Knowledge Center

White paper

Refrigerant scenario

Rules and trends in the near future

Concerns on environmental issues such as the greenhouse effect and the PFAS contamination are driving governments to create new rules to control emissions.

In the coming years, significant actions are planned, and refrigerants will be particularly affected. Information is continuously being updated and the specificities of regulations create many questions among manufacturers and users:

How do the rules affect the most common refrigerants? What are the trends? Which is the best refrigerant for each application?

CAREL can help you answer these questions and find solutions that are compatible with the new regulations worldwide.

Do not hesitate to contact us for further information about the contents of this paper:

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Definition of terms and acronyms

AC: Air Conditioning

ACHP: Air Conditioning and Heat Pumps

CFC (Chlorofluorocarbon): substance which contains fluorine, carbon and chlorine. They are considered the "first generation" of refrigerants. CFC refrigerants have ODP and are greenhouse gases (high GWP). E.g. R-12.

Glide: temperature difference between the starting and ending temperature of a refrigerant phase change. It occurs when a refrigerant is a blend of components with different evaporation/condensation temperatures at the same pressure. This factor negatively affects the performance and related design of refrigeration circuits, especially evaporators.

GWP (Global Warming Potential): this is a characteristic factor estimating the greenhouse effect of a gas being released into the atmosphere compared to the effect of CO_2. For example, the GWP of CO_2 is 1 and the GWP of R-134a is 1430: this means that 1 kg of R-134a has the same greenhouse effect as 1430 kg of CO_2.

HC (Hydrocarbons): substance composed of hydrogen and carbon. They are natural, non toxic refrigerants that have no ozone depleting properties and minimal GWP.

HCFC (Hydrochlorofluorocarbon): substance which contains hydrogen, fluorine, carbon and chlorine. They are considered the "second generation" of refrigerants, substituting CFCs (chlorofluorocarbons) such as R-12. HCFC refrigerants have ODP and are greenhouse gases (high GWP). E.g. R-22.

HFC (Hydrofluorocarbon): substance containing hydrogen, fluorine and carbon. They are considered the "third generation" of refrigerants, with no ODP, but are greenhouse gases (high GWP). E.g. R-134a, R-32, R-404A.

HFO (Hydrofluoroolefin): substance composed of hydrogen, fluorine and carbon. They are considered the "fourth generation" of refrigerants, with a thousand times lower GWP than HFCs. E.g. R-1234yf, R-1234ze(E).

HP: Heat Pumps

Natural refrigerants: chemicals which occur in nature's bio-chemical processes, i.e.: air, water, carbon dioxide, ammonia and hydrocarbons. They do not deplete the ozone layer and make a negligible or no contribution to global warming.

ODP (Ozone Depletion Potential): this is the potential for a single molecule of refrigerant to destroy the ozone layer, with R-11 being fixed as a reference at an ODP of 1.0.

PFAS (Per- and polyfluoroalkyl substances): a large class of synthetic chemicals with a wide range of different physical and chemical properties that contain carbon-fluorine bonds, which are one of the strongest chemical bonds in organic chemistry. They can be gases, liquids, or solid high-molecular weight polymers.

RACHP: Air Conditioning, Heat Pumps and Refrigeration

Rules and regulations

Fluorinated refrigerants are significant contributors to the greenhouse effect and are an important aspect of efforts to control emissions. In the framework of the Kigali amendment to the Montreal Protocol, several actions are being carried out by most countries to phase down and control the use of these refrigerants. Examples of related regulations are the F-gas regulation in the EU or the AIM Act in the USA, among others.

Lately, PFAS are also a matter of concern, due to their potentially negative effects to the environment and health. Possible restrictions on these substances could have a relevant impact in the RACHP sector, including refrigerants.

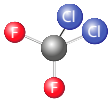
1. Refrigerant history overview

The history of refrigerants started almost 200 years ago. From the beginning, it has been marked by the discovery of the drawbacks of the different options, which has led to the research of alternative solutions. During the last years, the changes have also been dictated by international agreements that aim to protect people and environment. A summary is shown in the following timeline:

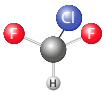
1834	The first working vapor-compression refrigeration system was built, using ethyleter as refrigerant
Refrigerants available in nature were used	
Natural refrigerants presented some security problems due to flammability and toxicity	
1930	Natural refrigerants were replaced by synthetic refrigerants, in particular **CFCs**
1950	The development of CFCs led to the discovery of **HCFCs**
1973	*It was found that the emissions of Cl^- atoms present in CFCs and HCFCs deplete the ozone layer*
1985	Vienna Convention for the Protection of the Ozone Layer
1987	**Montreal Protocol** on Substances that Deplete the Ozone Layer
Diffusion of **HFCs**	
It was discovered that fluorinated refrigerants negatively increases the greenhouse effect	
1992	United Nations Framework Convention on Climate Change, Rio de Janeiro
1997	**Kyoto Protocol**: it required the developed countries to reduce greenhouse gas emissions by 5%
2015	UN Climate Change Conference in Paris: agreement of limiting global warming to less than 2°C Celsius
2016	**Kigali Agreement** (Montreal Protocol Amended). Details are shown below.
Diffusion of HFOs and natural refrigerants (HCs, CO_2 and ammonia)	

Ammonia (**Natural**)

R-12 (**CFC**)

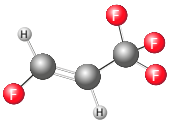


R-22 (**HCFC**)

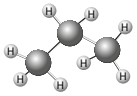


R-32 (**HFC**)

R-1234ze (**HFO**)



Propane (**HC, natural**)



Kigali Agreement

In the framework of the UN Climate Change Conference in Paris, an amendment to the Montreal Protocol was signed on October 2016 in Kigali. It involves the international phase-down of HFCs, which would help prevent a 0.5 °C rise in global temperature by 2100, while continuing to protect the ozone layer. Most developing countries will follow with a freeze on HFC consumption levels in 2024, and other developing countries will follow in 2028, as shown in the following graph (EU F-gas target limits have been included for comparison).

The Kigali Amendment to the Montreal Protocol entered into force on 1 January 2019. So far (May 2024), 159 countries have ratified/adopted/approved it.

As a consequence of these global treaties, each country establishes concrete measures to comply with the agreements. This is the basis for the rules and regulations presented in this document, for example F-gas in Europe or the EPA's SNAP rules in the USA.

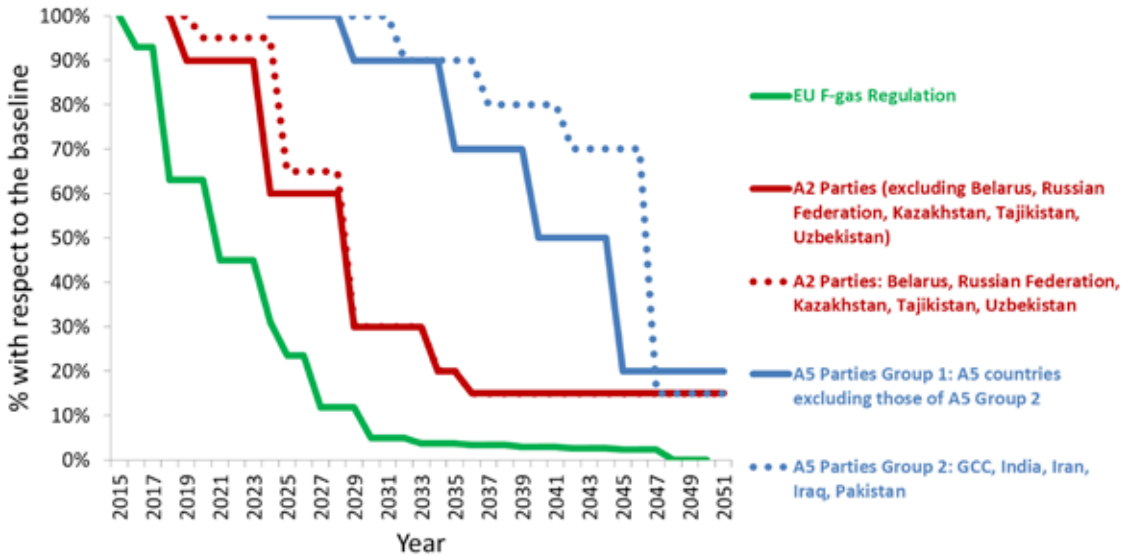


Fig. 1.a - Phase-down schedule for HFCs according to Kigali Agreement.

2. What are the rules in different parts of the world?

European union

The F-gas Regulation is part of the EU's environmental policy aim of protecting the environment by reducing emissions of fluorinated greenhouse gases.

The latest revision of the F-gas regulation was published in the EU's Official Journal on 20 February 2024, making it legally binding and entering into force 20 days later. This regulation repeals the F-gas regulation that was in force since 2014.

The fluorinated greenhouse gases that are subject to the regulations and are used in the RACHP sector comprise HFCs, HFOs and HCFCs. Mixtures containing these substances are also considered as fluorinated greenhouse gases, and thus are covered by the F-gas Regulation.

Before entering into the details of the new revision of the F-gas Regulation, it is worth noting that the GWP values of HFCs should be calculated in terms of the 100-year GWP based on the Fourth Assessment Report adopted by the Intergovernmental Panel on Climate Change (IPCC), whereas for other fluorinated greenhouse gases (e.g. HFOs), the Sixth IPCC Assessment Report should be used.

Phase down

The maximum quantity of HFCs available to be allocated as quotas for producers and importers from 2024 to 2050, in percentage terms with respect to the 2015 base-value (176.7 Mt CO2e), is represented in the graph below. The decreasing quotas are especially noticeable in the first five years. In essence, the maximum amount of HFCs allowed to be placed on the EU market in the period 2025-2026 will be 24.3% rather than the 32.1% that would have been available according to the previous F-gas regulation. This percentage will decrease to 12.3% for the period 2027-2029 and to 5.2% for the subsequent three years, followed by a gradual decrease until 2050, after which no HFCs will be allowed to be placed on the market in the EU.

It should be highlighted that the quota is applied only to HFC refrigerants, thus HFOs are not included. A mixture is considered to be a HFC if it contains a HFC refrigerant even if the proportion is small.

It should also be noted that the quota system will be extended to MDIs (Metered Dose Inhalers) from January 2025, which means that a part of the quota will not be available for the RACHP sector.

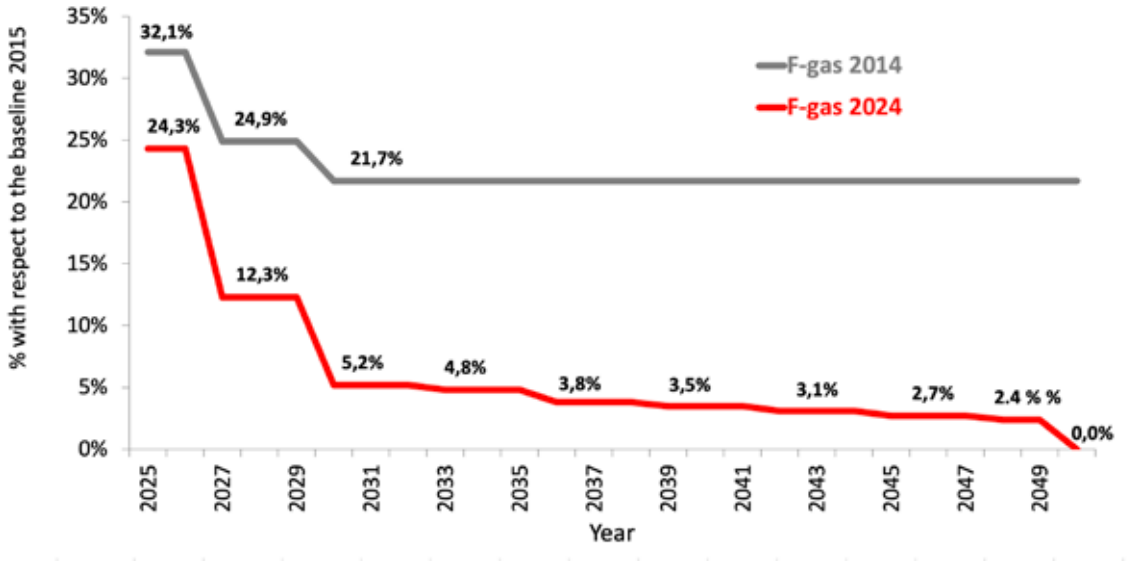


Fig. 2.b - Maximum amount of HFC refrigerants, in percentage with respect to the baseline, allowed to be placed on the EU market in the period 2025-2050.

It is worth noting that the Commission will allow for additional HFC quotas for the HP sector whenever severe shortages exist that could endanger attainment of the RePowerEU heat pump deployment targets. REPowerEU proposes a HP target of an additional 10 million HPs due to be installed between 2022 and 2027 and 30 million hydronic HPs by 2030.

Bans on placing on the market

The new F-gas regulation introduces new bans on the use of refrigerants for specific applications. One important introduction is that, in some cases, the use of any fluorinated refrigerant will be prohibited. Other bans are based on the extent to which the refrigerant contributes to global warming, in terms of GWP, as in the previous version of the F-gas. All these restrictions will impact ACHPs, refrigeration units and chillers.

As shown in the table below, fluorinated refrigerants with a GWP ≥ 150 will be banned sooner or later in all refrigeration applications, excluding chillers. The restriction in domestic applications goes beyond the limit of 150, as the use of all fluorinated refrigerants will be prohibited from 2026. The ban on using refrigerants with a GWP ≥ 150 for commercial and other self-contained units starts from 2025. Manufacturers of all other stationary refrigeration equipment will have 5 more years to adapt their units to refrigerants with GWP < 150, however only fluorinated refrigerants with GWP < 2500 will be allowed from 2025 (the GWP of 2500 for HFCs was in force since 2020, but has now been extended to all fluorinated refrigerants). Moreover, multi-rack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or more still have the GWP limit of 150, or 1500 for the primary refrigerant circuit of cascade systems, which has been in force since 2022.

The table below also shows the restrictions on the use of fluorinated refrigerants for chillers and ACHPs. As can be seen, for units below 12 kW (comprising to air-to-water split and self-contained ACHPs, as well as chillers) the use of fluorinated refrigerants with GWP ≥ 150 will be banned from 2027. For air-to-air ACHPs, the GWP limit of 150 will also apply, but from 2029. In any case, the end date for fluorinated greenhouse gases in all these low-capacity applications has been defined: 2032 for chillers and self-contained ACHP units, and 2035 for split ACHP systems.

For units over 12 kW, there are greater differences regarding bans. Self-contained ACHP units will have a GWP limit of 150. This will apply from 2027 for units in the range 12-50 kW, and from 2030 for higher maximum rated capacities. For split ACHPs, a GWP limit of 750 will apply from 2029, and will decrease to 150 from 2033. Finally, chillers above 12 kW are the only units in which fluorinated refrigerants with a GWP higher than 150 will be allowed, as the GWP limit will be 750 and will apply from 2027.

Most of the bans have exemptions, in some cases with a GWP limit of 750, if safety requirements cannot be met on the site of installation. This is another important new aspect of the revised F-gas regulation.

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Domestic refrigeration		No F-gases*									
Fridges/freezers for commercial use (self-contained)	<150 GWP										
Other self contained ref. equipment	<150 GWP*										
All other stationary refrigeration equipment	<2500 GWP (except equipment T<-50°C)					<150 GWP*					
Chillers (≤12 kW)			<150 GWP*					No F-gases*			
Self contained ACHP (≤12 kW)			<150 GWP**					No F-gases**			
Split ACHP (≤12 kW) Air-Water			<150 GWP*								No F-gases*
Split ACHP (≤12 kW) Air-Air					<150 GWP*						No F-gases*
Chillers (>12 kW)			<750 GWP*								
Self contained ACHP (12-50 kW)			<150 GWP**								
Self contained ACHP (>50 kW)						<150 GWP**					
Split ACHP (>12 kW)					<750 GWP*				<150 GWP*		

Tab. 2.a - Refrigerants that will be allowed in different RACHP applications starting from 2025 according to the new F-gas regulation

*except when required to meet safety requirements
**when safety requirements would not allow using fluorinated greenhouse gases with GWP of 150 or less, the GWP limit is 750

In addition to these bans, a GWP limit of 1000 on fluorinated gases will be set for the export of stationary RACHP equipment. It will apply starting on 12 March 2025 and the impact on the market will very likely be high, as there are high numbers of equipment containing refrigerants with GWP > 1000 that are exported from the EU to countries where these refrigerants are permitted.

Maintenance or servicing

The F-gas regulation includes some new prohibitions on the use of fluorinated refrigerants for maintenance or servicing.

As shown in the table below, the first applications affected correspond to refrigeration equipment, for which the use of fluorinated refrigerants with GWP≥ 2500 is prohibited for maintenance or servicing from 2025, except reclaimed and recycled gases that can be used until 2030. This prohibition extends the scope of the previous F-gas regulation, which banned the use of refrigerants with a GWP ≥ 2500 to service or maintain refrigeration equipment with a charge size of 40 tonnes of CO_2 equivalent or more from 2020. Moreover, the use of HFCs with a GWP ≥750 (except reclaimed and recycled) is prohibited for the servicing or maintenance of stationary refrigeration equipment from 2032, with the exclusion of chillers. It should be noted that refrigeration equipment intended for applications designed to cool products to T < -50°C are excluded from these rules.

The limit of GWP 2500 for maintenance or servicing applies in ACHP units from 2026, however HFOs and HCFCs are excluded. Recycled and reclaimed HFCs can be used in ACHP units until 2032, when the limit of GWP 2500 will be applied also to these types of refrigerants.

		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Refrigeration equipment	Virgin refrigerant	<2500 GWP							<750 GWP			
	Recycled or reclaimed						<2500 GWP					
ACHP	Virgin refrigerant		<2500 GWP									
	Recycled or reclaimed								<2500 GWP			

Tab. 2.b - Refrigerants that will be allowed in different RACHP applications for maintenance or servicing starting from 2025 (except refrigeration equipment intended for applications designed to cool products to T < -50°C).

Requirements for leak checks

The provisions on leak checks of the previous F-gas Regulation are extended to HFOs and HCFCs, however for these categories of refrigerants the frequency depends on the mass of refrigerant, rather than taking into account the CO_2 equivalents. The frequency of leak checks according to the refrigerant charge and the presence of a leakage detection system is shown in the following table:

Refrigerant charge in refrigeration and ACHP	Frequency	Frequency, with a leakage detection system
Less than 5 CO_2 equivalent tonnes of HFCs (Hermetically sealed: less than 10 CO_2 equivalent tonnes of HFCs or less than 3 kg in residential buildings)	Exempted	-
Less than 1 kg of HFOs or HCFCs (Hermetically sealed: less than 2 kilograms or less than 3 kg in residential buildings)		
5-50 CO_2 equivalent tonnes of HFCs	Every 12 months	Every 24 months
1-10 kilograms of HFOs or HCFCs		
50-500 CO_2 equivalent tonnes of HFCs	Every 6 months	Every 12 months
10-100 kilograms of HFOs or HCFCs		
Over 500 CO_2 equivalent tonnes of HFCs	-	Every 6 months (leakage detection system compulsory)
Over 100 kilograms of HFOs or HCFCs		

Tab. 2.c - Requirements for leak checks in RACHP equipment containing fluorinated refrigerants.

It is important to note that leakage detection systems shall be checked at least once every 12 months to ensure their proper functioning.

Certification and training

Certification and training are extended from HFCs to HFOs, HCFCs and natural refrigerants. Certification is compulsory for the following activities involving the use of refrigerants: installation, servicing, maintenance, repair or decommissioning of equipment; leak checks; and recovery from equipment.

United States

The use of fluorinated refrigerants in the US is regulated by The American Innovation & Manufacturing Act (AIM Act) [ii], signed in December 2020. According to this act, the US Environmental Protection Agency (EPA) has the authority to regulate HFCs in three ways: phasing down production and consumption, facilitating the transition to next-generation technologies through sector-based restrictions, and regulating refrigerant management.

Phase down of HFCs

In line with the Kigali Amendment to the Montreal Protocol, the objective of the AIM Act is to phase out the production and consumption of HFCs in the US by 85% before 2035 (Baseline - Consumption: 303.89 MMTEVe , Production: 382.55 MMTEVe 1). As shown in the following graph, the allowance limits have been reduced from 90 to 60% in 2024, the biggest reduction so far. The next step will be in 2029 (30%), followed by further reductions in 2034 (20%) and 2036 (15%).

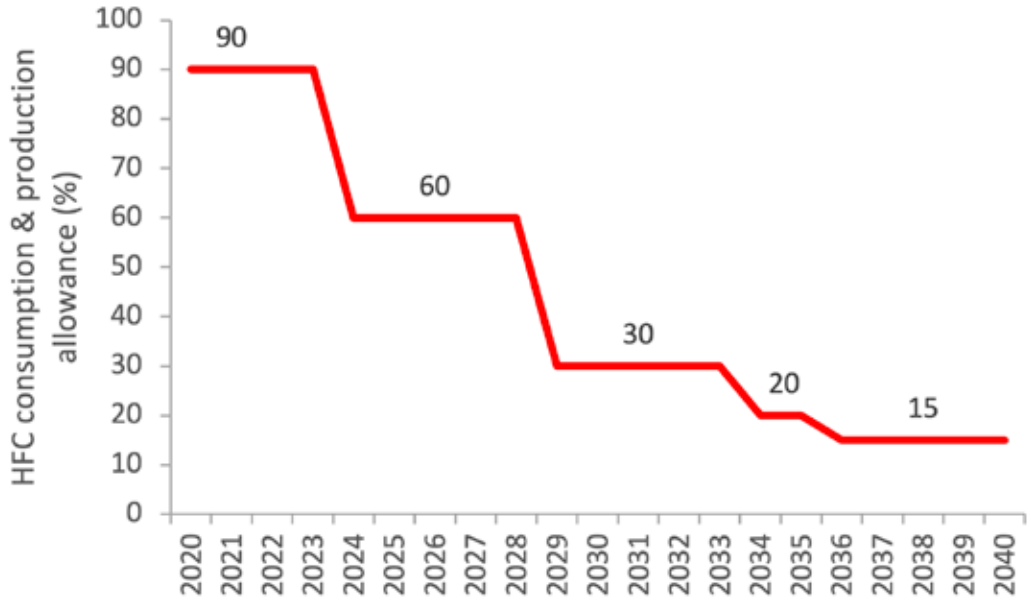


Fig. 2.c - HFC phase down schedule in the period 2020-2040 according to the AIM Act.

Regulatory Actions for Technology Transitions

The final rule "Phasedown of Hydrofluorocarbons: Restrictions on the Use of Certain Hydrofluorocarbons under Subsection (i) of the American Innovation and Manufacturing Act of 2020"[iii] was signed on 5 October 2023. This rule restricts the use of high GWP HFCs in new aerosol, foam, and RACHP products and equipment. In most applications, the EPA has set

1 MMTEVe: million metric tonnes of exchange value equivalent, which is numerically equivalent to one million metric tonnes of CO2 equivalent

a maximum GWP limit on HFCs or HFC blends that can be used, whereas in a few applications, the EPA has listed the specific HFCs or HFC blends that are restricted. It should be noted that the restrictions affect the sale, distribution, and export of products three years after the manufacture/import restriction dates.

The following table shows the GWP limits and the year of banning for the manufacture, import and installation of ACHPs, refrigeration units and chillers.

End-use		GWP limit	Year
Stationary residential and light commercial ACHP		700	2025
Residential dehumidifiers		700	2025
Household refrigerators and freezers		150	2025
Retail food refrigeration (stand-alone units)		150	2025
Vending machines		150	2025
Refrigerated transport (T> -50°C)		700	2025
Self-contained automatic commercial ice machines	Ice maker products (batch type: harvest rate ≤1000 lb (453.6 kg) ice per 24 hours; continuous type: harvest rate ≤1200 (544.3 kg) lb ice per 24 hours)	150	2026
Retail refrigerated food processing and dispensing products	Products outside the scope of UL 621, Ed.7	150	2027
Chillers (stand-alone)	Comfort cooling	700	2025
	Ice rinks	700	2025
	Industrial process refrigeration, T > −30 °C (−22 °F)	700	2026
	Industrial process refrigeration, T ≥ −50 °C (−58 °F) and T≤ −30 °C (−22 °F)	700	2028
Data centers, computer room AC and information technology equipment cooling	Data centers, computer room AC and information technology equipment cooling	700	2027
Motor vehicle AC	New light-duty passenger vehicles	150	2025
	New medium-duty passenger vehicles	150	2028
	Nonroad vehicles	150	2028
Cold storage warehouse systems	Refrigerant charge capacity ≥ 200 lbs (90.72 kg)	150	2026
	Refrigerant charge capacity < 200 lbs (90.72 kg)	300	2026
	Cascade refrigerant systems on the high temperature side of the system	300	2026
Industrial process refrigeration (not using chillers)	Refrigerant charge capacity ≥ 200 lbs (90.72 kg), T> −30 °C (−22 °F)	150	2026
	Refrigerant charge capacity < 200 lbs (90.72 kg), T> −30 °C (−22 °F)	300	2026
	The high T side of cascade systems with T>−30 °C (−22 °F)	300	2026
	T≥−50 °C (−58 °F) and T≤ −30 °C (−22 °F)	700	2028
Remote condensing units in retail food refrigeration systems	Refrigerant charge capacity ≥ 200 lbs (90.72 kg)	150	2026
	Refrigerant charge capacity< 200 lbs (90.72 kg)	300	2026
	Cascade refrigerant systems	300	2026
Supermarket systems	Refrigerant charge capacity ≥ 200 lbs (90.72 kg)	150	2027
	Refrigerant charge capacity < 200 lbs (90.72 kg)	300	2027
	Cascade refrigerant systems, on the high T side of the system	300	2027

Tab. 2.d - Restricted products in the USA for RACHP according to the GWP values of the refrigerants contained in such products.

Note that the interim final rule provides one additional year for the installation of new residential and light commercial ACHP systems when using components that were manufactured or imported before 2025. It should be also highlighted that residential ice makers are not included in the household refrigerator and freezer subsector and are not subject to the restrictions indicated in the previous table.

The following table shows specific HFCs or HFC blends that are restricted by the AIM Act.

End-use		Refrigerant bans	Year
Refrigeration transport	Road and Marine (Self-contained products)	R–402A, R–402B, R–404A, R–407B, R–408A, R–410B, R–417A, R–421A, R–421B, R–422A, R–422B, R–422C, R–422D, R–424A, R–428A, R–434A, R–438A, R–507A, R–125/290/134a/600a (55/1/42.5/1.5), RS–44 (2003 formulation) or GHG–X5	2025
Automatic commercial ice machines	Batch type with harvest rate >1000 lb ice per 24 hours, and continuous type with harvest rate >1200 lb ice per 24 hours	R–402A, R–402B, R–404A, R–407A, R–407B, R–407C, R–407F, R–408A, R–410A, R–410B, R–411A, R–411B, R–417A, R–417C, R–420A, R–421A, R–421B, R–422A, R–422B, R–422C, R–422D, R–424A, R–426A, R–428A, R–434A, R–437A, R–438A, R–442A, R–507A, HFC–134a, R–125/290/134a/600a (55/1/42.5/1.5), RB–276, RS–24 (2002 formulation), RS–44 (2003 formulation), GHG–X5, G2018C, or Freeze 12	2027
	Remote condenser	R–402A, R–402B, R–404A, R–407B, R–408A, R–410B, R–417A, R–421A, R–421B, R–422A, R–422B, R–422C, R–422D, R–424A, R–428A, R–434A, R–438A, R–507A, R–125/290/134a/600a (55/1/42.5/1.5), RS–44 (2003 formulation), or GHG–X5	2027
Refrigerated food processing and dispensing products	Products outside the scope of UL 621, Ed.7	R–402A, R–402B, R–404A, R–407A, R–407B, R–407C, R–407F, R–407H, R–408A, R–410A, R–410B, R–411A, R–411B, R–417A, R–417C, R–420A, R–421A, R–421B, R–422A, R–422B, R–422C, R–422D, R–424A, R–426A, R–427A, R–428A, R–434A, R–437A, R–438A, R–507A, HFC–134a, HFC–227ea, R–125/290/134a/600a (55/1/42.5/1.5), RB–276, RS–24 (2002 formulation), RS–44 (2003 formulation), GHG–X5, or Freeze 12	2027
	Products within the scope of UL 621, Ed.7	R–402A, R–402B, R–404A, R–407A, R–407B, R–407C, R–407F, R–407H, R–408A, R–410A, R–410B, R–411A, R–411B, R–417A, R–417C, R–420A, R–421A, R–421B, R–422A, R–422B, R–422C, R–422D, R–424A, R–426A, R–427A, R–428A, R–434A, R–437A, R–438A, R–507A, HFC–134a, HFC–227ea, R–125/290/134a/600a (55/1/42.5/1.5), RB–276, RS–24 (2002 formulation), RS–44 (2003 formulation), GHG–X5, or Freeze 12	2028
	Remote condenser	R–402A, R–402B, R–404A, R–407A, R–407B, R–407C, R–407F, R–407H, R–408A, R–410A, R–410B, R–411A, R–411B, R–417A, R–417C, R–420A, R–421A, R–421B, R–422A, R–422B, R–422C, R–422D, R–424A, R–426A, R–427A, R–428A, R–434A, R–437A, R–438A, R–507A, HFC–134a, HFC–227ea, R–125/290/134a/600a (55/1/42.5/1.5), RB–276, RS–24 (2002 formulation), RS–44 (2003 formulation), GHG–X5, or Freeze 12	2027

Tab. 2.e - Refrigerant banned in the USA for refrigeration applications in the next years.

Proposed emissions reduction and reclamation program

A proposed rule on emissions reduction and reclamation for the management of HFCs and their substitutes [iv] was published in the Federal Register in October 2023. The primary goal of this proposed rule is to establish a program that reduces emissions of HFCs from equipment such as AC and refrigeration systems, and maximises the amount of HFCs that can be reclaimed.

To implement this program, the EPA is proposing: leak repair provisions for certain appliances, use of automatic leak detection for certain new and existing equipment, a proposed reclamation standard, requirements for the use of reclaimed HFCs for certain types of equipment in certain RACHP subsectors, requirements for the use of recycled HFCs in fire suppression equipment, certain provisions for equipment in the fire suppression sector (including technician training), recovery of HFCs from disposable cylinders, container tracking for HFCs that could be used in the refrigerant-containing equipment or fire suppression equipment, and record keeping, reporting, and labelling. Additionally, the EPA is also proposing an alternative recycling criteria for used ignitable refrigerants, including some HFCs and their equivalents, under the authority of the Resource Conservation and Recovery Act.

The following table shows the proposed requirements and effective date for leak repair, automatic leak detection systems and use of reclaimed HFCs.

Proposed requirements	Equipment	Proposed effective date
Leak repair for appliances with refrigerant of GWP > 53	Charge size ≥ 50 lbs (22.7 kg)	60 days after publication of final rule
	Charge size: 15 - 50 lbs (6.8-22.7 kg)	1 year after publication of final rule
Automatic leak detection (ALD) systems for commercial refrigeration and industrial process refrigeration appliances with a charge size ≥ 1500 lbs (680.4 kg)	Installed prior to effective date of the final rule	1 year after publication of final rule
	Installed on or after effective date of the final rule	30 days after appliance installation
Use of reclaimed HFCs	Installation of residential and light commercial ACHP, cold storage warehouses and industrial process refrigeration; installation, servicing and/or repair of stand-alone retail food refrigeration, supermarket systems, refrigerated transport and automatic commercial ice makers	1 January, 2028

Tab. 2.f - Proposed requirements according to Proposed Emissions Reduction and Reclamation Program.

Listing of substitutes under the SNAP Program

Manufacturers must ensure that, in addition to meeting the restrictions set under the AIM Act Technology Transition Rule, they also comply with the EPA's Significant New Alternatives Policy (SNAP) regulations. The SNAP program reviews substitutes on the basis of the environmental and health risks, including factors such as ODP and GWP, toxicity, flammability, and exposure potential within a comparative risk framework of different industrial sectors, including refrigeration and AC.

SNAP Rule 25[v] and the Proposed Rule 26[vi] are the latest published regulations.

SNAP Rule 25, which came into force on 30 May 2023, lists seven refrigerants as acceptable (subject to use conditions), revises use conditions for R-32 in new self-contained room ACHP for consistency with other SNAP listings, and adopts recent AC and refrigeration industry standards to ensure safe use of the covered refrigerants.

End-use	Substitutes
Centrifugal chillers for comfort cooling	R-32, R-1234yf, R-452B, R-454A, R-454B, R-454C
Positive displacement chillers for comfort cooling	
Industrial Process AC using a chiller	
Residential Dehumidifiers	
Self-contained room AC	
Very low T refrigeration	R-1150 (ethylene)

Tab. 2.g - Acceptable refrigerants (subject to use conditions) as per SNAP Rule 25.

The Proposed Rule 26 lists 10 refrigerants as acceptable (subject to use conditions), modifies the use conditions for R-290, references the latest versions of UL 60335-2-89, ASHRAE 15-2022, and ASHRAE 34-2022, and exempts R-290 in refrigerated food processing and dispensing equipment from the CAA section 608 venting prohibition.

End-use	Substitutes
Commercial Ice Machines	R-32, R-1234yf, R-454A, R-454B, R-454C, R-455A, R-457A, R-516A
Industrial Process Refrigeration	R-32, R-1234yf, R-1234ze(E), R-454A, R-454B,2 R-454C, R-455A, R-457A, R-516A
Ice Skating Rinks	R-1234yf, R-1234ze(E), R-454C, R-455A, R-457A, R-516A
Refrigerated Food Processing, Dispensing Equipment and Stand-alone Units	
Supermarket Systems and Remote Condensing Units	R-1234yf, R-1234ze(E), R-454A, R-454C, R-455A, R-457A, R-516A
Cold Storage Warehouses	
Commercial Ice Machines (Self-contained Units)	R-290
Retail Food Refrigeration (Stand-alone Units)	
Refrigerated Food Processing and Dispensing Equipment	

Tab. 2.h - Acceptable refrigerants (subject to use conditions) or modified use conditions as per SNAP Rule 26.

US State regulations

California, New York and Washington go beyond the SNAP rulings and impose GWP limits in some applications.

California

In September 2018, the existing HFC phase-out was enshrined into California's law SB 1013[vii] , which incorporated, with a few changes, EPA SNAP Rules 20 and 21, except for mobile vehicle AC, and established the Fluorinated Gases Emission Reduction Incentive Program. In December 2021, CARB (the California Air Regulatory Board) added new equipment prohibitions, which can be summarised as followed [viii]:

- New stationary refrigeration systems charged with more than 50 lbs (22.7 kg): Refrigerants with GWP≥150 are banned (effective 2022)
- Existing food retail systems with more than 50 lbs (22.7 kg) must attain a company-wide weighted average GWP of less than 1400 or 55% greenhouse gas potential (GHGp) reduction relative to a 2019 baseline (effective 2030)
- New AC and VRF equipment: GWP limit of 750. The effective date depends on the specific AC equipment category:
  - Room/wall/window AC equipment, packaged terminal ACHP, portable AC equipment, and residential dehumidifiers (effective 2023)
  - Other new AC equipment (effective 2025)
  - VRF systems (effective 2026)
- Chillers
  - AC and industrial process refrigeration for chilled fluid leaving the chiller at temperatures > +35 °F (2 °C): GWP limit of 750 (effective 2024)
  - Chillers designed for chilled fluid leaving the chiller at temperatures ≤ +35 °F (2 °C) and > -10 °F (-23 °C): GWP limit of 1500 (effective 2024)
  - Chillers designed for chilled fluid leaving the chiller at temperatures ≤ -10 °F (-23 °C) and > -58 °F (-50 °C): GWP limit of 2200 (effective 2024)

Washington

In alignment with the federal EPA SNAP Rules 20 and 23, Washington enacted HB 1112[ix] , prohibiting certain HFCs in specific stationary refrigeration and AC end-uses. In 2021, the Washington Legislature passed HB 1050, Hydrofluorocarbons – Emissions Reduction (Chapter 70A.60 RCW). This law requires the Washington State Department of Ecology (Ecology) to establish maximum GWP thresholds for new stationary refrigeration and AC equipment sold in Washington and to establish a refrigerant management program to reduce HFC leakages. It also requires Ecology to adopt GWP thresholds for refrigerants used in ice rinks and prohibits the sale of small cans of HFC refrigerant with a GWP greater than 150, as well as non-essential consumer products (e.g., air horns, noisemakers) containing these refrigerants. The GWP limits can be summarised, without considering the exemptions, as follows [x]:

- Commercial refrigeration and industrial process refrigeration: Refrigerants with GWP ≥ 150 will be prohibited (from 2025 for new equipment, from 2029 for retrofits);
- Chillers used for industrial process refrigeration: GWP limit of 750 (from 2025 for new equipment, from 2029 for retrofits);
- Ice rinks including chillers: GWP limit of 150 for new and GWP limit of 750 for retrofits, in both cases from 2024;
- Room ACs and residential dehumidifiers GWP limit of 750 (from 2024 for new equipment, from 2029 for retrofits);
- Other types of AC equipment used in residential and non-residential applications GWP limit of 750 (from 2026 for new equipment if UL 60335-2-40 Edition 4 is adopted by the Washington state building code council by 31 December 2023, from 2029 for retrofits);
- VRF: GWP limit of 750 (from 2026 for new equipment, from 2029 for retrofits)

New York

The Department of Environmental Conservation (DEC) has adopted 6 NYCRR Part 494 [xi], Hydrofluorocarbon Standards and Reporting, which establishes prohibitions on certain HFC substances in certain end-uses as previously included in the US Environmental Protection Agency, Significant New Alternatives Policy (SNAP) program. These prohibitions went into

effect statewide starting in 2021 and include the sale, installation, and commercial use of certain refrigerants in new or retrofitted food refrigeration equipment, large AC equipment (or chillers), and vending machines, as well as prohibitions on substances used in foams and as aerosol propellants in new consumer products.

New York has also initiated a new rulemaking[xii] under NYCRR Part 494, which uses the 20-year GWP value rather than the traditional 100-year GWP value.

China

The following table shows the "Recommended List of Hydrochlorofluorocarbon Alternatives in China"[xiii] . It indicates the refrigerant that can substitute R-22 for each application, according to the General Office of the Ministry of Ecology and Environment.

Alternatives	ODP	GWP	Typical applications	Common refrigerants
R-290	0	3	Room AC, domestic HP water heater, commercial self-contained refrigeration system, industrial refrigeration systems	R-22
R-600a	0	3	Freestanding refrigeration equipment for commercial use	R-22
R-744	0	1	Household HP water heaters, industrial or commercial HP water heaters, industrial or commercial refrigeration equipment, refrigeration equipment for cold storage	R-22
R-717	0	0	Industrial refrigeration equipment, refrigeration equipment for cold storage, compression condensing units	R-22
R-32	0	675	Unitary AC, chilled water (HP) units, industrial or commercial HP water heaters, multi-connected AC (HP) units	R-22
R-1234ze	0	<1	Large and medium-sized chilled water (HP) units	R-22
R-1234zd	0	1	Large and medium-sized chilled water (HP) units	R-22
R-515B	0	287	Large and medium-sized chilled water (HP) units	R-22
R-513A	0	631	Large and medium-sized chilled water (HP) units	R-22

Tab. 2.i - Recommended refrigerants in China for typical RACHP applications.

Canada

In 2017, the Ozone-depleting Substances and Halocarbon Alternatives Regulations were amended[xiv] to control HFCs through a phase-down of consumption of bulk HFCs complemented by controls on specific products containing or designed to contain HFCs.

The Regulations Amending the Ozone-depleting Substances and Halocarbon Alternatives Regulations establish a phase-down of HFC consumption (manufacture plus import minus export) from an established baseline. The phase down begins in 2019 with a 10% reduction in consumption, with further reduction steps in 2024, 2029 and 2034 in order to achieve an 85% reduction in HFC consumption by 2036. The amendments also introduce prohibitions, by specific dates, on the manufacture and import of certain products and equipment that contain, or are designed to contain, HFCs and HFC blends, with a GWP above a specific limit. These prohibitions are shown in the following table:

Product	Use	Date	GWP
Stand-alone medium-temperature refrigeration system	Commercial or industrial	1 January 2020	1400
	Domestic appliances	1 January 2025	150
Stand-alone low-temperature refrigeration system	Commercial or industrial	1 January 2020	1500
	Domestic appliances	1 January 2025	150
Centralized refrigeration system	Commercial or industrial	1 January 2020	2200
Condensing unit	Commercial or industrial	1 January 2020	2200
Chiller	Commercial or industrial	1 January 2025	750
Mobile refrigeration system	Commercial or industrial	1 January 2025	2200

Tab. 2.j - Regulations Amending the Ozone-depleting Substances and Halocarbon Alternatives Regulations in Canada

Australia

Australia's HFC phase-down [xv] started in January 2018. The HFC phase-down in Australia means a gradual reduction in the maximum amount of HFCs permitted to be imported into Australia, as reduced imports lead directly to reduced emissions.

The HFC phase-down is being implemented through the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989[xvi] and associated regulations through a quota system for imports of HFCs as bulk gas.

It should be noted that the HFC phase-down covers only imports of bulk gas such as in cylinders. This means that refrigerants imported in pre-charged equipment such as ACs or refrigerators are not included, because they are accounted for in the country of manufacture. Moreover, existing equipment that has already been imported into Australia is not affected by the phase-down.

As regards specific HFC prohibitions, the import and manufacture of small AC equipment using refrigerant with a GWP over 750 will be prohibited in Australia from July 2024, including equipment that is imported without refrigerant.

The ban will apply to equipment with up to a 2.6 kg refrigerant charge (per the compliance/rating plate), where it is intended for use in cooling, heating, or both heating and cooling, a stationary space, primarily for human comfort. However, similar AC equipment that is ducted, for mobile applications such as caravans and boats, or to systems for use in electrical enclosures and computer rooms are not included.

Japan

The regulation "Act on Rational Use & Proper Management of Fluorocarbons" addresses issues throughout the lifecycle of fluorocarbons. It also classifies refrigerants according to their GWP and specifies the date these are banned for each application (see the following table).

Other requirements:

- indications and label to designated products (showing "non-F-gas using" or degree of achievements to the target GWP value, target year and target GWP value, GWP value of the refrigerant used in the products), with the purpose of promoting designated products using low-GWP or natural refrigerants.
- regular leak checks, call service to arrange repairs before refilling as soon as leakages are found, record maintenance, and disclosure to maintenance operators, etc.
- calculation of the annual F-gas leakage amounts. If that amount exceeds 1,000 tonnes of CO2 equivalent, users, as a company, need to report it to the competent ministries, with information on the offices and factories from which the leakage was detected. The Ministry of the Environment (MOE) and the Ministry of Economy, Trade and Industry (METI) will notify the relevant municipal and prefectural governors on the results and the names of the companies, etc., and will publish them.

3. Potential PFAS restrictions

PFAS stands for "per- and polyfluoroalkyl substances" and are molecules that are widely used in industry due to their unique desirable properties. For instance, they are chemically inert, resistant to radiation and temperature, and oil-, water- and stain-repellent. Some of the major industry sectors that use PFAS substances include aerospace and defence, automotive, aviation, food contact materials, textiles, leather and apparel, construction and household products, electronics, fire-fighting, food processing, and medical articles.

PFAS are used also in the RACHP sector. On one hand, most fluorinated refrigerants are PFAS, or degrade to them. On the other, components of RACHP equipment that normally contain PFAS substances include filters, O-rings, seals, washers and gaskets, bearings and bushings, diaphragms, seat plates, caps, lubricants, sensors and cylinders.

However, PFAS are colloquially known as "forever chemicals" because they do not easily degrade in the environment and are very mobile in water. Once released into the environment, these chemicals tend to migrate into water and remain intact for very long periods of time. Adverse effects of PFAS on human health include raised cholesterol levels, weakened immune systems, kidney and testicular cancer and damage to the liver, as confirmed by several scientific studies.

European Union

In January 2023, the national authorities of Denmark, Germany, the Netherlands, Norway and Sweden submitted a proposal to the European Chemicals Agency (ECHA) to restrict PFAS under REACH, the EU chemicals regulation [xviii].

As regards refrigerants, the main concern reported in the proposal is the formation of trifluoroacetic acid (TFA) as a product of degradation due to its persistence in the environment. The list of single component refrigerants defined as PFAS are R-125, R-134a, R-143a, R-1234yf, R-1234ze(E), R-1336mzz(E), R-1336mzz(Z), R-1224yd and R-1233zd(E).

Considering all the blends that contain these refrigerants, it is evident that most of the refrigerants currently in use in RACHP applications would be banned should the Restriction Proposal be accepted. However, R-32 and R-152a would be excluded from the PFAS restrictions if the Restriction Proposal is left unchanged. Clearly, natural refrigerants are also excluded from the definition of PFAS.

The PFAS Restriction Proposal underwent public consultation in 2023 [xix]. The next step is the publication of the opinions of ECHA's Risk Assessment Committee (RAC) and the Socioeconomic Analysis Committee (SEAC) on whether the proposed restriction is appropriate for reducing the risks to people's health and the environment, and the socio-economic impacts associated with the proposal, respectively. Thereafter, they will be sent to the European Commission that, together with the REACH Committee, will decide on the potential restrictions. The draft decision will then go for comment and approval to the EU Parliament and the EU Council. Approval is scheduled for 2025, with an 18-month transition period

to alternatives, but it will probably be delayed due to the high number of comments received during the consultation period.

It should be noted that some exemptions have been proposed for certain applications, such as the use of refrigerants in RACHP equipment in buildings, where national safety standards and building codes prohibit the use of alternatives. The proposal also includes a transition period of 18 months and a 12-year exemption for maintenance and recharging existing RACHP equipment where drop-in alternatives are not available.

United States

The first US action on PFAS at a federal and state level was the "PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024"[xx] . EPA Administrator Michael Regan established the EPA Council on PFAS in April 2021 and called on it to develop a bold, across-the-board EPA strategy to protect public health and the environment from the impacts of PFAS. The roadmap sets timelines by which the EPA plans to take specific actions and commits to bolder new policies.

Meanwhile, the state of Maine has already started to take action on PFAS. In particular, the use of PFAS intentionally added to any product to be sold, offered for sale, or distributed for sale will be prohibited in the state, effective from 2030. In California, the manufacturing, selling and distributing of textiles containing PFAS levels exceeding 100 parts per million (ppm), which is now considered the unsafe limit, will be prohibited from 2025.

Moreover, the US Senate proposed a bill on PFAS in June 2023 in which the definition of PFAS specifies that substances subject to restrictions contain at least 2 fully fluorinated carbon atoms, therefore excluding fluorinated refrigerants. However, the definition adopted by the states of Maine and California, as well as by the EU, also covers substances that contain one fully fluorinated methyl or methylene carbon atom, which means that most of the refrigerants used today will be banned.

Canada

In May 2023, the federal government released a "Draft State of Per- and Polyfluoroalkyl Substances (PFAS) Report" [xxi]. According to this, the federal government proposes to recommend that PFAS, as a class of substances, be added to the Toxic Substances List. If that step is taken, the Risk Management Report outlines additional regulatory measures that the government is considering taking, including:

- introducing regulations and/or other instruments (i.e., guidelines, codes of practice) to minimise environmental and human exposure to the class of PFAS from fire-fighting foams
- gathering information (including through mandatory reporting) needed to identify and prioritise options for minimising environmental and human exposure to PFAS from other sources and products
- aligning with actions in other jurisdictions, where appropriate

The commenting period on the Draft Report and the Risk Management Report closed on 19 July 2023. The comments received on the reports have yet to be published, but this is expected to happen concurrently with the publication of a "Final State of PFAS Report" and the government's proposed risk management approach.

Australia

Australian Governments have taken a precautionary approach to managing existing PFAS contamination, working to prevent or reduce environmental and human PFAS exposure wherever possible [xxii]. Efforts have mainly been directed at dealing with contamination created by historical use of these chemicals by:

- Conducting investigations across Australia to establish a greater understanding of the extent of contamination and likely impacts on surrounding communities, and where necessary, developing management strategies tailored to the unique conditions of the site
- Where identified, ensuring PFAS exposure pathways are broken wherever possible, primarily by providing alternative water where necessary and providing advice to affected communities on other ways to reduce their exposure
- Providing community support, information and advice

- Investing in closing the knowledge gaps on the health effects of PFAS, and developing remediation strategies, through funding research
- Reviewing environmental legislation with a view to better regulation of PFAS and other emerging contaminants
- Developing guidance for all site managers to respond to PFAS contamination appropriately;
- Increasing coordination and collaboration between all levels of government and across the Commonwealth

Trends in RACHP applications

Refrigerant trends in the RACHP market are changing definitively as a result of different factors, above all international rules and regulations. The period 2025 – 2030 will be highly challenging in many countries, as different new requirements will need to be complied with.

In this context, the choice of a refrigerant for a specific application becomes more complex.

Learning about the regulations and market trends of refrigerants, and how they are correlated, can represent the first step in being ready for the new scenario.

1. How will the new regulations affect the refrigerant applications market?

In the EU, whether or not the PFAS Restriction Proposal is approved could have an important effect on the market, even if the new F-gas regulation already includes some restrictions for refrigerants defined as PFAS. On one hand, for applications in which the use of fluorinated refrigerants will be banned by the F-gas regulation, the ECHA restrictions could apply several years earlier, giving manufacturers less time to adapt their units. This is the case of chillers and ACHP units with a nominal capacity lower than 12 kW, applications in which a complete ban on the use of fluorinated refrigerants is required by 2032 or 2035. The use of fluorinated refrigerants will also be prohibited in domestic refrigerators, but already from 2026, thus the F-gas ban will most probably apply before the potential ECHA restriction. On the other hand, the types of equipment where the use of fluorinated refrigerants will not be completely banned by F-gas could be greatly affected by PFAS restrictions. These applications include commercial and industrial refrigeration units, as well as chillers and ACHP systems with a capacity higher than 12 kW.

In the USA, where PFAS restrictions on refrigerants may be applied in some states (the first one to announce this was Maine), the impact on refrigerant trends can be huge, as the AIM Act does not ban the use of all fluorinated refrigerants in any application and the use of natural refrigerants is less widespread than in the EU. In other countries too, the use of fluorinated refrigerants is not prohibited in any application, thus potential PFAS restrictions may have a considerable impact on refrigerant trends.

Moreover, in all countries where new regulations will be applied in the next few years, the potential effect on prices and availability of high GWP refrigerants should not be ignored, as happened after the publication of the previous F-gas regulation in the EU. For instance, the price of R-404A (GWP of 3922) rose by 900% from January to December 2017. In the same period, R-410A and R-407C prices (GWP of 2088 and 1774, respectively) saw a 600% increase, whereas the price of R-134a (GWP=1430) increased by about 300%. Undoubtedly, these were unprecedented price rises in the history of refrigerants! Indeed, in 2017, a lot of news about refrigerant price increases and less availability scared RACHP stakeholders.

The prices of refrigerants in the EU have already increased since the end of 2020, also due to other factors not correlated with regulations, such as the COVID-19 pandemic and supply shortages, as shown in the following graphs [xxiii]:

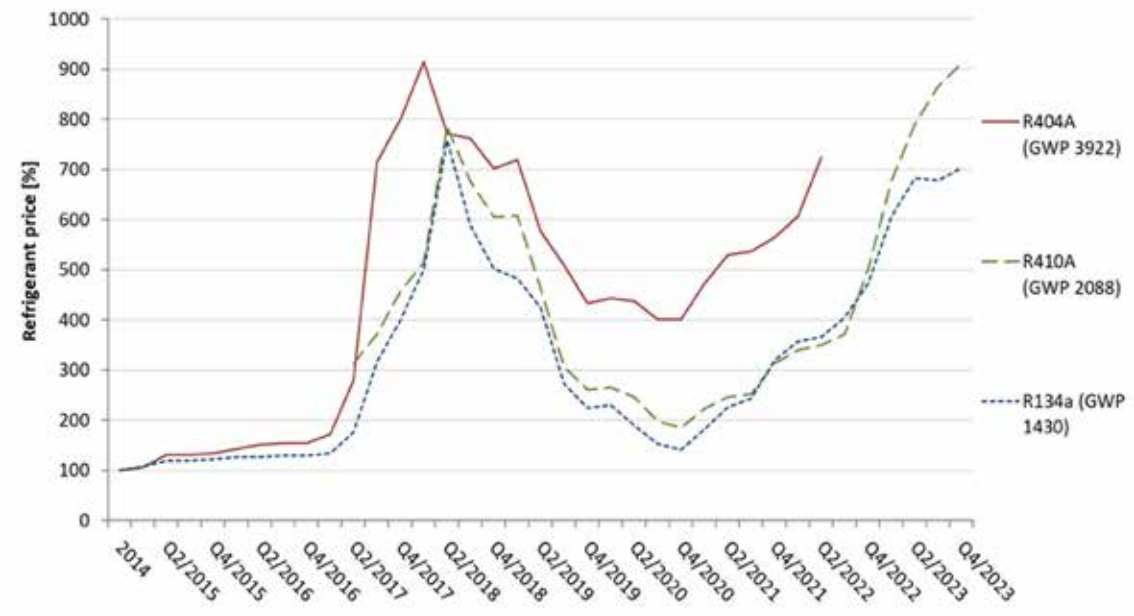


Fig. 1.b - Trend in average relative HFC selling prices reported by gas producers.

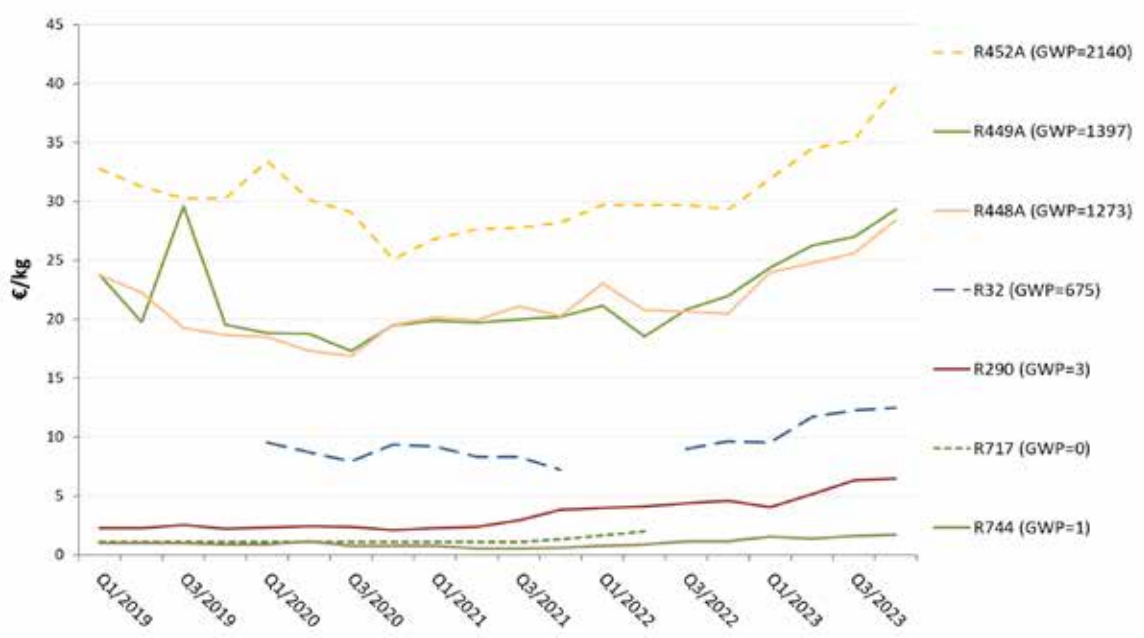


Fig. 1.c - Trend in average relative HFC selling prices reported by gas producers.

Over recent years, technologies have been developed very quickly and international standards have been revised to facilitate the use of low GWP refrigerants and overcome their drawbacks, such as flammability and high pressure. These trends will most probably continue in the next few years.

2. What are the trends?

In this section, refrigerant trends are analysed, taking as a reference the categorisation in the new F-gas regulation and considering the information reported in this document for each country.

Domestic refrigeration:

- In the EU, the use of fluorinated refrigerants will be banned from 2026. This is an application where HCs are the predominant refrigerants in new units, thus the ban on fluorinated refrigerants is not expected to have a relevant impact. Moreover, potential PFAS restrictions will not impact this application because the use of fluorinated refrigerants will be banned by F-gas.
- In the USA, the GWP limit for this application is 150 from 2025. The use of HCs is high also in the USA for domestic refrigeration, however fluorinated refrigerants with a GWP lower than 150 will also be allowed. PFAS restrictions already scheduled in the state of Maine will limit the choice to natural refrigerants, among the options that are currently used.
- According to the information reported in this document, there are no specific bans for this application in Australia, Canada, China or Japan.

Refrigeration equipment (self-contained):

- In the EU, the use of fluorinated refrigerants with GWP≥150 will be prohibited from 2025 for commercial and other self-contained units. In these applications, HCs are already used, especially R-290. Other refrigerants with a GWP<150, including fluorinated ones, will be allowed by the F-gas regulation, but these could be banned by PFAS restrictions. Some examples include, R-454C or R-455A.
- In the USA, the GWP limit of 150 applies from 2025 for retail food refrigeration stand-alone units and from 2026 for self-contained commercial ice machines. The options for this application are the same as in the EU.

- In China, R-290 is the recommended refrigerant for commercial self-contained refrigeration systems.
- In Canada, only refrigerants with a GWP<150 will be allowed from 2025 in self-contained refrigeration systems. As a consequence, the refrigerant options will be the same as in the EU and US.

Refrigeration equipment (not self-contained):

- In the EU, multi-rack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or higher have had a GWP limit of 150 since 2022 (1500 for the primary refrigerant circuit of cascade systems). In new units, R-744 is the most common option. For all other refrigeration equipment, the use of refrigerants with a GWP up to 2500 is allowed until 2030. This means that high GWP refrigerants such as R-448A, R-449A and R-452A are allowed in the next six years unless banned by PFAS restrictions beforehand. From 2030, the GWP limit is 150. One option is natural refrigerants, the choice of which depends on the type of unit. Generally, R-290 is used for units with a low refrigerant charge, whereas R-744 is the preferred option for units with a higher charge. The other option is refrigerants with a low GWP (for example, R-471A, R-454C or R-455A), if not previously banned by PFAS restrictions.
- In the USA, for units in the "retail food-refrigerated food processing and dispensing equipment" category with less than 500 g of refrigerant, except for ice makers, refrigerants with a GWP higher than 150 will be banned from 2027. Therefore, the options are the same as those for stand-alone units. However, in applications with more than 500 g of refrigerant, specific refrigerants will be banned from 2027, except in ice makers, where they will be banned from 2028. For instance, R-404A, R-410A, R-134a and R-407C will be banned, whereas R-448A and R-449A will be allowed.
- In China, R-744 is the recommended refrigerant for industrial and commercial refrigeration equipment.
- In Canada, refrigerants with a GWP>2200 are banned in commercial or industrial centralised refrigeration systems and condensing units from 2020. All the refrigerants mentioned for the other countries, including R-448A, R-449A and R-452A, are allowed.
- In Japan, refrigerants with a GWP>1500 are banned in condensing units and refrigerating units from 2025. This limit excludes R-452A, but not R-448A and R-449A.

Chillers:

- In the EU, a GWP limit of 150 will apply from 2027 for chillers with a capacity of less than 12 kW, whereas the use of fluorinated refrigerants will be banned from 2032. Some of the options for this application until 2032 include R-1234yf, R-1234ze and R-152a (typically used in medium-pressure chillers). From 2032, only natural refrigerants will be allowed. For units with a capacity higher than 12 kW, which will have a GWP limit of 750 from 2027, the most popular options with a medium GWP are R-513A, R-450A or R-515B (medium-pressure chillers), and R-32, R-452B or R-454B (high-pressure chillers).
- In the USA, the GWP limit is 700 for stand-alone chillers. This limit starts in 2026 for industrial process refrigeration with fluid leaving the unit at temperatures higher than -30°C, in 2028 for temperatures greater than or equal to 30 °C, and in

2025 for comfort cooling and ice rinks. The refrigerants shown as examples in the EU have a GWP value under 700, thus they will be allowed in the USA as well.

- In China, R-32, R-1234ze, R-1234zd, R-515B, R-513A are the recommended refrigerants for large and medium-sized chilled water (HP) units.
- In Canada, the GWP limit is 750 from 2025, thus the same refrigerants listed for the EU will be allowed.

Air conditioning and heat pumps:

- In the EU, for self-contained units with a capacity lower than 50 kW, the GWP limit is 150 from 2027, whereas all F-gases will be banned from 2032. This means that the commonly used R-410A, R-32, R-452B and R-454B will be banned already starting in 2027. The option that will most probably be used is R-290, as self-contained units can be located outdoors, and this facilitates compliance with safety standards. However, other refrigerants with a GWP<150 will be allowed until 2032 unless they are banned by PFAS restrictions.
  For self-contained units with a capacity higher than 50 kW, the GWP limit of 150 will apply from 2030. Apart from natural refrigerants, synthetic refrigerants with GWP values lower than 150 will be allowed if not banned by PFAS restrictions, for example R-1234ze and R-1234yf.
  Split units with a capacity lower than 12 kW will have a GWP limit of 150 from 2027 (air-water) and from 2029 (air-air), whereas the use of F-gases will be banned from 2035. R-1234yf and R-1234ze are some of the options available until 2035, unless they are not banned by PFAS restrictions.
  Split units with a capacity higher than 12 kW will have a GWP limit of 750 from 2029, thus R-32, R-452B and R-454B will be allowed. In 2033, the GWP limit will be 150. The options are the same as described for smaller units.
- In the USA, a GWP limit of 700 for stationary residential and light commercial ACHP will be in force from 2025. This means that the commonly used R-32, R-452B and R-454B will be allowed.
- In China, the recommended refrigerants are R-290 for room AC and R-32 for unitary AC and chilled water (HP) units.
- In Japan, a GWP limit of 750 has been in force for room AC since 2018 and for commercial AC since 2020. This means that the same refrigerants described for the USA can be used in Japan.
- In Australia, a limit of 750 for small AC equipment with a refrigerant charge up to 2.6 kg will apply from 2024. The refrigerants listed for the USA can be used in Australia as well.

	High GWP refrigerants	Refrigerants with a GWP<700	EU	USA	China	Japan	Australia	Canada
Domestic refrigeration	R-134a (1430, A1)	R-600a (0, A3) R-290 (0.02, A3)	No F-gases from 2026	GWP<150 from 2025				
Refrigeration equipment (self-contained)	R-134a (1430, A1)	R-290 (0.02, A3) R-454C (146, A2L) R-455A (146, A2L)	GWP<150 from 2025	GWP<150 from 2025 (ice machines from 2026)	R-290 is the recommended refrigerant			GWP<150 from 2025
Refrigeration equipment (not self-contained)	R-404A (3922, A1) R-507C (3985, A1) R-452A (2139, A1) R-449 (1409, A1) R-448 (1386, A1)	R-290 (0.02, A3) R-744 (1, A1) R-471A (143, A1) R-454C (146, A2L) R-455A (146, A2L)	GWP<2500 in force GWP<150 from 2030	-GWP<150 from 2027 (less than 500 g, except ice makers) -Ban on some specific refrigerants, (more than 500 g and ice makers)	R-744 is the recommended refrigerant	GWP< 1500 from 2025		GWP<2200 from 2020
Chillers	High pressure chillers: R-410A (2088, A1) R-407C (1774, A1)	R-290 (0.02, A3) R-454B (465, A2L) R-32 (675, A2L) R-452B (698, A2L)	LESS THAN 12 kW: GWP<150 from 2027 No F-gases from 2032 MORE THAN 12 kW: GWP<750 from 2027	GWP<700 for stand-alone chillers: -industrial process refrigeration from 2026 (T>-30°C) and 2028 (-50°C<T<-30°C), - comfort cooling and ice rinks from 2025	R-32, R-1234ze, R-1234zd, R-515B, R-513A are the recommended refrigerants			GWP<750 from 2025
	Medium pressure chillers: R-134a (1430, A1)	R-717 (0, B2L) R-290 (0.02, A3) R-1234yf (0.501, A2L) R-744 (1, A1) R-1234ze (1.37, A2L) R-152a (124, A2) R-515B (288, A1) R-450A (601, A1) R-513A (629, A1)						
ACHPs	R-410A (2088, A1)	R-290 (0.02, A3) R-1234yf (0.501, A2L) R-1234ze (1.37, A2L) R-454B (465, A2L) R-32 (675, A2L) R-452B (698, A2L)	SELF-CONTAINED 12-50 kW: GWP<150 from 2027 No F-gases from 2032 SELF-CONTAINED MORE THAN 50 kW: GWP<150 from 2030 SPLIT LESS THAN 12 kW: GWP<150 from 2027 (air-water) or 2029 (air-air) No F-gases from 2035 SPLIT MORE THAN 12 kW: GWP<750 from 2029 GWP<150 from 2033	GWP<700 from 2025	R-290, R-32 are the recommended refrigerants	GWP<750 in force	GWP<750 from 2024 (systems with a refrigerant charge up to 2.6 kg)	

Tab. 2.b - Refrigerants that can be used in different RACHP applications, and summary of the restrictions in each country. Potential/future PFAS restrictions are not included. Each refrigerant is followed, in brackets, by the approximate GWP value (European F-gas criteria: HFCs based on the 4th IPCC Assessment Report, other F-gases based on the 6th IPCC Assessment Report) and safety class according to ISO 817.

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