic support, better coefficient of performance (COP)
- Enables lower refrigerant charge Qty.
- Suited to high loads: EV battery cooling and cabin comfort

Sustainable

- Naturally occurring hydrocarbon refrigerant (Propane, C₃H₈)
- Degrades primarily to CO₂ and water — no significant hazards reported
- Supports transition to low-impact, future-compliant refrigerants

Compatible

- Chemically stable under normal operating conditions
- Proven compatibility with POE, mineral oil, alkyl-benzene lubricants
- Non-corrosive when system moisture is controlled

Available & cost-effective

- Widely available, well-established industrial refrigerant
- Lower cost vs. next-generation synthetic refrigerants
- Mature global supply chain and service ecosystem

Key challenge: A3 flammability

- Classified as A3 — highly flammable refrigerant
- Requires optimized charge limits, leak detection & ventilation
- Needs crash-safe architecture and ISO/SAE safety compliance

Research Highlights

+67.4%

Cooling capacity

vs R134a under similar conditions

+2.8 to 22.4%

COP improvement

depending on operating condition

~60% less

Refrigerant charge

500–600 g vs 1300–1400 g

+39 to 42%

Volumetric capacity

enables compact system design

1430 → 3

GWP shift

future-ready natural refrigerant

Project Overview

CCAC-UNIDO DEMONSTRATION PROJECT

- Develop R290-based EV HVAC system
- Demonstrate technical feasibility
- Develop safety guidelines

CCAC



UNIDO



Tata Motors Passenger Vehicles Ltd.



TACO-Air International

TACO Air International

Pilot Demonstration Vehicles

PASSENGER

Punch EV

India's No. 1 micro-SUV in FY2025; trusted by 5.5+ lakh customers; best-selling micro-SUV of 2024; continues to lead the market.



COMMERCIAL

Intra EV

Trusted by 1+ lakh customers; fastest in segment to reach the milestone; designed for small businesses and last-mile logistics; 1.0–1.3 Ton payload class.



Technology Approach

SECONDARY LOOP / MONOBLOCK

Cabin cooling

Battery cooling

Heating
functions

Integrated into one sealed RHU architecture

Refrigerant confined inside sealed RHU

Reduced refrigerant exposure in
passenger cabin

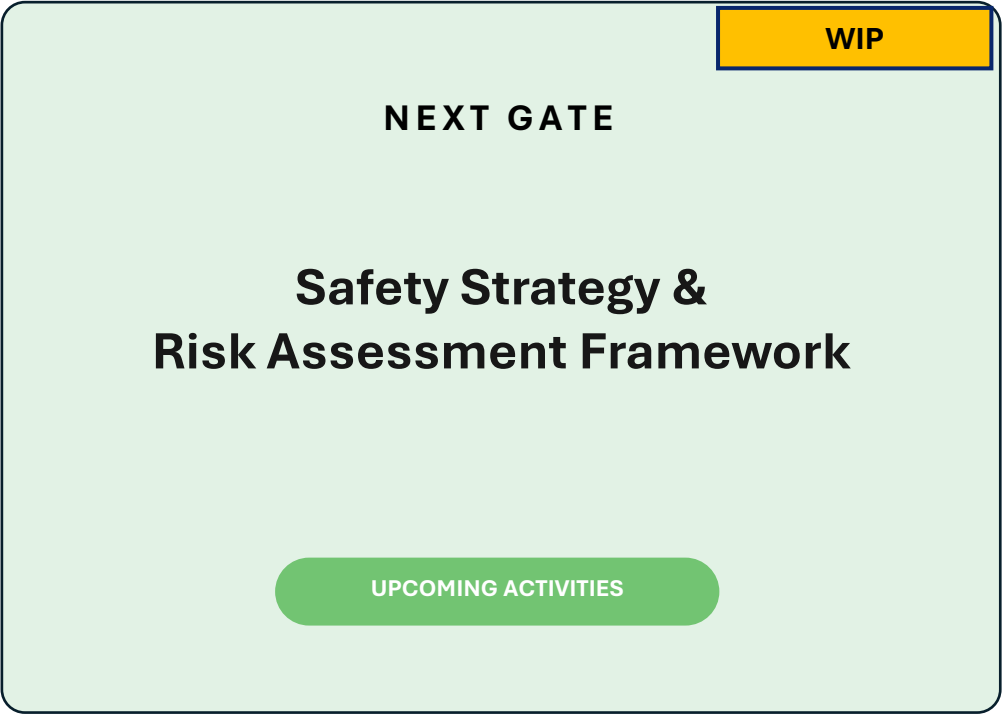
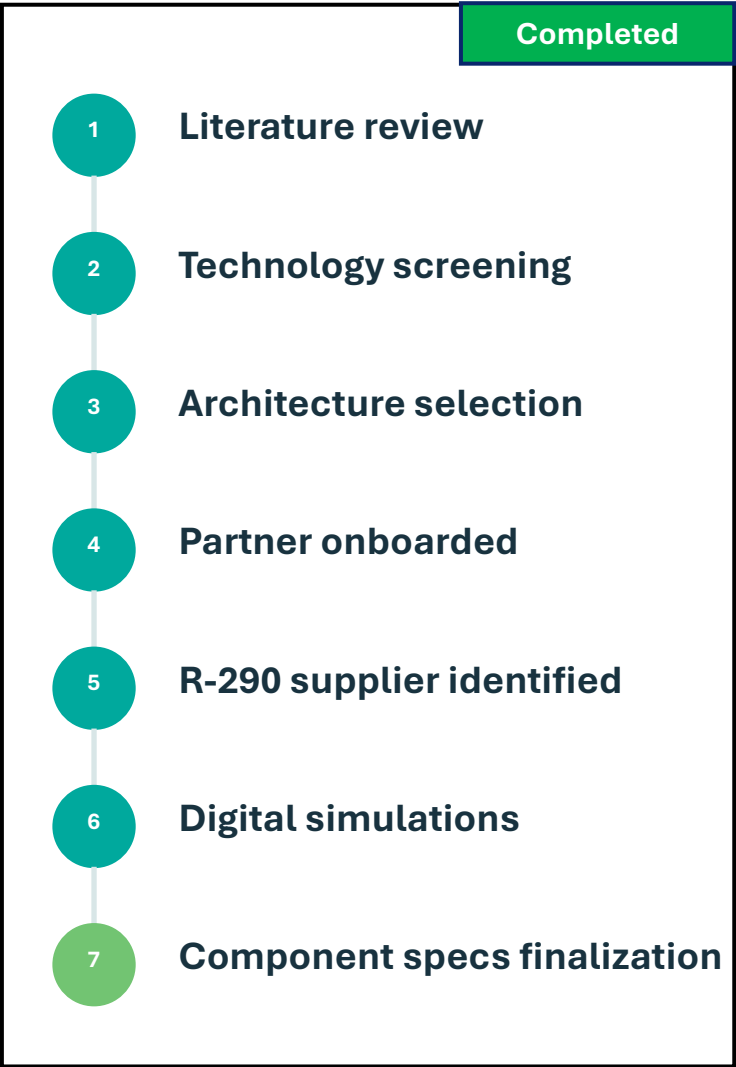
Enhanced safety



Simpler risk management



Project Workflow



Upcoming Activities

1



2



3



4



5

Bench validation

Prototype build

Vehicle validation

Safety testing

**Industry
dissemination**

Key Messages

01

R-290 shows strong technical potential for EV thermal management.

02

Secondary-loop architecture offers a promising safety pathway.

03

Technology validation must be complemented by standards and training.

04

International cooperation can accelerate commercialization.

05

Pilot projects are essential for informed policy decisions.

ACKNOWLEDGEMENTS

With sincere gratitude for guidance, technical support and collaboration

CCAC

**Climate and Clean Air
Coalition (CCAC)**

Driving global initiatives
promoting climate-friendly
cooling technologies

UNIDO

**United Nations Industrial
Development Organization
(UNIDO)**

Strategic leadership and
support in advancing
sustainable refrigerant
transition projects

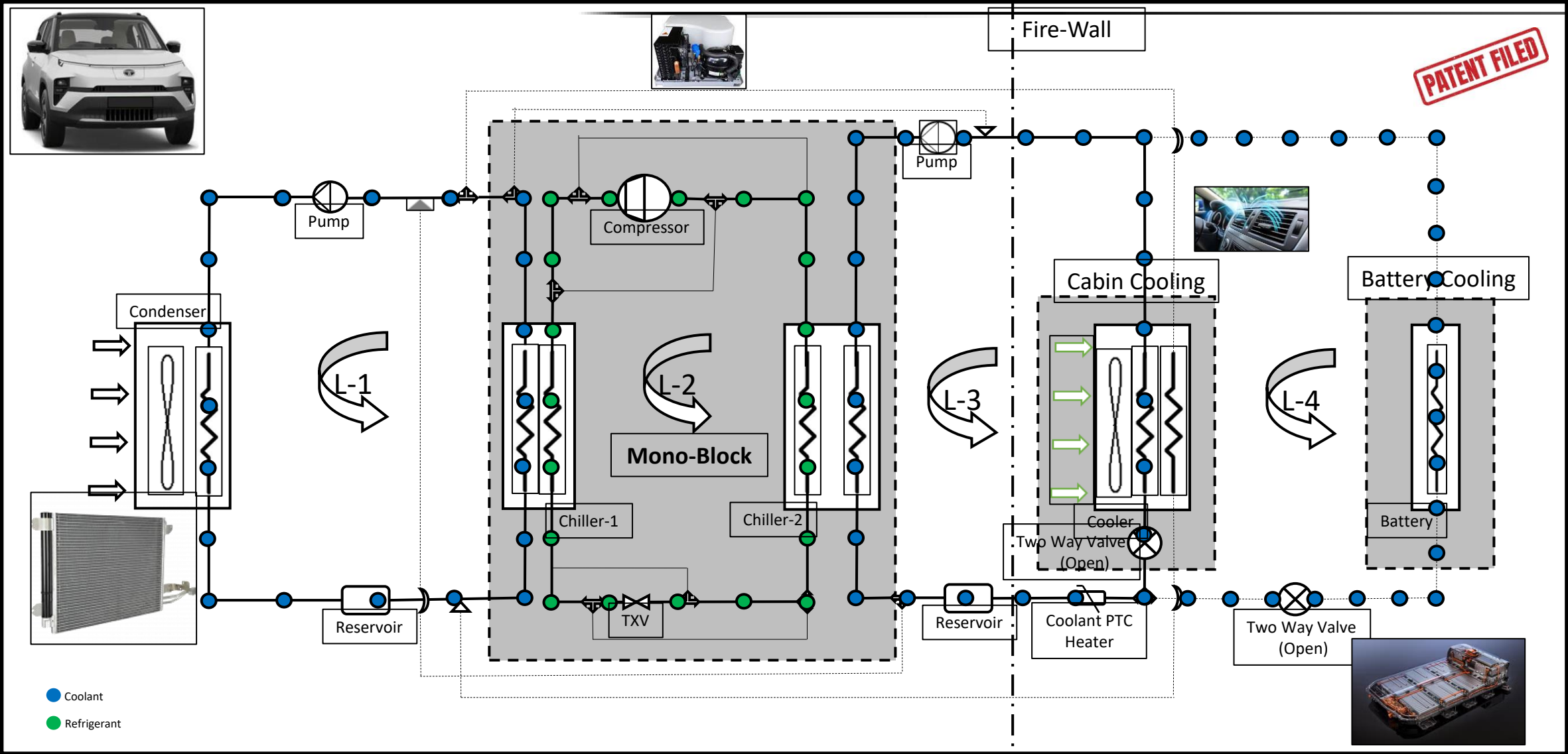
TACO AI

**Tata AutoComp Systems Ltd.
Artificial Intelligence
(TACO AI)**

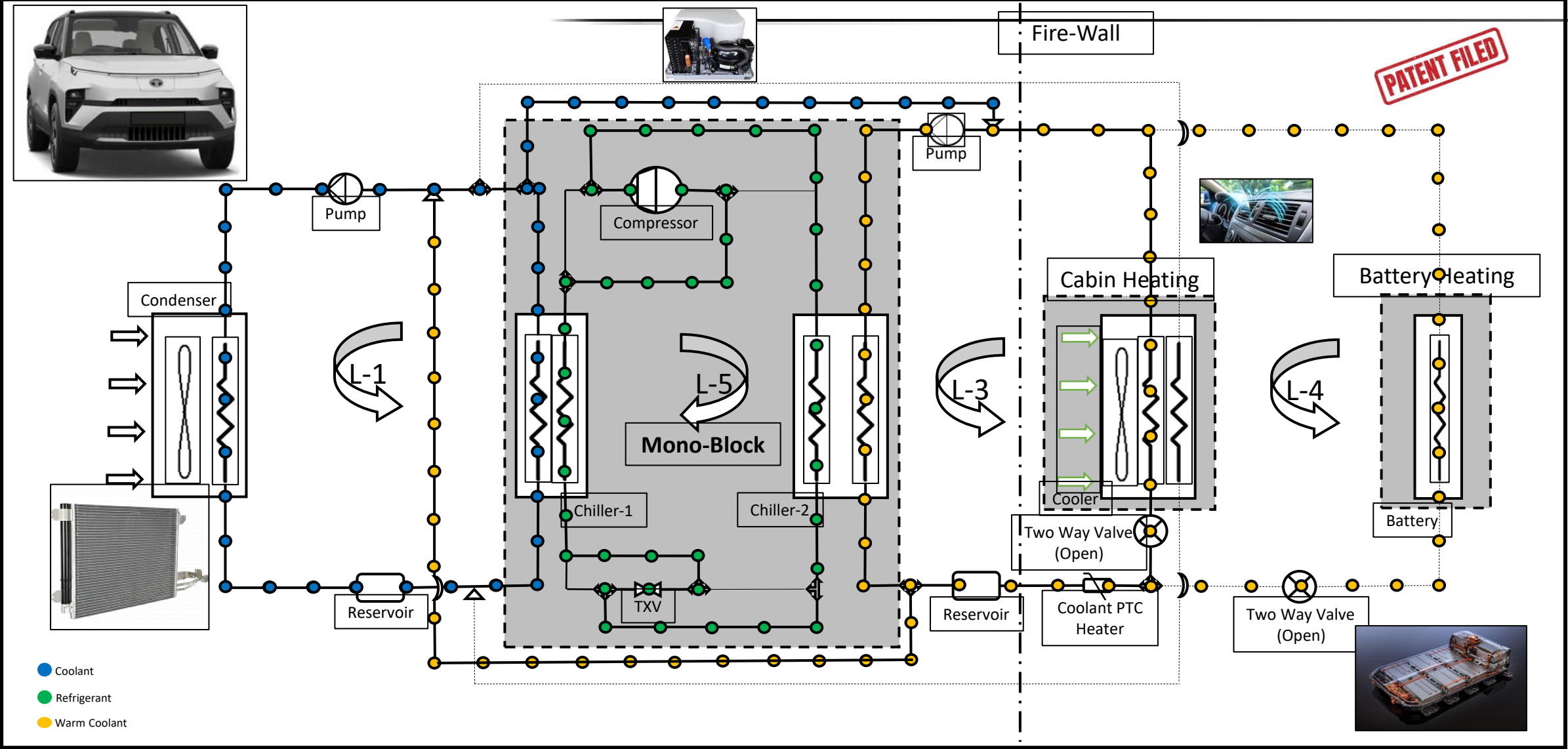
Technical partnership,
innovation support and
contributions toward project
execution

Thank you

Cabin + Battery Cooling



Cabin + Battery Heating



Technical Feasibility Results

ACHIEVED

Cooling

Equivalent performance achieved versus baseline R-134a.

ACHIEVED

Heating

Equivalent performance achieved, similar to baseline.

CONFIRMED

Validation

Multi-mode operation confirmed across scenarios.

Cabin cooling

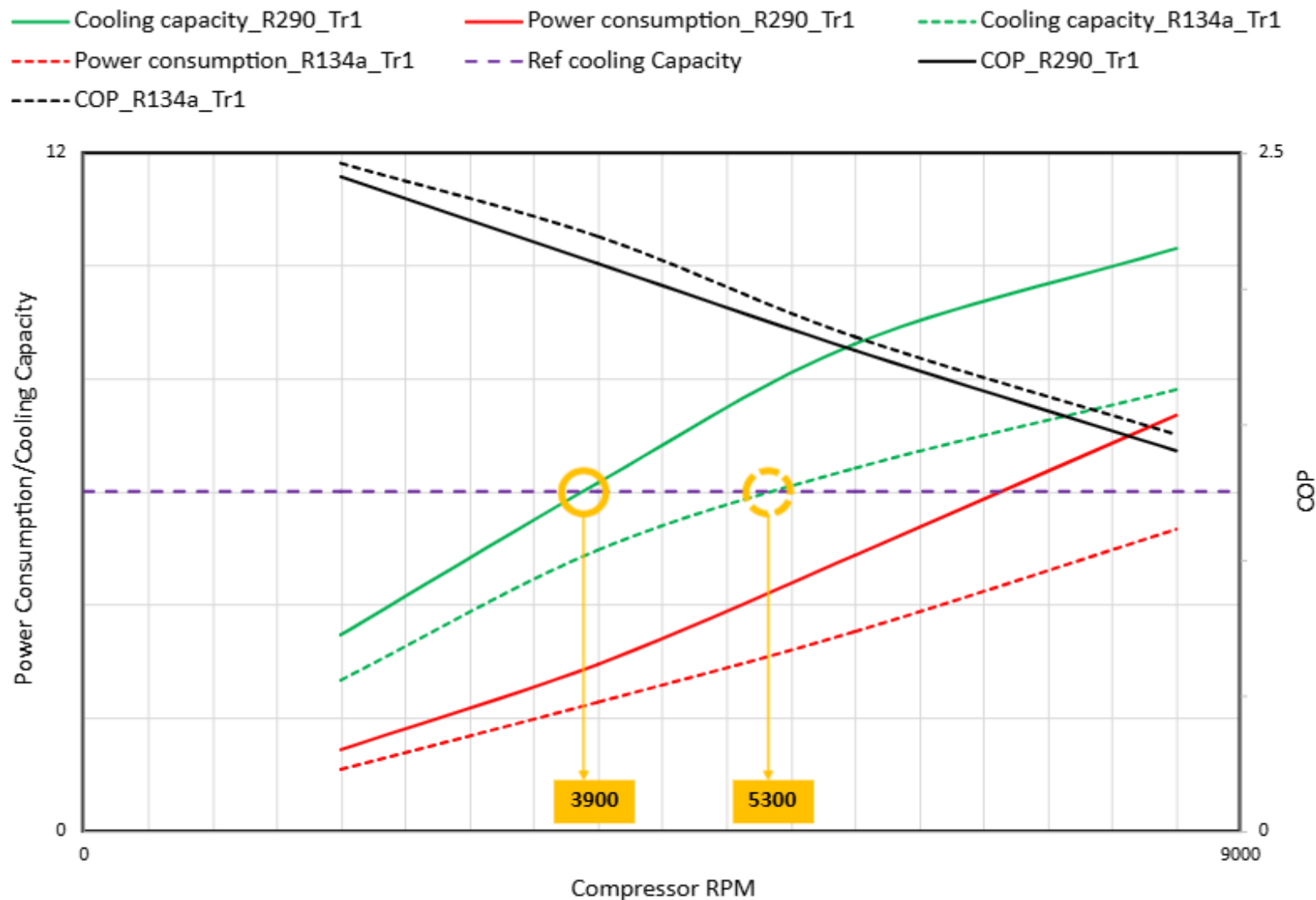
Battery cooling

Cabin + battery cooling

Cabin heating

Battery heating

Drop-In Study: Cooling Mode

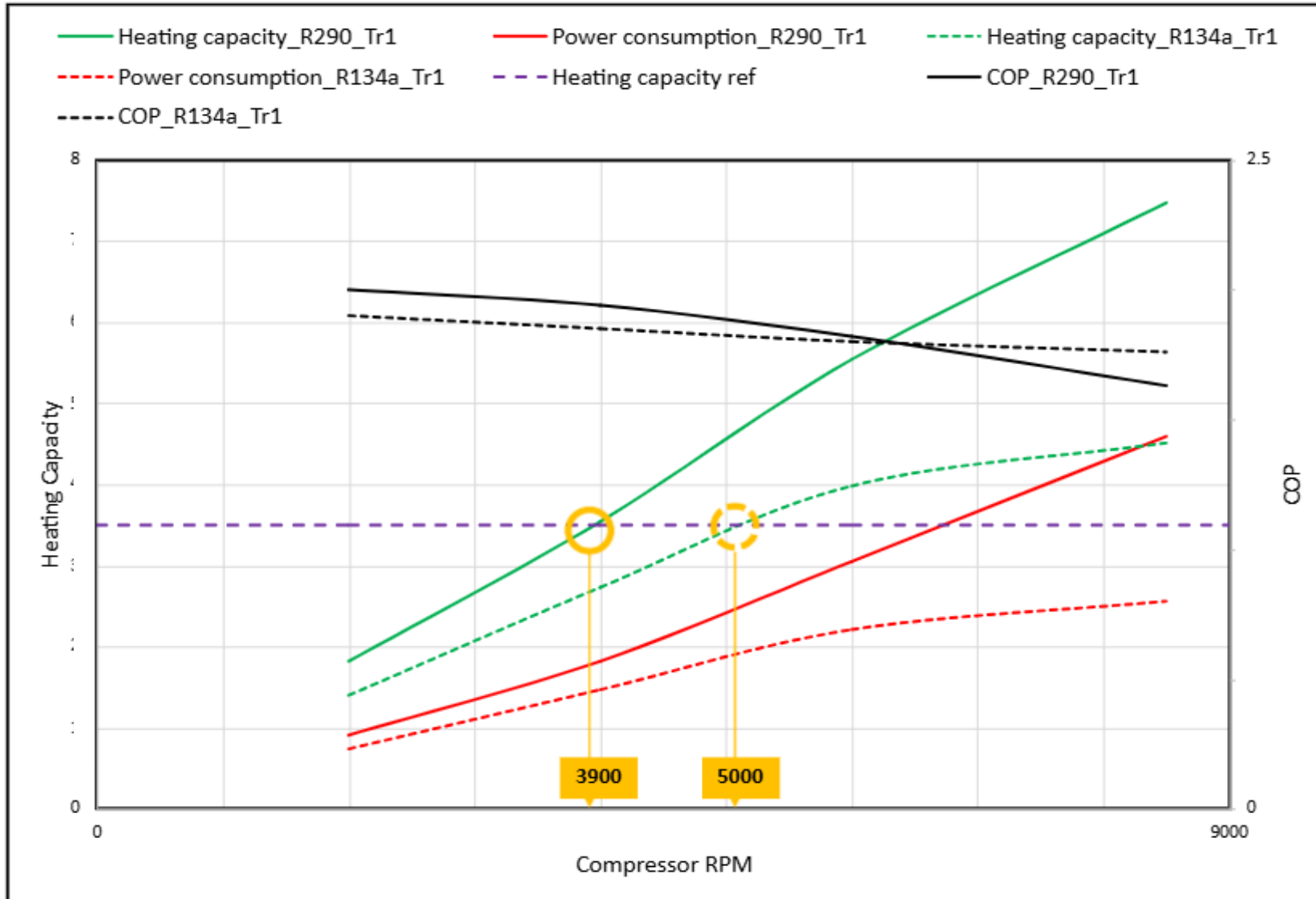


Observations:

- For the same cooling capacity of ~6 kW, R290 system require ~1400 rpm lesser as compared to R134a system in drop in analysis
- Power consumption to achieve similar cooling capacity is almost similar for both refrigerant
- COP of R290 system is observed to be lower in cooling mode



Drop-In Study: Heating Mode



Observations:

- For the same Heating capacity of ~3.5 kW, R290 system require ~1100 rpm lesser as compared to R134a system in drop in analysis
- Power consumption to achieve similar cooling capacity is almost similar for both refrigerant
- COP of R290 system is observed to be higher in cooling mode as compared to R134a till a certain RPM~6500



Performance Highlights

LOWER RPM

Lower compressor speed than R134a

SIMILAR POWER

Comparable power consumption

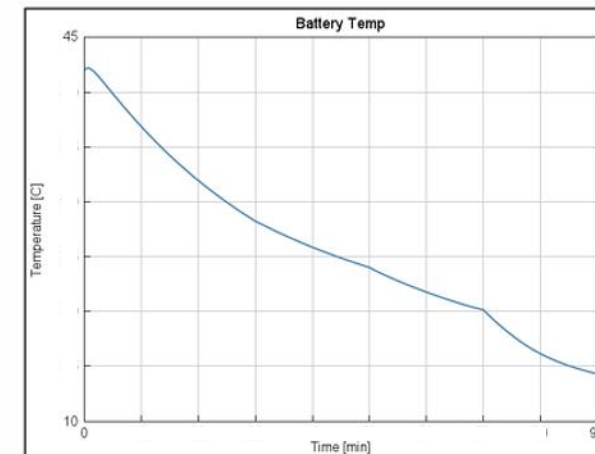
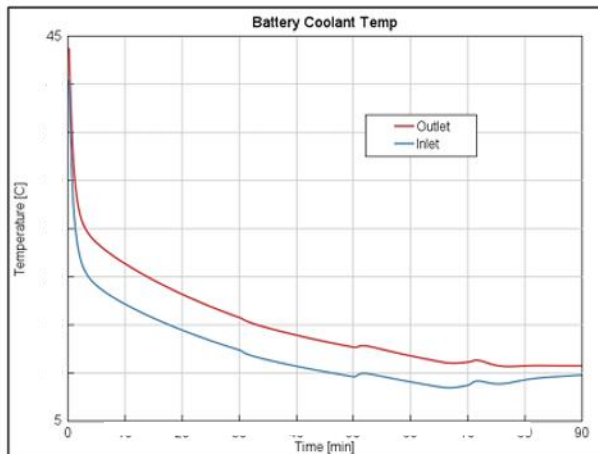
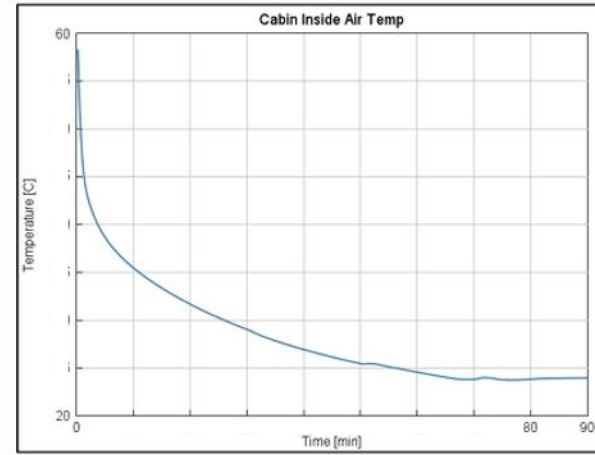
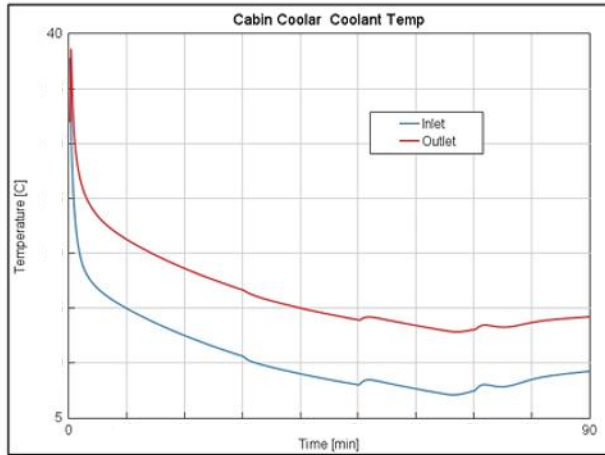
TARGET MET

Cooling and heating requirements achieved

STABLE

System pressures remain stable

Vehicle Level Simulation (Cabin+ Battery cooling)

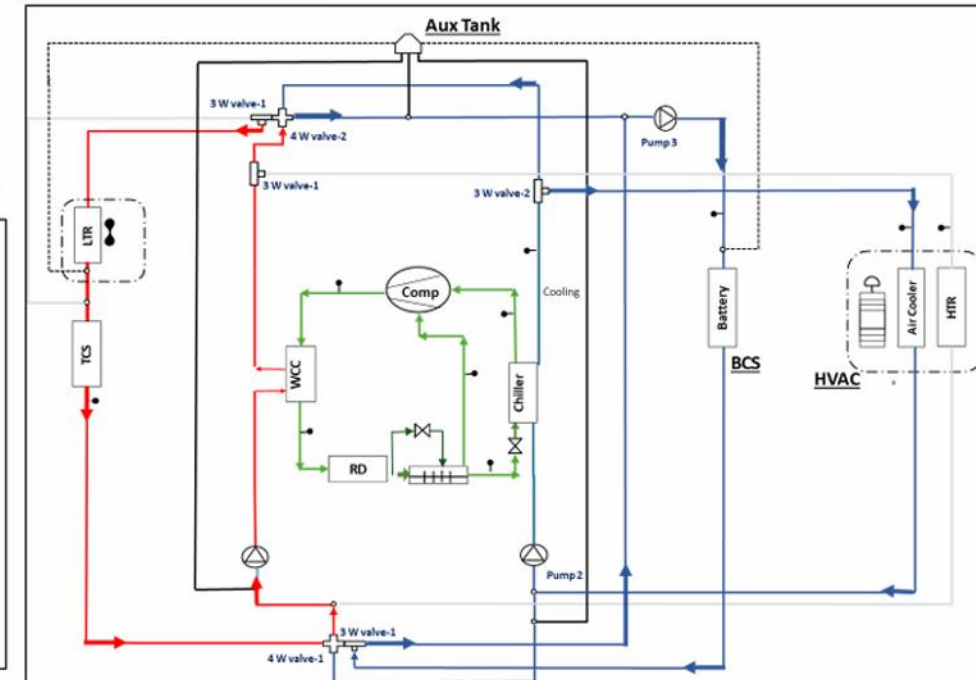


- Ambient: 45°C
- Vehicle state: in running condition
- Cabin ,battery and traction cooling

Vehicle : Running

Cabin + Battery Cooling

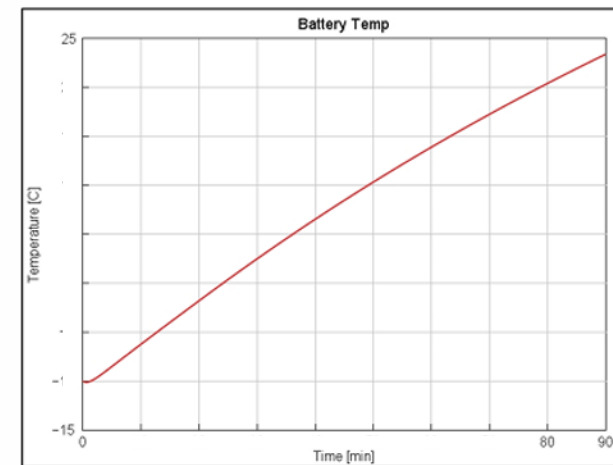
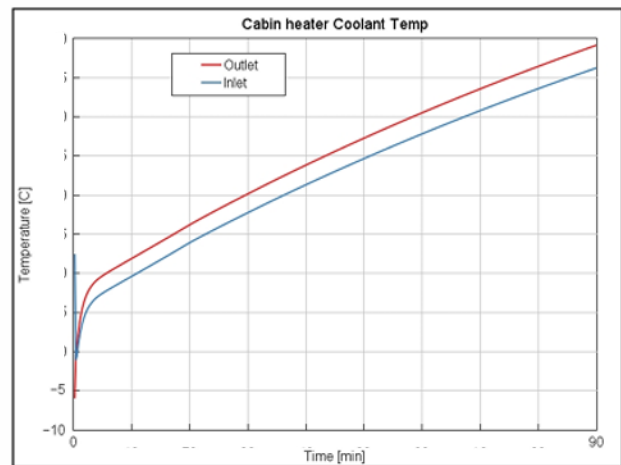
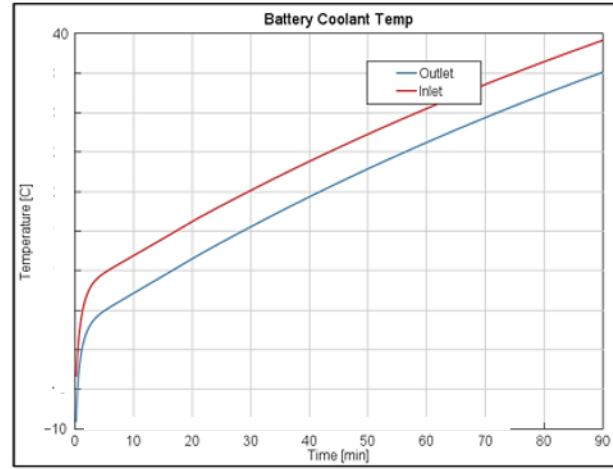
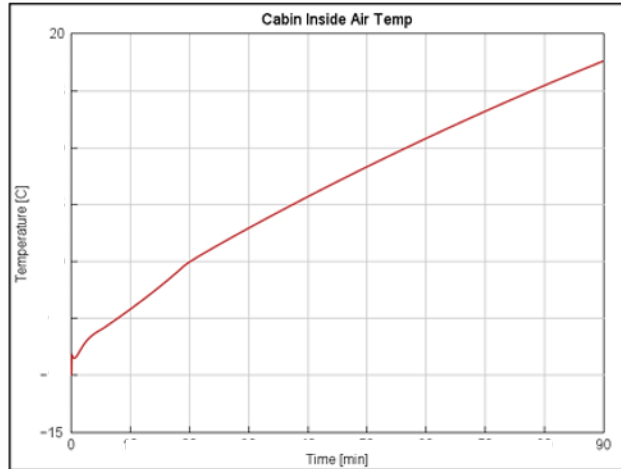
- Traction Coolant circulation
- Chilled Coolant circulation
- Refrigerant circulation



Cabin + battery Cooling Loop

- Vehicle is running condition where cabin and Battery cooling demand is required along with P/T cooling
- Cabin cool down meeting the requirement as per specification

Vehicle Level Simulation (Cabin+ Battery Heating)

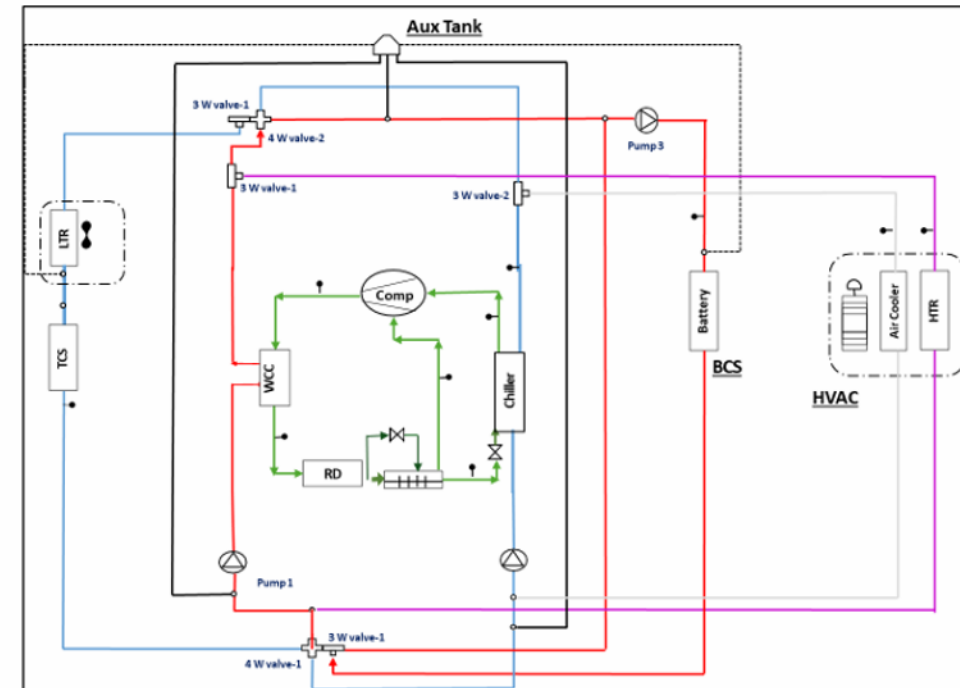


- Ambient: < -10°C
- Vehicle state: Parked
- Cabin warm up with compressor refrigerant heat pump

Vehicle : parking condition

- Cold Coolant circulation
- Hot Coolant circulation
- Refrigerant circulation

Cabin & Battery warm up with traction coolant heat utilization

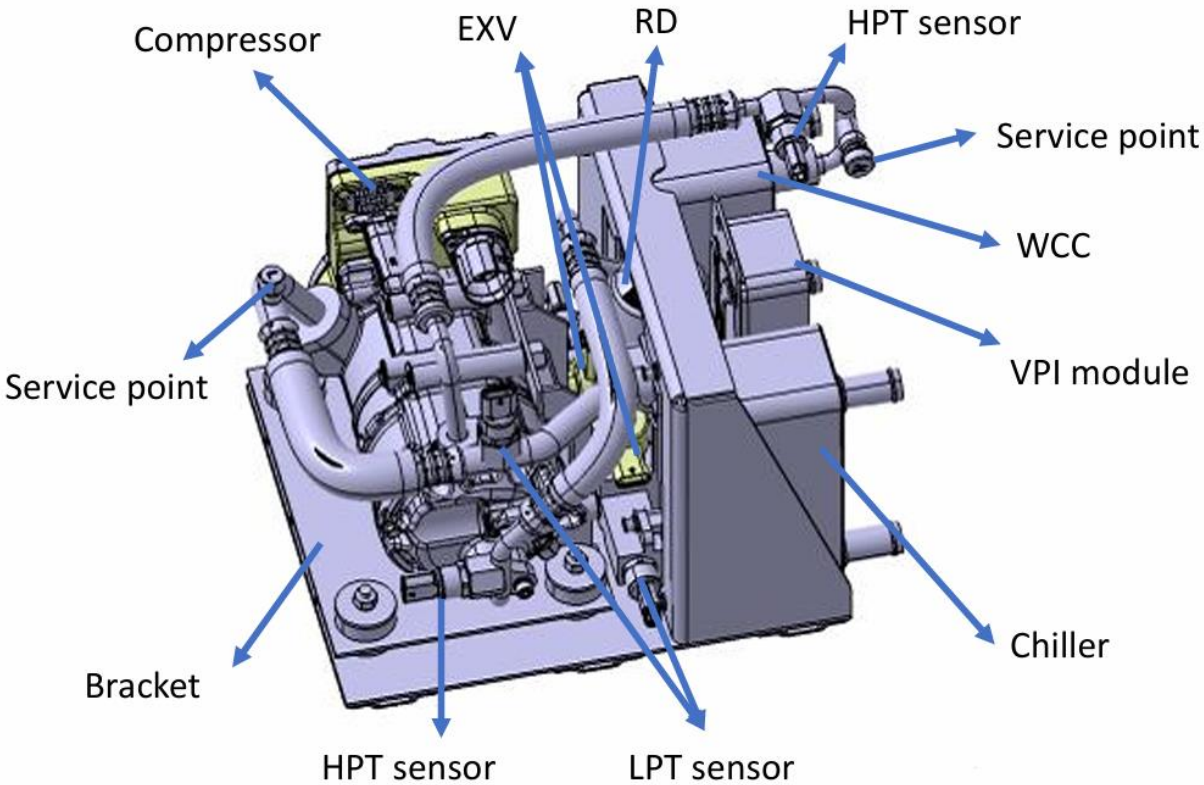


- Cabin and Battery heating meeting the requirement as per specification



System and Component Specifications

RHU Overview



No.	component	Quantity	Items
1	Compressor	1	350VDC,34cc,with VPI,LIN
2	EXV-chiller	1	12VDC,3.0Ton,LIN
3	Chiller	1	10kW@R134a
4	WCC	1	18kW@R134a
5	Receive dryer	1	Volume≥100ml
6	VPI module	1	1.5kW@R290
7	EXV-VPI	1	12VDC,2.0Ton,LIN
8	HPT sensor	2	0.8-35.0 bar A
9	LPT sensor	2	0.5-10.15bar A

Safety Strategy & Risk Framework

Secondary Loop Architecture

Enhancing Sealing

Pressure Sensors

Leak Detection

Isolation Concept

Automatic Shutdown Logic

RISK-BASED SYSTEM DESIGN

Normal operation

Crash events

Fast charging

Vehicle parking

After-sales service

Leak Detection Mechanism & Sensor Selection

01

Semiconductor (MOS) Sensors

PROS
Affordable and compact

CONS
Low selectivity; drift over time



02

Infrared (NDIR) Sensors

PROS
Highly selective and accurate

CONS
Higher cost; periodic calibration



03

Catalytic Bead Sensors

PROS
Proven and fast response

CONS
Humidity/poisoning sensitivity



04

Photoionization Detectors (PIDs)

PROS
Very sensitive at low concentration

CONS
Costly and complex for vehicles

