

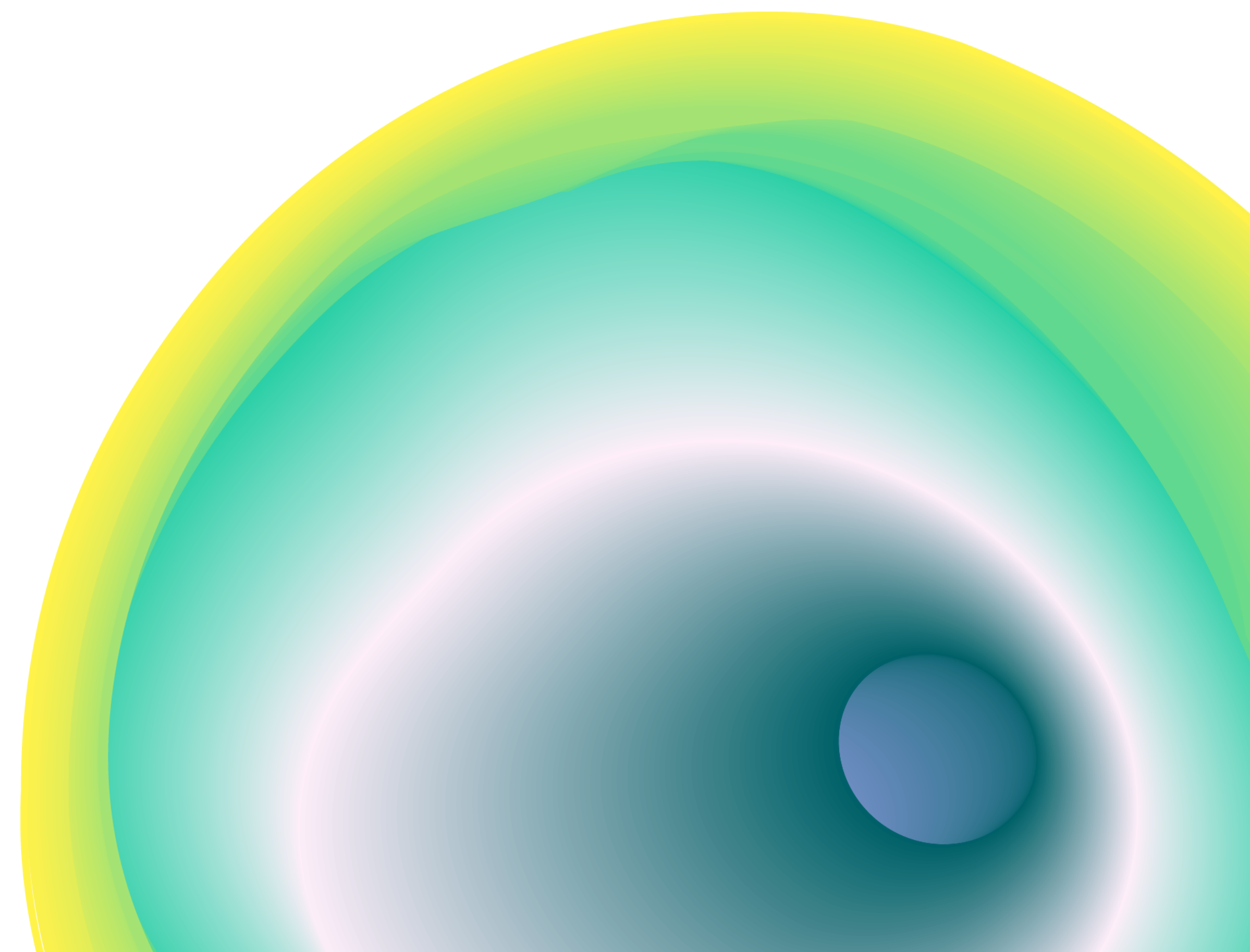


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## **Overview of PFAS refrigerants used in HVAC&R and relevance of refrigerants in the PFAS Restriction Intention**

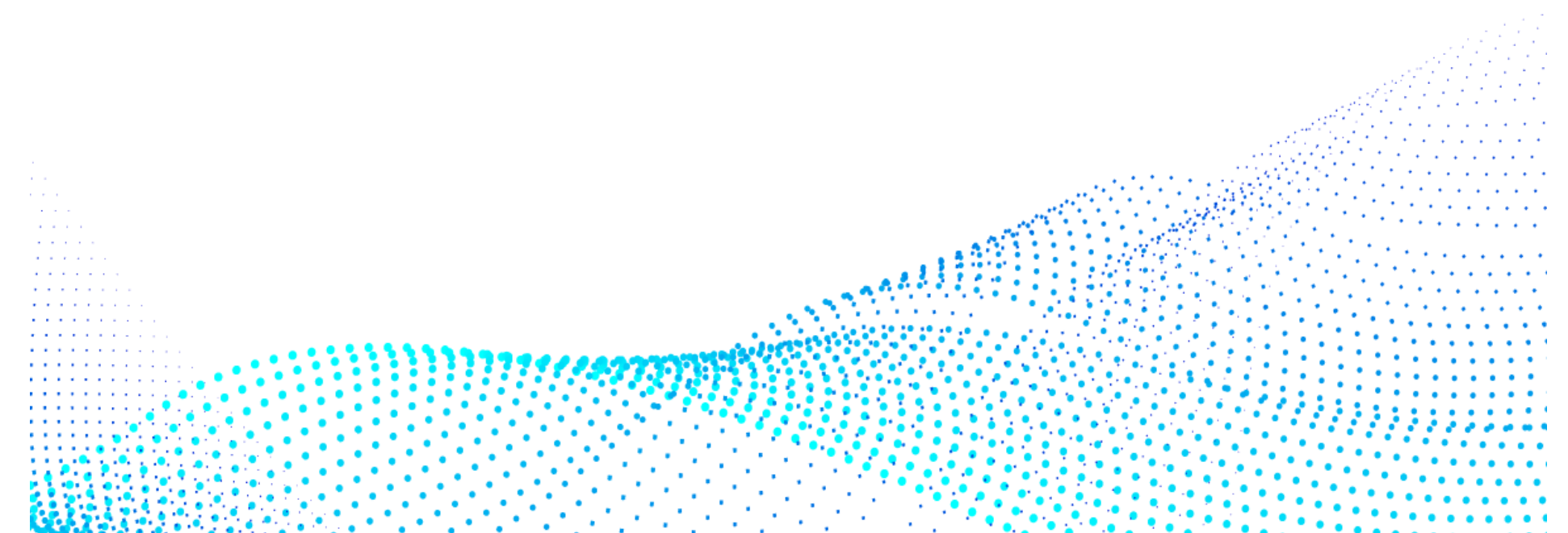
Thomas Trevisan – Deputy manager for Public Affairs – Ozone, Climate, Energy and Chemicals.



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PFAS and persistent chemicals: the state of play in Europe with focus on refrigerants in HVAC&R systems



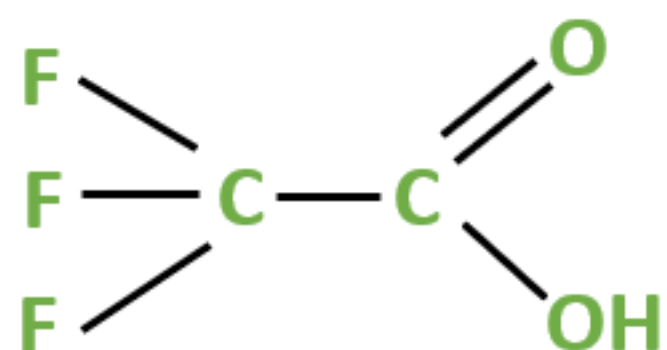
ATMOsphere is a global, independent market accelerator with a mission to clean up heating and cooling.

ATMOsphere is a recognised industry observer to the UN Montreal Protocol.

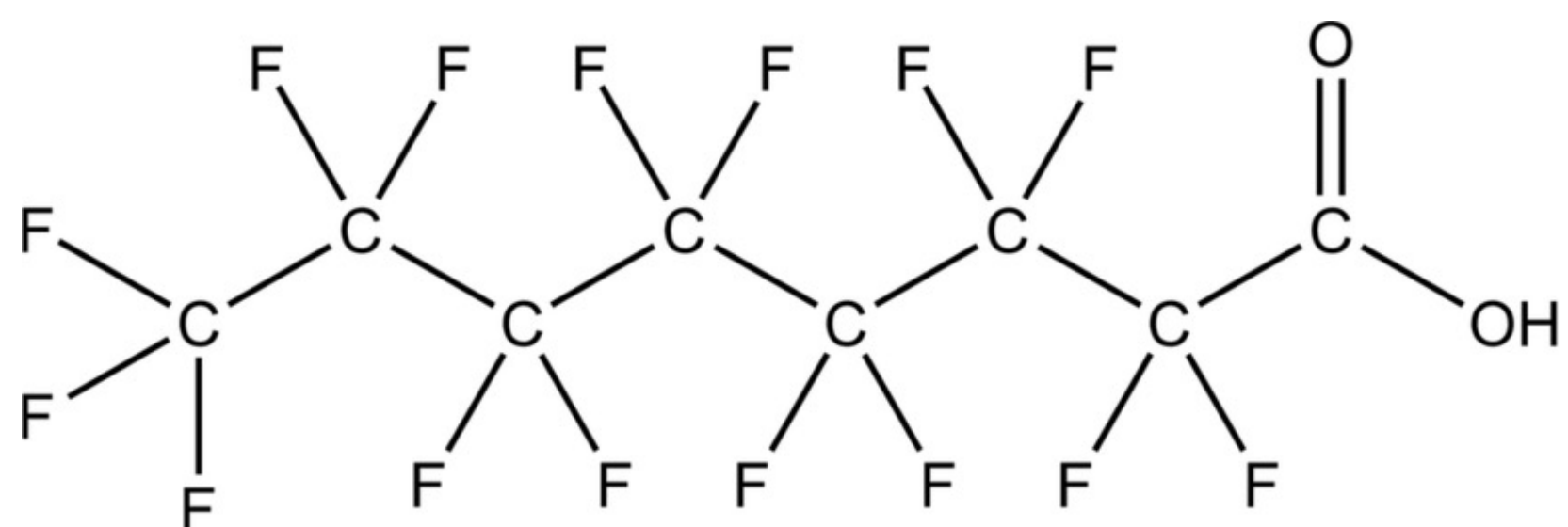


The proposal defines PFAS as “substances that contains at least one fully fluorinated methyl (CF<sub>3</sub>-) or methylene (-CF<sub>2</sub>-) carbon atom (without any H/Cl/Br/I attached to it).”

TFA

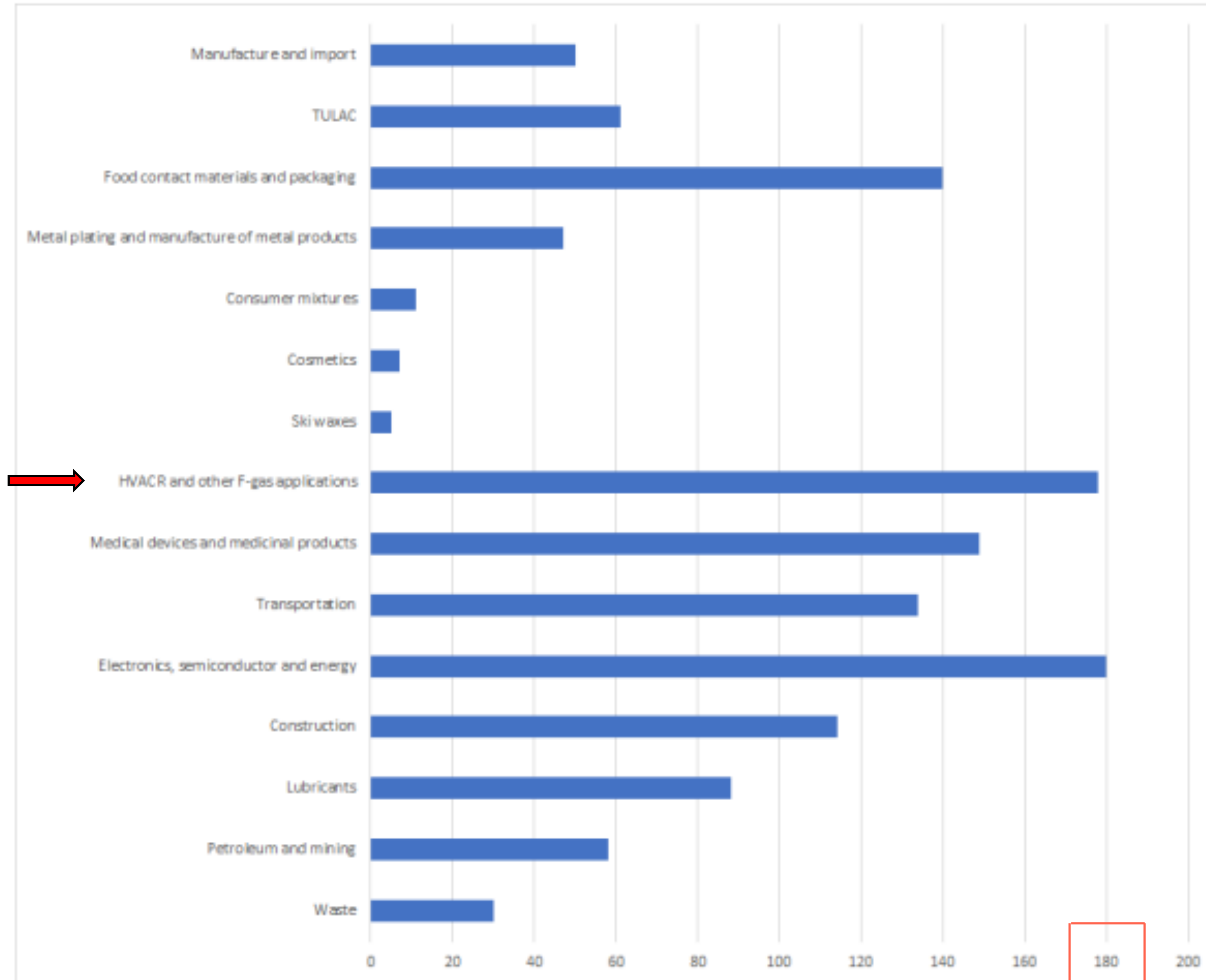


PFOA - Annex A under SC POPs



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	CF <sub>3</sub> -CHF <sub>2</sub>	Not analysed yet
1,1,1,2-Tetrafluoroethane	Freon 134a, Dymel 134a, Forane 134a, Genetron 134a	HFC-134a	CF <sub>3</sub> -CH <sub>2</sub> F	7-20%
1,1,1-Trifluoroethane	Fluorocarbon FC143a	HFC-143a	CF <sub>3</sub> -CH <sub>3</sub>	Up to 10%
1,1,1,3,3-Pentafluoropropane	Enovate 3000; Genetron 245fa	HFC-245fa	CF <sub>3</sub> -CH <sub>2</sub> -CHF <sub>2</sub>	Up to 10%
1-Chloro-3,3,3-trifluoro-1-propene	Solstice® zd	HFO-1233zd(E)	CHCl=CH-CF <sub>3</sub>	2%
2,3,3,3-Tetrafluoropropene	Opteon™ YF	HFO-1234yf	CH <sub>2</sub> =CF-CF <sub>3</sub>	100%
Trans-1,3,3,3-tetrafluoroprop-1-ene	Solstice® ze	HFO-1234ze(E)	CHF=CH-CF <sub>3</sub>	Up to 10%
Trans-1,1,1,4,4,4-hexafluorobut-2-ene	Opteon™ SF33	HFO-1336mzz(E)	CF <sub>3</sub> -CH=CH-CF <sub>3</sub>	Up to 20%
(Z)-1-Chloro-2,3,3,3-tetrafluoropropene	AMOLEA™ 1224yd	HCFO-1224yd	CHCl=CF-CF <sub>3</sub>	100% (estimated)
Trans-1-chloro-3,3,3-trifluoropropene	Solstice® zd	HCFO-1233zd(E)	CHCl=CH-CF <sub>3</sub>	2%

# Relevance of refrigerants in the Proposal



Sources: PFAS Restriction Intention

Application	Tonnage range	Emission range % emitted in manufacturing and use phase	Emission contribution - contribution to total emission
Applications of fluorinated gases	5	2	5
TULAC	5	2	4
Medical devices	5	2	3
Manufacture	5	1	2
Food contact materials and packaging	5	1	1
Transport	5	1	1
Construction products	4	3	2
Electronics and semiconductors	4	2	1
Lubricants	4	2	1
Petroleum and mining	4	1	1
Energy sector	4	1	1
Metal plating and manufacture of metal products	3	1	1
Cosmetics	2	5	1
Consumer mixtures	2	4	1
Ski wax	1	3	1

Tonnage range (t/y)	Emission range (%)	Emission contribution (%)
1 0 - 10	1 0 - 5	1 0 - 1
2 10 - 100	2 5 - 25	2 1 - 5
3 100 - 1 000	3 25 - 75	3 5 - 10
4 1 000 - 10 000	4 79 - 95	4 10 - 50
5 > 10 000	5 > 95	5 > 0-50

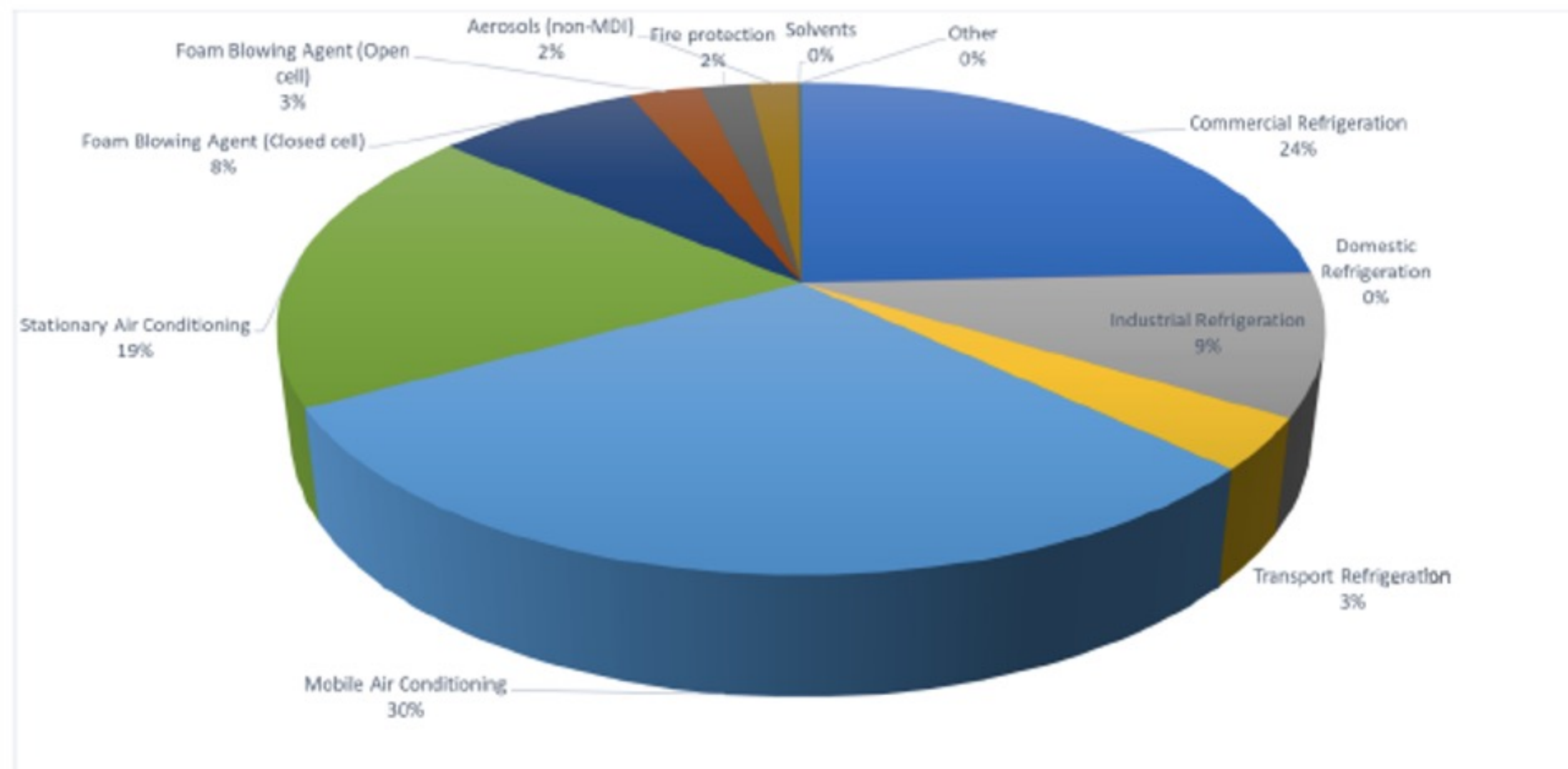


Figure B.73. Emissions of fluorinated gases from stocks 2018. Source EEA (2022).

# Where are these refrigerants used?

FACTORY SEALED  
DOMESTIC AND  
COMMERCIAL  
REFRIGERATION  
APPLIANCES

Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
R-600a	Single component – Isobutane	Less than 1	No	No
R-290	Single component – propane	Less than 1	No	No
R-454C	Blend	502 - 580	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes, HFO-1234yf: 100%
R-455A	Blend	502 - 580	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes, HFO-1234yf: 100%
R-450A	Blend	1611 - 1742	Yes, HFC-134a: CF <sub>3</sub> -CH <sub>2</sub> F HFO-1234ze: CHF=CH-CF <sub>3</sub>	Yes HFC-134a: 7 – 20% HFO-1234ze: less than 10%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOSphere

# Where are these refrigerants used?

FOOD RETAIL AND  
FOOD SERVICE  
REFRIGERATION  
(LARGER SYSTEMS)

Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
R-290	Single component – propane	Less than 1	No	No
R-744	Single component – carbon dioxide	1	No	No
R-717	Single component - ammonia	No	No	No
R-455A	Blend	502 - 580	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes, HFO-1234yf: 100%
R-450A	Blend	1611 - 1742	Yes, HFC-134a: CF <sub>3</sub> -CH <sub>2</sub> F HFO-1234ze: CHF=CH-CF <sub>3</sub>	Yes HFC-134a: 7 – 20% HFO-1234ze: less than 10%
R-407A	Blend	4538 - 4890	Yes, HFC-125: CF <sub>3</sub> -CHF <sub>2</sub> HFC-134a: CF <sub>3</sub> -CH <sub>2</sub> F	Yes, HFC-134a: 7 – 20%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOSphere

# Where are these refrigerants used?

## TRANSPORT REFRIGERATION

Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
R-744	Single component – carbon dioxide	1	No	No
R-717	Single component - ammonia	No	No	No
R-1234yf	Single component	1.81 - 0.501	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%
R-452A	Blend	4003 - 4273	Yes, HFC-125: CF <sub>3</sub> -CHF <sub>2</sub> HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%
R-404A	Blend	6010 - 7208	Yes, HFC-125: CF <sub>3</sub> -CHF <sub>2</sub> HFC-134a: CF <sub>3</sub> -CH <sub>2</sub> F HFC-143a: CF <sub>3</sub> -CH <sub>3</sub>	Yes, HFC-134a: 7 – 20% HFC-143a: less than 10%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOSphere

# Where are these refrigerants used?

AIR-TO-AIR AIR  
CONDITIONERS AND  
HEAT PUMPS

Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
R-290	Single component – propane	Less than 1	No	No
R-32	Single component	2690 - 771	No	No
R-454B	Blend	1606 - 1854	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%
R-452A	Blend	2006 - 2275	Yes, HFC-125: CF <sub>3</sub> -CHF <sub>2</sub> HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOSphere

# Where are these refrigerants used?

APPLIED BUILDING  
COOLING SYSTEMS

Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
Hydrocarbons	Single components – isobutane, propane, propene...	Less than 1	No	No
R-717	Single component - ammonia	No	No	No
R-718	Single component - water	No	No	No
R-32	Single component	2690 - 771	No	No
R-1234ze	Single component	4.94 - 1.37	Yes, HFO-1234ze: CHF=CH-CF <sub>3</sub>	Yes HFO-1234ze: less than 10%
R-1233zd(E)	Single component	14 - 3.88	Yes, HCFO-1233zd(E): CHCl=CH-CF <sub>3</sub>	Yes HCFO-1233zd(E): around 2%
R-452B	Blend	2006 - 2275	Yes, HFC-125: CF <sub>3</sub> -CHF <sub>2</sub> HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOSphere

# Where are these refrigerants used?

MOBILE AIR  
CONDITIONING

Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
R-744	Single component – carbon dioxide	1	No	No
R-1234yf	Single component	1.81 - 0.501	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOsphere

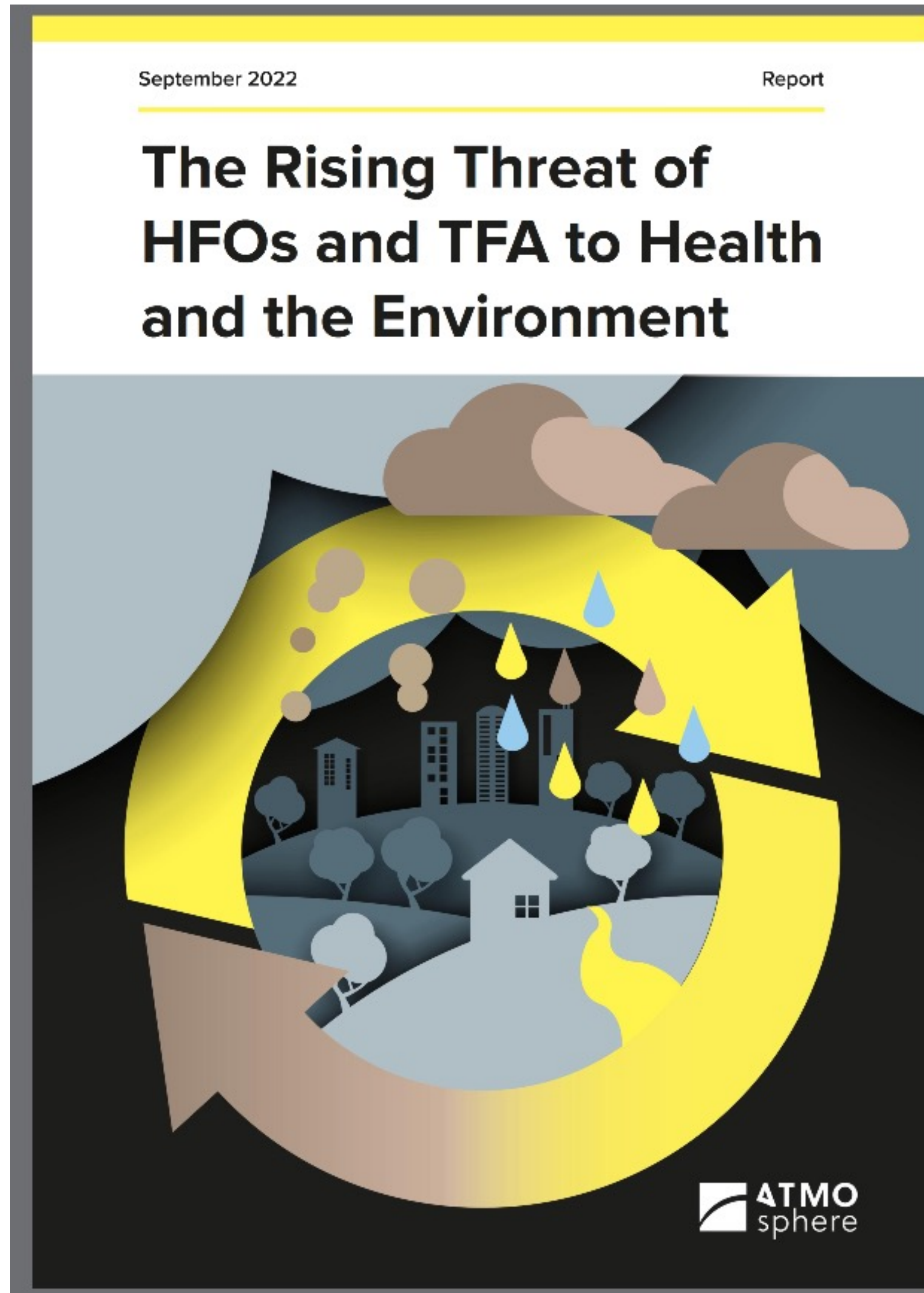
# Where are these refrigerants used?

## INDUSTRIAL REFRIGERATION

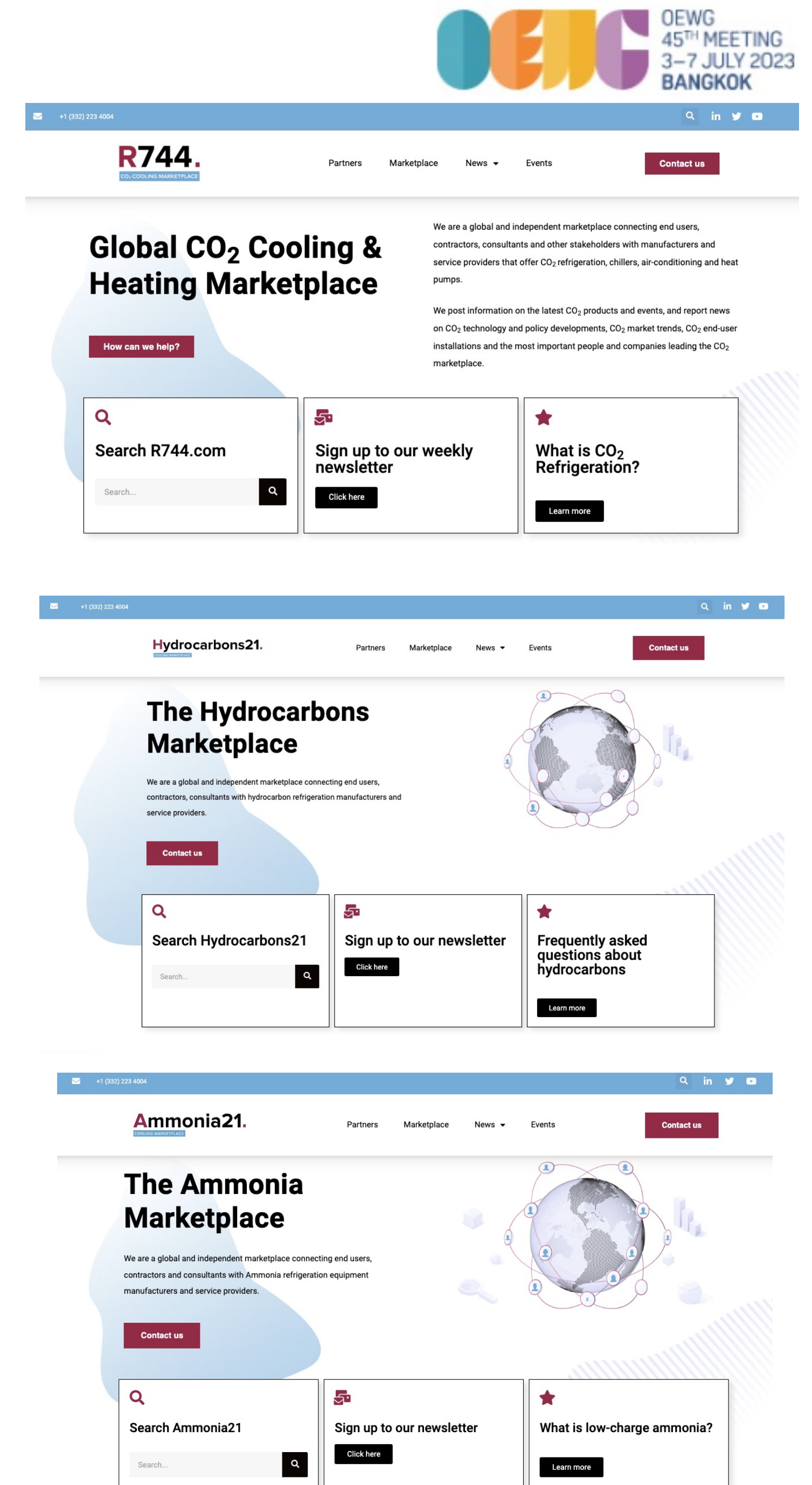
Refrigerants	Composition	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)	TFA creation (UBA)
R-744	Single component – carbon dioxide	1	No	No
R-290	Single component – propane	Less than 1	No	No
R-717	Single component - ammonia	No	No	No
R-718	Single component - water	No	No	No
R-1234yf	Single component	1.81 - 0.501	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%
R-454C	Blend	502 - 580	Yes, HFO-1234yf: CH <sub>2</sub> =CF-CF <sub>3</sub>	Yes HFO-1234yf: 100%

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOsphere

Raising awareness in the industry and informing on alternatives!



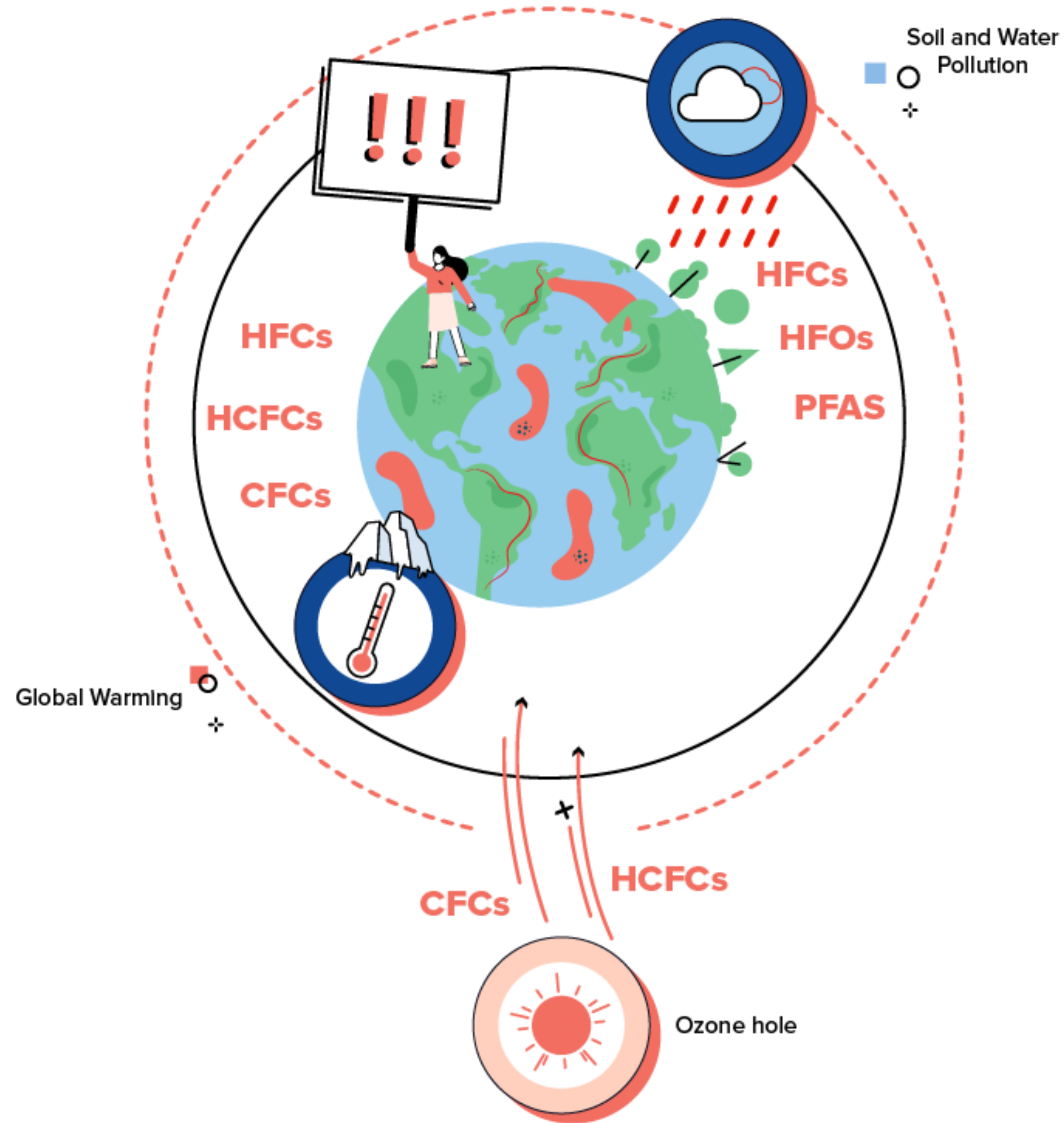
Source: ATMOsphere



Call on policy makers  
 to not work in silos!

Refrigerants / Brand Name	Type	Composition	IPCC AR4 (2007)		IPCC AR6 (2021)		PFAS
			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 <sub>2</sub>	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 <sub>3</sub>	0	0	0	0	No
R718	Natural	H <sub>2</sub> O	0	0	0	0	No
R729	Natural	Air	0	0	0	0	No

Enough of the halogenated chemicals treadmill in refrigerants, especially since alternatives are available!





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**Thank you  
for listening.**

