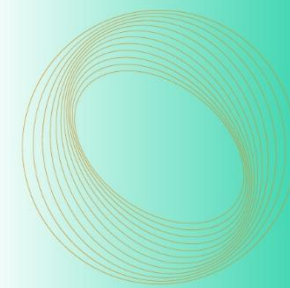




The Business Case Natural Refrigerants



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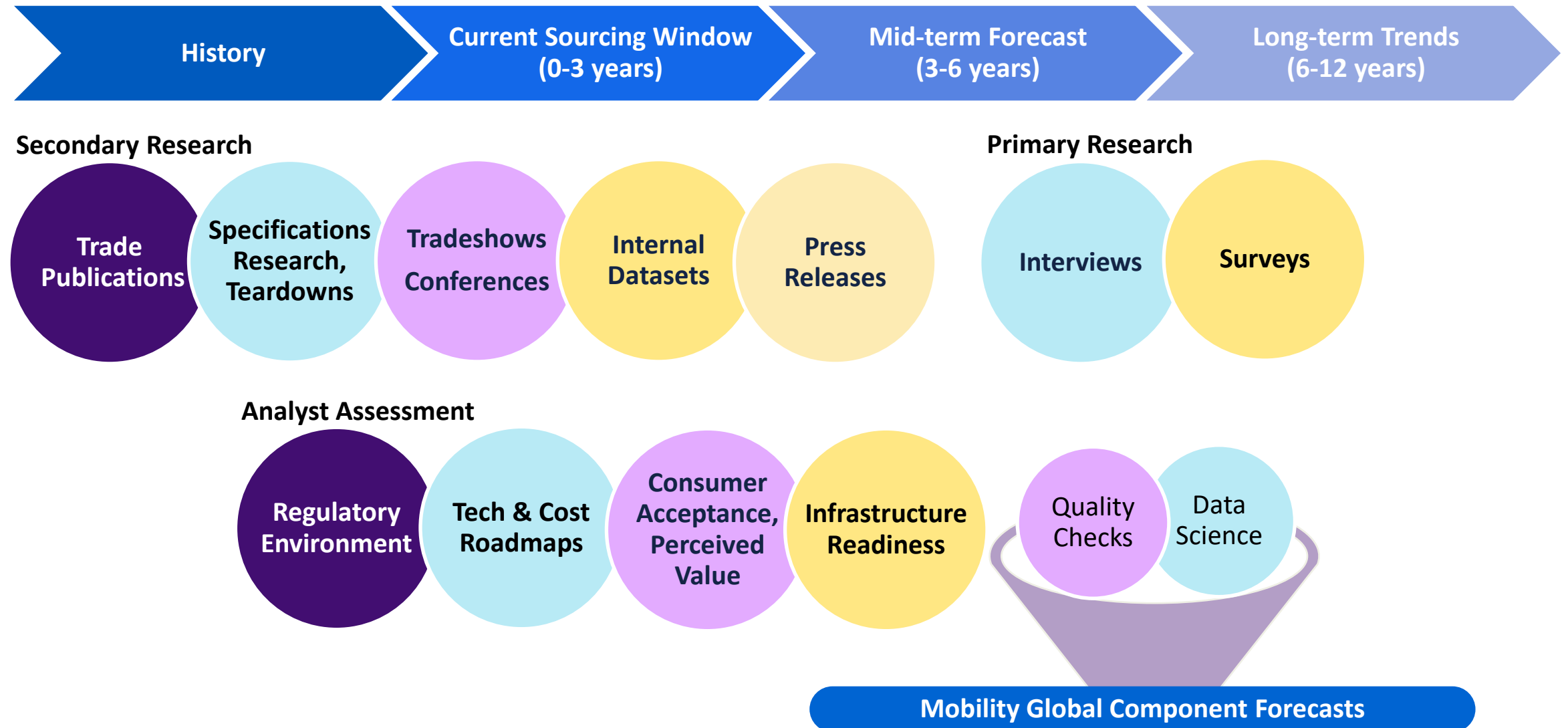


Market Dynamics of Air Conditioning Refrigerants

Matteo Martini, Supply Chain and Technology Associate Director
Mobility Global | Planning Solutions

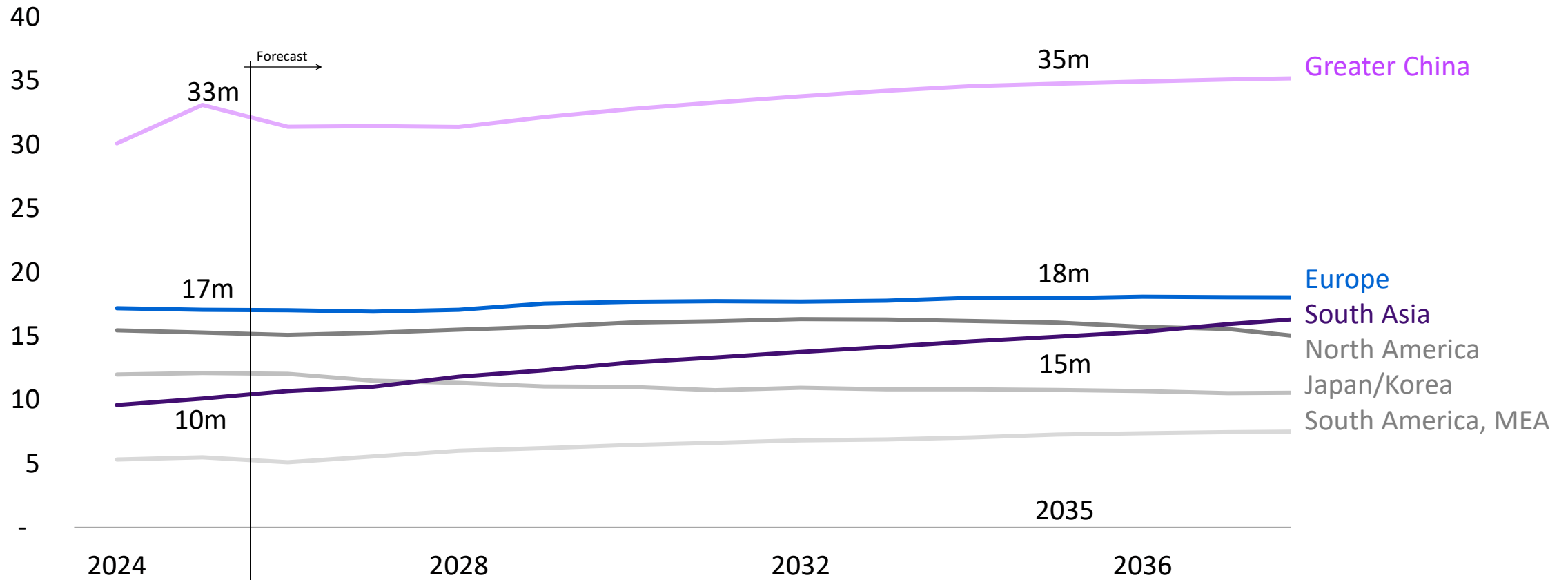


Research Background



A 17 million per year market pushing for AC refrigerant changes

Light Vehicle Production by Region (million vehicles)



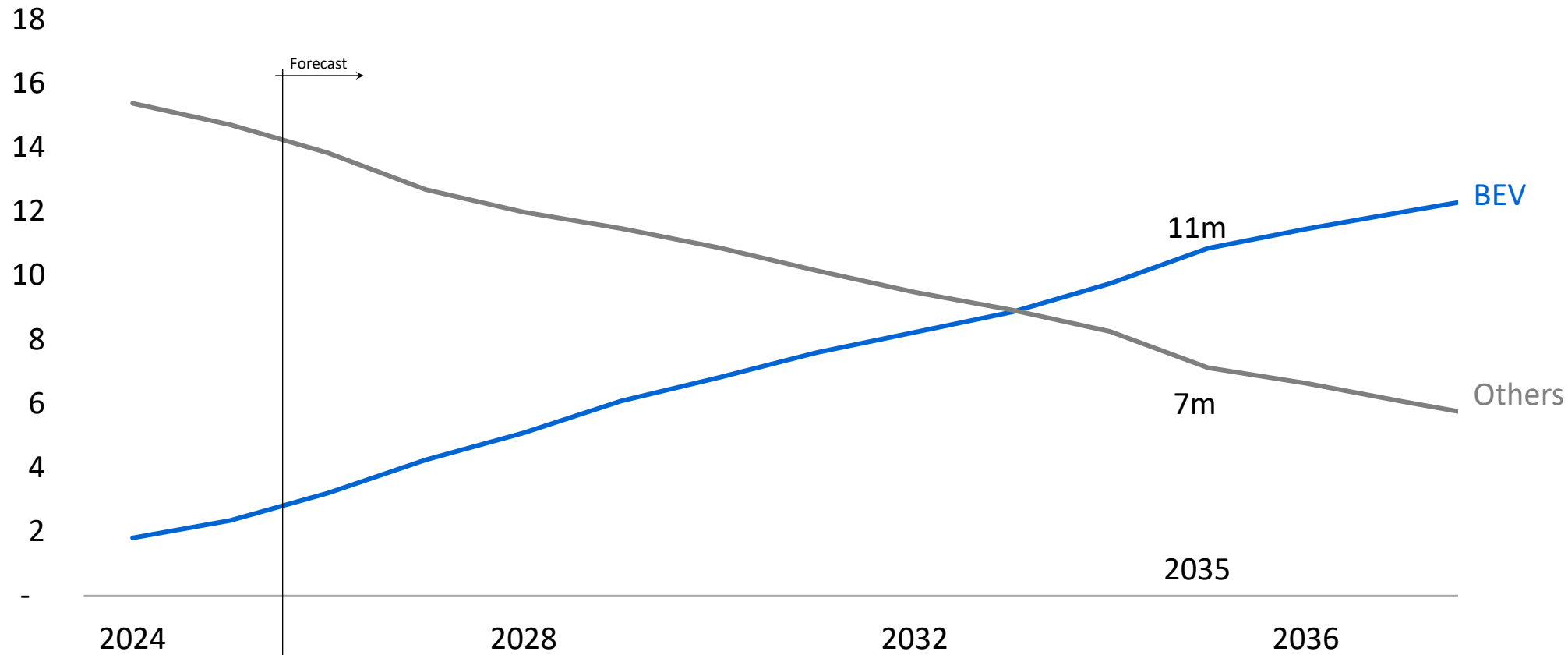
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. MEA=Middle East and Africa.

Source: Mobility Global | Planning Solutions

By 2035 in Europe, BEVs will be the majority but other propulsions will still be relevant

Europe's Light Vehicle Production by Propulsion Type (million vehicles)



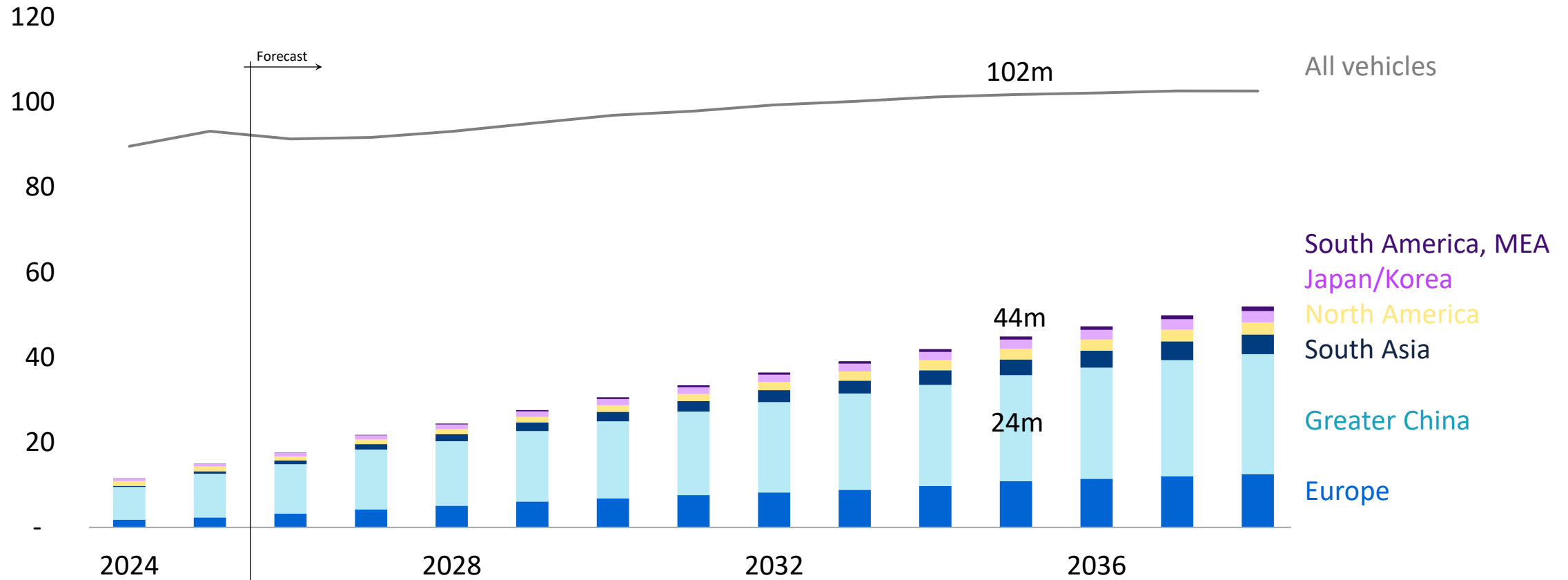
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. BEV=Battery electric vehicle. Others include internal combustion engines, mild hybrid, full hybrid, plug-in hybrid, series and range extender vehicles.

Source: Mobility Global | Planning Solutions

By 2035, BEVs will be almost half of all vehicles worldwide, with majority in China

BEV Light Vehicle Production by Region (million vehicles)



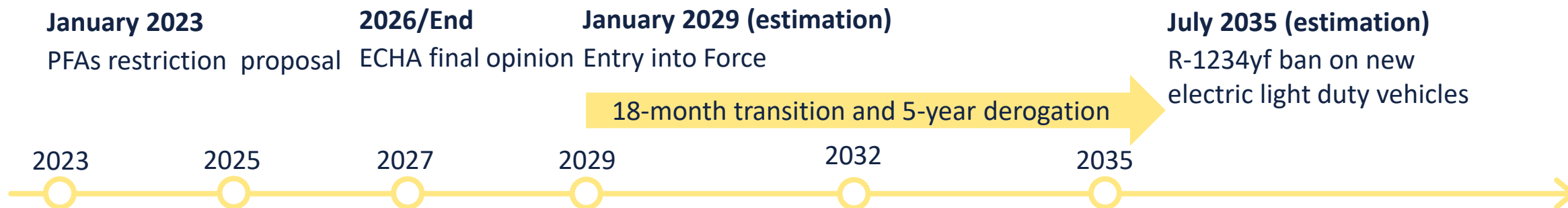
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. BEV=Battery electric vehicle. All vehicles also include internal combustion engines, mild hybrid, full hybrid, plug-in hybrid, series and range extender vehicles.

Source: Mobility Global | Planning Solutions

Main AC refrigerant regulatory changes with impact on light vehicles

European Union



China

July 2025
Regulation on high GWP AC refrigerants

July 2029
Ban of R-134a

India

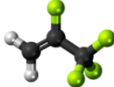
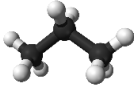
2032
HFC 10% reduction in comparison with 2028

As of September 2026

Note: China's regulation by Ministry of Ecology and Environment (MEE). PFAs restriction proposal by Denmark, Germany, the Netherlands, Norway, Sweden. ECHA=European Chemicals Agency. Entry into Force (EiF) by virtue of EU member states' vote. Proposed timeline for PFAs-free AC refrigerant enforcement on all vehicles other than BEV light duty vehicle is 18 months transition + 12 years derogation=13.5 years after EiF.

Source: echa.europa.eu, www.mee.gov.cn, Mobility Global | Planning Solutions

Natural and chemical refrigerants are already available

		 R-1234yf Opteon YF, Solstice yf	 R-744 Carbon Dioxide (CO ₂)	 R-290 Propane (C ₃ H ₈)	R-444A, R-494B, R-4101A, R-474A*
		R-134a substitute	OE use since 2017	Demo BEV in 2015	Chemical alternatives
Performance	Cooling	(baseline)	-	~	~
	Heating	"	++	+	~
Availability		"	+	+	~
Handling safety		"	+	-	~
Cost per vehicle	Refrigerant	"	+	++	~
	System	"	--	-	~
Status		In use	In use	SNAP approval pending	Direct replacement

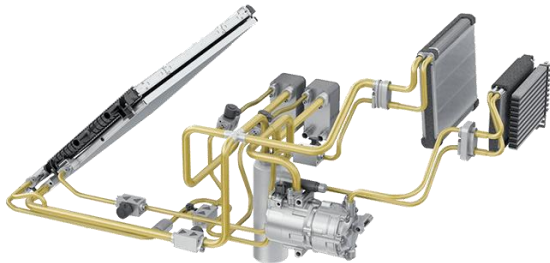
As of September 2026.
Note: + means better, - means worse than R-1234yf, which is the baseline. *There could be more chemical refrigerant alternatives.
Source: Mobility Global | Planning Solutions. <https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/>. <https://ika.rwth-aachen.de/en/competences/projects/energy-and-drivetrain-management/optemus.html>. Pictures from Wikimedia.org.

Natural refrigerant alternatives to R-1234yf

Technological implications

R-1234yf Opteon YF, Solstice yf

Baseline



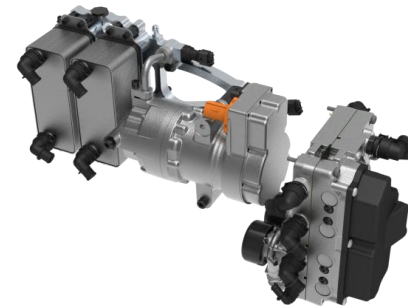
R-744 Carbon Dioxide (CO₂)

Same system layout
New components



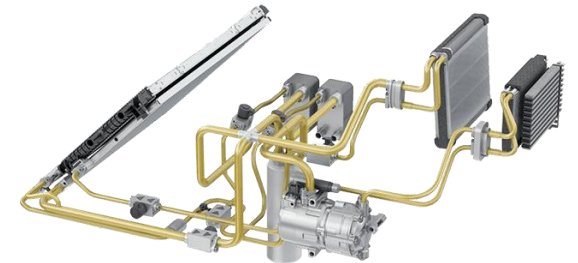
R-290 Propane (C₃H₈)

Fully indirect system
Similar components



R-444A, R-494B, R-4101A, R-474A*

Direct replacement



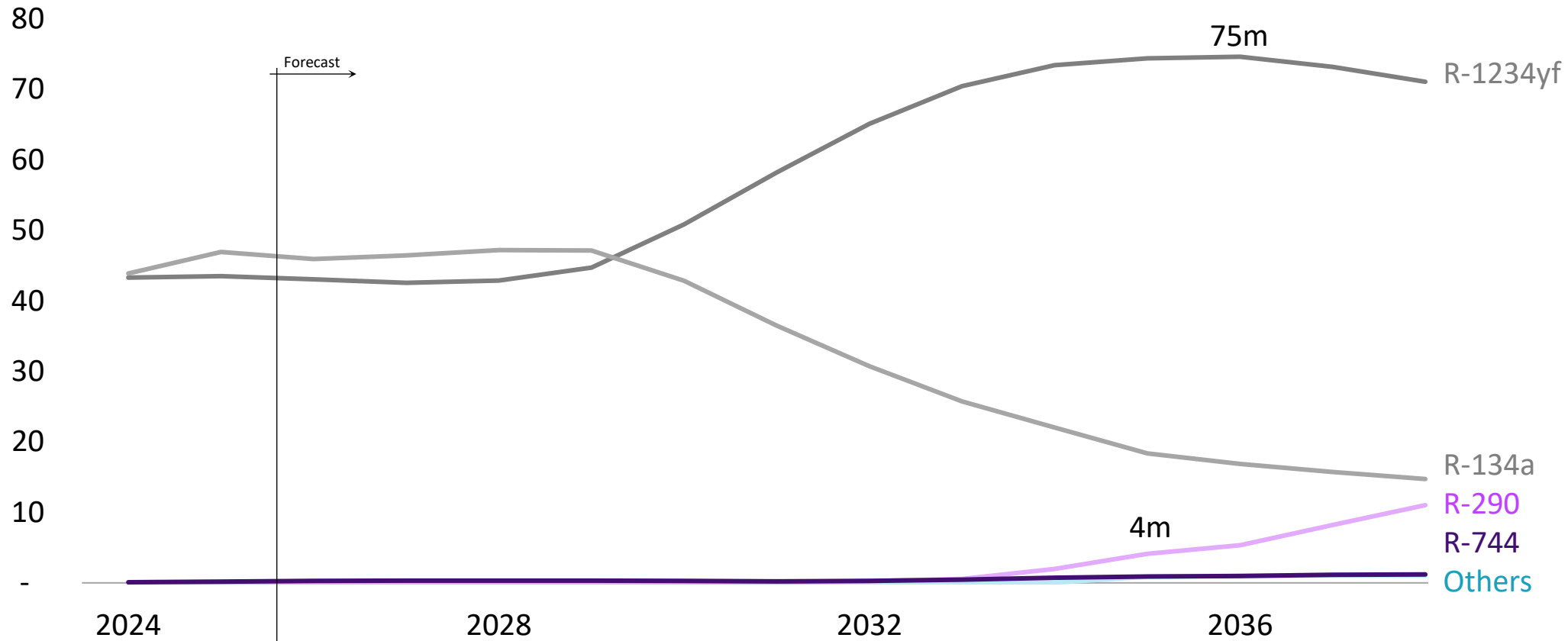
As of September 2026.

Note: + means better, - means worse in comparison to R-1234yf which is the baseline. *There could be more chemical refrigerant alternatives.

Source: S&P Global Mobility, www.valeo.com, www.zf.com

More than 10 million vehicles will use natural refrigerant by 2038

Light Vehicle Production by AC refrigerant (million vehicles)



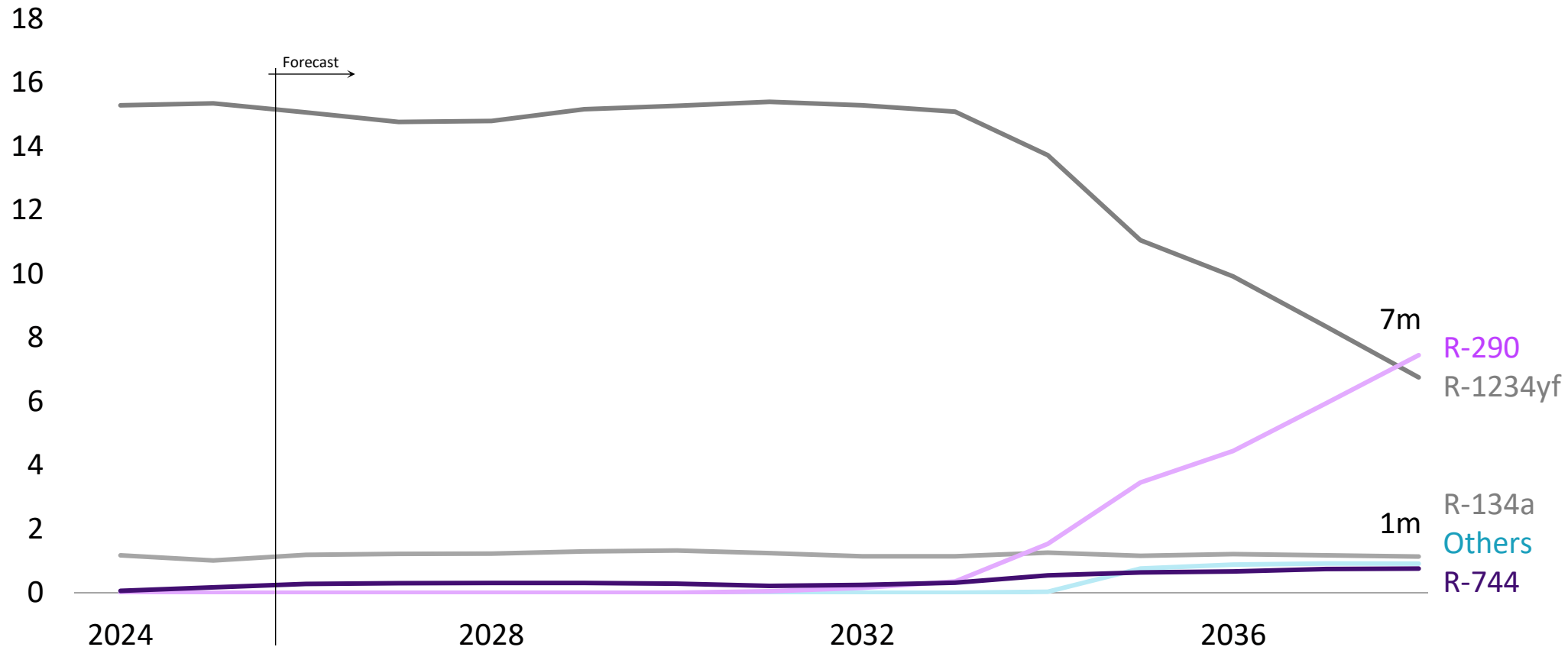
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. Others include chemical refrigerants compliant with PFAs regulation.

Source: Mobility Global | Planning Solutions

More than 8 million vehicles will use natural refrigerant by 2038 in Europe

Europe's Light Vehicle Production by AC refrigerant (million vehicles)



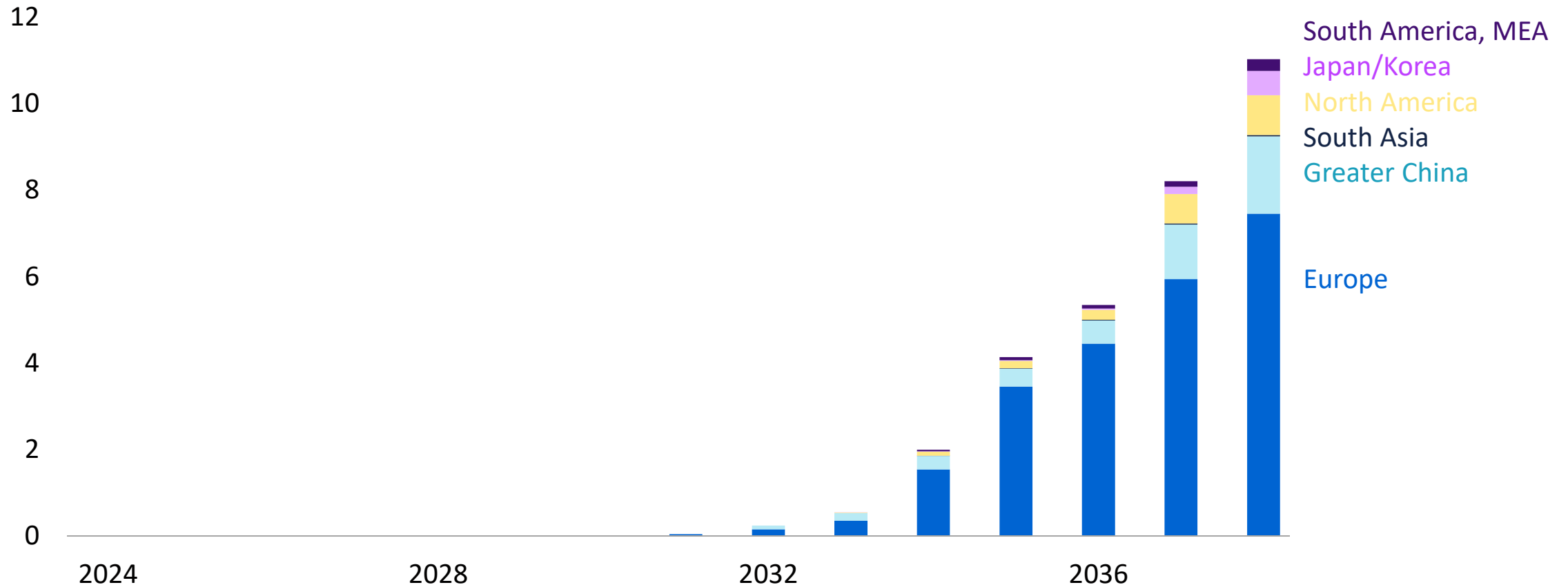
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. Others include chemical refrigerant compliant with PFAs regulation.

Source: Mobility Global | Planning Solutions

R-290 will also appear outside Europe for technical standardization

R-290 Equipped Light Vehicle Production by Region (million vehicles)



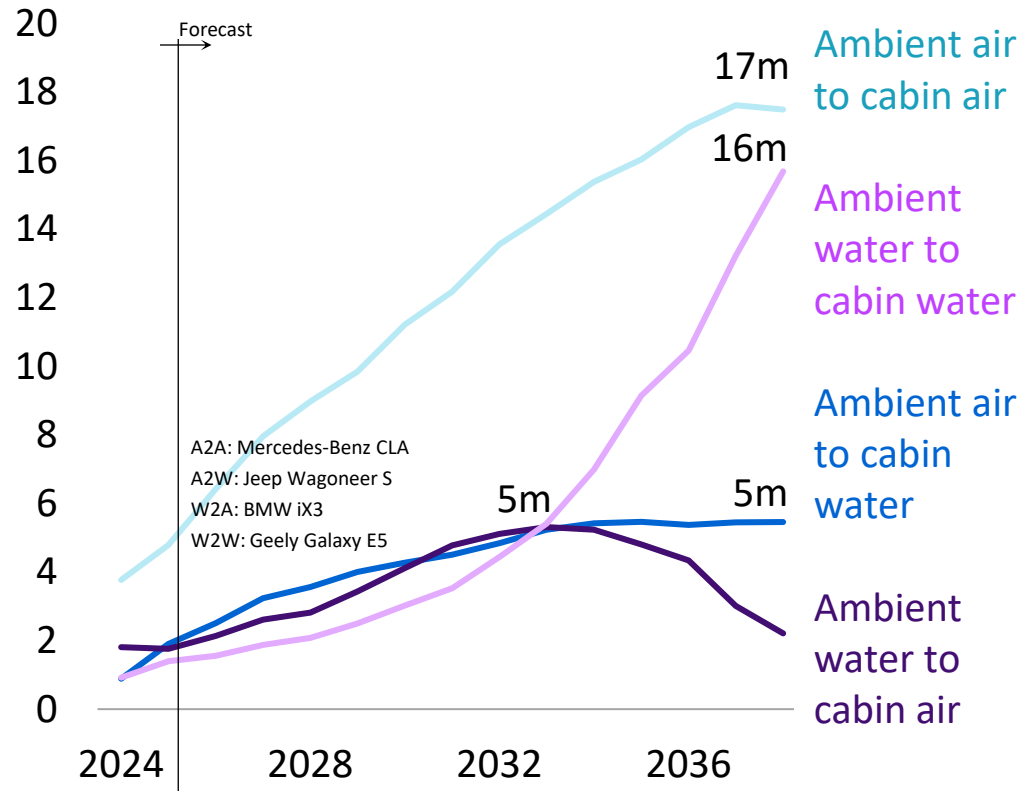
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles.

Source: Mobility Global | Planning Solutions

Natural refrigerant will push W2W heat pump adoption

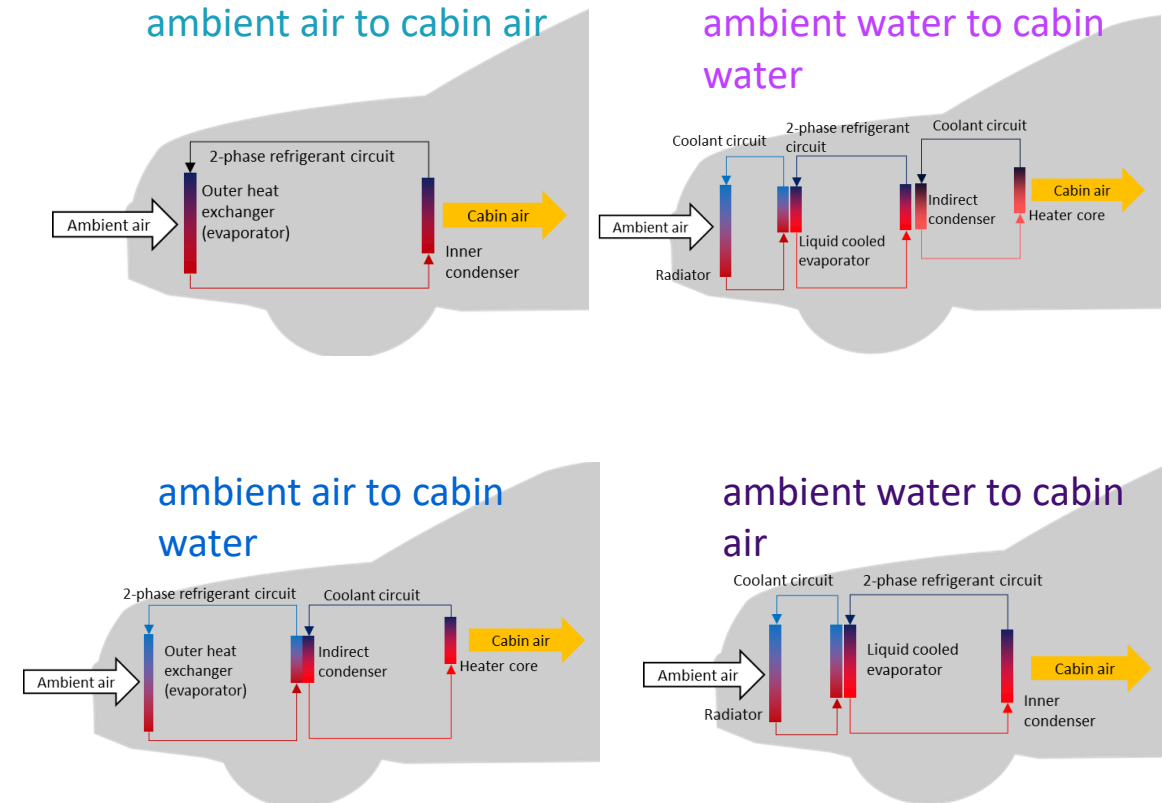
BEV Production by AC System (million vehicle)



As of August 2026

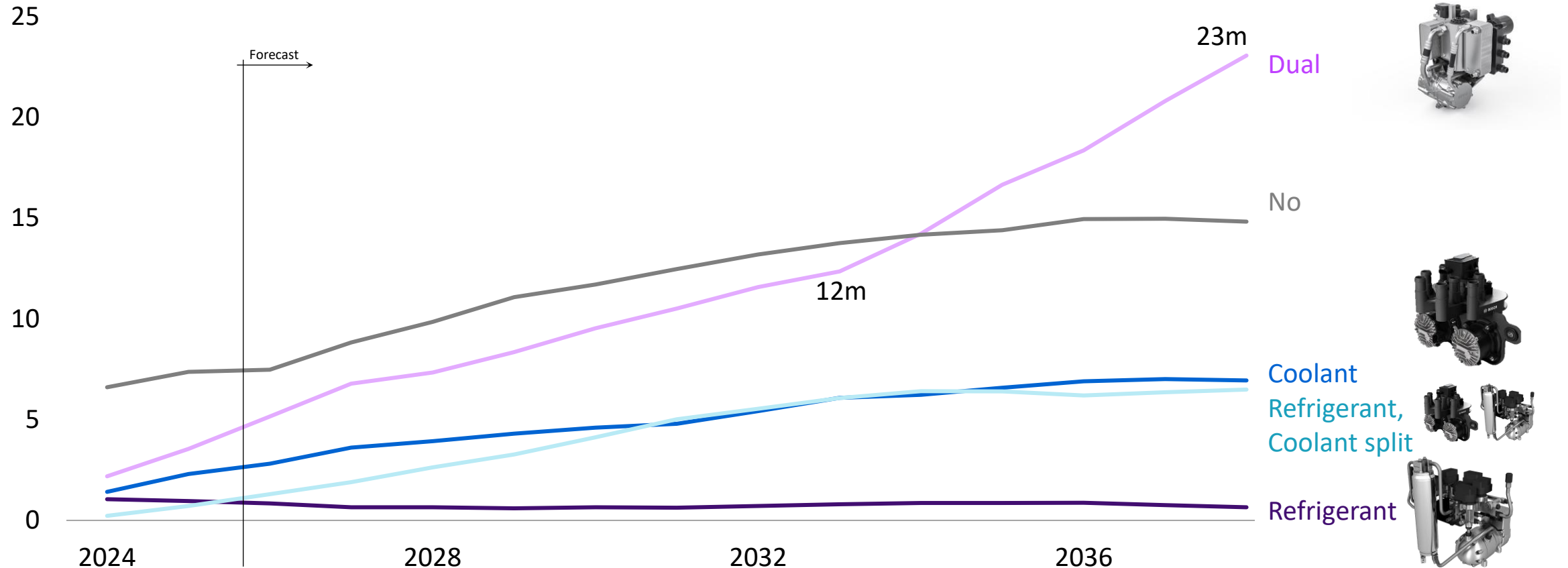
Note: Chart includes all battery electric vehicles (BEV) with weight 0 to 6 T vehicles.

Source: Mobility Global | Planning Solutions



Dual thermal management modules will become «mandatory» with R-290

BEV Light Vehicle Production by Thermal Management Module configuration (million vehicles)



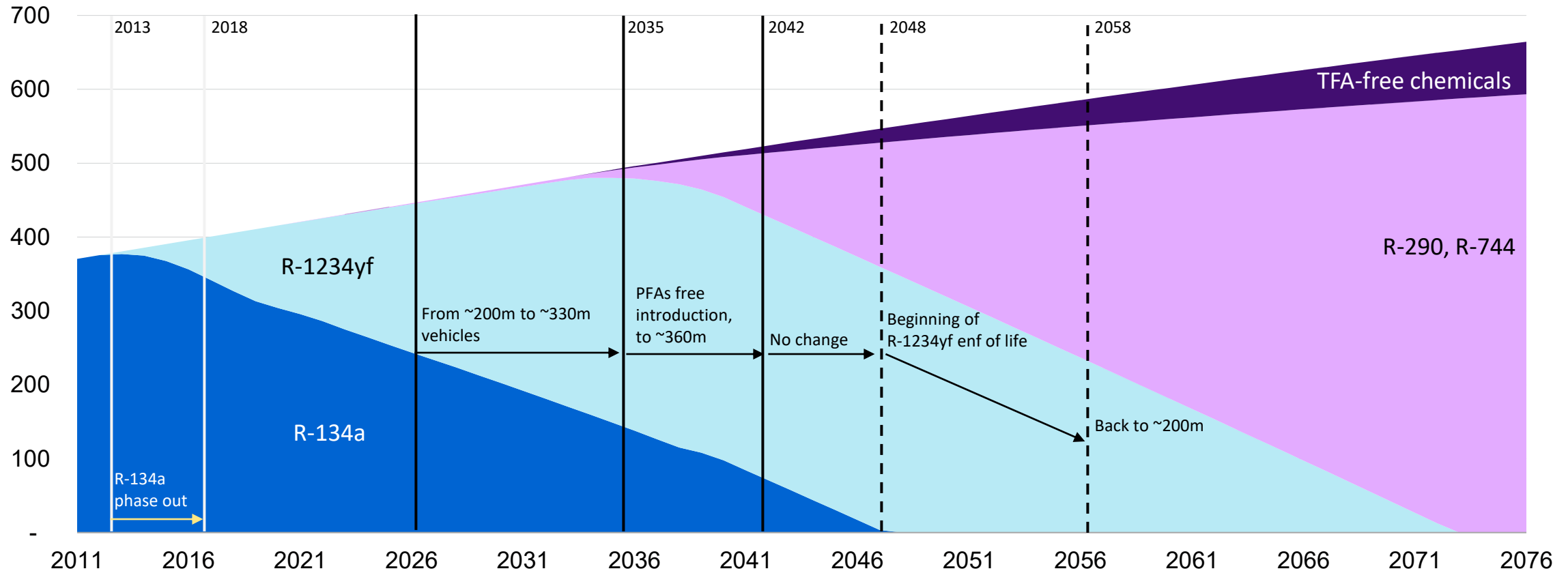
As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. BEV=battery electric vehicle.

Source: Mobility Global | Planning Solutions

Based on ECHA's proposed timeline, VIO with R-1234yf will be the same as today in 2056

Europe's Light Vehicles in Operations by refrigerant (million units)



As of August 2026

Note: Light Vehicles include all 0 to 6 T vehicles. BEV=battery electric vehicle.

Source: Mobility Global | Planning Solutions

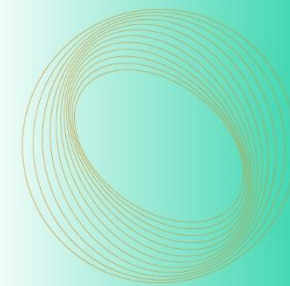
China's automotive industry continues to lead the sector and is well positioned to remain at the forefront of future thermal management technologies, despite a recent **slowdown** in the industry's focus **on natural refrigerants**.

A **PFAs ban** in the European Union could become a key catalyst for the adoption and standardization of **fully indirect heat pump** architectures and **sealed thermal management modules**.

Based on the proposed timeline, the PFAs restriction would **not** deliver **meaningful emission reductions** compared with current levels **until** approximately **2056**.



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Thank you
for listening
Any questions?



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