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Global Policy and Market Trends: Accelerating Natural Refrigerant based technologies

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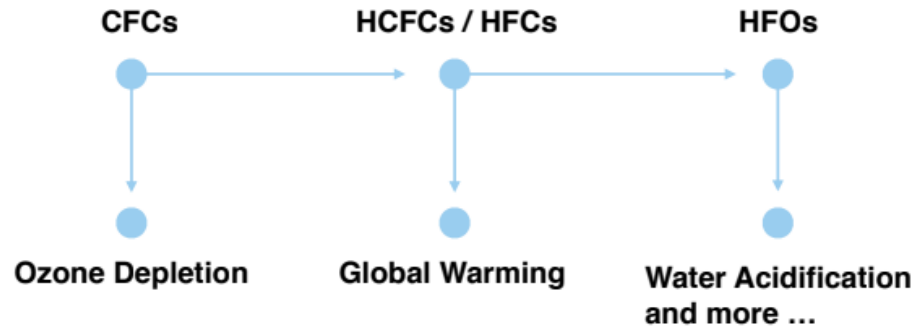
ATMOsphere is a global market accelerator with a mission to clean up cooling and heating.



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What do we stand against and for

Dirty Cooling Paradigm



Refrigerants: Real GWP and PFAS

Refrigerants / Brand Name	Type	Composition	IPCC AR4 (2007)		IPCC AR6 (2021)		PFAS Yes/No
			GWP 100 years	Real GWP 20 years	GWP 100 years	Real GWP 20 years	
R143a	HFC	100% R143a	4470	5890	5810	7840	Yes
R125	HFC	100% R125	3500	6350	3740	6740	Yes
R134a	HFC	100% R134a	1430	3830	1530	4140	Yes
R32	HFC	100% R32	650	2330	771	2690	No
R404A Freon 404A	HFC	44% R125 / 4% R134a / 52% R143a	3922	6010	4728	7208	Yes
R407A Freon 407A	HFC	20% R32, 40% R125, 40% R134a	2102	4538	2262	4890	Yes
R410A Freon 410A	HFC	50% R125 / 50% R32	2075	4340	2255	4715	Yes
R407C Freon 407C	HFC	23% R32 / 25% R125 / 52% R134a	1768	4115	1908	4457	Yes
R452A Opteon XP44	HFC/ HFO	11% R32 / 59% R125 / 30% R1234yf	2137	4003	2292	4273	Yes
R449A Opteon XP40	HFC/ HFO	24.3% R32 / 24.7% R125 / 25.7% R134a / 25.3% R1234yf	1390	3119	1504	3383	Yes
R448A Solstice N40	HFC/ HFO	26% R32 / 26% R125 / 21% R134a / 7% R1234ze / 20% R1234yf	1379	3062	1494	3321	Yes
R449C Opteon XP20	HFC/ HFO	20% R32 / 20% R125 / 29% R134a / 31% R1234yf	1245	2847	1346	3087	Yes
R452B Opteon XL55	HFC/ HFO	67% R32 / 7% R125 / 26% R1234yf	681	2006	779	2275	Yes
R454B Opteon XL41	HFC/ HFO	68.9% R32 / 31.1% R1234yf	448	1606	531	1854	Yes
R513A Opteon XP10	HFC/ HFO	44% R134a / 56% R1234yf	629	1686	673	1823	Yes
R450A Solstice N13	HFC/ HFO	42% R134a / 58% R1234ze	601	1611	643	1742	Yes
R454C Opteon XL20	HFC/ HFO	78.5% R1234yf / 21.5% R32	140	502	166	580	Yes
R455A Solstice L40X	HFC/ HFO	75.5% R1234yf / 21.5% R32 / 3% R744	140	502	166	580	Yes
R744	Natural	CO ₂	1	1	1	1	No
R600a	Natural	Isobutane	<1	<1	<1	<1	No
R290	Natural	Propane	<1	<1	<1	<1	No
R1270	Natural	Propylene	<1	<1	<1	<1	No
R717	Natural	NH ₃	0	0	0	0	No
R718	Natural	H ₂ O	0	0	0	0	No
R729	Natural	Air	0	0	0	0	No



Global

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GLOBAL COOLING PLEDGE FOR COP28

- Voluntary measure adopted by 60+ Parties to the UNFCCC to mainstream cooling-related policies at COPs
- Reducing at least by 68% cooling related emissions by 2050
- Move towards environmentally-friendly low-GWP refrigerants
- ATMOsphere amongst the first non-state actors signatories

Kigali Ratification



- 156 out of 197 Parties to the UN
- Different deadlines among Article 5 and non Article 5 Parties on production and consumption.
- Measures on HFCs can be varied, however, spanning from closer attention to lifecycle management to straightforward bans

PFAS amendment after Kigali?

- EU & other countries pushed for PFAS review by the Montreal Protocol Scientific Panels, EEAP (Environmental Effects Assessment Panel, Scientific Assessment Panel, Technology and Economic Assessment Panel) (Decision at MOP 35 in Nairobi, Kenya)
- **Will there be an amendment tackling PFAS that are F-gases in the near future?**



Europe - Policy

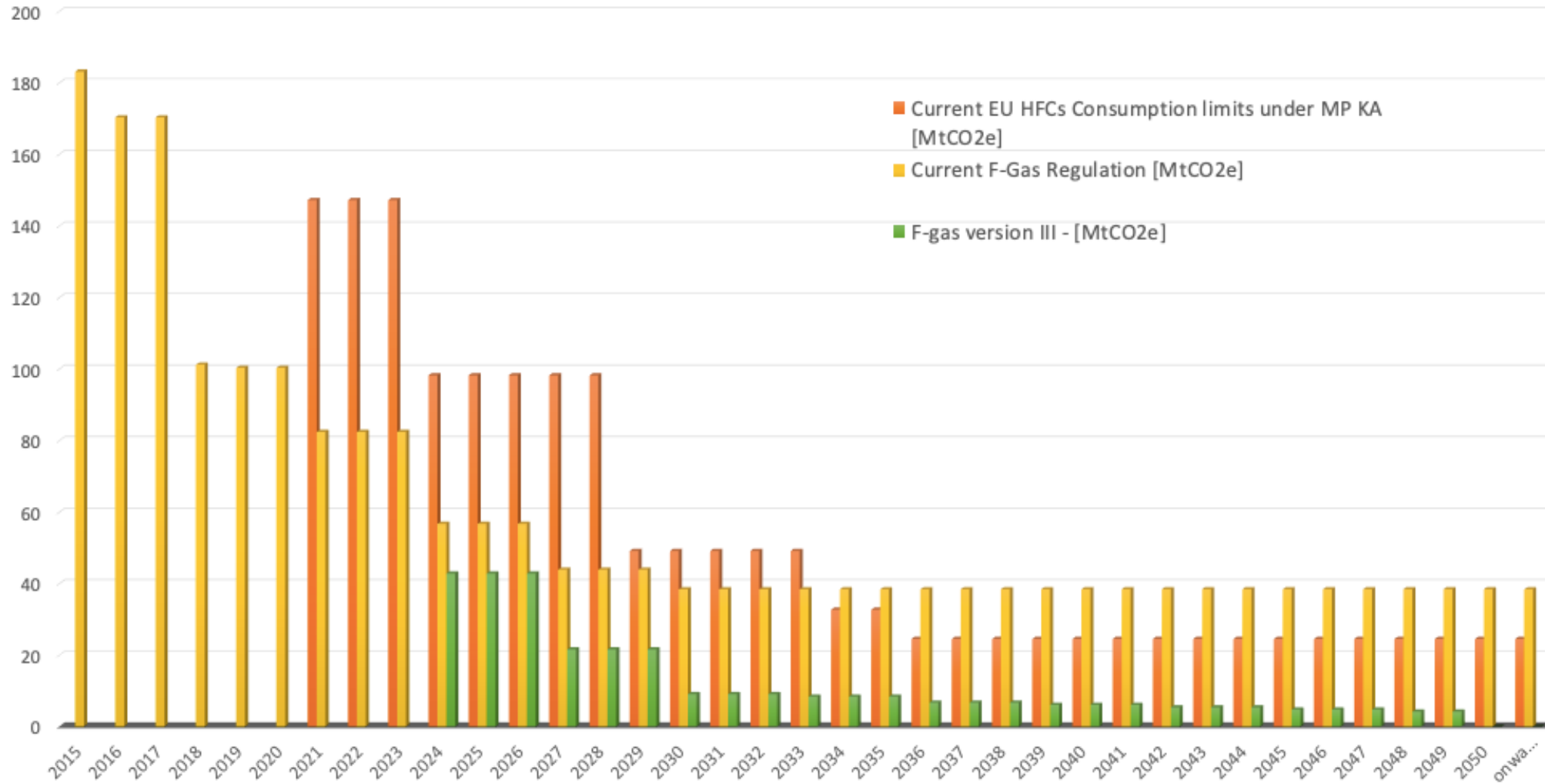
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- F-gases contributed to 2.8% of total GHG emissions in Europe in 2022 (European Commission, 2023)
- Legal tool used in Europe to transpose the requirements of the Kigali Amendment
- Published in the Official Journal on 20.02, enforceable as of 11.03
- More ambitious than current F-gas Regulation (adopted in 2014)
- Mandatory training and certification for natural refrigerants
- PFAS considered in legal text (Precautionary Principle)
- Mobile systems in the spotlight with report due by 2027



First in the world phase out of HFC consumption



EU F-gas v.3 -> New placing on the market provisions (bans) - Refrigeration

Application	GWP	Date
Domestic refrigerators and freezers	f-gases (HFCs and HFOs)	1 January 2026
Refrigerators and freezers for commercial use (self-contained equipment)	f-gases above 150 GWP	1 January 2025
Any self-contained refrigeration equipment	f-gases above 150 GWP	1 January 2025
Refrigeration equipment	- f-gases above 2500 GWP	- 1 January 2025
	- f-gases above 150 GWP	- 1 January 2030
Servicing or maintenance on any refrigeration equipment	f-gases above 2500 GWP	1 January 2025
Servicing or maintenance of stationary refrigeration equipment	- HFC in Annex I above 750 GWP	1 January 2032

Safety standards provisions and exclusions for particular applications are included in the Regulation. For a more complete overview check Annex IV of the legal text: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202400573

EU F-gas v.3 -> new placing on the market provisions (bans) - Chillers

Application	GWP	Date
Chillers (capacity up to 12 kW)	f-gases above 150 GWP	1 January 2027
Chillers (capacity up to 12 kW)	f-gases	1 January 2032
Chillers (capacity above 12 kW)	f-gases above 750 GWP	1 January 2027

Safety standards provisions and exclusions for particular applications are included in the Regulation. For a more complete overview check Annex IV of the legal text: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202400573

EU F-gas v.3 -> new placing on the market provisions (bans) - Split ACs and Heat Pumps

Application	GWP	Date
Split air-to-water systems of a rated capacity up to and including 12 kW	f-gases above 150 GWP	1 January 2027
Split air-to-air systems of a rated capacity up to and including 12 kW	f-gases above 150 GWP	1 January 2029
Split systems of a rated capacity up to and including 12 kW	f-gases	1 January 2035
Split systems of a rated capacity of more than 12 kW	f-gases above 750 GWP	1 January 2029
Split systems of a rated capacity of more than 12 kW	f-gases above 150 GWP	1 January 2033

Safety standards provisions and exclusions for particular applications are included in the Regulation. For a more complete overview check Annex IV of the legal text: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202400573

EU F-gas v.3 -> new placing on the market provisions (bans) - Heat Pumps

Application	GWP	Date
Plug-in room, monoblock air-conditioning and other self-contained heat pump equipment, up to and including 12 kW	f-gases above 150 GWP	1 January 2027
Plug-in room, monoblock air-conditioning and other self-contained heat pump equipment, up to and including 12 kW	f-gases	1 January 2032
Monoblock and other self-contained air-conditioning and heat pump equipment, with a maximum rated capacity of larger than 12kW but not exceeding 50 kW	f-gases above 150 GWP	1 January 2027
Other self-contained air-conditioning and heat pump equipment	f-gases above 150 GWP	1 January 2030

Safety standards provisions and exclusions for particular applications are included in the Regulation. For a more complete overview check Annex IV of the legal text: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202400573

EU Universal PFAS Restriction

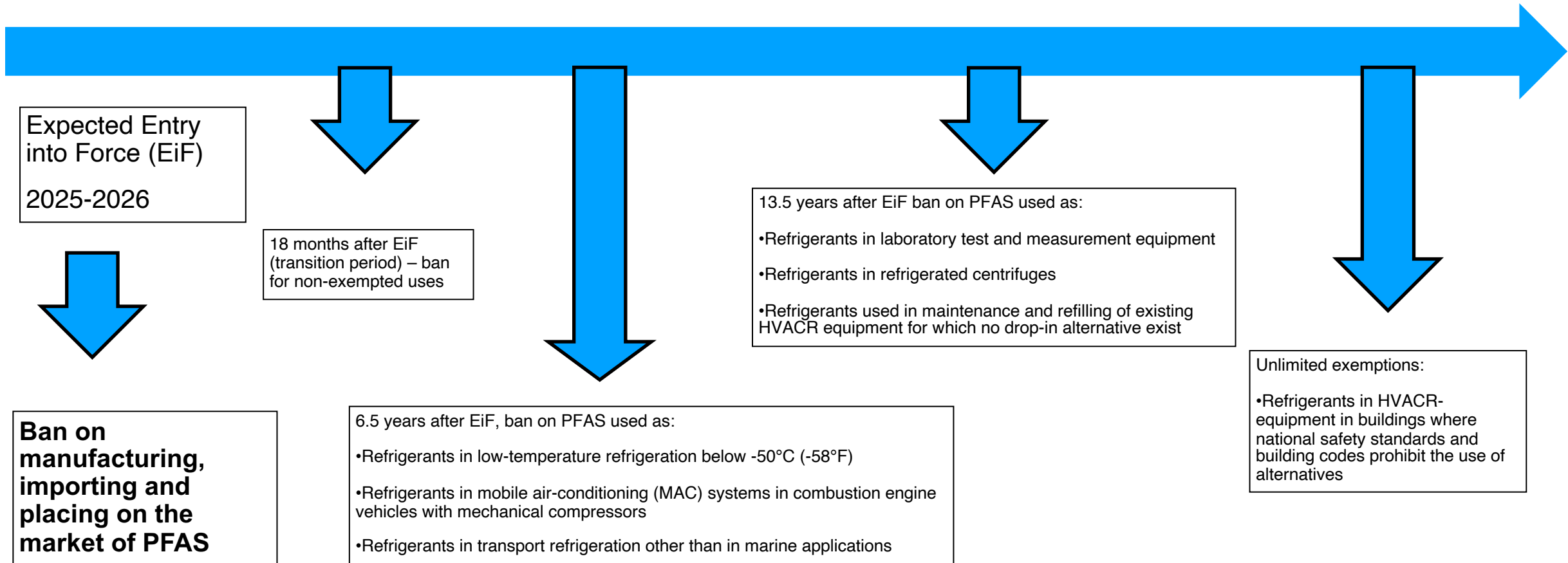
- Blanket ban proposed on fluorinated refrigerants that are per and polyfluoroalkyl substances (PFAS)
- Broad family of chemicals sharing persistence as a problem
- Derogations introduced where alternatives are not considered mature
- The proposal defines PFAS as “substances that contains at least one fully fluorinated methyl (CF₃-) or methylene (-CF₂-) carbon atom (without any H/Cl/Br/I attached to it).”
- Some fluorinated gases controlled by the Kigali Amendment as well as their low GWP halogenated replacements fall in the scope of the ban



- Some of the substances in scope

Preferred IUPAC name (PIN)	Brand name	F-name	Chemical structure	Molar TFA yield
Pentafluoroethane	Genetron HFC 125, Khladon 125, Suva 125, Freon 125	HFC-125	CF₃-CHF₂	Not analysed
1,1,1,2-Tetrafluoroethane	Freon 134a Dymel 134a Forane 134a Genetron 134a	HFC-134a	CF₃-CH₂F	7-20%
1,1,1-Trifluoroethane	Fluorocarbon FC143a	HFC-143a	CF₃-CH₃	Up to 10%
1,1,1,3,3-Pentafluoropropane	Enovate 3000; Genetron 245fa	HFC-245fa	CF₃-CH₂-CHF₂	Up to 10%
1-Chloro-3,3,3-trifluoro-1-propene	Solstice® zd	HFO-1233zd(E)	CHCl=CH-CF₃	2%
2,3,3,3-Tetrafluoropropene	Opteon™ YF	HFO-1234yf	CH₂=CF-CF₃	100%
Trans-1,3,3,3-tetrafluoroprop-1-ene	Solstice® ze	HFO-1234ze(E)	CHF=CH-CF₃	Up to 10%
Trans-1,1,1,4,4,4-hexafluorobut-2-ene	Opteon™ SF33	HFO-1336mzz(E)	CF₃-CH=CH-CF₃	Up to 20%
(Z)-1-Chloro-2,3,3,3-tetrafluoropropene	AMOLEA™ 1224yd	HCFO-1224yd	CHCl=CF-CF₃	100% (estimated)
Trans-1-chloro-3,3,3-trifluoropropene	Solstice® zd	HCFO-1233zd(E)	CHCl=CH-CF₃	2%

EU PFAS – Measures on PFAS in HVAC as refrigerants



Other measures:

- Reporting obligation for manufacturers and importers for PFAS used in exemptions → yearly reports on identity and quantity of the substances placed on the market the previous year



Market Trends

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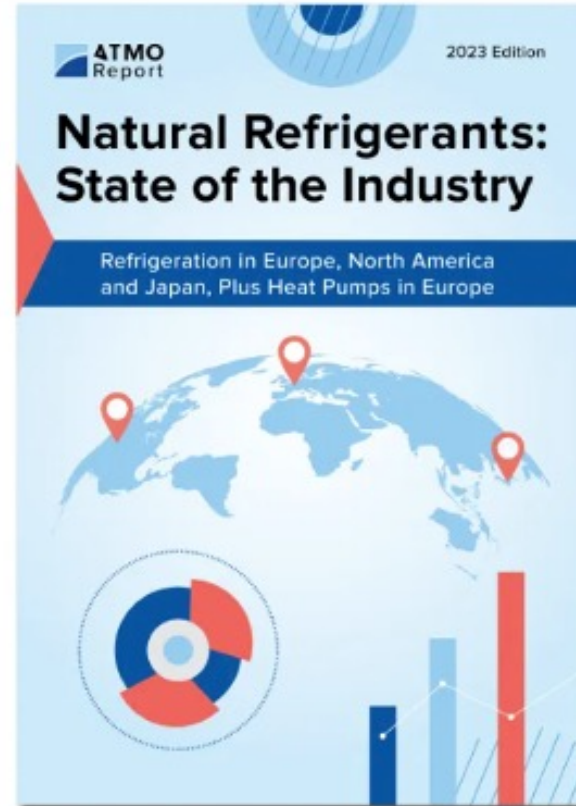
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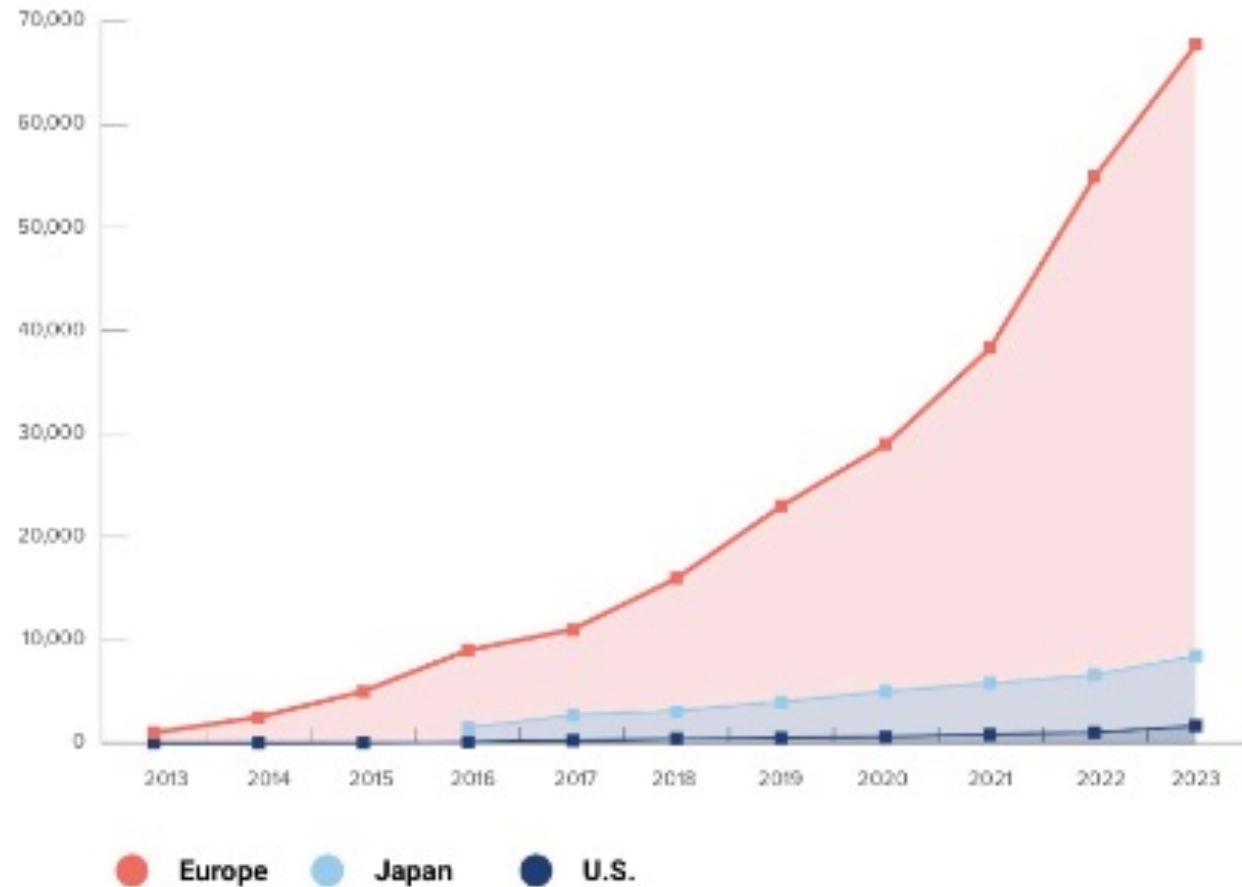
Market Trends: Europe, North America, Japan



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Transcritical CO2 Installations Growth in Major Regions



Europe - Transcritical CO₂ in Commercial Refrigeration: State of Play

Figure 7: Transcritical CO₂ Installations in Europe

(as of December 2023)

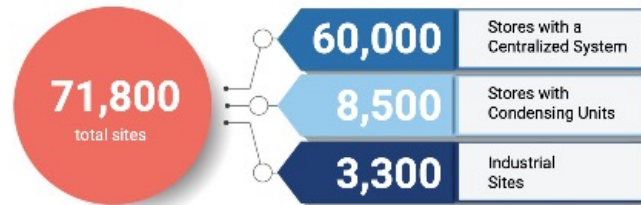
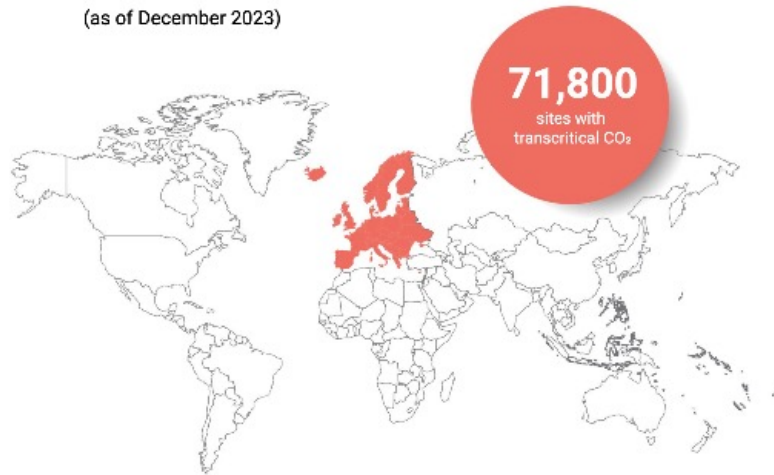


Figure 8: Transcritical CO₂ Commercial Refrigeration Market Penetration in Europe

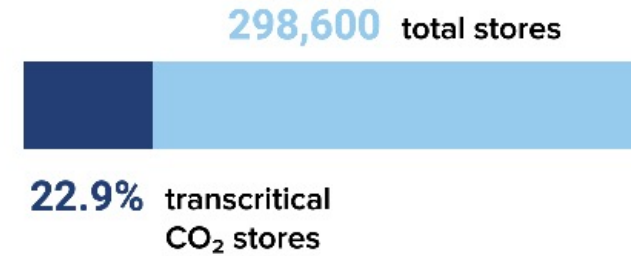
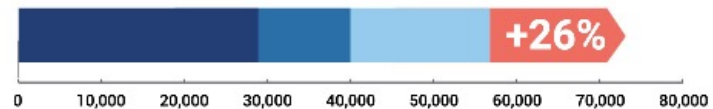


Figure 9: Transcritical CO₂ Installation Growth in Europe

(stores and industrial facilities)



Percentage growth in 2021 - 2023



Europe – Hydrocarbons-based systems: State of Play

Figure 11: Self-Contained Hydrocarbon Cabinets Installed in Europe

(as of December 2023)



Figure 12: Self-Contained Hydrocarbon Cabinets, Historical Installation Growth in Europe

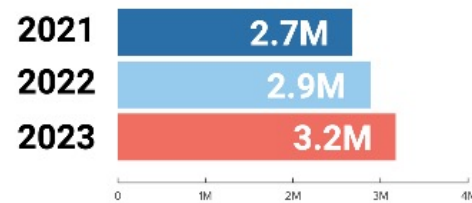


Figure 14: Growth of Low-Charge Ammonia in Europe

(industrial sites)

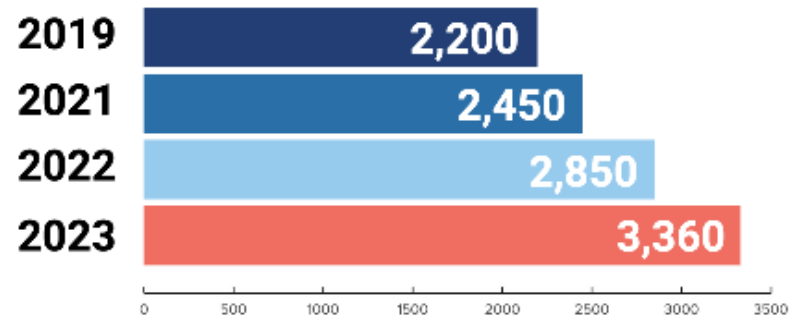
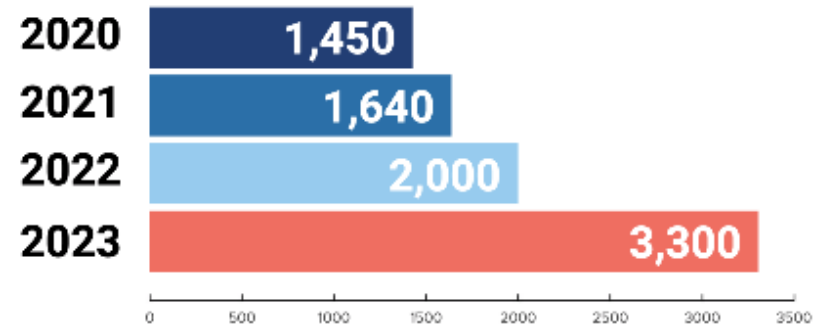


Figure 13: Growth of Transcritical CO₂ Installations in Europe

(industrial sites)



US - Transcritical CO₂: State of Play

Figure 18: Transcritical CO₂ Installations in North America

(as of December 2023)

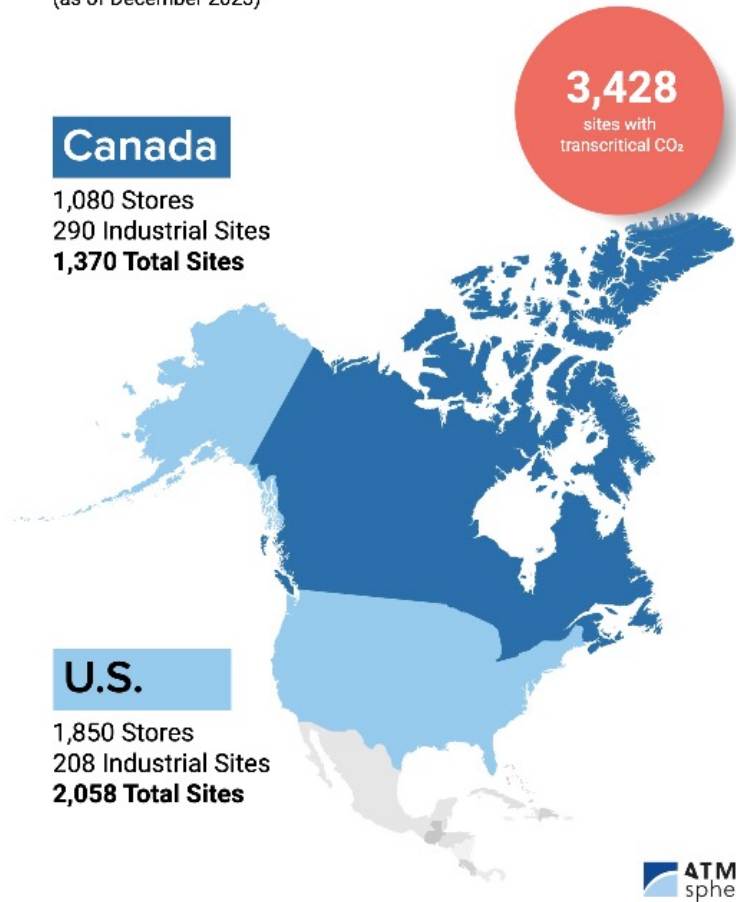
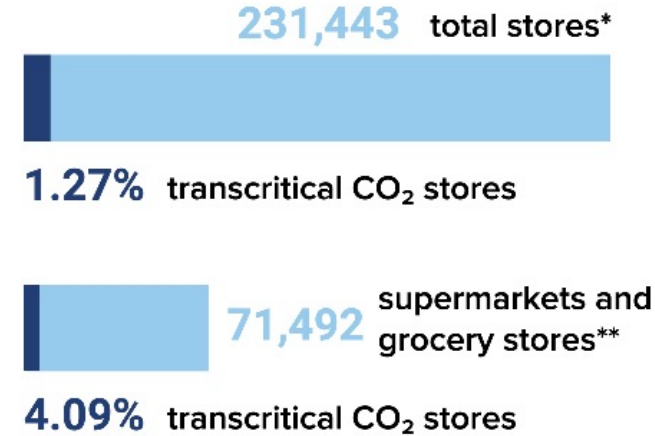


Figure 19: Transcritical CO₂ Commercial Refrigeration Market Penetration in North America



*IBISWorld and NACS
**IBISWorld

US - Transcritical CO₂: Growth Reported

Figure 20: Transcritical CO₂ Installation Growth in North America

(stores)

2020	945
2022	1,605
2023	2,930

U.S.

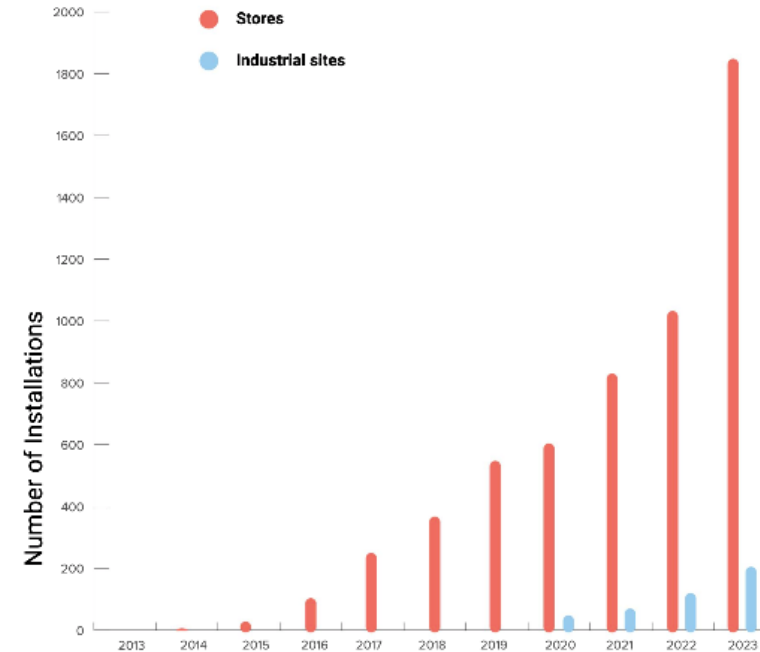
2020	605
2022	1,030
2023	1,850

Canada

2020	340
2022	575
2023	1,080

Figure 21: Transcritical CO₂ Installation Growth in U.S.

(stores and industrial sites)



Note: Prior to 2020, most installations were at stores.

US - Transcritical CO₂: Growth Reported in Industrial Sites

Figure 23: Growth of Transcritical CO₂ in North America

(industrial sites)

2022	290
2023	498

U.S.

2022	120
2023	208

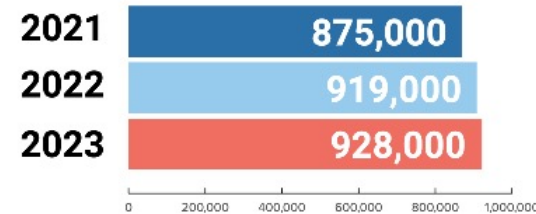
Canada

2022	170
2023	290

US – Hydrocarbons-based systems: State of Play

Figure 22: Self-Contained Hydrocarbon Commercial Cabinets Installed in U.S.

(as of December 2023)



US – Ammonia in Industrial Sites: State of Play

Figure 25: Growth of Low-Charge Ammonia in U.S.

(Industrial sites)

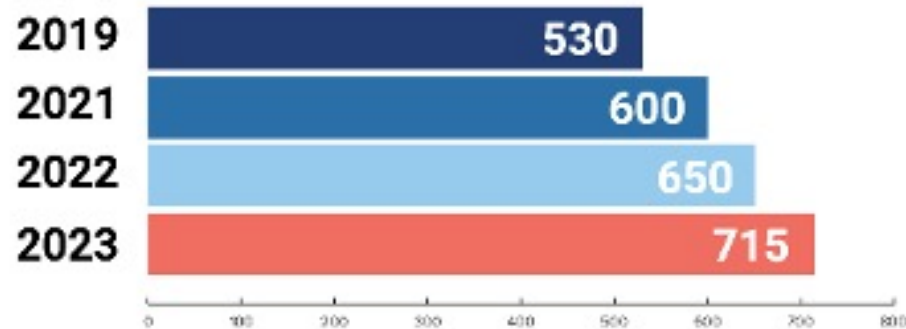
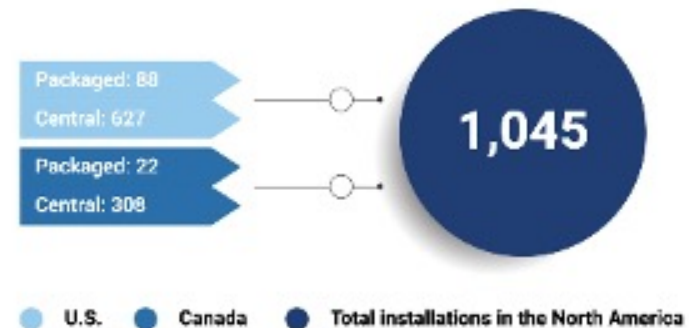


Figure 24: Installations of Low-Charge Ammonia Systems in North America

(Industrial sites as of December 2023)



Japan - Transcritical CO₂: State of Play

Figure 27: Transcritical CO₂ Installations in Japan

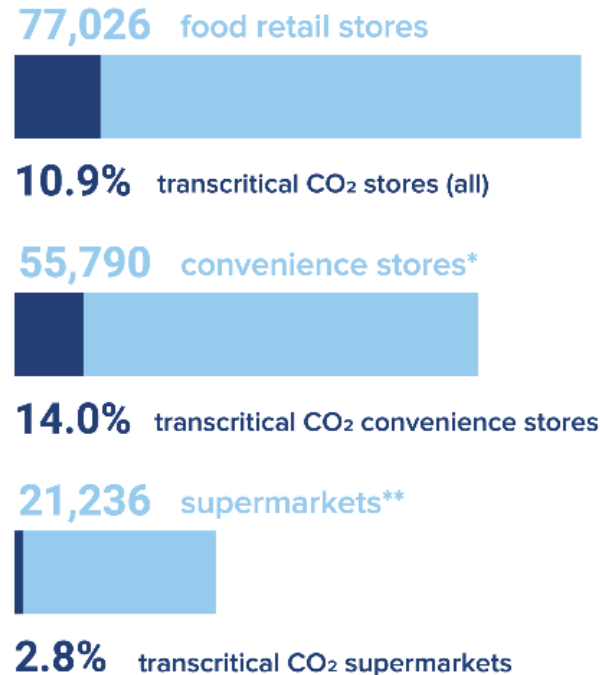
(as of December 2023)

7,800 Convenience Stores
585 Supermarkets
400 Industrial Sites



Japan - Transcritical CO₂: Growth Reported

Figure 28: Transcritical CO₂ Commercial Refrigeration Market Penetration in Japan



*Japan Franchise Association
**Japan Supermarket Statistics Survey Office

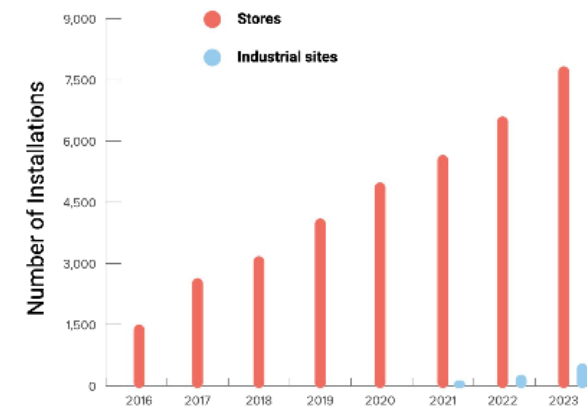
Figure 29: Transcritical CO₂ Installation Growth in Japan

(stores)



Figure 30: Transcritical CO₂ Historical Installation Growth in Japan

(stores and industrial sites)



Note: Prior to 2020, most installations were at stores.

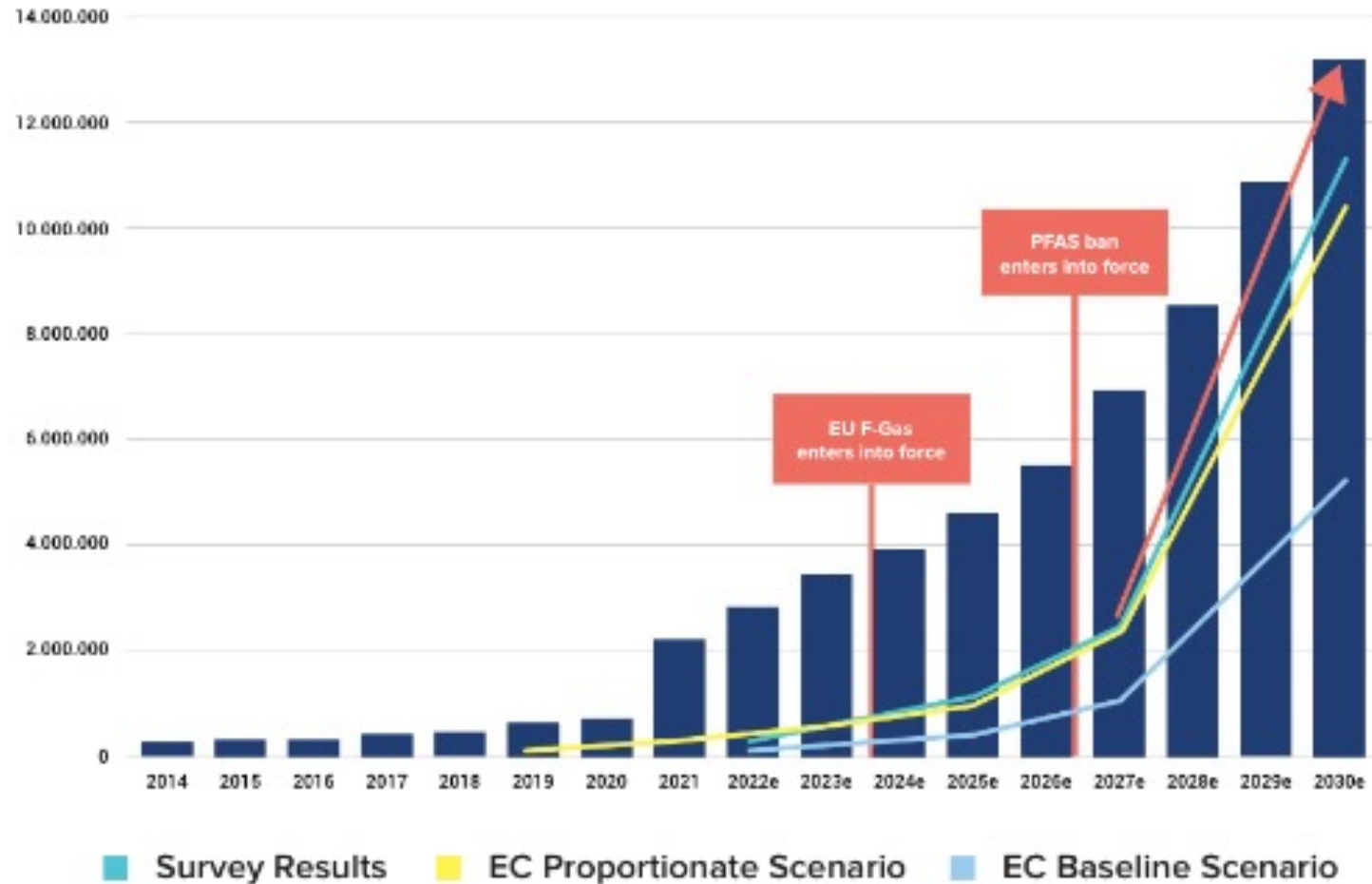
Europe – Hydrocarbons-based Chillers: State of Play

Figure 15: Hydrocarbon Chiller Installations in Europe

(as of December 2023)



Europe - Domestic Heat Pumps - ATW





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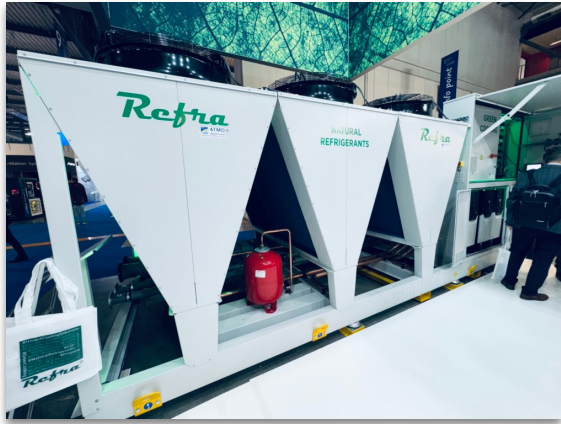


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MCE 24 All about R290 Heatpumps



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Will #mce2024 go down in the history books as the 'Propane takeover of commercial heatpumps' ?

I spent two days in #milan with [Sabrina Munao](#) and talked with a lot of people. I started in the morning of day 1 taking pictures of every single new #R290 Heatpump i could see. I basically got overwhelmed very quickly and stopped. It was nuts. Literally EVERYBODY had at least one R290 heatpump on display at their booth.

Insight 1) this mega switch happened because of the #EUFgas bans coming. Two years ago it was only talk and all the traditional players were saying 'we're not ready' 'we need more time' 'jobs will be destroyed if we move too fast' etc

Insight 2) is this for 'real or for show' ? Real means that the incumbents will proactively sell these solutions to their customers over high gwp R32 and pfas blend R454B alternatives. My suspicion is NO. They just want to have it in their portfolio to not be caught out by the competition. And will still push the #synthetics until the last day before they are banned. Unless an #enduser insists on R290 of course.


Insight 3) the propane innovators / the ones that did not wait for #MCE24 to #gonatrefs are happy. Because they know that they are ahead and will push for more and more innovations to optimize R290 whilst the others have divided loyalties.

Insight 4) so where does this leave #R744 heatpumps. I counted 2 players. There are more. We talk to them. But it's a pretty safe bet to assume that #heatpumps will be 80% Propane / 20% R744 going forward just like we have 80% CO2 in #refrigeration / 20% Propane today.

End users will have choice at different price points to meet their needs. #naturalefrigerants will take over heatpumps just like they did in refrigeration in Europe. 🍌🍌

See you at #Chillventa2024 :-)

ATMOsphere #cleancooling [Michael Hines](#) [Jan Dusek](#)



👤 Jan Dusek and 104 others
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**Thank you
for listening.**