

Advancing Low-GWP Technologies and Workforce Readiness in India's MAC Sector

OEWG-48 Side Event, 14th July 2026



Application of Natural Refrigerant R-290 in India's Mobile Air Conditioning Sector

CCAC – UNIDO – TATA MOTORS DEMONSTRATION PROJECT

Santosh Venu (Depute General Manager, TMPVL)

OUR CULTURE CREDO

AT TATA MOTORS

We are connecting aspirations by being bold in thought and action, owning every opportunity and challenge, Solving together as one team and engaging all our stakeholders with empathy.

We are **MORE WHEN ONE!**



Why This Project Matters

India's MAC Transition Challenge



India enters Kigali phase-down implementation in 2028



MAC sector expected to become a major HFC emission contributor



Rapid growth of EVs and automotive cooling demand



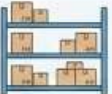
Need for low-GWP alternatives suitable for high ambient climates

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

R-290: Why Consider Propane?

Refrigerant Comparison

Comparison of Refrigerants R134a vs. R-290

R134a (Conventional HFC)			R-290 (Natural Propane)		
	GWP 1430			GWP ~3	
	ODP 0			ODP 0	
	Cost Cost: Higher			Cost Cost: Lower	
	Availability: Moderate			Availability : Widely Available	

Additional Advantages

Excellent Thermodynamic property



No PFAS/TFA Concern



Suitable for future low-carbon mobility





R-290 offers a ~500x lower GWP than R134a, with near-zero ODP and stronger cooling efficiency — positioning it as a natural, future-ready refrigerant for low-carbon mobility.

Project Overview

CCAC–UNIDO Demonstration Project

Objectives

- ✓ Develop R290-based **EV HVAC system**
- ✓ Demonstrate technical feasibility
- ✓ Develop safety guidelines
- ✓ Support future policy decisions

Project Partners

UNIDO



CCAC



Tata Motors



TACO-Air International

TACO Air International

Pilot Demonstration Vehicles

Proof-of-Concept Vehicles



Punch EV

About TATA Punch

- 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



Intra EV

About TATA Intra

- Trusted by 1+ Lakh Customers,
- Fastest in its segment to achieve the 1 Lakh customer milestone
- Designed for small businesses and last-mile logistics
- High payload capability (1.0–1.3 tons class) with superior fuel efficiency and low operating costs.

Chosen to demonstrate applicability across vehicle classes — from passenger mobility to commercial last-mile delivery.

Technology Approach

Secondary loop / Monoblock architecture

Integrated Thermal Management

Cabin cooling



Battery cooling



Heating functions

→ Integrated into a single monoblock architecture

Benefits

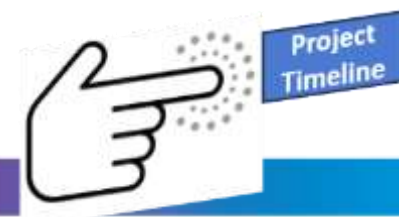
-  Refrigerant confined inside sealed RHU
-  Reduced refrigerant exposure in passenger cabin
-  Enhanced safety
-  Simpler risk management



Project Approach Workflow

- ✓ Literature review
- ✓ Technology screening
- ✓ Architecture selection
- ✓ Technology partner onboarded
- ✓ R-290 supplier identified
- ✓ Digital simulations & Component Specification Finalization
- ✓ Component specifications finalized

Upcoming activities



Technical Feasibility Results

Digital validation results



Cooling

Equivalent cooling performance achieved
(with baseline R-134a)



Heating

Equivalent Heating performance achieved
(similar as baseline)



Validated

Multi-mode operation confirmed across all
scenarios

Multi-Mode Operation Validated

Cabin cooling

Battery cooling

Cabin & battery cooling

Cabin heating

Battery heating

Performance Highlights

Key observations



Lower compressor speed requirement than R134a



Similar power consumption



Cooling/heating requirements achieved

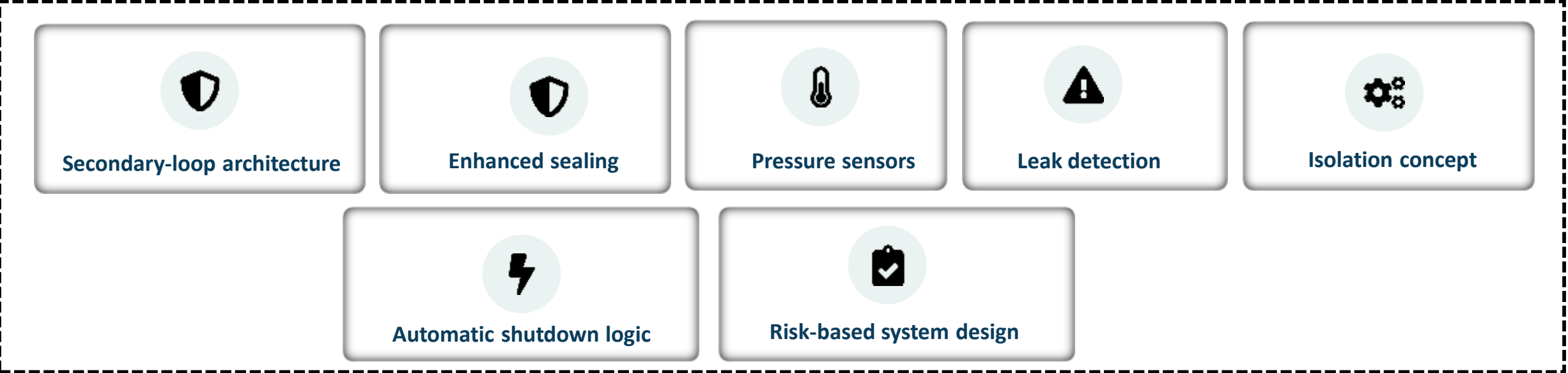


Stable system pressures

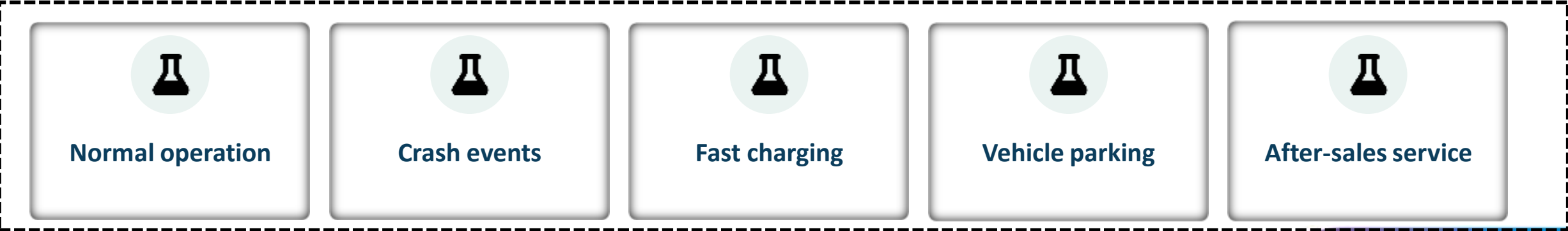
Important: Results confirm technical feasibility of R-290-based architecture in EV applications.

Safety Strategy & Risk Assessment Framework

Safety Strategy



Risk Assessment Framework



Major Implementation Challenges

Realistic outlook

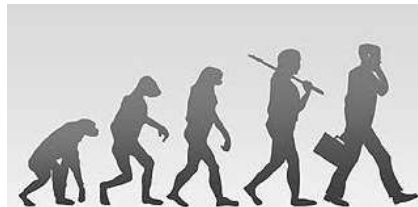
- Flammability (A3 classification)



- Component optimization



- Standards evolution



Key Messages

Takeaways

- 1 R-290 shows strong technical potential for EV thermal management.
- 2 Secondary-loop architecture offers a promising safety pathway.
- 3 Technology validation must be complemented by standards and training.
- 4 International cooperation can accelerate commercialization.
- 5 Pilot projects are essential for informed policy decisions.



Thank You

“Natural refrigerants can play a significant role in supporting Kigali-compliant, climate-friendly mobility cooling pathways in developing countries.”

Back Up-Project Timeline

Project Plan and Timeline																																								
Sr. No.		Task Name	FY 24-25		FY 25-26												FY 26-27												FY 27-28											
		Content	Q1		Q2			Q3			Q4			Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4					
			Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec			
1	Milestone 1	Project Definition, Scop finalization and Budgeting																																						
2		Literature survey, Concept selection thermal system and architectural screening with technology integration in vehicle sector																																						
3		Defining the success criteria for meeting the objectives for the HP-AC (Heat Pump-Air Conditioning) and SL-MAC (Secondary Loop) layouts.																																						
4		On-boarding an appropriate project partner to design and develop R290-based MAC aggregates and components for vehicle application, as per required technical specifications.																																						
5	Milestone 2	Onboarding a local vendor for sourcing of R290 refrigerant.																																						
6		System level CAE simulations for selection of aggregates such as e-compressors, pumps, cooling fans, blowers, valves and sizing of aggregate typically heat exchangers, pipes and hoses.																																						
7		Component and prototype parts development for two vehicle prototypes.																																						
8		Development of electronic control unit and sensors for two vehicle prototypes.																																						
9		Component and system validation for the HP-AC and SL-MAC refrigerant layouts that work with R290.																																						
10	Milestone 3	Vehicle proto build																																						
11		Vehicle level validations including, design of experiments, gap analysis, solutions and calibration activities for evaluating thermal performance, durability and safety aspects for 2 vehicles.																																						
12	Milestone 4	Evaluation of safety risk due to refrigerant flammability and developing appropriate risk mitigation strategies for 2 prototype vehicles with different refrigerant architectures.																																						
13		Formulation of guidelines for standard operating procedures on the safe use of R290 in MAC application for vehicles operating in typical Indian ambient conditions.																																						
14		Dissemination of the project																																						

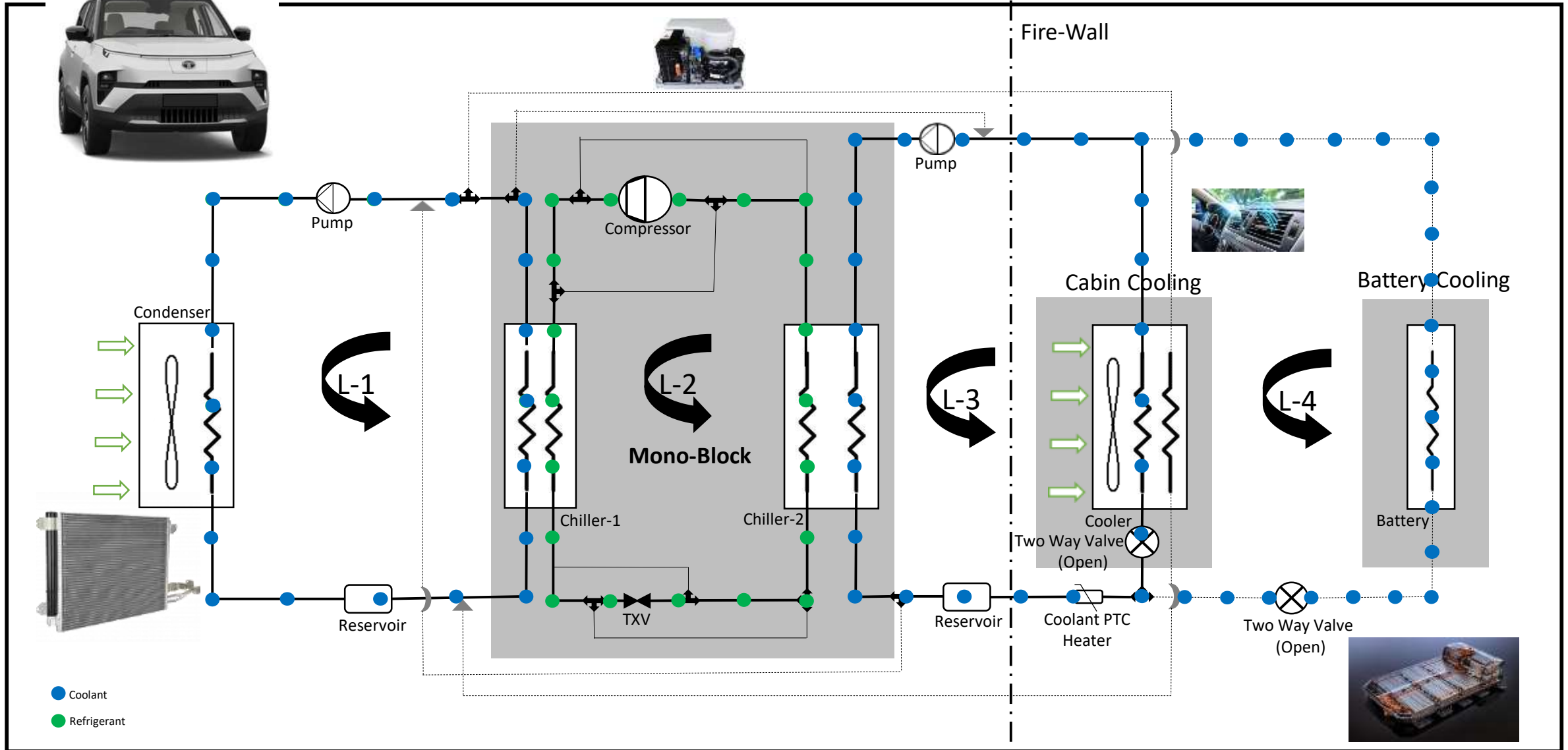
Original Timeline

Expected Timeline

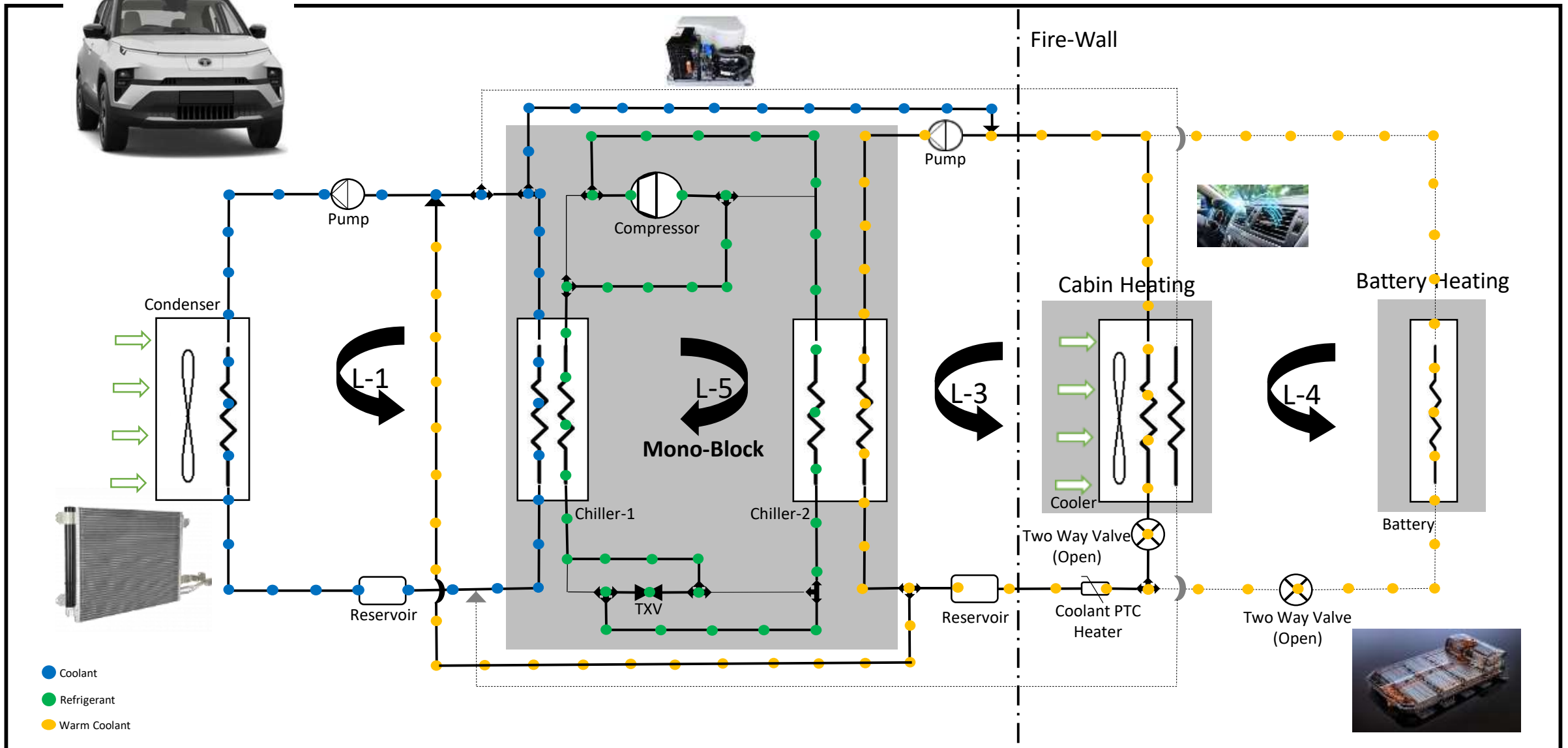
Completed

Milestone 2 pending part (WIP)

Cabin + Battery Cooling



Cabin + Battery Heating



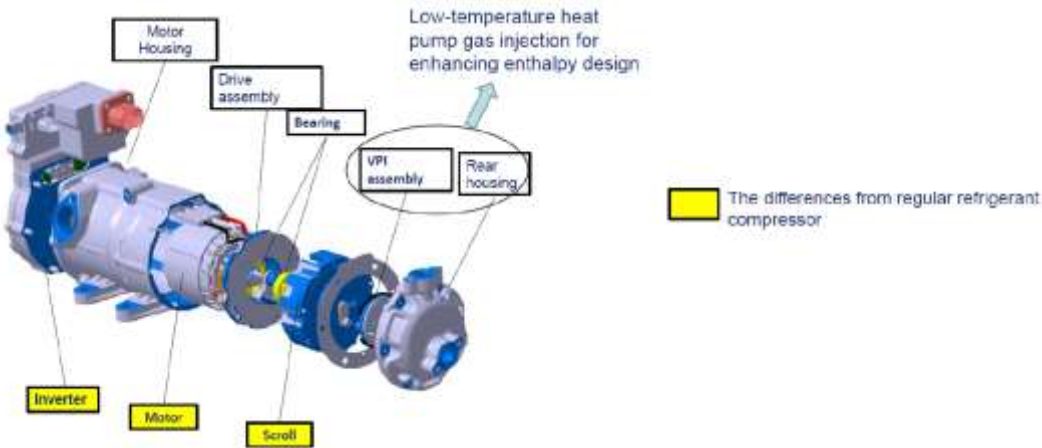
System and Component Specifications (now finalized)

All components are compatible for R-290 and R-1234yf

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

AC Compressor Specification	
Item	34 cc VPI
Displacement	34CC
Refrigerant	R290
Oil	PAG
Motor	10KW
High voltage range	400-900V
Low voltage range	9-16V
Operating temperature	-35-125°C
Storage temperature	-40-125°C
Rpm	800-8500rpm
IP rating	IP67
Communication protocol	CAN/LIN
Weight	6.82kg

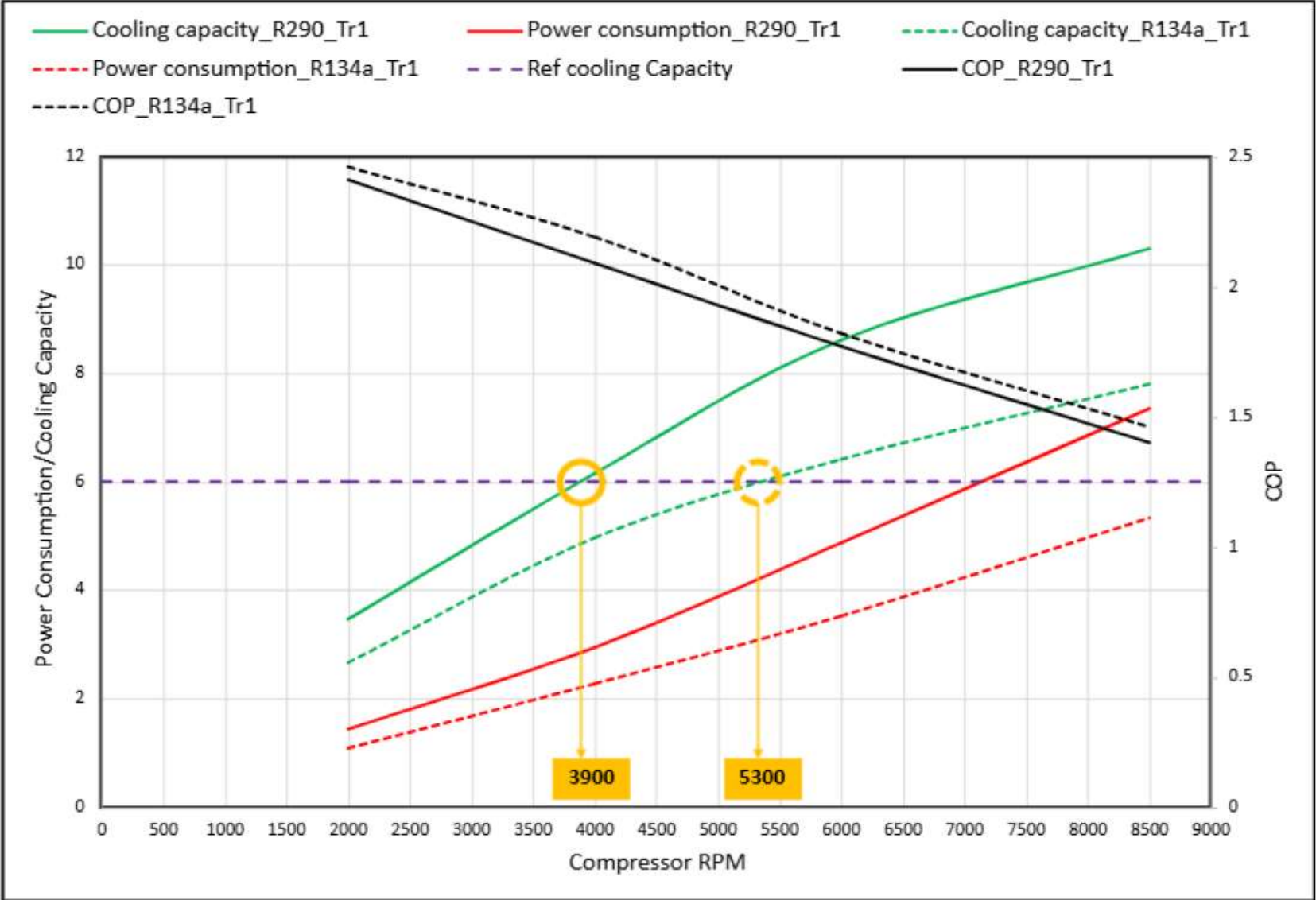
1st mass produced R-290 AC compressor



TACO Air International

Refrigerant Drop In Study: R-134a (baseline) vs. R-290 (proposed)

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 as compared to R134a



R-290 Use Cases and Potential Risk of Thermal Incidence



Sr. No.	Risk Scenarios	Potential Causes
1	Normal Use	Fast leak - damaged seals, charge port valves, pipe fatigue failure, rupture of rubber hoses due to high pressure - Sparks from relays, fuse, switches, static electricity, wiring components, other electronic devices & gadgets - Battery cell overheating - Overheating of AC compressor
2	Crash Events	A crash could lead to a sudden release of R-290 from HVAC aggregates, exposing to heat or electrical sparks - Frontal crash - Side impact crash - Vehicle rollover
3	Vehicle Parked (Garage or Outside)	Fast leak - damaged seals, charge port valves, pipe fatigue failure, rupture of rubber hoses due to high pressure - Lighting firecrackers near the vehicle during festival seasons and other celebrations - A person is smoking a cigarette near the vehicle and throws it close to the vehicle - Electrical short circuit/ fire incident in the vehicle parking area
4	Vehicle Parked (HV Fast Charging)	- Battery Control System (BCS) failure during extreme temperatures, overheating, internal short circuits - AC pre-cooling stage - refrigerant leakage due to high pressures due to failure of cooling module or other faults in the AC system
5	After Sales Service	- Incorrect procedures/ poor ventilation during venting out the gas, refrigerant charging - Improper R290 cylinder storage and handling could cause propane to accumulate and ignite - AC maintenance/ repair near hot work areas ignition sources including static sparks, water heaters and small electrical devices such as an electric drill or the like - Unauthorized modifications or retrofit systems

Note: These are only some real world conditions, additional potentially hazardous conditions continue to be identified