



The natural refrigerant Pivot

Valeo's Development Roadmap for R744 & R290 Mobile Thermal Systems

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Agenda

01 WW regulation & Market Trends

02 Optimized system design for 1234yf, R290 and R744

03 Price positioning

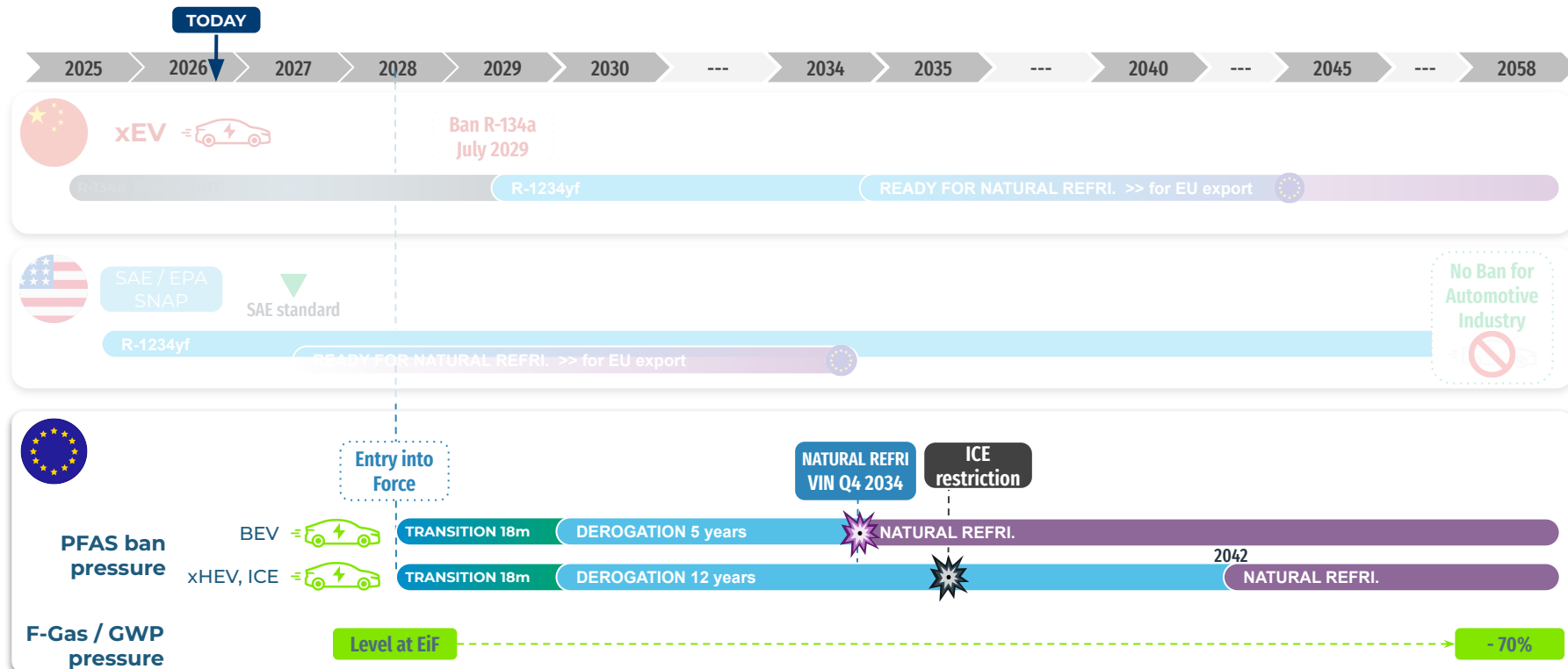
04 Wind Tunnel and road tests

05 Conclusions

01

WW regulation & Market Trends

Regulations increasing the strategic relevance of Natural Refrigerants



Regulation is global. The technology pathway is not.
But Valeo is prepared to support the refrigerant switch in all regions.

02

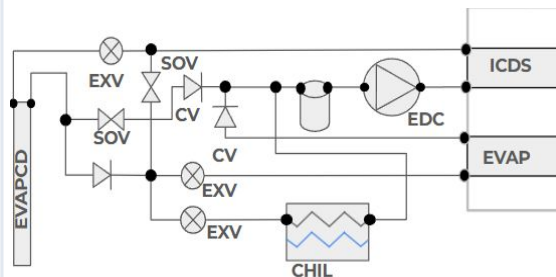
Optimized system design for R1234yf, R290 and R744

THERMAL ARCHITECTURES PER REFRIGERANT

R1234yf

Heating: **A2A**
Cooling: **A2A**

ACCU w & wo IHX



REFRIGERANT
3 EXV + 2 SOV

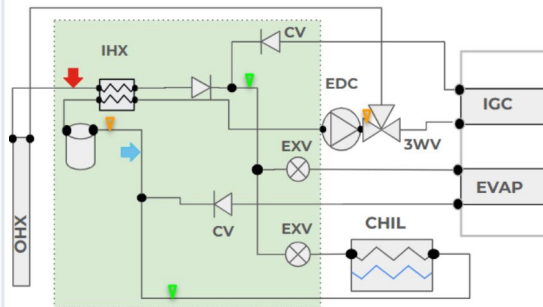
COOLANT
2 x Pumps + 2 x 3 way valves + HVCH

HEX
16 mm EvapoCDS + 12 mm Radiator

R744 Optimized

Heating: **C2A**
Cooling: **A2A**

ACCU and IHX



REFRIGERANT OPTIMIZED
2 EXV + 1 3 way valve

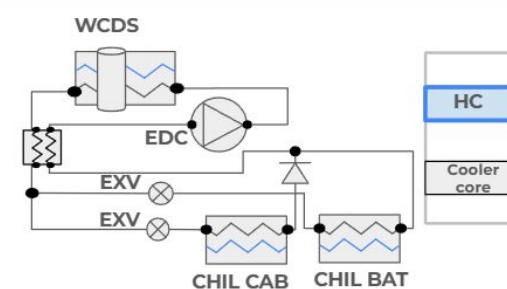
COOLANT
2 x Pumps + 3 x 3 way valves + HVCH

HEX
16 mm Gas cooler + 21 mm Radiator

R290

Heating: **C2C**
Cooling: **C2C**

RD w IHX



REFRIGERANT
2 EXV

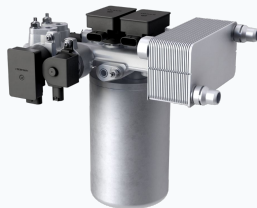
COOLANT
4 x Pumps + 4 x 3 way valves + HVCH

HEX
27 mm Radiator

All architectures are optimized per refrigerant
while meeting functional requirements and taking into account **same front end and HVAC sizing**

SMART HEAT PUMP MODULE DESIGN

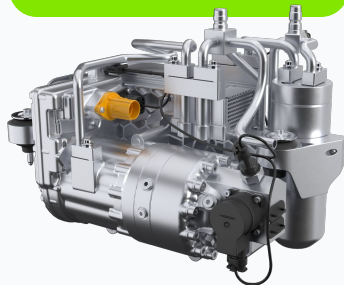
R1234yf



Key characteristics

- **Modular HP Architectures:** Integrated systems.
- **5 e-valves** integrated in one compact manifold.
- **> 20** operating modes.
- **Compact 12L** design volume.
- **Lightweight 2.9 kg** (Manifold, ACCU, Chiller, valves).

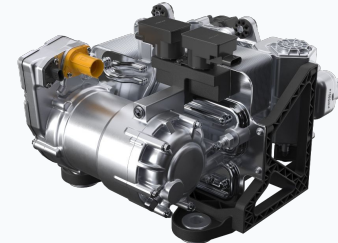
R744



Key characteristics

- **High performance** 8cc 800V EDC.
- **Compact Module** 22L overall sizing.
- **> 20** operational modes.
- **Simplified architecture** with only 3 refrigerant e-valves.

R290



Key characteristics

- **Modular design** supporting 1 or 2 chillers.
- **Scalable** architecture (EDC & compact HEX).
- **Compact dual module** (refrigerant + coolant): < 32 l.
- **Up to 27** operating modes.
- **R290 safety:** -25% leakage & -6% charge.

PERFORMANCE & EFFICIENCY BENCHMARK

(Data based on system bench evaluation)

R1234yf**R744****R290****Cabin cooling @35°C HVAC/45°C Ext. (kW)**

Performance @6000 RPM

5.7 kW**7 kW****6.5 kW****Cabin cooling @30°C (COP) efficiency (2.7kW)****2.8****2.4** (a)**2.5** (a)**Battery cooling @35°C (kW) @6000 RPM****8.4 kW****9.4 kW****10.6 kW****Cabin heating COP @-7°C (@2,5kW)****2.4****2.5****2.1** (a)**Cabin heating COP @-7°C (@5,7kW)****2,0****2.3****2.0****Cabin heating (kW/COP) @-18°C****3.3 kW / 2.7****7.0 kW / 1.9****6.9 kW / 1.7**

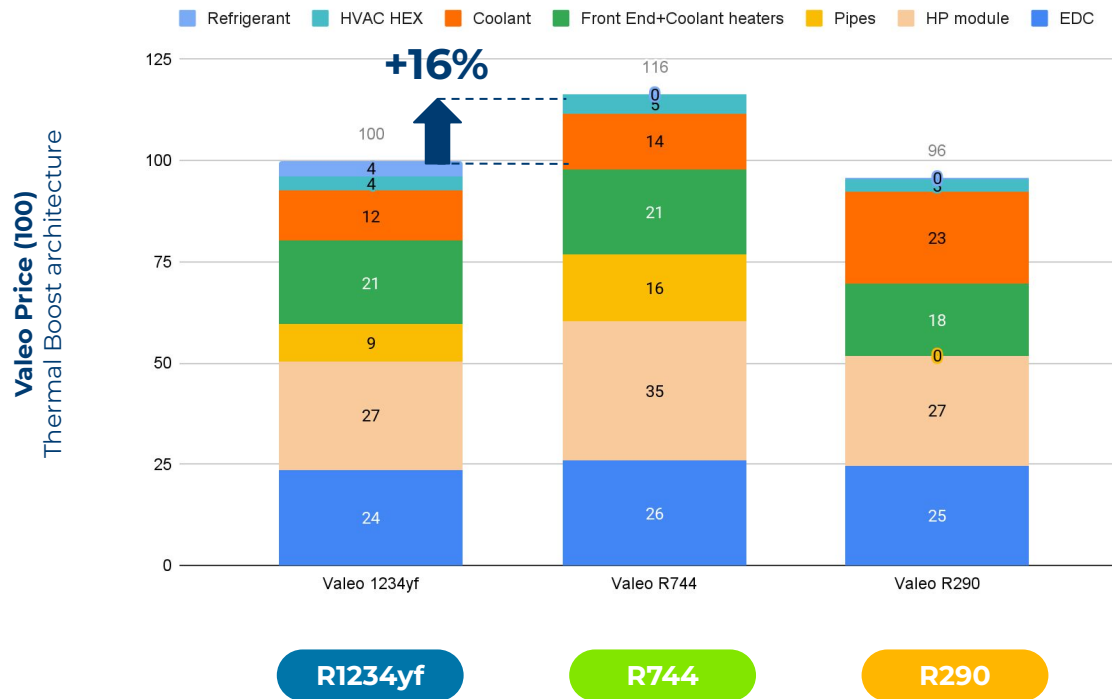
(a) improvement measures under development

Both **R744** and **R290** can replace **R1234yf** Heat Pump
and meet current performance/efficiency requirements

03

Price positioning

ECONOMIC BENCHMARK - THERMAL SYSTEM SCOPE



R290 total system competitive price positioning vs. 1234yf excluding safety risk/measures

R744 total system price with optimized module is +16% above 1234yf

04

Wind tunnel and road test

DEMOCAR Configuration

     	MODEL	 R744  BMW iX3 (RWD only)	 R290  CHERY EXEED
	EXTERNAL SIZE (LxWxH)	4.73m x 1.89m x 1.67m	4.95m x 1.98 x 1.69
	HVAC max flow AC/Heating (kg/h)	630 / 490	630 / 480
	Front End Size	OHX 25 dm2 16 mm + LTR 21mm	LTR 26.6 dm2 27 mm
	Fan power (W)	700	600
	Estimated cabin inner volume (l)	2871	3450

The 2 Democar have similar **Front Cooling Module** & **HVAC** performances
but **R290 vehicle have a bigger cabin volume**

Warm-up comparison @ -7°C

Cabin Heat Up @ -7°C

Applied heating protocol:

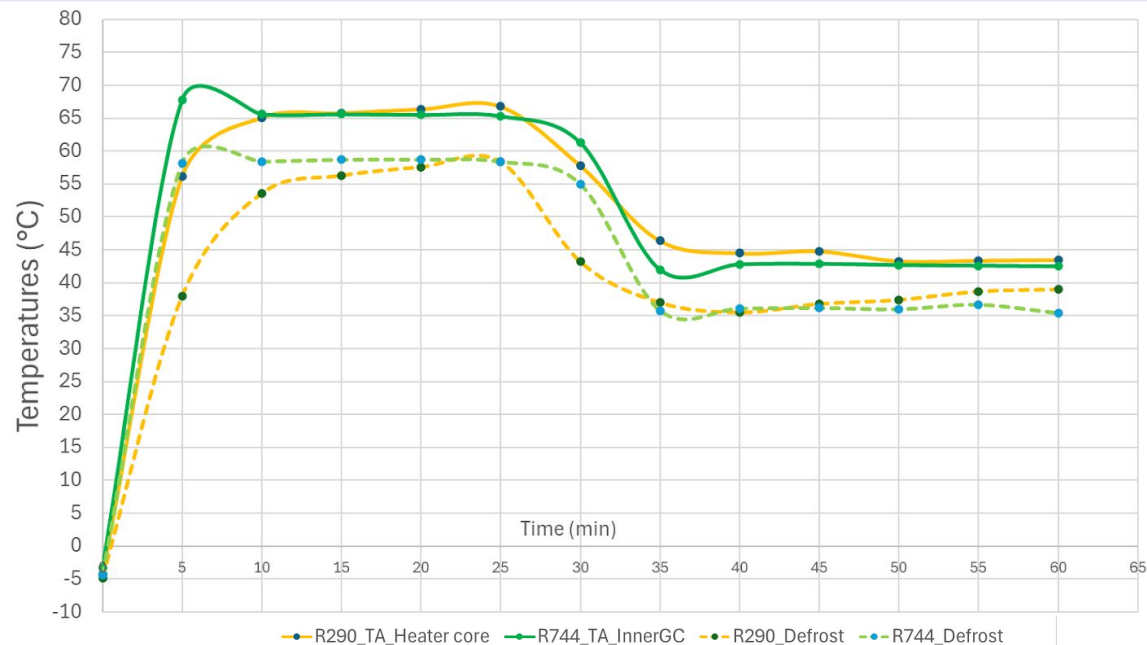
- 30 min max hot (65°C Air)
- 30 min AUTO 21 (45°C Air)
- No electrical heater used



System A
R744
optimized



System B
R290



Heating Capacity

Both fluids offer excellent time to comfort without any additional Electrical Heater.

Start-up Phase (First 5 mins)

R744 achieves a better time to comfort than R290. (mainly due to R290 added coolant inertia.)

Cool down comparison @ 40°C

VDA Cool Down

max cold protocol:

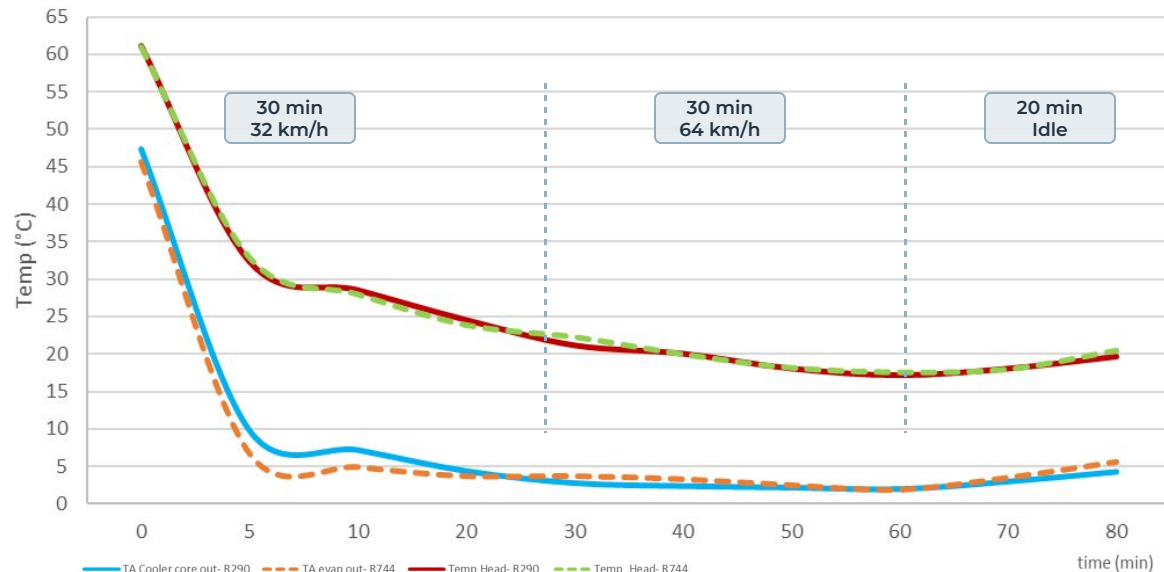
- 30 min - 32 km/h
- 30 min - 64 km/h
- 20 min Idle



System A
R744
optimized



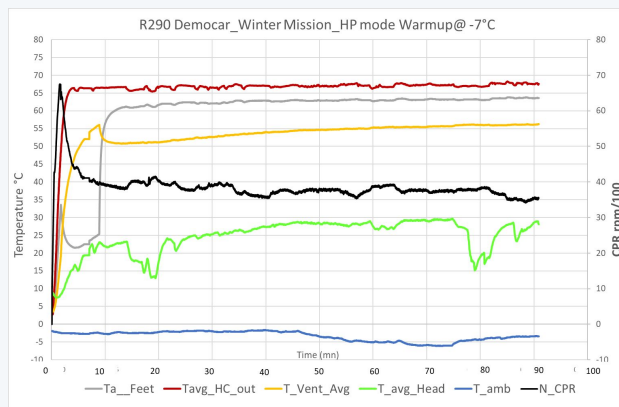
System B
R290



Good cool down performance for both fluids in line with current benchmark data.

Dynamic (Starting Phase 0-10 min): R744 achieves a faster cool down than R290 (mainly due to R290 added coolant inertia).

❄️ WINTER MISSION: -7°C cabin warm-up performance



☀️ SUMMER MISSION: +40°C extreme cooling



★ Heating & cooling performance successfully demonstrated in the field

05 Conclusion

Strategic Transition

In summary, the transition away from chemical refrigerants like R1234yf, is both environmentally necessary and technically feasible.

Proven Performance

Current development and system-level testing of R290 and R744 demonstrate that these natural alternatives deliver comparable cooling and heating performance to the current baseline.

Future Viability

While R744 requires handling higher operational pressures and R290 mandates robust flammability safety measures, their system-level efficiency confirms that a clean, Natural Refrigerant future is within reach.



Driving Change Together