ATMO Report

2024 Edition

Natural Refrigerants: State of the Industry

Refrigeration in Europe, North America, Japan, Australia and New Zealand, and Latin America

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Refrigeration system mechanical designer

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2024 EDITION

ATMO Report

Natural Refrigerants: State of the Industry

Refrigeration in Europe, North America, Japan, Australia and New Zealand, and Latin America

Originally published in February 2025.

ATMO sphere

ATMO Report

OUR SUPPORTERS

About Us

Founded in 2007 as shecco, ATMOsphere is a global, independent market accelerator for clean cooling and heating and natural refrigerant solutions. The company boasts more than 50 years of industry experience throughout its global team located in Europe, Japan and the U.S.

ATMOsphere combines the company's extensive natural refrigerant expertise with the power of its wider network of like-minded experts who share an ambition for scaling up the global clean-cooling economy.

ATMOsphere's business includes product and news marketplaces, events and market research. As of December 2024, the company has held 78 events around the world. In June 2022, ATMOsphere launched its natural refrigerants label, which serves as a global gold standard highlighting best-in-class manufacturers of natural refrigerant systems and components and contractors from around the world. For 2025, the natural refrigerants label has been updated to include avoided TFA emissions.

Overall, the ATMOsphere platform offers a one-stop solution for – among others – investors, end users, original equipment manufacturers, component manufacturers, contractors and others with the goal of scaling up clean cooling.

The ATMOsphere core team includes journalists, analysts, engineers, event organizers, designers and other highly skilled individuals with a diverse background – all working together to gather information and analyze this niche market. As industry experts in this field, the team offers unique insights into trends and market size that cannot be replicated by organizations that lack a similar history and knowledge.

However, the real power of the ATMOsphere brand lies in its network. It spans the whole globe and includes more than 50,000 industry stakeholders – from policymakers and end users to academics, manufacturers and everyone in between.

ATMOsphere is not just a company but a community of people who believe that the future of cooling is clean and natural.

For more information, visit atmosphere.cool

CONTRIBUTORS

ATMOsphere Founder & CEO
Marc Chasserot

ATMOsphere Co-Founder & Group COO
Jan Dusek

Managing Editor
Michael Hines

Editor-at-Large
Michael Garry

Research and Market Analysis
Sabrina Munao
Angie Tao

Writers
Christina Hayes
Jae Haroldsen

Art Direction & Design
Georgiana Butnaru
Vlad Koert
Anna Salhofer

Ad Sales & Coordination
Silvia Scaldaferri

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The Market Has Moved

The market for commercial and industrial refrigeration has moved to natural refrigerants – and there is no going back. This is most evident in Europe but is also starting to be seen around the world, as our 2024 Market Report proves.

In this year's report, we not only focus on the markets we have traditionally covered – Europe, North America and Japan – but also Australia/New Zealand and Latin America, which ave been slowly but surely embracing CO_2, propane and ammonia in commercial and industrial refrigeration.

The natural refrigerants industry continued its global expansion, fueled by policy changes and technological innovation. The climate and energy benefits of natural refrigerant-based systems are persuading more and more end users that natural working fluids are the only sensible and future-proof solution.

The latest iteration of fluorinated gases – HFOs – is running into the kind of regulatory scrutiny that has doomed previous generations of f-gases. At issue is PFAS (per- and polyfluorinated substances), the notorious collection of chemical pollutants that include many f-gases and, importantly, trifluoroacetic acid, a by-product of some major f-gases.

In 2025, the EU will consider regulating HFOs as PFAS. The entire world will be watching this regulatory debate unfold, with its outcome being key to the future of the cooling industry. In the U.S., state governments are providing arguments for optimism, with Maine enacting regulations banning non-essential PFAS refrigerants by 2040 and Minnesota considering a 2032 ban. The increased scrutiny of PFAS shows that the future may be even brighter for natural solutions.
This report will serve as the world's leading resource for information on the installations and penetration of natural refrigeration in the commercial and industrial sectors. We will be highlighting it throughout 2025 at our ATMO conferences in Latin America, Australia, the U.S. and Europe and at trade shows such as AHR Expo (where I will be speaking), IIAR and FMI Energy in the U.S., ISH in Europe and the Supermarket Trade Show in Japan. We will also be featuring it in webinars and extensively on social media.

The 2024 Market Report is a gold mine of information and insights on natural refrigerants that will help stakeholders worldwide move faster to clean cooling solutions. Please let us know what else you would like to see covered in the report as we endeavor to improve it every year.

Marc Chasserot
Founder & Publisher
ATMOsphere

Expanded Horizons

In recent years, the ATMOsphere Market Report has focused on the state of the natural refrigerants marketplace for commercial and industrial refrigeration in Europe, North America (the U.S. and Canada) and Japan. These regions have powered the industry's growth, and the 2024 ATMOsphere Market Report reflects this while also acknowledging that natural refrigerants are beginning to establish themselves in other markets.

This year, we've assessed the state of the natural refrigerants marketplace in Europe, North America, Japan, Australia and New Zealand, and Latin America (Mexico, Central America and South America). We expect to see strong growth in Australia and New Zealand and Latin America in the coming years, with our optimism backed by solid foundations in each region.

For example, in New Zealand, there are an estimated 240 supermarkets and grocery stores using transcritical CO_2 systems, a market penetration of 22%, while in Ecuador the figures are an estimated 125 supermarkets and a market penetration of 13%.

In addition, Latin America is a leading market for self-contained hydrocarbon cases. There are an estimated 8.5 million installed in Latin America: 2.6 million in Mexico and a combined 5.9 million in Central and South America.

The market for natural refrigerants in Australia and New Zealand and Latin America has formed largely in the absence of national f-gas regulations and government subsidies. By contrast, regulations and subsidies continued to support the industry's growth in Europe, North America and Japan.

The revised EU F-gas Regulation became law in March 2024, and throughout the year the chorus to regulate PFAS, which would include f-gases and f-gas by-product trifluoroacetic acid (TFA), became louder. Amid these developments, the number of food retail stores in Europe using transcritical CO_2 systems reached 90,700, a market penetration of 30%, while the total of installed self-contained hydrocarbon cabinets reached 17 million. A total of 4,900 European industrial sites used transcritical CO_2, an increase of 48% from 2023.

The U.S. EPA's SNAP 26 regulation raised the maximum allowable charge for hydrocarbon cabinets, paving the way for an increased adoption of self-contained propane cases. The states of New York and Washington enacted new f-gas regulations, while Maine and Minnesota have revised their PFAS regulations.

The number of stores in North America using transcritical CO_2 rose to 4,100, up 40% from 2023, while the number of installed hydrocarbon self-contained cases reached 4.6 million. There were 870 industrial sites using transcritical CO_2, an increase of 74%. Low-charge ammonia continued its climb: The 1,230 sites in 2024 were an increase of 17% over 2023, with the number of packaged units jumping 38%.

Ongoing government support in the form of subsidies for installing natural refrigerant systems continued to boost transcritical CO_2 in Japan. Installations in supermarkets, grocery stores and convenience stores reached 12,250, with convenience stores accounting for 11,500 of that total, a gain of 47% year-over-year.

The progress of natural refrigerants is not just measured in total installations but also in evolving regulations. This report takes an in-depth look at the PFAS restriction proposal under consideration in Europe, the raft of new state regulations in the U.S. limiting the GWP of refrigerants and efforts to institute GWP limits for refrigerants in Australia and New Zealand, among other examples.

Regardless of the measurement you prefer, our 2024 Market Report shows that the horizons for natural refrigerants are expanding, both in new markets and established ones.

Michael Hines
Managing Editor
ATMOsphere

Methodology

In this 2024 State of the Industry report on natural refrigerants, ATMOsphere investigates the state of the market for key natural refrigeration technologies in commercial and industrial applications in Europe, North America and Japan, the leading and fastest growing markets for natural refrigeration in the world. We're also examining two emerging markets for natural refrigerants: Australia and New Zealand and Latin America.

To fully understand and analyze these markets, ATMOsphere used a combination of qualitative and quantitative research methods, leveraging our expansive knowledge and experience with the subject matter, as well as ATMOsphere's global network of natural refrigerant experts.

The following methods were used:

Desk Research

Desk research was conducted regarding the current state of the commercial and industrial refrigeration markets, policy trends and the available natural refrigerant-based options. ATMOsphere leveraged a combination of external reports and academic publications, together with its own articles and reports, to build an understanding of the market.

As the leading market accelerator for natural refrigerants, ATMOsphere is powered by a database of natural refrigerant and clean cooling information, diligently constructed over the years by its analysts and journalists.

Data Collection

The primary source of data for the European, North American, Australian and New Zealand, and Latin American markets was an industry survey designed by the ATMOsphere team and sent to key manufacturers of natural refrigerant-based CO_2 systems (racks and/or condensing units), low-charge (below 1.3kg/kw or 10.1/lbs/TR) ammonia systems, hydrocarbon-based self-contained retail cabinets and hydrocarbon chillers.

ATMOsphere also contacted a number of end users, academics and other experts to improve its understanding of current trends and the state of the market for natural refrigeration installations.

For the Japanese market, in lieu of a survey, in-depth interviews were held with the key suppliers of natural refrigerant-based systems. In Australia and New Zealand, information on commercial installations was gathered from end users.

In all regions, manufacturers of CO_2 racks and condensing units were asked to provide the approximate number of stores (new and existing) and/or industrial facilities (new or existing) that have installed their equipment. Manufacturers of low-charge ammonia systems (packaged or centralized, including NH_3/CO_2 systems) and hydrocarbon chillers were asked to provide the approximate number of industrial facilities (such as cold storage or food processing, new or existing) that have installed their equipment.

Manufacturers of hydrocarbon-based self-contained refrigerated- and/or frozen-food retail cabinets were asked to provide the approximate number of units (air- and water-cooled) they have sold. In addition to manufacturers, our estimates for hydrocarbon-based self-contained cabinets were informed by trusted industry sources.

All companies were asked to provide an approximation of their market share of stores and/or industrial facilities using their equipment or their market share for hydrocarbon cabinets.

All companies were guaranteed that their data would be kept in confidence and only used anonymously in combination with data received from other companies to create an aggregate picture at the marketplace.

The survey and interviews received responses from manufacturers of transcritical CO_2 equipment, low-charge ammonia equipment, hydrocarbon chillers and hydrocarbon cabinets that together represent a substantial share of the market for natural refrigerant equipment in Europe, North America, Japan, Australia, New Zealand and South America.

We also leveraged public data on natural refrigerant system installations from other manufacturers available on their websites, provided at conferences, in interviews with ATMOsphere journalists or other sources. Additional data was gathered with the help of industry associations.

Our data indicate the number of sites (locations, whether stores or industrial facilities) using CO_2, ammonia equipment or hydrocarbon chillers. An individual site could use more than one system. However, the number of units is indicated for hydrocarbon-based cabinets.

Market Definitions

The European market is defined as encompassing the European Union as well as the U.K., Norway, Switzerland, Iceland, non-EU Balkan states, Ukraine, Belarus, Moldova and the European part of Russia.

The North American market is defined as the United States and Canada.

The Latin American market as we've defined it consists of 20 countries divided into three sub-regions: Mexico, Central America and South America.

Central America

Belize
Costa Rica
El Salvador
Guatemala
Honduras
Nicaragua
Panama

South America

Argentina
Bolivia
Brazil
Chile
Colombia
Ecuador
Guyana
Paraguay
Peru
Suriname
Uruguay
Venezuela

Abbreviations

AIM Act – American Innovation and Manufacturing Act

ASHRAE – American Society of Heating, Refrigeration and Air-Conditioning

CAGR – Compound Annual Growth Rate

CARB – California Air Resources Board

CCR – Carrier Commercial Refrigeration

COP – Coefficient of Performance

CSRD – Corporate Sustainability Reporting Directive

DCCEEW (Australia) – Department of Climate Change, Energy, the Environment and Water

DX – Direct Expansion

EPA (U.S.) – Environmental Protection Agency

FMI – Food Marketing Institute

FRIP – F-gas Reduction Incentive Program

GWP – Global Warming Potential

HCFC – Hydrochlorofluorocarbons

HFC – Hydrofluorocarbon

IIAR – International Institute of All-Natural Refrigeration

IIR – International Institute of Refrigeration

JARW – Japan Association of Refrigerated Warehouses

MBIE (New Zealand) – Ministry of Business, Innovation & Employment
MOE (Japan) – Ministry of the Environment

MfE (New Zealand) – Ministry for the Environment

NASRC – North American Sustainable Refrigeration Council

OEM – Original Equipment Manufacturer

RETA – Refrigeration Engineers and Technical Association

RMP – Risk Management Program

SNAP – Significant New Alternatives Policy

SME – Small- and Medium-sized Enterprises

UL – Underwriters Laboratories

UNDP – United Nations Development Programme

UNEP – UN Environment Programme

VHOP – Very High Operating Pressure

Natural Refrigerants

R744 – Carbon Dioxide (CO_2)

R717 – Ammonia (NH_3)

R290 – Propane

R600a – Isobutane

R1270 – Propylene/propene

R718 – Water

R729 – Air

Executive Summary

All figures in this report are estimations, unless otherwise stated, made as of December 2024.

Our figures in Latin America are referred to as a "snapshot" as they provide a minimum estimate of the current number of natural refrigerant systems installed. This report provides a foundation for our understanding of natural refrigerants in Latin America, one ATMOsphere intends to build upon in the coming years. As our Latin America chapter is intended to provide a broad overview, trends in the region were not covered.

Estimates for self-contained hydrocarbon cases in Europe and North America are much higher than in 2023. This is the result of better and more complete data gathered from a combination of manufacturers, OEMs and trusted industry sources.

As the hydrocarbon-case data gathered are historical, the increases should not be interpreted as year-over-year gains. The 2024 estimate is our new baseline for Europe and North America, and as such we do not refer to estimates from previous years in this report.

Our data collection process, as well as the model underpinning our analysis, is continually being refined. This year's iteration resulted in a more complete look at the global market for self-contained hydrocarbon cabinets, which were undercounted in previous reports.

European Market Data

There were approximately 90,700 food retail stores in Europe that use transcritical CO_2 systems; of these 76,200 used a centralized system (one or more racks), and 14,500 used condensing units. The number of stores with racks grew by 27% from 60,000 in December 2023, while the number with condensing units grew by 71% from 8,500.

There were an estimated 4,900 industrial sites using this technology, an increase of 48% from 3,300 in December 2023. In total there were 95,600 transcritical CO_2 sites in Europe (commercial and industrial), up 33% from 71,800 in 2023.

The market penetration of transcritical CO_2 systems in stores has increased this year to 30% – the percentage of all food retail stores in Europe estimated to feature transcritical CO_2 installations (including condensing units), up from 22.9% in 2023 and 18.4% in 2022.

ATMOsphere estimates that 17 million self-contained hydrocarbon cabinets (mostly R290) have been installed in Europe. This is a significant increase from 2023 when we estimated there to be 3.2 million.

The estimated 4,900 industrial sites using transcritical CO_2 refrigeration accounted for 5.1% of the 95,600 transcritical CO_2 sites in Europe. These 4,900 sites represent a growth of 48% from the 3,300 industrial sites using transcritical CO_2 a year ago (4.6% of the total 71,800 transcritical CO_2 sites).

ATMOsphere estimates there were 3,600 industrial sites using low-charge (below 1.3kg/kW or 10.1lbs/TR) ammonia systems in Europe, based on production numbers from leading OEMs. This represents a growth rate of 7% from 2023, when there were an estimated 3,360 such sites.

There were 6,650 industrial sites with hydrocarbon-based chillers in Europe in December 2024. This represents a 33% increase from December 2023, when ATMOsphere estimated that there were 5,000 industrial sites in Europe with hydrocarbon-based chillers.

European Trends

On March 11, 2024, the EU's revised F-gas Regulation became law, and with it the clock began ticking on the use of f-gases in the bloc, with a complete ban set for 2050. The revised F-gas Regulation places new limits on the GWP of refrigerants used in stationary refrigeration equipment and chillers.

In addition, the regulation also established a link between f-gases and PFAS, stating: "Some fluorinated greenhouse gases subject to this Regulation are Per- and Polyfluorinated Substances (PFAS) or are proven to or suspected to degrade into PFAS."

The European Chemicals Agency (ECHA), an EU body, is considering a "universal restriction" proposal to regulate PFAS as a category, including f-gases and TFA, under REACH, the EU's chemicals regulation. ECHA published the universal PFAS restriction proposal – made jointly by the national authorities of Denmark, Germany, the Netherlands, Norway and Sweden – in February 2023. PFAS restrictions have been proposed that would include either a ban or a ban with derogations (time-limited exemptions) where alternatives are not yet available.

North American Market Data

There were approximately 4,100 food retail stores in North America using transcritical CO_2 systems, up more than 40% from 2,930 in 2023. Of these 4,100 food retail stores, 2,800 are in the U.S., and 1,300 are in Canada.

There were also 870 industrial sites using transcritical CO_2 in North America for a total of 4,970 transcritical CO_2 sites.

The market penetration of transcritical CO_2 systems in the estimated 70,562 North American supermarket and grocery stores is 5.8%, up from 4.1% a year ago. When considering convenience stores as well, the market penetration out of 232,390 retail food stores in North America is 1.8%, up from 1.27% in 2022.

ATMOsphere estimated 3.8 million self-contained hydrocarbon cases installed in U.S. food stores and 800,000 cases installed in Canadian food stores. In total, there are an estimated 4.6 million self-contained hydrocarbon cases installed in North American food stores.

The estimated 870 industrial sites using transcritical CO_2 in North America made up 17% of the total of 4,970 transcritical CO_2 sites. The 870 industrial sites, which represents a 74% increase from the 498 North American sites in 2023, consists of 380 in the U.S. (up from 208 in 2023) and 490 in Canada (up from 290 in 2023).

ATMOsphere estimates there were 1,230 industrial sites using low-charge ammonia systems in North America: 152 with packaged units and 1,078 with central systems. This is an increase of 17% from 2023.

The 1,230 industrial sites comprise 842 sites (717 with central and 125 with packaged systems) in the U.S. and 388 (361 central and 27 packaged) in Canada.

North American Trends

In May 2024, the U.S. Environmental Protection Agency (EPA) announced the finalization of its Significant New Alternatives Policy (SNAP) 26 rule, which aligns hydrocarbon charge limits with those outlined in UL 60355-2-89 for self-contained commercial cases and ice makers.

UL 60355-2-89 covers safety requirements for commercial refrigeration appliances and ice makers with an incorporated or remote refrigerant unit or motor compressor. The second edition of UL's standard raised the hydrocarbon charge limit in closed cases to 300g and 500g in open cases. The prior limit for commercial cases was 150g.

Maine enacted a sweeping PFAS regulation in 2021 and updated it in August 2024. The state has set an effective date of January 1, 2040, for the prohibition on sales of products containing "intentionally added PFAS," including cooling, heating, ventilation, air-conditioning and refrigeration equipment.

The New York State Department of Environmental Conservation (DEC) amended the state's HFC regulations in December 2024. The amended regulation, DEC's 6 NYCRR Part 494, "Hydrofluorocarbon Standards and Reporting," notably sets 20-year GWP limits, as opposed to the commonly used 100-year GWP limits. The amended regulation applies to refrigeration systems used in commercial and industrial refrigeration.

The 2025 Presidential Transition Project – known as Project 2025 – recommends in its section on the EPA that a future Trump administration repeal Biden-administration HFC regulations authorized by the American Innovation and Manufacturing (AIM) Act "that are unnecessarily stringent and costly."

Project 2025, an almost 900-page collection of conservative policy proposals, was organized by the Heritage Foundation, a Washington, D.C.-based think tank, and has been tied to President Donald Trump.

Japanese Market Data

There were 12,250 stores, including 11,500 convenience stores and 750 supermarkets, using transcritical CO_2 systems (mostly condensing units), up 46% from the 8,385 stores (7,800 convenience/585 supermarkets) reported in December 2023. With 470 industrial site installations, the total number of transcritical CO_2 installations in Japan was 12,720 sites.

The market penetration of transcritical CO_2 in convenience stores is 20%, an increase from 14% in 2023. The market penetration of transcritical CO_2 CO_2 in supermarkets is 3.5%, up from 2.8% in 2023. The market penetration of transcritical CO_2 across all food retail stores in Japan is 16%, up from 10.9% in 2023.

The estimated 470 industrial sites (mostly cold storage facilities) using transcritical CO_2 systems (mostly condensing units) in Japan's industrial refrigeration sector is an increase of 17% from the 400 reported in 2023.

Japanese Trends

In the summer of 2023, the Japanese Ministry of the Environment (MOE) announced it would continue its natural refrigerant equipment installation subsidy project through fiscal year 2027 with a budget of ¥7 billion ($48.7 million/€42.5 billion) for fiscal year 2023. In addition, the MOE said it changed the program to make it more accessible to small- and medium-sized enterprises.

The changes included making the application process easier and relaxing the equipment installation schedule. The maximum subsidy available was also raised from one-third of the construction costs to one-half. The changes have had the desired effect, according to Teruo Kogu, Director of the Office of Fluorocarbons Control Policy at the MOE.

Kogu, speaking at the ATMOsphere APAC Summit 2024, held in Tokyo in February, said the program saw a 10% increase in the number of SMEs (small- and medium-sized enterprises) receiving subsidies and a 10% increase in food retailer renovation projects. Kogu cited the increased maximum subsidy as the driving force behind the increases.

Japan's use of natural refrigerants in its cold storage sector has steadily increased since the country ratified the Kigali Amendment in 2018, according to information shared with the UNEP by Yutaka Matsuzawa, the country's Vice Minister for Global Environmental Affairs. As of January 2024, 43% of the country's refrigerated warehouses use natural refrigerants.

At the ATMOsphere APAC Summit 2022, Japan's Association of Refrigerated Warehouses (JARW) shared data showing that 40% of the warehouses operated by its members – which represent around 90% of the total sector – used natural refrigerants. The share of the association's members using natural refrigerants increased to 51.4% in 2023 and has been rapidly growing every year since 2015.

Australian and New Zealand Market Data

There were an estimated 330 supermarkets using transcritical CO_2 systems in Australia. The market penetration of transcritical CO_2 in the Australian supermarket sector is 6.6%. With 20 industrial site installations, the total number of transcritical CO_2 installations in Australia was 350.

There were an estimated 60 industrial sites using low-charge ammonia systems in Australia's industrial refrigeration sector. Survey respondents indicated that the majority of low-charge ammonia installations are for central systems.

There were an estimated 240 supermarkets using transcritical CO_2 systems in New Zealand. The market penetration of transcritical CO_2 in the New Zealand supermarket sector is 22%. With an estimated 60 industrial sites, the total number of transcritical CO_2 installations in New Zealand was 300.

Australian and New Zealand Trends

In June 2024, Australia's Department of Climate Change, Energy, the Environment and Water (DCCEEW) opened a public consultation period of policy options designed to reduce the use of HFCs in commercial refrigeration, particularly R404A, which has a 100-year GWP of 4,728 and a 20-year GWP of 7,208. The DCCEEW noted that imports of R404A, as a percentage of total HFC imports, increased from 12.6% in 2016 to 16.3% in 2021, with condensing units and small racks helping drive demand.

The policy proposals directly and indirectly target R404A-based commercial refrigeration equipment. The direct measures include a ban on new imports of R404A or a restriction that the refrigerant only be used to service existing equipment. Controls on recycled R404A were proposed too. The DCCEEW said it was considering exemptions for both the import ban and recycled refrigerant controls.

The indirect measures consist of GWP limits for refrigerants in commercial refrigeration equipment, with the proposed limits varying by equipment type.

New Zealand's Ministry for the Environment (MfE) released its first-ever emissions reduction plan in 2022 with the goal of reducing its emissions from 290 metric tons of CO_2e in 2022–2025 to 240 metric tons of CO_2e in 2031–2035. The plan contains a chapter on fluorinated gasses, which accounted for 2% of the country's gross greenhouse gas emissions in 2019. New Zealand ratified the Kigali Amendment in 2019.

In the chapter, the MfE identified four "key actions" for reducing f-gas emissions:

Build the capability to shift to alternative low-emissions refrigerants, which includes developing training and accreditation for handling alternative gases
Prohibit the import of pre-charged equipment
Investigate prohibiting f-gases with high GWP
Introduce a mandatory product stewardship scheme for refrigerants

Latin American Market Data

There were a minimum of 580 supermarkets and grocery stores using transcritical CO_2 systems in Latin America. With at least 100 industrial site installations, the total number of transcritical CO_2 installations was a minimum of 680. There were an estimated 125 supermarkets and grocery stores in Ecuador, 80 in Colombia and 70 in Argentina using transcritical CO_2 systems.

ATMOsphere estimated 8.5 million self-contained hydrocarbon cases installed in food stores in Latin America. Of those, there were an estimated 2.6 million self-contained hydrocarbon cases installed in Mexico and 5.9 million self-contained hydrocarbon cases installed in Central and South America combined.

The 100 industrial sites using transcritical CO_2 in Latin America represent 14% of the total 680 transcritical CO_2 sites. Of the 100 industrial sites, 50 are in South America, 35 are in Mexico and 15 are in Mexico.

ATMOsphere estimates there were 60 industrial sites using low-charge ammonia systems in LATAM. Of the 60 industrial sites using low-charge ammonia, Mexico has an estimated 30 sites, South America 20 and Central America 10

Figure 1: Transcritical CO_2 Installations in Major Regions

(stores and industrial sites, as of December 2024)

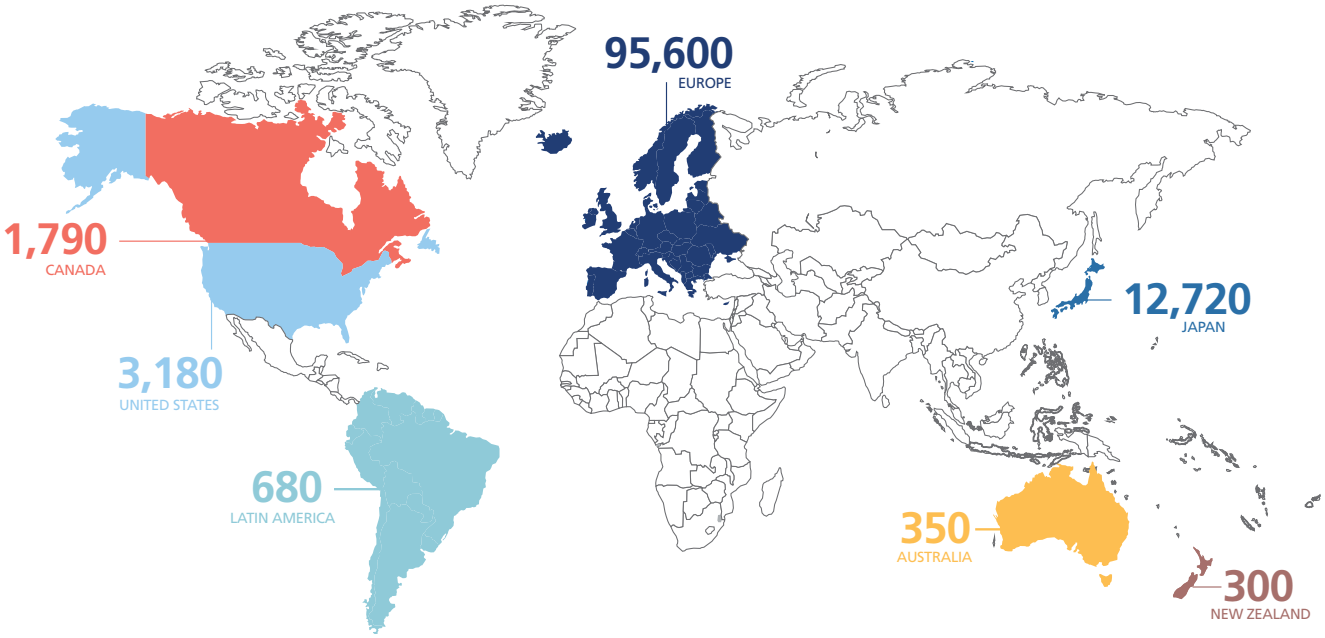


Figure 2: Transcritical CO_2 Market Penetration Growth in Major Regions

(supermarkets, grocery stores and convenience stores, as of December 2024)

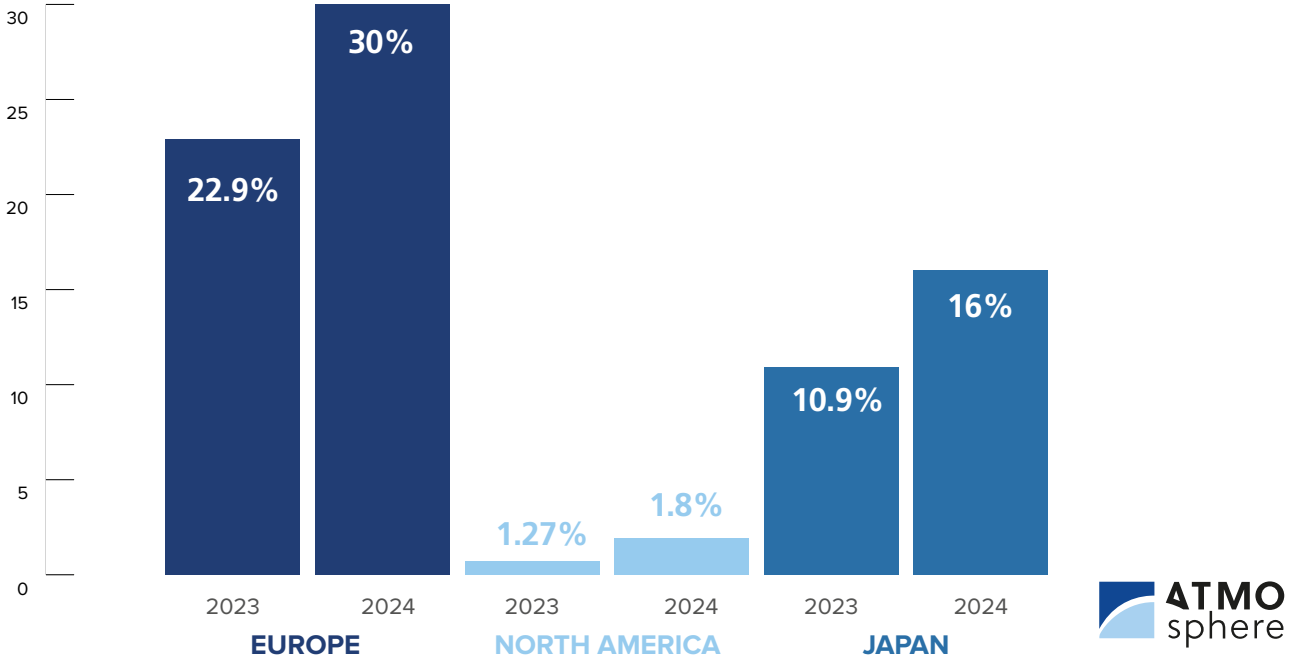


Figure 3: Transcritical CO_2 Installation Growth in Major Regions

(stores)

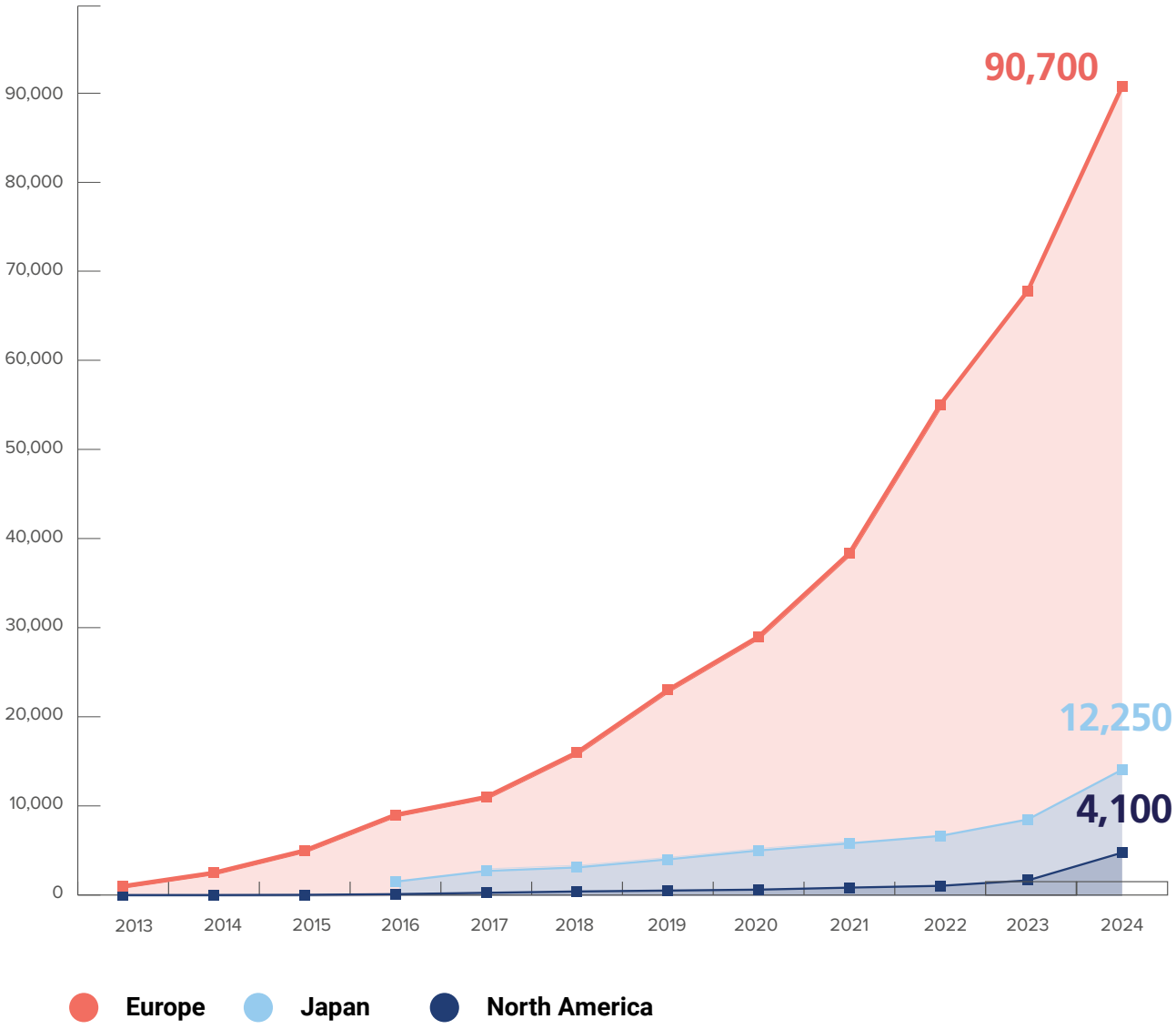
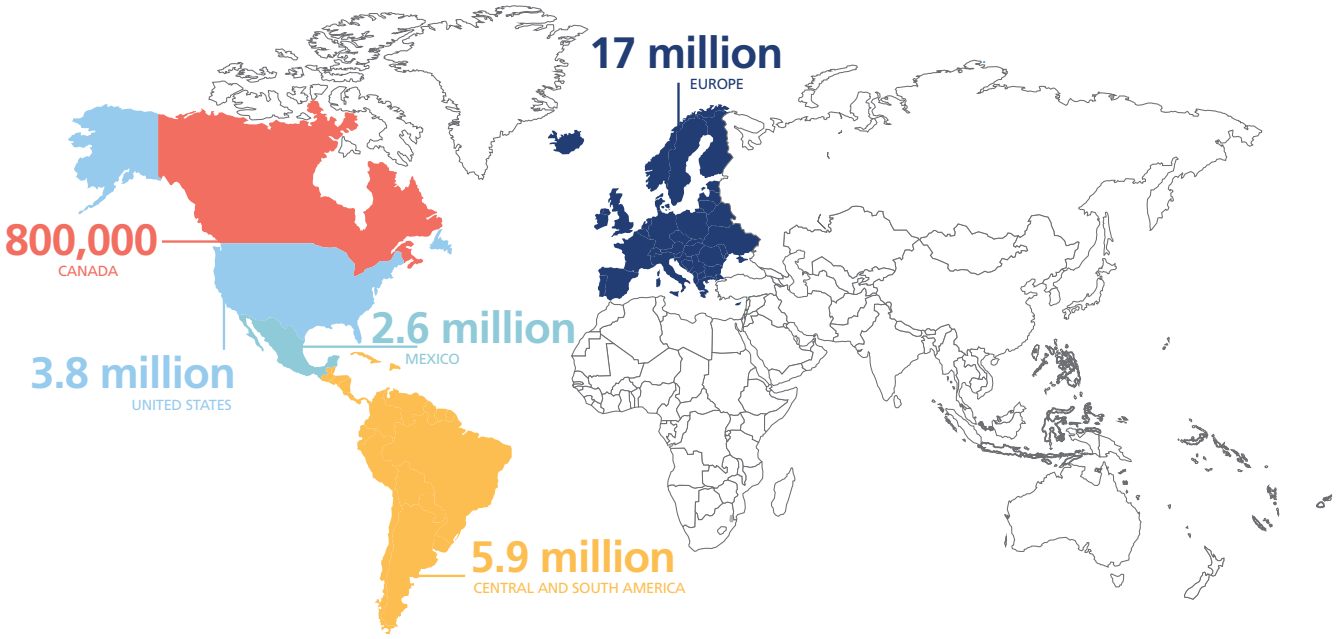


Figure 4: Self-Contained Hydrocarbon Cabinets Installed in Major Regions

(as of December 2024)



ATMO sphere

ATMOsphere Natural Refrigerants Label

ATMOsphere launched a label to meet growing market demand for a globally recognized quality label for the natural refrigerant industry that qualifies and celebrates the best natural refrigerant companies and products.

Aimed at natural refrigerant manufacturers (both system and component) and contractors, our custom process considers company vision, customer satisfaction, measurable impact, and investment in training.

atmosphere.cool/natural-refrigerants-label/

CHAPTER 1

Global Trends

1.1 The Impact of Market Leaders

The natural refrigerants industry scored major regulatory victories in 2024 thanks in part to end users that could see a future without f-gases before their competition.

The critical mass of first movers on transcritical CO_2 (R744), propane (R290) cabinets and low-charge ammonia (R717) systems, among other technologies, helped show European Union policymakers that the refrigeration industry could survive and thrive without f-gases[1]. It also helped show regulators in the United States that self-contained cases with R290-charge limits higher than 150g were safe.[2]

In Europe, ALDI UK, Migros Ticino and international food wholesaler METRO are among the leaders in the commercial sector. In the U.S., ALDI US has led the supermarket industry while other chains like Kroger made major commitments to natural refrigerants in 2024. In Australia, Woolworths celebrated the opening of its 100th transcritical CO_2 supermarket in April 2024.

Market Leader Highlights

- Aldi, that country's fifth-largest supermarket chain, converted more than 30 stores to natural refrigerant-based refrigeration systems during summer 2024.[3] The company's goal is to move its more than 1,000 stores completely to natural refrigerants by 2029.[4] ALDI UK has installed natural refrigerant systems at new stores since 2018.
- In summer 2024, Switzerland-based retailer Migros Ticino opened a new supermarket in Bellinzona, Switzerland, with an integrated R744 HVAC&R system that meets all of the building's refrigeration, heating, air-conditioning and hot water needs.[5] The refrigeration system and building are powered by more than 1,200 photovoltaic panels installed on the facade. Migros Ticino's goal is for all 34 of its supermarkets to use CO_2 by 2025; as of July 2024 it is just one store shy of reaching that goal, according to the company.
- METRO announced in May 2024 that more than 50% of its 658 stores and distribution centers exclusively used natural refrigerants in their refrigeration systems, which includes transcritical and subcritical CO_2, propane plug-in units and ammonia absorption systems.[6] In addition, nine of its cold storage facilities use ammonia. Based in Germany, METRO operates in 21 countries and plans to cease using f-gases entirely by 2030 under its F-Gas Exit Program.
- ALDI US announced in January 2024 that all of its stores will use natural refrigerants by 2035, making it the first supermarket chain in the U.S. to commit fully to naturals.[7] ALDI operates more than 2,400 stores across the country, of which 745 already use transcritical CO_2 refrigeration systems.[8] ALDI US has also fully equipped almost 30 new stores with propane-based display cases and walk-ins for medium- and low-temperature refrigeration, including nine "hybrid" stores with R290 cases and R448A walk-ins.
- U.S.-based retailer Kroger announced that all new supermarkets would use transcritical CO_2 starting in 2025 during a panel at the ATMOsphere (ATMO) America Summit 2024.[9] Michael Dellecave, Manager of Mechanical Services, said Kroger would open five new CO_2 stores in the 2024 fiscal year and noted that it is piloting manufacturer Kysor Warren Epta's XTE technology. XTE is a transcritical CO_2 rack equipped with Energy Recovery's PX G1300 pressure exchanger. The PX G1300 is designed to increase efficiency by recovering and reusing lost pressure in the system.
- Australian retailer Woolworths celebrated its 100th birthday in April 2024 by opening its 100th transcritical CO_2 store, a retrofit located in Wollongong, New South Wales. Woolworths operates more than 1,000 stores in Australia and 191 in New Zealand, 32 of which are equipped with transcritical CO_2 refrigeration systems. The company installed its first transcritical CO_2 unit in Australia in 2017.

- Scantec, an Australia-based provider of low-charge ammonia refrigeration systems, has a "full order book for the 2024-2025 financial year and a little beyond," according to Managing Director Stefan Jensen.[10] Jensen said his company can install between eight and 25 low-charge ammonia systems per year, depending on the project size, and that its largest project to date was for a chicken processing plant in Truganina, Victoria, with a total refrigerated volume of 248,000m^3 (8,758,037ft^3).
- Ahold Delhaize, a European supermarket conglomerate that also operates in the U.S. and Indonesia, named "low global warming potential and natural refrigerants" one of its four "top priorities" to reduce Scope 1 and Scope 2 emissions in its updated Climate Plan.[11] In the plan, released in January 2024, the company wrote that its U.S. stores are "planning" to move to low-GWP or natural refrigerants while its European stores will go completely natural by 2040. Ahold Delhaize's brands include the Netherlands' Albert Heijn, Food Lion in the United States and Indonesia's Super Indo.[12]

1.2 Natural Refrigerants Training Accelerates Worldwide

Ensuring technicians are properly trained to install and service refrigeration systems using natural refrigerants is key to accelerating their adoption in both mature and emerging markets. While ammonia is well-known around the world, CO_2 presents new challenges related to high pressures, and emerging technologies such as ejectors, and propane raises flammability concerns.

Government bodies, developmental organizations, manufacturers and nonprofits are working to solve the training problem. The recently revised EU F-gas Regulation, which became law in March 2024, requires the bloc's member states to establish a certification program for technicians working with natural refrigerants.[13]

Outside of Europe, the GIZ (German Society for International Cooperation) has trained technicians in emerging markets on natural refrigerant systems. In 2024, the GIZ Proklima's Green Cooling Initiative hosted propane-based refrigeration system workshops in Vietnam[14] and Honduras,[15] flew Brazilian technicians to Germany to learn how to handle natural refrigerants[16] and hosted an online training program focused on supermarket CO_2 systems with ejectors.[17]

Along with the GIZ, the United Nations Development Programme's (UNDP) "Cool Up" program hosted a workshop in Egypt on managing natural refrigerants in small-capacity commercial systems, a technical and safety training course in Türkiye and a hands-on course for HVAC technicians in Jordan.

In the U.S., manufacturers have teamed up with the North American Sustainable Refrigeration Council (NASRC), a nonprofit organization that promotes natural refrigerants in supermarkets, to host free multi-day training summits on CO_2 and propane systems. In 2024, the NASRC hosted three training summits across the country, with its final event in Seattle attracting participation from more than 10 OEMs and manufacturers, including Hillphoenix, Copeland and Danfoss.

A lack of trained natural refrigerant technicians in established and emerging markets will continue to pose a challenge for the adoption of CO_2- and propane-based refrigeration systems. However, it is clear that the training issue is receiving attention from multiple sources, and efforts to upskill techs will only increase as f-gases are phased out due to political and market forces.

1.3 IIR and Cool Coalition to Develop Database to Track Refrigeration Sector Emissions

The International Institute of Refrigeration (IIR) and the Cool Coalition, which is led by the UN Environment Programme (UNEP), have formed a working group to measure greenhouse gas emissions from the cooling and refrigeration sectors. [22] The Cooling and Refrigeration Emissions Data Working Group, announced in June 2024, aims to bring experts together to develop a methodology for measuring current – and estimating future – GHG emissions from the refrigeration and cooling sectors.

The working group aims to develop a database for the information and a tool to assist policymakers and industry stakeholders to "facilitate better decision-making" that helps countries develop strategies to meet their climate goals.[23] According to the IIR, while there is data available on refrigeration sector emissions, it mostly relies on high-level estimates. The IIR and the Cool Coalition aim to take a bottom-up approach to better understand where there are gaps in the data and identify areas where proxy estimators may be required.

In March 2024, the IIR shared data from an upcoming informatory note showing that the refrigeration sector's electricity consumption, excluding heat pumps, accounted for 20% of global electricity consumption and that the associated CO_2 emissions were equivalent to 10% of global energy-related emissions.[24]

The IIR said it would publish the informatory note on the role of refrigeration in the global economy "in the coming months;" at the time of writing, the note had not been published.

1.4 HFOs and the Growing Threat of TFA

Because of their harmful impact on the ozone layer, CFC and HCFC refrigerants have been phased out globally under the Montreal Protocol, while HFCs are being phased down under the Kigali Amendment to the Montreal Protocol because they are high-GWP greenhouse gases.

This leaves the fourth generation of f-gases, HFOs, which don't have the negative environmental impact of their predecessors because of their zero ozone depletion potential and extremely low GWP. HFOs and their blends are now the biggest competition facing natural refrigerants.

However, HFOs have their own issues, namely that some of them – notably the most prevalent one, HFO-1234yf – readily form trifluoroacetic acid upon leaking into the atmosphere; TFA is absorbed in rainfall and infiltrates the environment. TFA, like many f-gases, falls under the chemical class called PFAS, or forever chemicals that don't break down in the environment, according to the scientific community.[25]

TFA has been found in increasing amounts everywhere in the environment – in rain, surface water, soil, human blood serum, plants, plant-based foods and drinking water – and there are signs it could be harmful to human health. HFOs may be the biggest source of TFA but others include the breakdown products of certain insecticides, pharmaceuticals, fluoropolymers and other PFAS, as well as the direct release of industrially produced TFA and TFA emitted from wastewater treatment plants and landfills. TFA is extremely hard to remove from water, though recently a possible improvement to the process has been proposed.[26]

HFO-1234yf, a slightly flammable (A2L) gas, has become the standard refrigerant in millions of car air-conditioning systems throughout the world, replacing HFC-134a. When HFC-134a leaks into the atmosphere, it takes more than a decade for 10–20% to transform into TFA; but when HFO-1234yf escapes into the atmosphere, it takes no more than a few weeks for all of it to convert to TFA. Moreover, HFO-1234yf is commonly found in blends with HFCs such as R448A and R513A that are used globally in commercial and industrial refrigeration; these systems leak significant amounts of refrigerant due to their complex piping systems.

Regulations in Europe and the U.S. now call for – or are heading toward – requiring refrigerants with a GWP less than 150 in new equipment. This has led to the development of new HFO/HFC blends such as R454C, R455A and R471A, which have a GWP of 148.

The use of HFOs will not slow down until regulatory bodies in the EU and possibly in certain U.S. states take action to restrict them. Globally, the chemical industry has opposed regulations on HFOs, saying they do not represent a threat to human health. However, Robert Bilott, an award-winning and widely profiled U.S. environmental attorney, whose lawsuits over a two-decade period first exposed the environmental and health threat of PFAS, sees "history repeating itself" in the way the chemical industry is characterizing refrigerants.

Among the many stakeholders voicing concern about TFA, Christine Luetzkendorf, Policy Advisor on Fluorinated Greenhouse Gases for Deutsche Umwelthilfe/DUH (Environmental Action Germany), recently called for an immediate stop to TFA emissions given its infiltration throughout the global environment and its "real risk" to human health.[27] Another observer – Michael Kauffeld, Professor at the Karlsruhe University of Applied Sciences, Institute of Refrigeration, Air-Conditioning and Environmental Engineering in Germany – predicts that because of TFA's environmental impact, in eight years HFOs will no longer be a viable refrigerant, leaving natural refrigerants as the primary option.[28]

Spate of studies

Regulatory action may be supported by the spate of studies tracking the proliferation – and potential harm – of TFA in the environment. One of the more striking recent studies makes the case that TFA meets the criteria of a "planetary boundary threat" because of increasing planetary-scale exposure, where "potential irreversible disruptive impacts on vital earth system processes could occur."[29] The paper reviewed 43 studies from the late 1990s to the 2020s that reported on TFA concentrations, concluding that "collectively, these data indicate that TFA exposure is widespread and is increasing."

Exposure to TFA, an ultrashort-chain PFAS with two carbon atoms, has not been conclusively associated with health effects, but the German government in 2024 proposed to the EU linking TFA to reproductive toxicity in labeling based on evidence of embryo-fetal developmental toxicity in rabbits; TFA has also been connected to liver dysfunction in rats. The planetary boundary threat study states that "there are more than sufficient data to conclude that TFA poses a risk to humans and the environment" and that "transitioning away from TFA and its precursors is the most effective way of safeguarding future generations from this planetary boundary threat."

Meanwhile other reports of TFA in the environment abound. The government of Wallonia – the French-speaking southern region of Belgium – disclosed in October 2024 preliminary results on the presence of TFA in drinking water, finding it in in 598 out of 642 distribution zones (93%), including 13 in which the 2.2mcg/L guidance value was exceeded.[30] Also in October, researchers reported increasing concentrations of TFA in Denmark's groundwater over the last 60 years.[31] In September, Swedish researchers said they found "elevated levels" of TFA in juices and drinks – especially orange juice and some hand-squeezed oranges – as well as in fruit purées for small children.[32] And in the U.S., a study of PFAS in rainwater in the state of Michigan found TFA to be the largest contributor in two out of three sample locations and one of the largest in the third location.[33]

The chemical industry addressed the environmental deposition of TFA in an October 2021 study funded by the Global Forum for Advanced Climate Technologies (globalFACT), which represents f-gas producers Chemours, Honeywell, Arkema and Koura.34 The study concluded that "with the current knowledge of the effects of TFA on humans and ecosystems, the projected emissions through 2040 would not be detrimental." But the study also acknowledged that "the major uncertainty in the knowledge of the TFA concentrations and their spatial distributions is due to uncertainties in the future projected emissions.

CHAPTER 2

European Trends

2.1 The European Food Industry: Economic Outlook

The European food industry has faced a volatile economic landscape in recent years, with rising costs – largely due to energy and labor – shifting consumer behaviors and inflationary pressures shaping the sector's trajectory.

The war in Ukraine has continued to cast a shadow over the European landscape, impacting energy costs and complicating the energy supply chain and other economic factors.

Despite these challenges, signs of recovery and long-term growth are beginning to emerge, driven by innovation, strategic investments and evolving market dynamics.

GROCERY RETAIL

Europe's grocery retail sector has been under significant strain due to soaring costs and waning consumer confidence. In 2023, grocery sales grew nominally, but this growth was largely fueled by price inflation, which peaked at 19% in March and averaged 12.8% for the year. Adjusted for inflation, however, real sales declined due to a 2% drop in volume and a 1.8% downtrading effect as consumers prioritized essentials and gravitated toward budget-friendly options.[35]

Energy costs were a significant driver of these price hikes, affecting production and distribution expenses.

By 2024, inflation had eased significantly to 1.86% in April, providing some relief to the industry.[36] Despite this, the sector's revenue, estimated at €2.2 trillion ($2.3 trillion), had declined at a compound annual growth rate (CAGR) of 4% since 2019.[37]

Looking ahead, industry forecasts signal a brighter horizon. The grocery retail market is expected to grow at a CAGR of 8.3%, reaching €2.9 trillion ($3 trillion) by 2027.[38] Retailers are embracing strategies such as investing in technology, sustainability and smaller-format stores to drive profitability and redefine the competitive landscape.[39]

The Rise of Discounters and Convenience Stores

As consumers became increasingly cost-conscious in 2023, discounters gained traction, registering a market share increase of 0.8 percentage points. These value-focused retailers outpaced traditional supermarkets, achieving a revenue growth of 12.4% in 2023 compared to 8.2% for supermarkets. Discounters also expanded their sales space by 3.5% in 2023, a marked contrast to supermarkets' 1% growth.

Despite the growth seen by discounters, the market share of supermarkets remained stable at 37.2% across the continent.

Hypermarkets, on the other hand, saw slower growth, with a 6.8% revenue increase and a modest 0.6% expansion in sales space. Consumers' changing habits since the COVID-19 pandemic, including a preference for home cooking and smaller, more frequent purchases, have shifted demand away from commercial catering and bulk buying.[40]

Online sales, which represented around 6% of total grocery sales, remained stable, demonstrating potential for future growth. Innovations such as refrigerated lockers are enhancing convenience for same-day pickups and deliveries, further driving consumer interest in online food shopping.[41]

The European food retail market – which consists of some 300,000 outlets – is largely dominated by chain retailers. The largest company, Schwarz Group – owner of Lidl and Kaufland – has more than 12,600 stores across the continent.[42]

The growing demand for convenience has also spurred the rise of smaller urban stores. In 2023, convenience store sales space grew by 3.3%, reflecting a shift in consumer preferences for accessibility and proximity. For example, in France, smaller outlets have seen a 49% increase in turnover since 2019 and now account for nearly 11% of mass distribution turnover. Similar trends are evident in Italy, where retailers are prioritizing city-center supermarkets.[43]

The Win-Win of Sustainability Initiatives

As in numerous industries, sustainability has become a defining trend in the grocery retail market, with retailers taking bold steps to reduce their environmental footprints. Initiatives include setting ambitious targets to reduce Scope 1 (direct emissions) and Scope 2 (indirect emissions) and preparing to meet EU regulatory requirements for Scope 3 (value chain emissions) under the Corporate Sustainability Reporting Directive (CSRD).[44]

Investments in sustainability not only align with international ambition and regulatory mandates but also present opportunities for cost savings. Up to 40% of food retailers' emissions can be reduced through measures that also improve operational efficiency, enhancing both profitability and green credentials.

Investing in Development

Investment in the grocery sector, while resilient, has seen a decline. In 2023, investments totaled €6 billion ($6.2 billion), a 19% drop from the previous year. The first half of 2024 saw further declines, with investment volumes reaching €2.7 billion ($2.8 billion), down 20% year-over-year.

Nevertheless, the market remains a relatively secure option for long-term income and is showing signs of recovery.[44] Future investments are expected to prioritize automation, cloud computing and analytical tools, with an estimated €40 billion ($41.3 billion) needed through 2030 to modernize infrastructure.

Additionally, the redevelopment of existing properties and the integration of mixed-use spaces are gaining traction, creating more resilient infrastructure.

COLD STORAGE

In 2023, the European refrigerated warehouse market was valued at €99.4 billion ($103.3 billion). It is projected to reach €159.2 billion ($165.3 billion) by 2031, growing at a CAGR of 8.18%.[46]

As of April 2024, the continent's top 10 largest refrigerated warehousing and logistics providers operated roughly 32.8 million cubic meters (1.16 billion cubic feet) across the continent, down slightly from 33.2 million cubic meters (1.2 billion cubic feet) in 2023.[47]

Growth in the market is driven by a rising population, online grocery sales and an increasing demand for frozen and chilled foods. Between 2024 and 2029, the European frozen food market is expected to see a CAGR of 6.2%, in part due to consumer interest in convenience and food waste reduction.[48]

Over the coming years, online grocery shopping is projected to grow faster than the overall grocery market. As more and more customers order their groceries online, retailers are expanding their temperature-controlled storage facilities to ensure perishable goods reach homes in peak condition.[49]

Despite strong growth, capacity issues persist, with Europe lagging behind global leaders such as the U.S., China and India in refrigerated warehouse space.[50] Addressing these challenges will be critical for meeting consumer expectations for same-day and next-day deliveries.

FOOD PROCESSING

The EU food and drink industry remains one of the region's largest manufacturing sectors, generating an annual turnover of €1.2 trillion ($1.3 trillion) and adding a further €246 billion ($255.5 billion) to the European economy in 2024,[51] up from €1.1 trillion ($1.1 trillion) and €229 billion ($238 billion), respectively, in 2023.[52] With a projected CAGR of 5.35% from 2024 to 2029, the sector is poised for sustained growth.53

Figure 5: Value of the European Refrigerated Warehouse Market

2023 €99.4 billion

2031 (projected) €159.2 billion

ATMO sphere

Figure 6: Revenue Growth of European Grocery Sector in 2023

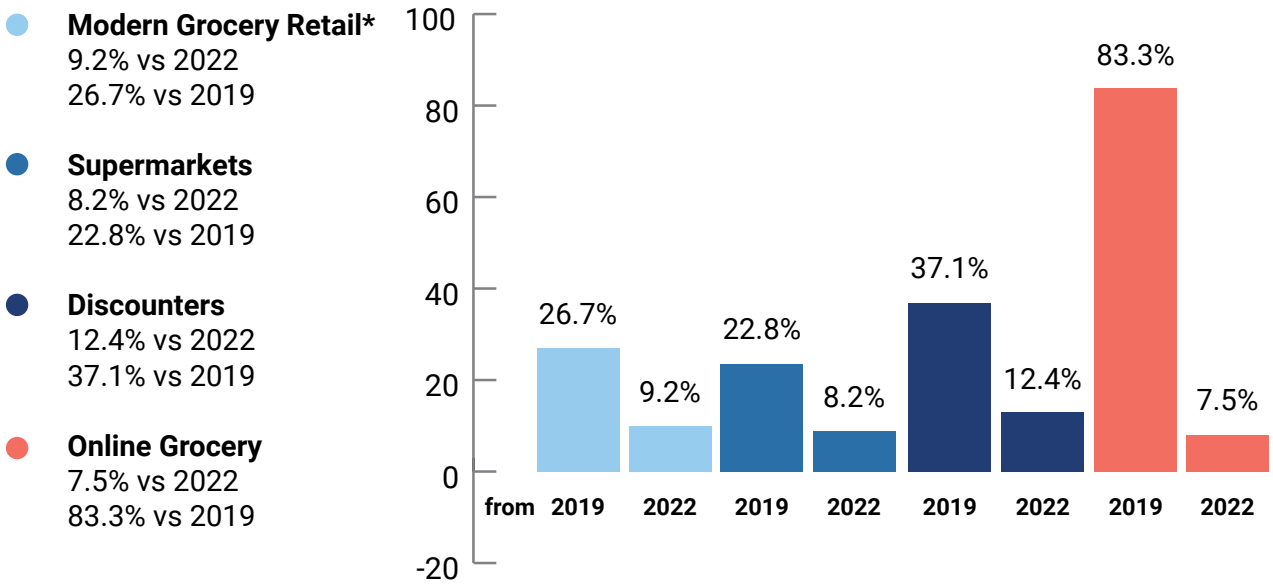
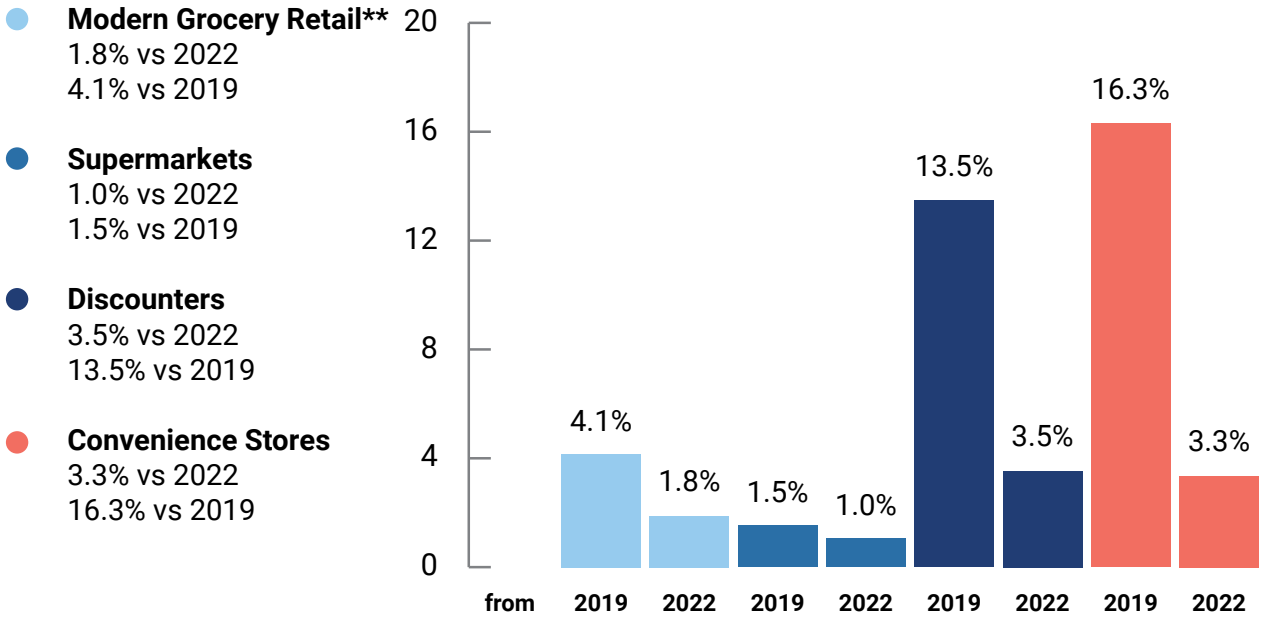


Figure 7: Sales Space Growth of European Grocery Sector in 2023



* Consists of hypermarkets, supermarkets, online grocery and discounters
** Consists of hypermarkets, supermarkets, discounters and convenience stores

Source: Signs of Hope – The State of Grocery Retail 2024: Europe (2024), McKinsey & Company, EuroCommerce Retail & Wholesale and Europanel

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2.2 The EU F-gas Regulation Becomes Law

On March 11, 2024, the EU's revised F-gas Regulation became law, and with it the clock began ticking on the use of f-gases in the bloc, with a complete ban set for 2050.[54] The ban, currently the only one of its type in the world, was overwhelmingly supported during voting in the European Parliament and the Council of the EU.[55]

In addition, the regulation also established a link between f-gases and PFAS, stating: "Some fluorinated greenhouse gases subject to this Regulation are Per- and Polyfluorinated Substances (PFAS) or are proven to or suspected to degrade into PFAS."

The revised F-gas Regulation places new limits on the GWP of refrigerants used in stationary refrigeration equipment and chillers. These limits only apply to new units and impact the following equipment types:

- **Stationary refrigeration:** Any new self-contained refrigeration equipment, with the exception of chillers and equipment required to meet safety requirements at the site of operation, using refrigerant with a GWP of 150 orv more will be banned starting in 2025. This includes self-contained refrigerators and freezers for commercial use. Other commercial refrigeration equipment, except certain chillers, using f-gases with a GWP of 150 or more will be banned starting in 2030.
- **Stationary chillers:** New chillers with a rated capacity up to and including 12kW (3.4TR) using f-gases with a GWP of 150 or more will be banned starting in 2027, with the use of fluorinated refrigerants in all chillers with a rated capacity up to and including 12kW banned completely starting in 2032. Chillers with a capacity above 12kW will be required to use refrigerants with a GWP of no more than 750 starting in 2027. Exceptions are made for chillers required to meet safety requirements at the site of operation.

In addition to establishing natural refrigerant-based equipment as the only future-proof option for refrigeration in Europe, the revised regulation also establishes new labeling requirements for fluorinated refrigerants and for exempted equipment.[56]

Starting in 2025, refrigerant containers must have visible and legible labels that last the product's lifetime and contain, among other information, the refrigerant's weight and CO_2e emissions expressed in GWP times weight. Furthermore, equipment sold using banned f-gases will be required, from the date the ban enters force, to display the following label: "Prohibited to be operated, unless required by safety requirements that have to be applied at the site of operation."

The revised EU F-gas Regulation also requires member states to establish minimum requirements for certification programs for technicians working with natural refrigerants and f-gases (see chapter 2.3). The European Commission released a proposed regulation in May of 2024 that would require a certificate to conduct leak checks, install equipment and to repair, service and decommission equipment using fluorinated or natural refrigerants,[57] with the finalized regulation released later that year in September.[58]

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2.3 Training Requirements for Natural Refrigerants

In September 2024, the European Commission published a regulation outlining the requirements for training and certification programs for technicians working with f-gases as well as "alternatives to fluorinated greenhouse gases," which include natural refrigerants. The requirement to develop training and certification programs for technicians working with natural refrigerants was included in the revised EU F-gas Regulation. Manufacturers are excluded from the regulation.

The training and certification regulation applies to stationary refrigeration equipment, stationary air-conditioning and heat pump equipment, stationary organic Rankine cycles, refrigeration units for trucks and trailers and refrigeration units for light-duty vehicles, intermodal containers and train wagons.

Technicians working with f-gases and natural refrigerants must be certified to install pre-charged equipment and to repair, maintain, service and decommission equipment. The regulation also requires certification for conducting leak checks on equipment using f-gases and for recovering f-gases from the cooling circuits of stationary refrigeration, air-conditioning equipment, heat pumps and refrigeration units installed on trucks and trailers.

Six types of certificates have been created:

- **Certificate A1:** covers equipment using hydrocarbons and f-gases
- **Certificate A2:** covers equipment using hydrocarbons and f-gases with a charge size of less than 3kg or, in the case of hermetically sealed systems, less than 6kg
- **Certificate B:** covers equipment using CO_2
- **Certificate C:** covers equipment using ammonia
- **Certificate D:** covers f-gas recovery and pertains to equipment with a charge size of less than 3kg or, in the case of hermetically sealed systems, less than 6kg
- **Certificate E:** covers leak checks of f-gas equipment provided it is not required to break into the refrigeration circuit

Next Steps

Member states are required to adapt or establish training programs to meet the new regulation's requirements within one year of its entering into force, which occurred on September 26, 2024. Technicians will be required to take a practical and theoretical examination whose questions and requirements vary depending on the certificate type.

However, all tests will feature questions pertaining to EU and national f-gas laws, knowledge of the characteristics of natural refrigerants and other non-fluorinated refrigerants in contrast to f-gas refrigerants, and a basic understanding of GWP and PFAS.

Those who are already certified under the previous version of the f-gas regulation will be required to refresh their knowledge and skills to the level required of the new certificates.

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2.4 The U.K.'s F-gas Regulation Review

The U.K. government has been urged to review its f-gas regulation by trade groups in the country's HVAC&R sector. The British Refrigeration Association (BRA) and the Federation of Environmental Trade Associations (FETA) both called for the government to continue with its review of the existing f-gas regulations after a national election held July 3, 2024, that swept the Conservative party out of power and ushered in a new Labour-led government.[59]

Neil Roberts, President of BRA, said the trade group would support the government in determining how the U.K.'s f-gas regulation should be adapted in response to the revised EU F-gas Regulation, which became law in March 2024. FETA – an alliance of trade unions of which BRA is a member – issued a statement calling on the government to "prioritize" work toward meeting the country's net-zero targets, "including the consultation on the Great Britain f-gas review."[60]

The U.K. government has not offered an update on the timeline to review its existing f-gas regulation. The Department for Environment, Food and Rural Affairs (DEFRA) was reportedly conducting a survey of HVAC&R industry stakeholders in the fall of 2023, with the goal to hold a public consultation on a draft of the revised regulation thereafter.[61] At the time of writing, DEFRA has not released an update on the result of the survey or the timeline for a public consultation of draft text.

In addition to its commitments under the Kigali Amendment to the Montreal Protocol, the U.K. government is obliged to review its f-gas regulation as part of the country's Net Zero Strategy.[62] The strategy, published in October 2021, commits the government to reviewing its f-gas regulation to see if the country can go further in the name of reaching its goal of net-zero emissions by 2050. The current f-gas regulation is modeled off of the EU's 2014 regulation, which the U.K. adopted as its own after Brexit.

Supermarkets Take Action

The U.K.'s revising its f-gas regulation to mirror the EU's would be a boon for the natural refrigerants industry. However, in the commercial sector, supermarket brands are showing that they're ready to move on from HFCs even in the absence of regulation. Rather than adopting HFOs, many of the country's top supermarket chains are opting for natural refrigerants.

The U.K.'s largest supermarket brand in terms of annual turnover, Tesco,[63] had installed transcritical CO_2 refrigeration systems at 1,000 of its stores, one third of its locations, as of October 2022 and plans to be HFC-free chain-wide by 2035.[64] Tesco also operates stores in Ireland, the Czech Republic, Slovakia and Hungary.

The country's second-largest supermarket brand, Sainsbury's, said in its 2024 sustainability report that it's replacing HFC refrigeration systems with those using "natural refrigerant gas." Morrison's, the fourth-largest supermarket operator in the U.K., said in 2021 that it is switching refrigerants to CO_2. The fifth-largest supermarket chain, ALDI U.K., spent the summer of 2024 retrofitting 33 stores with natural refrigerants as part of its drive to transition completely to natural refrigerants by 2029.

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2.5 Europe Looks at Regulating F-Gases and TFA as PFAS

Europe is the one region of the world that is seriously addressing the link between f-gases, particularly HFOs, and PFAS, also known as "forever chemicals" for their durability in nature.

Most importantly, the EU defines PFAS according to the OECD standard – fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom; this encompasses many HFCs and HFOs, as well as their atmospheric degradation product trifluoroacetic acid.[65] By contrast, the U.S. Environmental Protection Agency uses a definition of PFAS that excludes f-gases and TFA, though a number of states employ the OECD definition.

Following the OECD definition, the European Chemicals Agency (ECHA), an EU body, is considering a "universal restriction" proposal to regulate PFAS as a category, including f-gases and TFA, under REACH, the EU's chemicals regulation.[66] The organization will be dedicated to promoting natural refrigerants as alternatives to harmful PFAS in cooling and heating systems and supporting ambitious European PFAS legislation.

ECHA published the universal PFAS restriction proposal – made jointly by the national authorities of Denmark, Germany, the Netherlands, Norway and Sweden – in February 2023. PFAS restrictions have been proposed that would include either a ban or a ban with derogations (time-limited exemptions) where alternatives are not yet available. Recently, restriction options other than a ban have been proposed.[67]

In regard to refrigerants, the following ban derogations have been proposed:

- For 13.5 years after the regulation enters into force for refrigerants used in maintenance and refilling of existing HVAC&R equipment put on the market up to 18 months after the regulation enters into force.
- For 6.5 years after the regulation enters into force for refrigerants used in mobile air-conditioning systems in combustion engine vehicles with mechanical compressors.
- For 6.5 years after the regulation enters into force for refrigerants used in mobile air-conditioning in transportation vehicles for military applications.

Jonatan Kleimark, Senior Chemicals and Business Advisor at ChemSec, a Swedish environmental NGO, expects that when the discussions come to the f-gases in 2025, "the industry will propose a large set of [other] derogations for this use or this application."[68] Derogations are granted if there are no available and viable alternatives to f-gases, but with the availability of natural refrigerant-based systems, "we have a set of alternatives," he said. "We have already companies that have phased out of f-gases. So a lot of things are happening due to the upcoming legislation."

ECHA's scientific committees for Risk Assessment (RAC) and for Socio-Economic Analysis (SEAC) have been engaged in an evaluation of the proposal, with RAC receiving more than 5,600 comments. Over the next year SEAC will conduct its public consultation.[69]

After committees are finished with their evaluations, their opinions will be submitted to the European Commission. The Commission will write its proposal, which will be decided upon by the member states. "We probably won't have a decision until maybe 2028, or even later than that," said Kleimark. But I would like to stress that it's important that we have a comprehensive regulation in order to beat the PFAS crisis. And that's why it will take some time."

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Reproductive Toxicity

In a separate proceeding, ECHA is considering a proposal from the German government this year to update its classification, labeling and packaging of TFA to list it as "reprotoxic" – being toxic to reproduction – as well as persistent, mobile and toxic and very persistent and very mobile.[70]

The reprotoxic classification is based on evidence of embryo-fetal developmental toxicity in rabbits (in particular, malformation of the eyes in offspring); TFA has also been connected to liver dysfunction in rats. This would be the most direct association of TFA with harmful health effects in people, as to date the chemical has not been conclusively linked to health impacts in the way that longer chain PFAS such as PFOA have.

The CLP regulation requires manufacturers, importers or downstream users of substances or mixtures to classify, label and package their hazardous chemicals appropriately before placing them on the market so that the hazards are clearly communicated to workers and consumers. The CLP regulation also calls for harmonized classification and labelling into different hazard classes pertaining to physical threats like flammability, health issues and environmental concerns. TFA is already classified as harmful if inhaled, causing skin corrosion and harmful to aquatic life.

As of December 2024 ECHA was doing an "accordance check" of Germany's proposal. Following that, the proposal would then be made public and will have a consultation phase of 60 days during which stakeholders can react. Based on the consultation, RAC will adopt an opinion, after which it goes to the European Commission, which has a final vote on whether to approve the reclassifications.

The EU is also regulating PFAS levels in drinking water. Its Drinking Water Directive, which will take effect January, 12, 2026, establishes limits of 0.5mcg/L for "PFAS Total" (all PFAS, including TFA) and 0.1mcg/L for the "Sum of PFAS," which covers a list of 20 PFAS (not including TFA).

In many parts of Europe, such as the Wallonia region of Belgium, more than 0.5mcg/L of TFA alone has been detected.[71] Wallonia and the Netherlands have both established a 2.2mcg/L guidance value for TFA in drinking water, which has also been exceeded in some areas. In Denmark, the TFA limit in drinking water is 9mcg/L while Germany has a health guideline value for TFA of 60 mcg/L and an advisory level of 10 mcg/L.

The European Commission recommends that in the analysis of PFAS Total, the contribution of TFA in water intended for human consumption should be separately evaluated as the TFA concentration could significantly exceed 0.5mcg/L.[72]

There is currently no legal EU limit for TFA in surface water (rivers and lakes) or groundwater per the Water Framework Directive.[73] However, in October 2022, the European Commission adopted a proposal to revise the lists of pollutants in surface water and groundwater.[74]

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2.6 Implementing the Corporate Sustainability Reporting Directive

The Corporate Sustainabiltiy Reporting Directive requires large companies and listed small- and medium sized enterprises to publish regular reports on the social and environmental risks they face along with how their activities impact people and the environment.[75] Reporting is done according to the European Sustainability Reporting Standards. For the HVAC&R industry, this includes refrigerants.

The deadline for EU member states to incorporate the CSRD into national legislation was July 6, 2024, and on September 25, 2024, the European Commission sent a letter of formal notice to 17 member states that had yet to do so.[76] At the time of writing, 13 member states have still not, although many of those have introduced implementing legislation.[77]

On November 8, 2024, the Council of the European Union issued the Budapest Declaration in which it called for, among other things, "reduced administrative, regulatory and reporting burdens, in particular for SMEs."[77] The Council of the EU called on the European Commission to make "concrete proposals" on ways to reduce reporting requirements by 25% in the first half of 2025.

Ursula von der Leyen, President of the Commission, responded by announcing that the CSRD may be combined into an "omnibus regulation" with the Taxonomy Regulation and Corporate Sustainability Due Diligence Directive.[79] Von der Leyen noted that while the content of the regulations was "good" and "correct" and that the Commission wanted to maintain them, too many data points were being collected.

No update has been given about a potential omnibus regulation as of the time of writing, but an "omnibus simplification package" is currently on the agenda for a European Commission meeting in February 2025.[80]

TYPE OF COMPANY	CSRD DEADLINE
Large listed companies, banks and insurance undertakings (more than 500 employees) and non-EU listed companies with more than 500 employees	Financial year 2024, with the first sustainability statement published in 2025.
Other large companies, including non-EU listed companies	Financial year 2025, with the first sustainability statement published in 2026.
Listed SMEs, including non-EU listed SMEs*	Financial year 2026, with first sustainability statements published in 2027.
Non-EU companies that generate over €150 million ($157 million) per year in the EU and that have in the EU either a branch with a turnover exceeding €40 million ($41 million) or a subsidiary that is a large company or a listed SME	Sustainability impacts at the group level from financial year 2028, with the first sustainability statement published in 2029.

*However, listed SMEs may decide to opt out of the reporting requirements for two years. The last possible date for a listed SME to start reporting is financial year 2028, with the first sustainability statement published in 2029.

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2.7 European Market Data: Stores Using Natural Refrigerants

Total Addressable Market

The total addressable market in Europe for food retail outlets, including supermarkets, hypermarkets, grocery, discount and convenience stores, is estimated at 300,000 stores. This is a slight increase from 2023 when we estimated a market size of 298,600 stores.

In this report, Europe is defined as including the EU, U.K., Norway, Switzerland, Iceland, non-EU Balkan states, Ukraine, Belarus, Moldova and the European part of Russia.

TRANSCRITICAL CO_2 RACKS AND CONDENSING UNITS

The Market Today

According to data collected by ATMOsphere, as of December 2024, there were approximately **90,700** food retail stores in Europe that use transcritical CO_2 systems; of these **76,200** used a centralized system (one or more racks) and **14,500** used condensing units. The number of stores with racks grew by 27% from 60,000 as of December 2023, while the number with condensing units grew by 71% from 8,500. There were an estimated **4,900** industrial sites using this technology, an increase of 48% from 3,300, with the rapid rise attributable to underestimations from past reports. In total there were **95,600** transcritical CO_2 sites in Europe (commercial and industrial), up 33% from 71,800 last year.

More than half of the CO_2 store units were for new construction, according to manufacturers, with the remainder for retrofits/remodels in existing stores. New stores represented 54% of installations for racks and 51% of installations for condensing units. The percentage of installations in existing food retail stores is likely to grow in the coming years as these stores, seeking to comply with regulations, increasingly replace aging HFC-based refrigeration systems with ones using CO_2.

The market penetration of transcritical CO_2 systems in stores has increased this year to 30% – the percentage of all food retail stores in Europe estimated to feature transcritical CO_2 installations (including condensing units) as of December 2024, up from 22.9% in 2023 and 18.4% in 2022.

Adoption of transcritical CO_2 systems in European food retail has grown markedly since March 2021, when the number of stores using transcritical CO_2 systems was estimated to be 38,400. There were 1,640 industrial sites using transcritical CO_2 at that time for a total of 40,040 transcritical CO_2 sites in Europe.

As of March 2020, 27,550 European stores employed transcritical CO_2 refrigeration systems. Thus, in just five years, that figure has grown by 229% despite nearly constant economic uncertainty during that time, attributable to the Covid-19 pandemic and Russia's war in Ukraine, among other issues.

Behind the Numbers

The recent revision of the EU F-gas Regulation (see chapter 2.2) has cemented CO_2's future in the commercial refrigeration sector. New commercial refrigeration racks and condensing units cannot use a refrigerant with a GWP of 150 or more, starting in 2030.

The ascension of transcritical CO_2 could be further accelerated if the ECHA determines that PFAS should be banned in the refrigerants sector in the EU (see chapter 2.5), which would impact many HFCs and HFOs. Even if ECHA reaches this conclusion, a PFAS ban in the refrigerants sector would need to be supported by the European Commission and voted on by member states.

The trend toward smaller-format food stores (see chapter 2.1) may also clear a wider lane for CO_2 condensing units. These outside units free up building space that a rack would otherwise occupy, space that could be used for additional storage or to display more merchandise.

Panasonic in particular has big ambitions in this regard. In July 2024, it acquired Polish CO_2 condensing unit manufacturer Area Cooling Solutions, giving it a condensing unit factory in Europe.[81] Panasonic has installed around 4,000 CO_2 condensing units in Europe since bringing its 2HP unit to the market in 2017, with demand from supermarkets growing to account for more than 50% of sales since 2023.

HYDROCARBON SELF-CONTAINED CASES

The Market Today

Using data collected from a survey of OEMs as well as insights from trusted industry sources, ATMOsphere estimates that **17 million** self-contained hydrocarbon cabinets have been installed in Europe by December 2024. This is a significant increase from 2023 when we estimated there to be 3.2 million.

This higher estimate is the result of better and more complete data gathered from a combination of manufacturers, OEMs and trusted industry sources. As the data gathered is historical, the increase from 3.2 to 17 million self-contained hydrocarbon cabinets should not be interpreted as a year-over-year gain. It is our new baseline for Europe, and as such we do not refer to estimates from previous years in this report.

Our data collection process, as well as the model underpinning our analysis, is continually being refined. This year's iteration resulted in a more complete look at the global market for self-contained hydrocarbon cabinets, which were undercounted in previous reports.

Behind the Numbers

The revised EU F-gas Regulation will also play a big role in boosting the number of self-contained hydrocarbon cabinets installed in stores because it mandates that new self-contained refrigeration equipment cannot use a refrigerant with a GWP of 150 or more beginning in 2025.

The year before the updated regulation became law, the charge level for propane in commercial cabinets in Europe was increased from 150g to 500g across all case types in the EN IEC 60335-2-89:2022 standard.[82] According to another standard, EN 378, Europe allows for a maximum hydrocarbon refrigerant charge of up to 1.5kg, but this is dependent on the specific cabinet design and room size, with strict requirements to prevent flammable refrigerant concentrations in case of a leak.

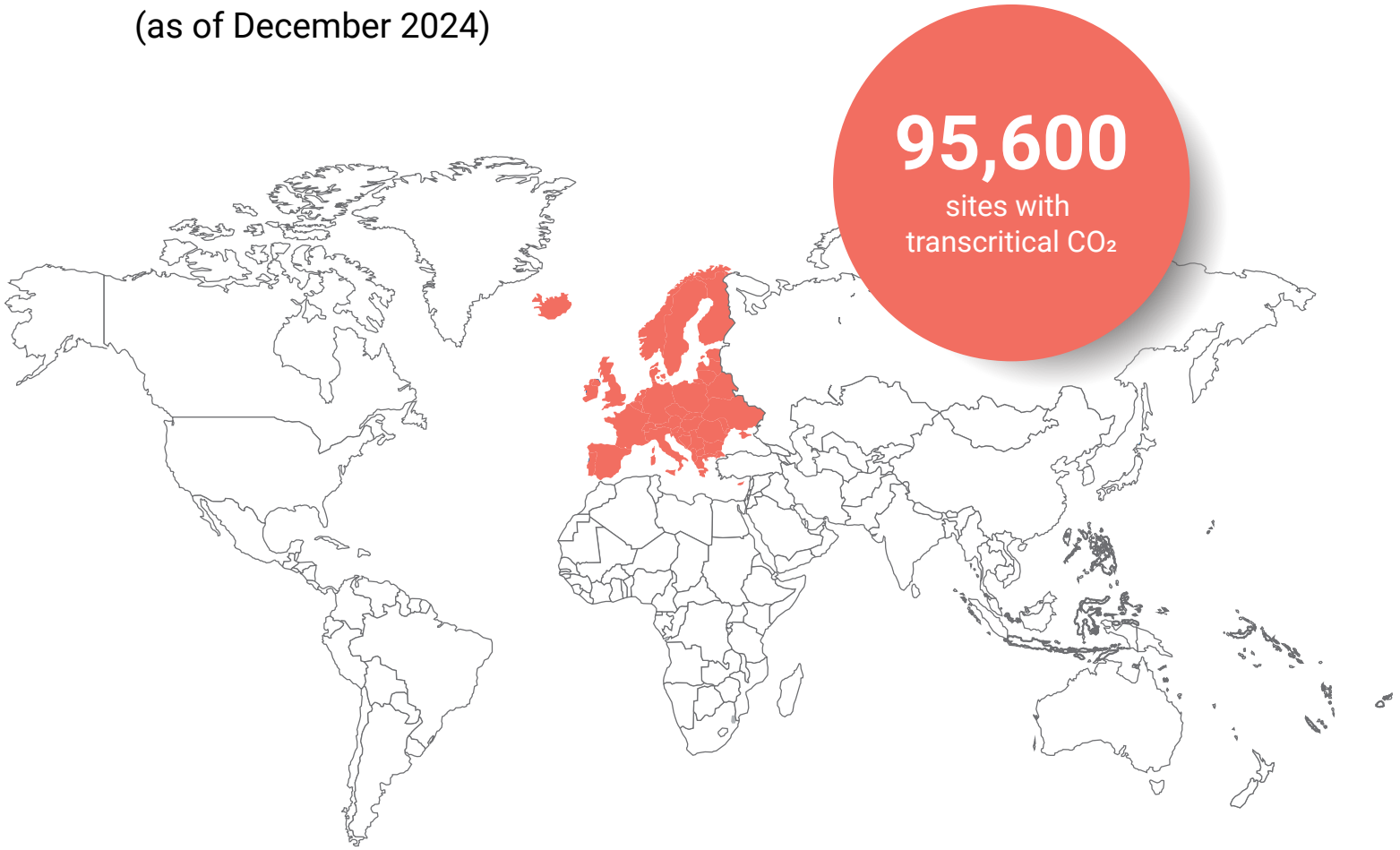
These regulations and standards mirror a broader shift in the industry that has seen compressor manufacturers move from f-gases to hydrocarbons. Embraco, a subsidiary of Nidec Global Appliance, said in 2022 that 70% of its total compressor sales for the residential and light commercial sectors used R290 or R600a. Embraco has been manufacturing hydrocarbon compressors since 1994, and the company estimates that the self-contained case market will be nearly 100% hydrocarbons by 2030.

In addition to eventually pushing self-contained f-gas cabinets out of the market, hydrocarbon cases may end up competing for floor space with remote CO_2 units, as an E.Leclerc hypermarket in Ville-la-Grand, France, recently showed.

In April 2024, the Ville-la-Grand E.Leclerc was declared a real-world showroom for Irish manufacturer Novum's LEAP line of R290-based freezers and cabinets.[83] The manufacturer noted that the store replaced 30% of its remote CO_2 cabinets with Novum's LEAP units. While the store's transcritical CO_2 rack was installed in 2017, its general manager said long waits for servicing appointments pushed management to seek equipment it could maintain in-house. Many stores in Europe use only propane cases for refrigeration.

Figure 8: Transcritical CO_2 Installations in Europe

(as of December 2024)



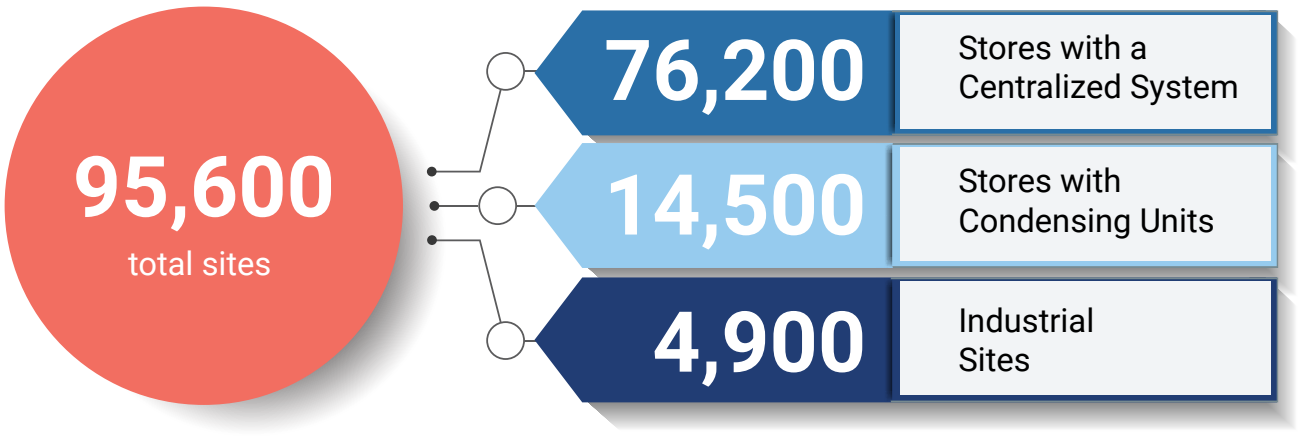


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Figure 9: Transcritical CO_2 Commercial Refrigeration Market Penetration in Europe

300,000 total stores

30% transcritical CO_2 stores

Figure 10: Transcritical CO_2 Installation Growth in Europe

(stores and industrial facilities)

2021	40,000	2023	71,800
2022	57,000	2024	95,600

Percentage growth in 2023 - 2024

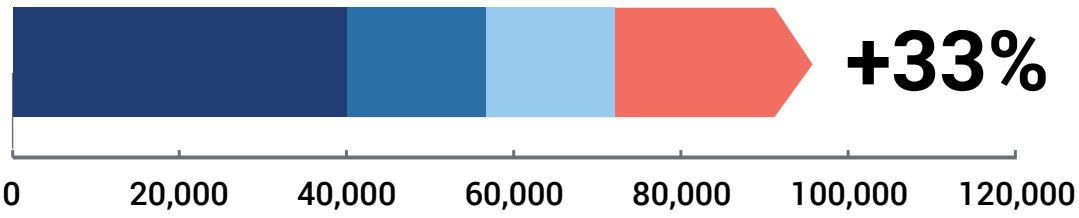

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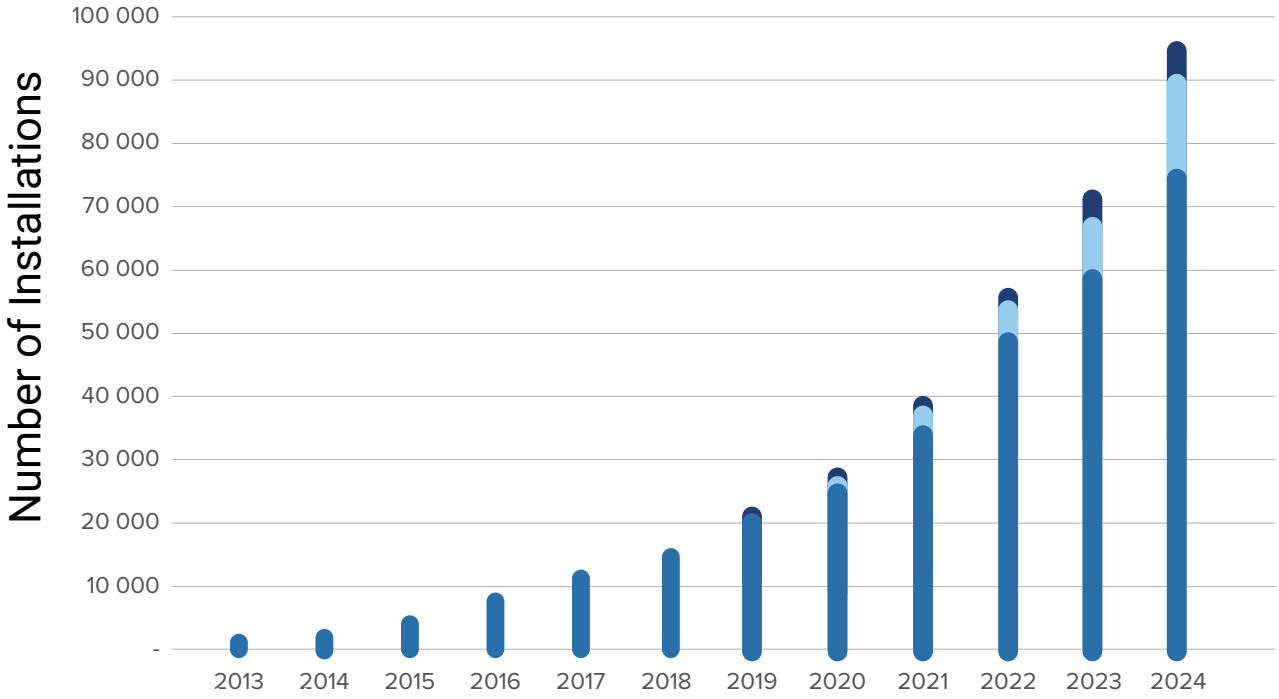
Figure 11: Transcritical CO_2 Historical Installation Growth in Europe

(stores and industrial sites)



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

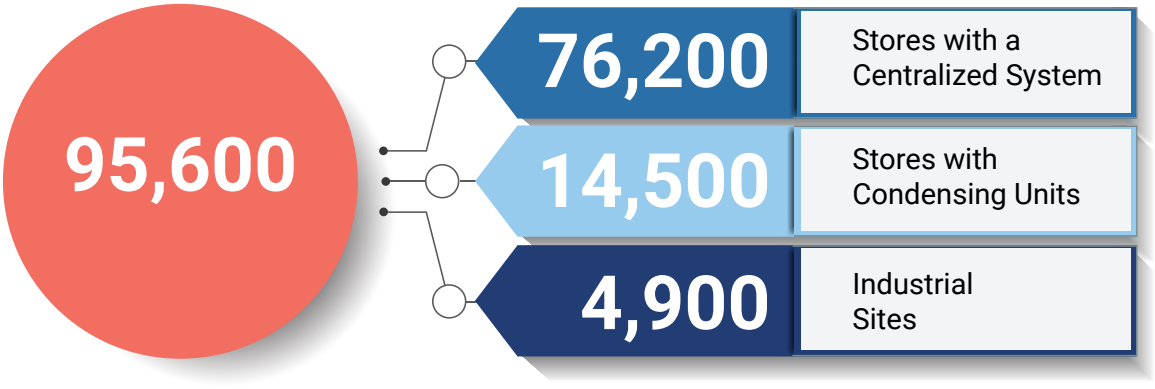


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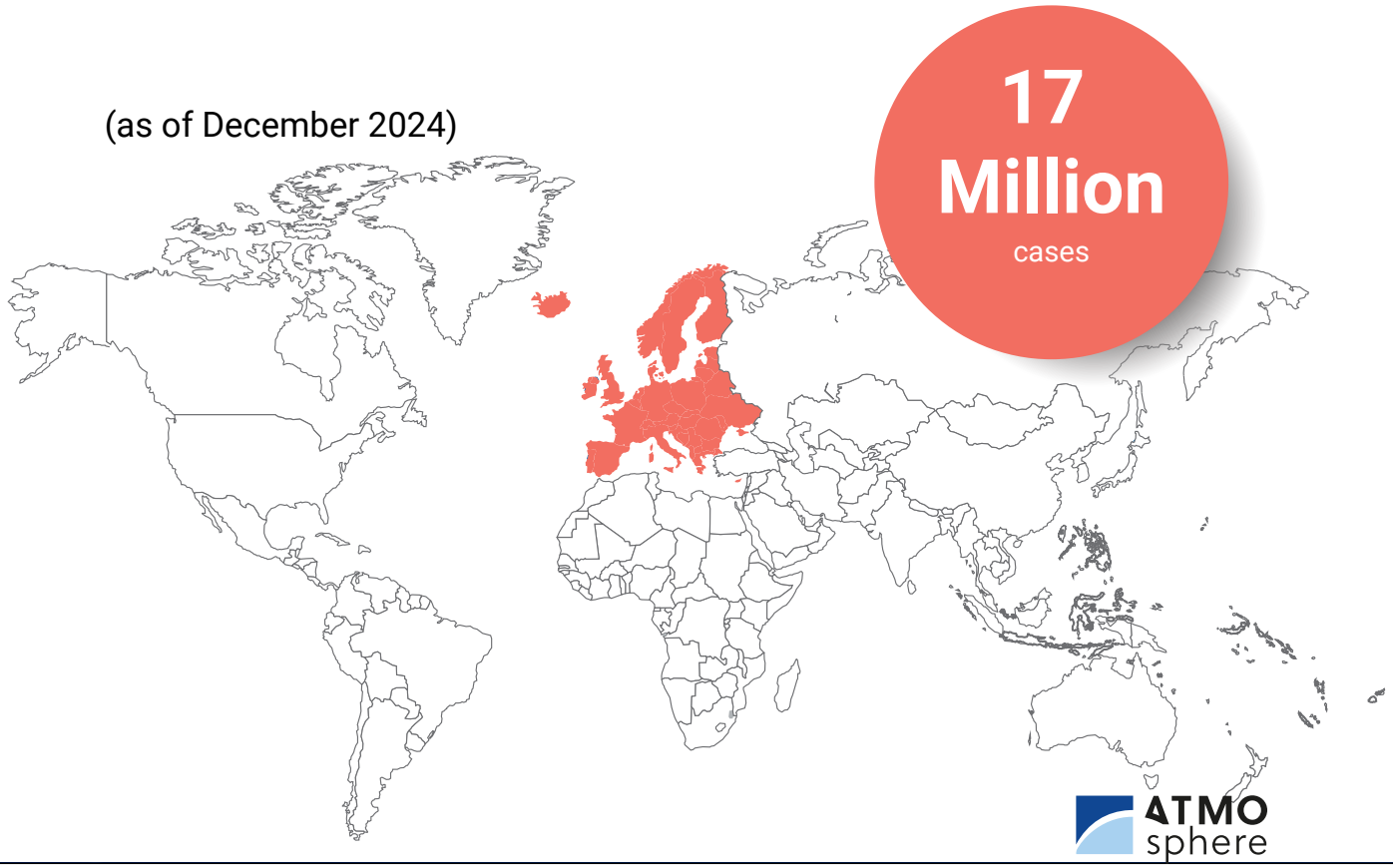
Figure 12: Self-Contained Hydrocarbon Cabinets Installed in Europe



2.8 European Market Data: Industrial Sites Using Natural Refrigerants

TRANSCRITICAL CO_2

The Market Today

As of December 2024, there were an estimated **4,900** industrial sites using transcritical CO_2 refrigeration, accounting for 5.1% of the **95,600** transcritical CO_2 sites in Europe (the rest being food retail stores). These 4,900 sites represent a growth of 48% from the 3,300 industrial sites using transcritical CO_2 a year ago (4.6% of the total 71,800 transcritical CO_2 sites).

Historically, there were an estimated 1,640 industrial sites using transcritical CO_2 systems (4.1% of the total) in March 2021 and 2,000 (3.5% of the total) in December 2022.

Behind the Numbers

Components manufacturers are helping drive the adoption of transcritical CO_2 in the industrial sector by making larger compressors. Having larger compressors means end users can employ fewer compressors to achieve the same capacity, thereby reducing costs and improving efficiency.

Dorin debuted an eight-cylinder CO_2 compressor at Chillventa 2024 last October that makes between 500–750 horsepower and will be available in open and semi-hermetic configurations.[84] The company noted that the compressor could be an attractive option for end users in the industrial sector operating in countries with laws that restrict the use of hydrocarbons or ammonia or in places where technicians lack training with these refrigerants.

Also in October 2024, the six-cylinder Danfoss BOCK HGX56 CO_2 T compressor was named the winner in the refrigeration category of the 2025 AHR Expo Innovation Awards.[85] The semi-hermetic compressor has a heating capacity of 135kW (38TR) and a cooling capacity of 360kW (102TR).

LOW-CHARGE AMMONIA

The Market Today

As of December 2023, ATMOsphere estimates there were **3,600** industrial sites using low-charge (below 1.3kg/kW or 10.1lbs/TR) ammonia systems in Europe, based on production numbers from leading OEMs. This represents a growth rate of **7.1%** from 2023 when there were an estimated 3,360 such sites.

The number of industrial facilities using low-charge ammonia systems has slowly been growing the past few years, rising from 2,450 in June 2021 to 2,850 in December 2022. From June 2021 to December 2024, the number of industrial facilities in Europe using low-charge ammonia has grown by 47%.

Behind the Numbers

Regulation and safety concerns have driven manufacturers to seek ways to reduce the charge of ammonia industrial refrigeration systems. Danish sensor manufacturer HB Products and American valve and controls manufacturer Hansen jointly debuted an evaporator control sensor in the spring of 2024 that they claimed could cut the refrigerant charge of an industrial ammonia system by up to 75%.[86]

The sensor combines HB's vapor quality sensor and Hansen's motorized control valve, measuring the liquid coming from the evaporator and adjusting it to maintain a low liquid feed and ensure a small circulation rate. The evaporator control sensor is designed for both overfeed and direct expansion systems and can reportedly reduce energy consumption by 30–60%.

Along with a lower charge and increased energy efficiency, another less-spoken about benefit of low-charge ammonia systems – specifically packaged units – is their portability. Andy Pearson, Group Managing Director at Scottish OEM Star

Refrigeration, said at the 2024 Gustav Lorentzen Conference in August that 25% of the company's packaged low-charge ammonia systems "are not where we've delivered them" and that "customers are taking them elsewhere because their business has grown."[87]

HYDROCARBON CHILLERS

The Market Today

Based on production numbers from leading OEMs, ATMOsphere estimates there were **6,650** industrial sites with hydrocarbon-based chillers in Europe as of December 2024. This represents a 33% increase from December 2023 when ATMOsphere estimated that there were 5,000 industrial sites in Europe with hydrocarbon-based chillers.

Behind the Numbers

Italian manufacturer Euroklimat is one of the leading producers of R290 chillers in Europe, having built more than 3,000 propane chillers and heat pumps since 2006. Its chillers range in capacity from 30–1,000kW (8.5–284TR). In addition to cold storage and food processing they are also used for indoor climate comfort.[88]

Another Italian manufacturer, Enerblue, has also been working with propane for more than a decade. The company has put more than 1,000 propane heat pumps and chillers into operation since 2014, and at Chillventa 2024 it announced a new line of R290 chillers called Silver with a cooling capacity of up to 768kW (218.3TR).[89] Applications include process cooling and air-conditioning in hospitals, exhibition centers, data centers and other large facilities.

Outside of Italy, German chiller and heat pump manufacturer Yanmar Energy System Europe saw a "significant" increase in propane heat pump/chiller sales in the beginning of 2024. The company sold 19 units in the first three months of the year compared to five in the same period in 2023.[90]

Figure 13: Growth of Transcritical CO_2 Installations in Europe

(industrial sites)

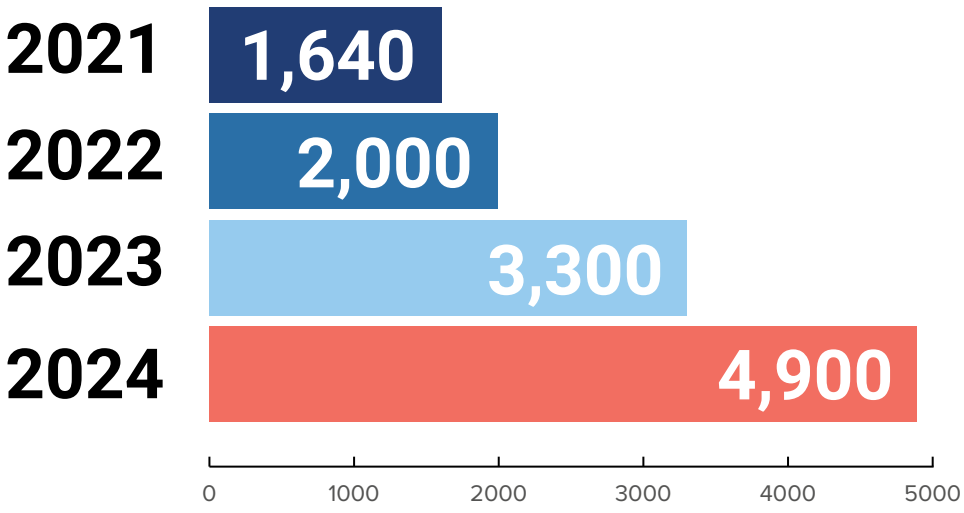


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Figure 14: Growth of Low-Charge Ammonia in Europe

(industrial sites)

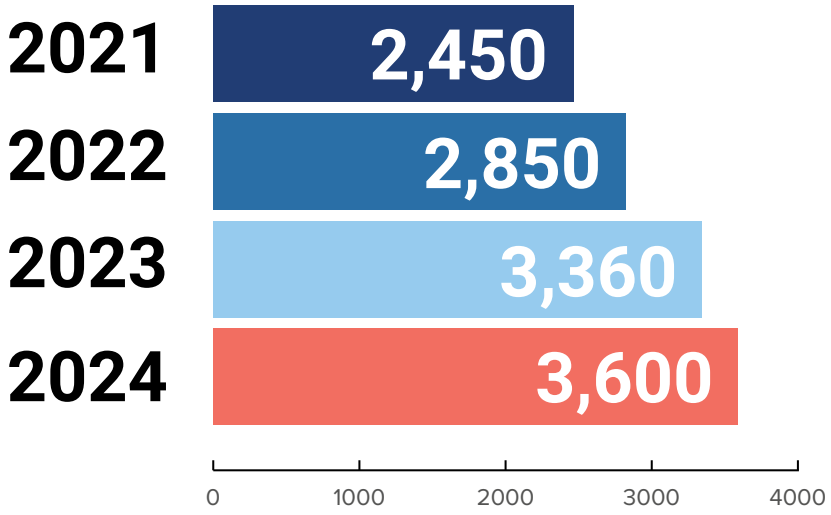

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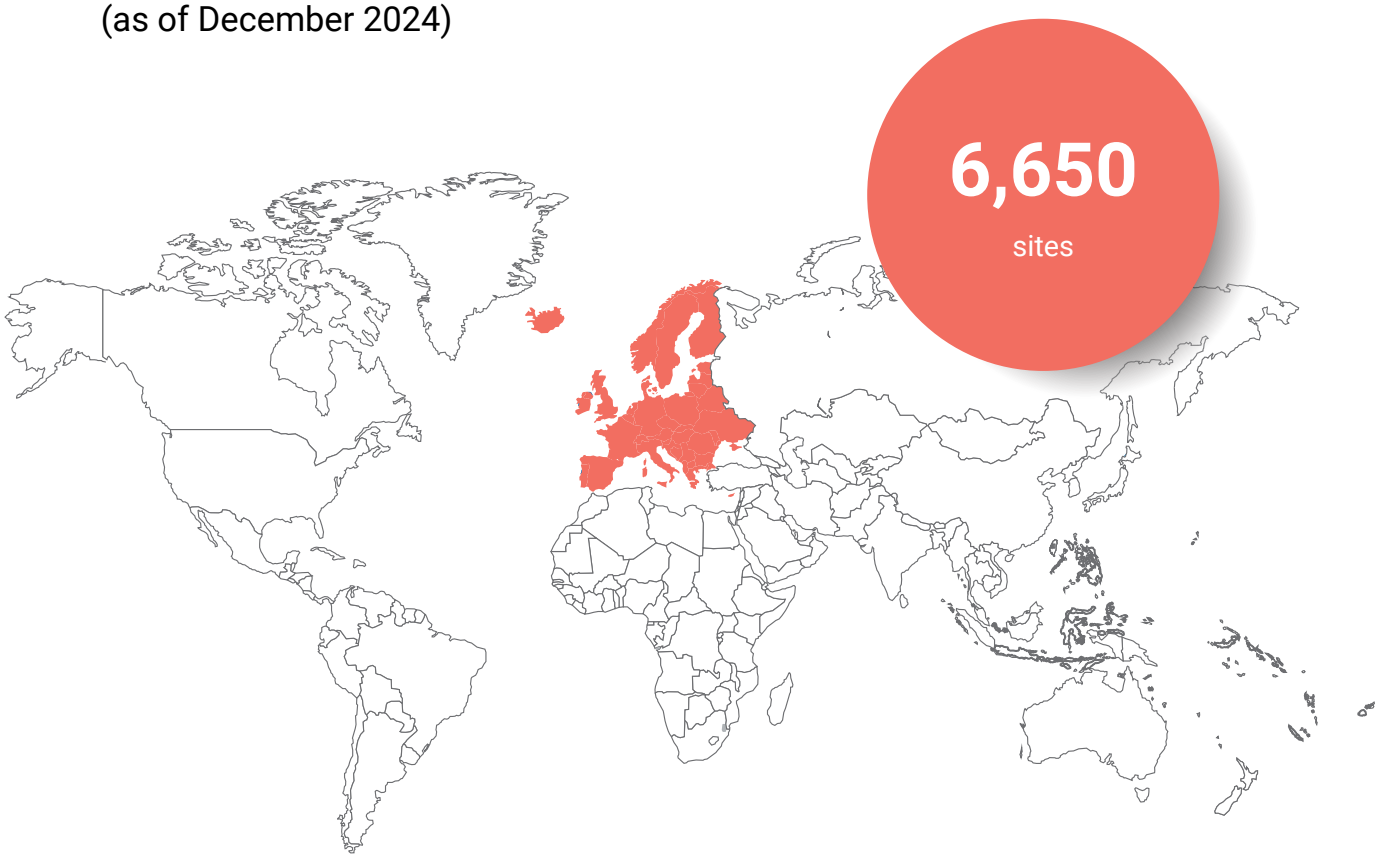
Figure 15: Hydrocarbon Chiller Installations in Europe

(as of December 2024)



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CHAPTER 3

North American Trends

3.1 The North American Food Industry: Economic Lookout

U.S. supermarkets and grocery stores saw a drop in revenue by 1.8% to $829.9 billion (€756.7 billion) in 2024.[91] In the U.S. convenience store sector, revenue grew by 12.1% to $45.5 billion (€41.5 billion).[92] In Canada, supermarket sales decreased by 4% to US$111.5 billion (€101.7 billion),[93] while convenience store sales dropped 3.2% to US$12.2 billion (€11.1 billion).[94]

Online grocery shopping remained strong and accounted for 7.2% of all sales in the region in 2023.[95] Refrigerated storage revenue, driven by industry stakeholders focused on sustainability and eliminating food waste, grew by 2.3% to $8.6 billion (€7.8 billion) in 2024.

North America accounted for more than 45% of the 2023 global cold storage construction market, which was valued at $14.3 billion (€13 billion) with a projected CAGR of 14% from 2024-2030.[97] Large companies with growing international trade continue to drive growth for refrigerated transportation and warehouses, focusing on constructing facilities near ports for temperature-sensitive exports and imports.

Technological advances in cold storage construction — including energy efficiency and management controls, cloud technology and automated storage and retrieval systems — are driving the cold storage construction market.

Since the COVID-19 pandemic, the increased development and trade of temperature-sensitive pharmaceuticals and biotech, medical and chemical applications have increased the demand for cold storage construction. Data center cooling also drives the need for large-scale refrigeration equipment.

The increasing demand for temperature-controlled storage comes from better cold chain management, including the transport logistics of fresh and frozen foods, vaccines and drugs.[98] Rising consumer interest in processed meats and seafood is also driving growth.

The U.S. Department of Agriculture's latest figures from October 2023 show that there are 2.99 billion ft^3 (80 million m^3) of usable refrigerated storage capacity in 900 U.S. warehouses.[99] The Global Cold Chain Alliance (GCCA) indicated that the largest 25 North American warehouse providers supply 4.7 billion ft^3 (130 million m^3) of temperature-controlled refrigerated warehousing and logistical space.[100]

Increased Economic Stabilization

In 2024, the annual inflation rate in the U.S. dropped for the second straight month to 2.5% in August from July's 2.9%, with energy prices falling. The U.S. Department of the Treasury's July 2024 report indicates that core inflation accelerated slightly in the first quarter of 2024, but it was down by more than 40% in March from its peak in the fall of 2022.[101]

According to Chris Rogers, Manager of Supply Chain Research at S&P Global, supply chain issues continue to improve, with most firms not experiencing delivery delays. However, companies expect inflationary costs with increased shipping prices correlated to labor strikes, especially in Asian countries. Rogers reported that investments in supply chain resilience, tech adoption and reshoring continue to rise to support declining inventories and provide supplier diversification.

Consumer Trends

In a March 2023 survey, 68% of Americans indicated that they were willing to pay more for sustainable products, with 72% of Millennials and 77% of Gen Z ready to pay more for sustainable products.[102] A poll conducted in the summer of 2023 found that 86% of Americans feel households should do more to reduce food waste.[103]

Frozen food dovetails with the sustainable consumer mindset. According to a 2023 survey, 50% of consumers who increased their frozen food purchasing reported doing so to reduce food waste.

Retail dollars spent on frozen foods climbed from 1.6% of sales in the fourth quarter of 2023 to 2.9% in the first quarter of 2024, while food service sales dropped from 4.8% to 3% over the same period.[104]

"While providing frozen products at (or near) price parity with other food items was important in the overall value chain for consumers, sustainability, convenience, nutrition and longer storage times were other key considerations for consumers purchasing frozen foods," said the Food Institute in a report at the Frozen IQ 2024 conference hosted by the American Frozen Food Institute (AFFI) and the Food Marketing Institute (FMI).[105]

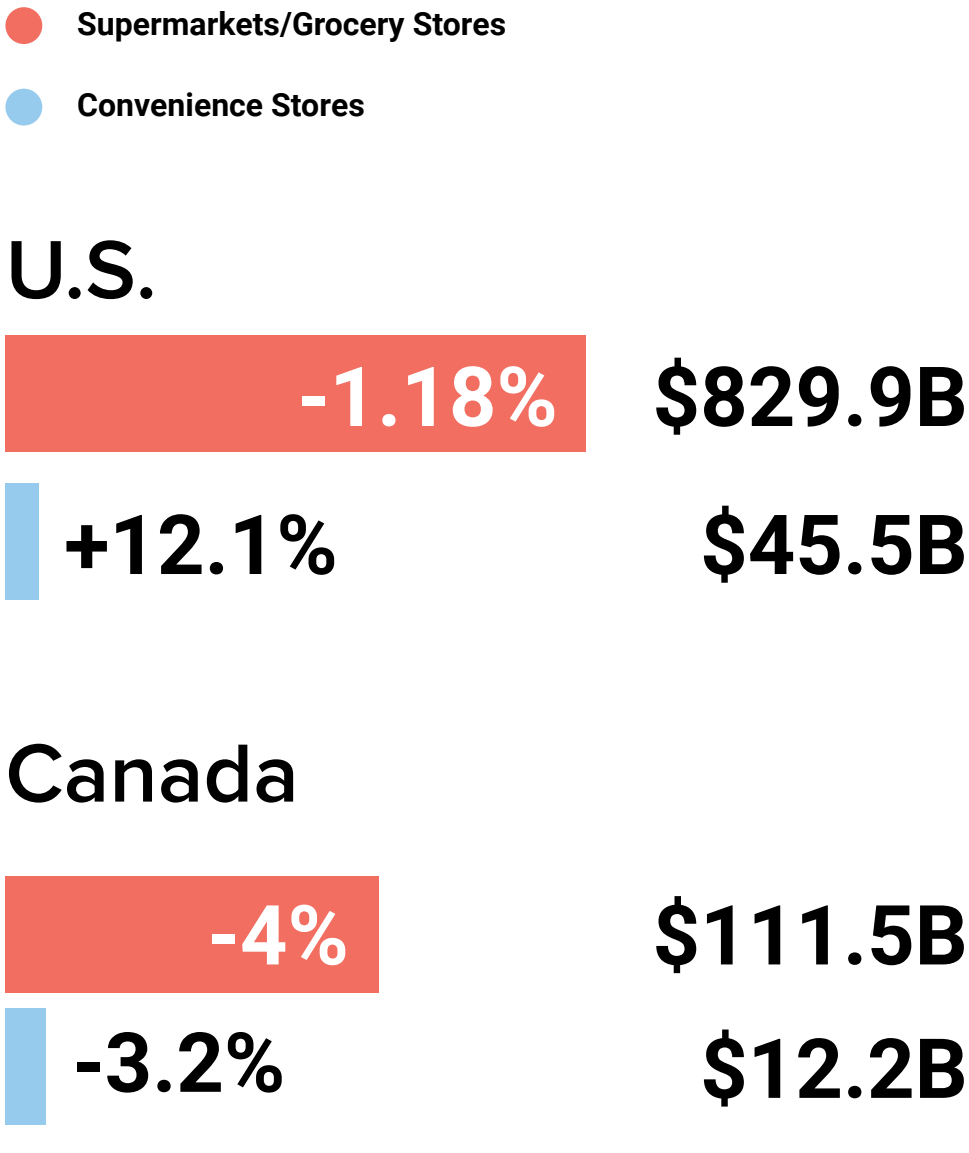
Although most consumers indicate that they take measures to support sustainability, the money spent on products with sustainability claims dropped by as much as 4% from the second quarter of 2023 to the beginning of 2024.[106]

However, according to Tom Simenc, Senior Engineer at Cascade Energy, companies are still facing increasing outside pressure to decarbonize operations.[107]

"In our current climate, decarbonization goals are no longer just a nice-to-have part of a company's environmental, social and governance plan," he said in a presentation at the 2024 RETA Conference.

Tightening regulatory requirements for emission tracking and reporting — including for HFC refrigerants – competitive advantages, investors, brand reputation and expanding ESG financial and legal risks are moving the market toward adopting more sustainable solutions.[108]

Figure 16: Revenue of North American Stores, 2024



3.2 U.S. EPA Excludes F-Gases and TFA from PFAS Definition

The U.S. Department of Environmental Protection, which regulates potentially harmful chemicals such as PFAS, has developed a definition of PFAS that differs with that recognized by the EU and the scientific community.

The EU defines PFAS according to the OECD standard – fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom; this encompasses many HFCs and HFOs, as well as their atmospheric degradation product trifluoroacetic acid.[109] Following the OECD definition, the European Chemicals Agency, an EU body, is considering a "universal restriction" proposal to regulate PFAS as a category, including f-gases and TFA, under REACH, the EU's chemicals regulation.[109]

In 2024, more than 150 scientists from around the world with expertise in PFAS co-signed a statement urging governmental bodies to adopt a science-based "at least one fully fluorinated carbon atom" definition of PFAS that includes f-gases and TFA; this is "nearly identical" to the OECD definition.[111]

However, the OECD and scientific community definition is not being used by the U.S. EPA's Office of Pollution Prevention and Toxics. In 2021 it announced a "working definition of PFAS" as chemicals with at least two adjacent carbon atoms, where one carbon is fully fluorinated and the other is at least partially fluorinated; this definition specifically excludes TFA. In 2023, the EPA said it would take a "case-by-case" approach to what the agency considers a PFAS. Then, in October 2023, the EPA announced a new rule requiring reporting by manufacturers of more than 1,400 PFAS; the definition of PFAS that applies to this rule includes one of the following structures:

- R-(CF2)-CF(R')R", where both the CF2 and CF moieties are saturated carbons;
- R-CF2OCF2-R", where R and R' can either be F, O or saturated carbons; and
- CF3C(CF3)R'R", where R' and R" can either be F or saturated carbons.

The EPA acknowledged that its latest definition "does not include substances that only have a single fluorinated carbon, or unsaturated fluorinated moieties (e.g., fluorinated aromatic rings and olefins)." As such it excludes f-gases and TFA.

Some U.S. states have followed the EPA in their PFAS definition, requiring at least two fully fluorinated carbon atoms and excluding gases, including Delaware and West Virginia. The "at least one fully fluorinated carbon atom" definition of PFAS is being used by at least 23 U.S. states (notably Maine, Minnesota and California), the U.S. Department of Defense and the U.S. Congress.

Canada Seeks Information

Meanwhile, in Canada, two federal agencies, Health Canada and Environment and Climate Change Canada, have been gathering feedback on the content of the agencies' "Revised Risk Management Scope for Per- and Polyfluoroalkyl Substances (PFAS)," which contains proposals for regulating PFAS, including HFOs and HCFOs, as a class.[112] Canada uses the OECD definition of PFAS.

Information sought includes:

- the availability of alternatives to PFAS, or lack thereof, in products and applications in which they are currently used;
- the socio-economic impacts of replacing PFAS, including costs and feasibility of elimination or replacement; and,
- the types, quantities and concentrations of PFAS in products manufactured in, imported into and sold in Canada.

The Revised Risk Management Scope report was released in July 2024, along with the "Updated Draft State of Per- and Polyfluoroalkyl Substances (PFAS) Report," which proposes treating PFAS as a class of chemicals that "may cause harm to human health and the environment."

The Revised Risk Management Scope report addresses HFOs and HCFOs as part of the PFAS class. The report notes that other f-gases, such CFCs, HCFCs and HFCs, are already controlled in Canada under the Ozone-Depleting Substances and

Halocarbon Alternatives Regulations. Should risk management actions on HFOs and/or HCFOs be required, the report adds, "they would be developed in alignment with, and complementary to, existing regulations with controls on PFAS, such as [ODSHAR] and the Prohibition of Certain Toxic Substances Regulations, 2012."

The Updated Draft State of PFAS Report, which calls TFA a PFAS on the basis of the OECD definition, has extensive information on the proliferation of TFA in the environment and its potential health impacts. The Canadian government plans to eventually publish a "Final State of PFAS Report" and an accompanying "Risk Management Approach" document. If the former report confirms that the class of PFAS is toxic, the latter report will outline and seek input on proposed risk management instruments.

Maine on the Move

Maine enacted a sweeping PFAS regulation in 2021[113] and updated it in August 2024[114]. The state has set an effective date of January 1, 2040, for the prohibition on sales of products containing "intentionally added PFAS," including cooling, heating, ventilation, air-conditioning or refrigeration equipment.

Maine defines "intentionally added PFAS"[115] as "PFAS added to a product or one of its product components to provide a specific characteristic, appearance or quality or to perform a specific function." This includes products that consist solely of PFAS under the law, meaning some HFC and HFO refrigerants would be covered by the law, including HFC-125, HFC-134a, HFC-143a, HFO-1234yf, HFO-1234ze(E), HFO-1336mzz(Z) and HFO-1336mzz(E). It would not cover HFC-32, which is not a PFAS.

Maine's updated PFAS law also establishes a "PFAS source reduction program" based on available funding aimed at reducing "the presence of PFAS in discharges to air, water and land by encouraging the use of safer alternatives to, and the proper management of materials containing, PFAS."

Maine's law notes that intentionally added PFAS includes "any degradation byproducts serving a functional purpose or technical effect within the product or its components." That would not apply to TFA. However, HFO-1234yf itself would be covered, thereby preventing the formation of TFA in the atmosphere. TFA may be prohibited as a PFAS by the Maine law in 2032 when bans of PFAS not already banned (except for refrigerants and HVAC&R equipment) go into effect.

3.3 New F-gas Regulations in New York and Washington

New York

In February 2024, the New York State Department of Environmental Conservation (DEC) opened a public comment period on a proposed rule amending the state's HFC regulations which included setting a GWP limit of greater than 10 by 2034 for many types of equipment used in commercial and industrial refrigeration.[116] The amended regulation, DEC's 6 NYCRR Part 494, "Hydrofluorocarbon Standards and Reporting," would notably set 20-year GWP limits, as opposed to the commonly used 100-year GWP limits.[117]

The public comment period was open until March 19, and on March 13 the DEC held a public online hearing to address misconceptions around the regulation, which attracted strong pushback from some retailers in the state concerned that the regulation would require existing equipment to be replaced before the end of its useful life.[118]

The amended regulation, which does not require existing equipment to be replaced before the end of its useful life, was finalized on December 23, 2024.[119] The following prohibition dates pertain to newly installed field-charged systems and newly manufactured systems:

- **Supermarket systems, remote condensing units, cold-storage warehouses and industrial process refrigeration:** regulated substances (f-gases including HFCs, HFOs and blends) with a GWP20 greater than 580 for equipment with refrigerant charge capacity of 50lbs (23kg) or greater, **January 1, 2026**; f-gases with a GWP20 greater than 943 for equipment with refrigerant charge capacity of less than 50lbs, **January 1, 2026**; f-gases with a GWP20 greater than 10, **January 1, 2034**.
- **Stand-alone commercial units (low- and medium-temperature):** f-gases with a GWP100 of 150 or greater, **January 1, 2025**; f-gases with a GWP20 greater than 10, **January 1, 2034**.
- **Ice rinks:** f-gases with a GWP20 greater than 580, **January 1, 2026**; f-gases with a GWP20 greater than 10, **January 1, 2030**.
- **Chillers for comfort cooling:** f-gases with a GWP100 of 700 or greater, **January 1, 2025**.
- **All chillers:** f-gases with a GWP20 greater than 20, **January 1, 2030**.
- **Heat pump chillers for comfort cooling:** f-gases with a GWP100 of 700 or greater, **January 1, 2025**.
- **All heat pump chillers:** f-gases with a GWP20 greater than 20, **January 1, 2034**.
- **Self-contained residential and light commercial air conditioning and heat pump products:** f-gases with a GWP100 of 700 or greater, **January 1, 2026**.
- **All residential and light commercial air-conditioning and heat pumps:** f-gases with a GWP20 greater than 10, **January 1, 2034**.

To help small businesses comply with the phaseout of HFCs from grocery stores and food storage facilities in disadvantaged communities, the DEC is finalizing the development of a new grant program. The DEC issued draft eligibility and guidelines in June 2024[120] and said grant availability and additional details will be provided in the coming months.

New York's new HFC regulations will drive an immediate uptick in the adoption of natural refrigerants in many newly built supermarkets, although the full impact in the commercial sector will take time to realize as existing equipment continues through its useful life. There are 24,000 food retail stores in New York licensed by the state's Department of Agriculture and Markets, a list that includes convenience stores, supermarkets and restaurants.[121]

On the industrial side, there are an estimated 28 refrigerated warehouses in the state.[122] Like in the commercial sector, the immediate impact of this policy will be limited to new developments. One such project is a 132,865 ft^2 (12,343m^2) cold storage facility under construction in West Seneca, near Buffalo.[123] The facility, slated for completion in 2025, will feature approximately 20,000 pallet positions and use a low-charge ammonia refrigeration system.

Washington

A new Washington State Department of Ecology regulation restricting the GWP of f-gases in new and retrofitted commercial and industrial refrigeration equipment – along with residential air conditioners and dehumidifiers – became law in 2024.[124]

Starting in 2025, the sale of new commercial and industrial refrigeration equipment (excluding chillers) that uses refrigerants with a GWP greater than 150 will be banned. For retrofit systems, the ban comes into effect in 2029. The regulation applies to equipment with a refrigerant charge of more than 50lbs. Beginning in 2029, the sale of new and retrofitted industrial chillers with a GWP greater than 750 is also banned.

The regulation also applies fees to operators of commercial and industrial refrigeration equipment using refrigerants with a GWP greater than 150 in systems with a charge of more than 200lbs (90.7kg). Starting in 2026, operators of equipment with a charge of 200–1,499lbs (679.9kg) of refrigerant will pay annual fees of $170 (€155), while systems requiring 1,500lbs (680.4kg) of refrigerant or more will owe a one-time fee of $150 (€137) and an annual fee of $370 (€338). The funds will be used to administer the state's new refrigerant management program, overseen by the Department of Ecology, which requires end users to record their HFC usage and take measures to repair leaks.

The Department of Ecology has also set leak rate thresholds for commercial operators using equipment with more than 50lbs of refrigerant. The thresholds use a 12-month rolling average, with businesses required to calculate leaks every time they're inspected for them or when new refrigerant is added. The threshold for commercial refrigeration is 16%, and for industrial process refrigeration it's 24%.

Businesses will be required to report all leaks to the Department of Ecology and will have to complete repairs within 14 days using a certified technician or within 45 or 120 days if an allowance is granted. The law authorizing the regulations was signed by Governor Jay Inslee in May 2021.[125]

3.4 CARB Opens Second Round of FRIP Program Funding

The California Air Resources Board (CARB) opened submissions for the second round of funding under its F-gas Reduction Incentive Program (FRIP) for commercial and industrial refrigeration in October 2024.[126] FRIP was open for submissions from October 14 to January 31, 2025, and targeted three primary sectors: retail food refrigeration, industrial and cold storage and other refrigeration.

A total of $65 million (€58.2 million) has been allocated to the program, of which $38.5 million (€34.5 million) is dedicated to replacing refrigeration systems with more than 50lbs of refrigerant in existing commercial and industrial facilities.

Of the rest, $2 million (€1.7 million) will go toward commercial and industrial refrigeration facilities with systems using less than or equal to 50lbs of refrigerant, $18 million (€16.1 million) is earmarked for sectors to be determined and $6.5 million (€5.8 million) is budgeted for administration of the program.

To be eligible for an award, a store or facility must have equipment using an f-gas that meets the minimum GWP and refrigerant charge requirements:

- For retail food refrigeration, all existing systems being replaced must have a GWP greater than 1,300, with no minimum charge requirement.
- For industrial process refrigeration, all existing systems being replaced must have a GWP of more than 1,800 and a minimum sum refrigerant charge of 2,000lbs (907kg).
- For cold storage and other refrigeration, all existing systems being replaced must have a GWP of more than 1,800 and a minimum sum refrigerant charge of 1,000lbs (454kg).

FRIP provides funding to replace these systems with ones using ultra-low-GWP refrigerants, defined as those with a GWP of less than 10. With GWPs of 3, 1 and 0, CO_2, propane and ammonia all easily meet the program requirements.

Of the $65-million total, $18.2 million (€16.3 million) has been set aside for companies operating large retail food chains, defined as those with 20 or more locations. A total of $12.3 million (€11 million) is being made available to retail stores with fewer than 20 locations. A further $5 million (€4.4 million) will be available for industrial process refrigeration facilities and $3 million (€2.6 million) for cold storage and other refrigeration.

FRIP awards differ depending on the type of system replacement: full system replacements receive larger awards, while partial replacements receive less. In addition, incentive awards vary depending on the project type and sector.

The First Round of FRIP Funding

Launched in 2020, FRIP initially provided $1 million (€910,000) in funding from the Greenhouse Gas Reduction Fund to support the installation of low-GWP refrigeration equipment in the food retail sector.[127]

With this funding, CARB supported 15 installations across the state – four of which were store remodels, while the remaining 11 were at new premises. The majority of the funded projects used CO_2-based technologies.

To date, FRIP has proven to be one of the most impactful and cost-effective programs administered by CARB, costing just $27 (€24.70) per metric ton of CO_2e saved. In comparison, California's Urban Greening and Community Solar programs cost $2,614 (€2,390) and $204 (€186), respectively, for every metric ton of CO_2e mitigated.[128]

With an additional $65 million in funding from the state's 2022–23 and 2023–24 budgets, FRIP aims to accelerate California's transition to climate-friendly refrigerants as the state works to reduce its use of HFCs by 40% below 2013 levels by 2030.

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3.5 Hydrocarbon Standards in the U.S.

Commercial Applications

In 2019, the International Electrotechnical Commission (IEC) updated its IEC 60335-2-89 standard, increasing the allowable charge of A3 flammable hydrocarbons like R290 from 150g to 500g in commercial cases. The standard-setting agency Underwriters Laboratories (UL) subsequently approved its 2nd edition of UL 60335-2-89 in October 2021 to include higher charge limits for A3 hydrocarbons and A2L refrigerants in the same equipment types.

UL 60355-2-89 covers safety requirements for commercial refrigeration appliances and ice makers with an incorporated or remote refrigerant unit or motor compressor. The 2nd edition of UL's standard raised the hydrocarbon charge limit in closed cases to 300g and 500g in open cases.[129] The prior limit for commercial cases was 150g.

Canadian Standards Association (CSA) 60355-2-89 covers the same equipment and allows the same hydrocarbon charge limits. The American Society of Heating, Refrigeration and Air-Conditioning (ASHRAE) also incorporated UL 60355-2-89 into its ASHRAE 15 standard for refrigeration safety.

In May 2024, the U.S. Environmental Protection Agency announced the finalization of its Significant New Alternatives Policy 26 rule, which aligns hydrocarbon charge limits with those outlined in UL 60355-2-89 for self-contained commercial cases and ice makers.[130] The rule also enables R290 to be used as a refrigerant in refrigerated food processing and dispensing equipment.[131]

Several states, including California, Colorado, Maine, New York, Texas and Washington, had legislation to accept the 2nd edition of UL 60355-2-89 once the EPA adopted it with SNAP 26. According to the Environmental Investigation Agency (EIA), 11 other U.S. states had previously adopted the UL standard in updated state building codes.[132]

Industrial Applications

SNAP 26 only applies to indoor self-contained cases. Currently, larger custom-built equipment requires case-by-case approval from local jurisdictions. Some companies, like Colorado-based New Belgium Brewing, are taking the initiative to decarbonize. American manufacturer G&D Chillers installed a propane chiller for the brewery in early 2024.

According to Paul Johnson, Director of Technology and R&D at G&D Chillers, the company's Elite R290 line applies several different U.S. standards, including those from UL, International Code Council and ASHRAE 15/34, which eases obtaining local approval.[133]

The U.S.-based International Institute of All-Natural Refrigeration (IIAR) is developing a safety standard for large-scale closed-circuit hydrocarbon refrigeration systems. The new hydrocarbon standard applies to propane, butane and isobutane and restricts the total hydrocarbon refrigerants onsite to 1,100lbs (500kg). The local authority having jurisdiction can approve higher charges.

IIAR received 161 comments during the first public review of the proposed standard. The organization set a second 45-day public review for the updated hydrocarbon standard with substantive changes from October 25 to December 5, 2024.

At the 2024 ATMOsphere America Summit held in June 2024, Tony Lundell, Senior Director of Standards and Safety at IIAR, said the hydrocarbons standard would be ready for review by the EPA SNAP team in 2025.[134]

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3.6 Trump-Linked Project 2025 Calls for Repeal of 'Unnecessarily Costly' HFC Regulations

The 2025 Presidential Transition Project – known as Project 2025 – recommends in its section on the U.S. EPA that a future Trump administration repeal Biden administration HFC regulations authorized by the American Innovation and Manufacturing (AIM) Act "that are unnecessarily stringent and costly." [135]

Project 2025, an almost 900-page collection of conservative policy proposals, was organized by the Heritage Foundation, a Washington, D.C.-based think tank, and has been tied to President Donald Trump.

During the presidential campaign against Democrat Kamala Harris, Trump distanced himself from the report but since the election has reversed course, nominating Russ Vought, one of the architects of Project 2025, to lead the White House Office of Management and Budget.[136] In addition, Trump transition officials are taking suggestions for potential hires from the extensive personnel database created by Project 2025.[137] Well over half of Project 2025's 307 authors and contributors have been in Trump's administration or on his campaign or transition teams.[138]

The author of Project 2025's EPA section, Mandy Gunasekara, served as Chief of Staff of the EPA during the first Trump administration. She has been Director at the Independent Women's Forum's Center on Energy and Conservation.

The AIM Act, a bipartisan bill supported by the HVAC&R industry, was enacted on December 27, 2020 (during the first Trump administration). It authorizes the EPA to phase down the production and import of HFCs, manage these HFCs and their substitutes and facilitate the transition to next-generation technologies through sector-based restrictions. The EPA has finalized regulations for all three phases, most recently the management rule.

Project 2025's EPA section did not indicate which regulations under the AIM Act it thought were unnecessarily stringent and costly. The section also urges that a Republican-led EPA, in implementing the AIM Act, "refrain from granting petitions from opportunistic manufacturers to add new restrictions that further skew the market toward costlier refrigerants and equipment," without indicating which refrigerants and equipment were costlier.

The section also asks that the EPA "conduct realistic cost assessments" of the AIM Act "that reflect actual consumer experiences instead of the current unrealistic ones claiming that the program is virtually cost-free." The EPA has disclosed that, in addition to the climate benefits from avoided emissions of HFCs, the Technology Transitions part of the AIM Act alone "provides up to $4.5 billion [€4.2 billion] in cost savings to consumers and businesses," largely driven by the lower cost of HFC substitutes and increased energy efficiency of products using lower-GWP substitutes.[139]

Other provisions of Project 2025's EPA section related to the HVAC&R industry include:

- If a new Risk Management Program (RMP) rule is finalized by the Biden administration, "it should be revised to reflect the amendments finalized in 2019 to protect sensitive information."
- The designation of PFAS as "hazardous substances" under CERCLA (the Comprehensive Environmental Response, Compensation and Liability Act), also known as Superfund, should be "revisited."

The RMP requires end users of more than 10,000lbs (4,536kg) of ammonia to ensure a safe working environment. The Biden EPA announced finalized amendments to the RMP on March 1, 2024. In 2019, the Trump EPA rescinded parts of the RMP.

Long-chain PFAS like PFOA and PFOS have been linked to cancer and other serious health effects, and the Biden administration set aggressive new drinking water restrictions on these and other PFAS in April 2024. However, the Biden EPA did not define f-gases like HFOs, and their degradation product trifluoroacetic acid as PFAS, though scientists believe it should, and the EU and many U.S. states define PFAS to include f-gases and TFA.

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Trump on Climate, Energy

According to his campaign website, Trump intends to substantially increase the production of domestic fossil-fuel energy resources, promote "energy security" and "eliminate the Green New Deal."[140]

Trump has vowed to rescind unspent funds earmarked for climate provisions contained in the Biden administration's Inflation Reduction Act (IRA), which includes incentives and rebates for heat pumps.[141] He also said he would reverse Biden's policies restricting greenhouse gas emissions and targeting 67% of new vehicles to be electric by 2032. Trump can also be expected to pursue policies adopted during his first administration, including:

- Withdraw again from the Paris climate accord. Trump has called climate change a "hoax" and relies on inaccurate talking points.[143]
- Reduce EPA regulations. The first Trump administration dismantled major climate policies and rolled back more than 100 rules governing clean air, water, wildlife and toxic chemicals.[144]

To implement his priorities, Trump has nominated New York's former U.S. Representative Lee Zeldin to run the EPA.[145]

States Commit to Climate Protection

In the face of potential regulatory rollbacks by the EPA under the second Trump administration, the U.S. Climate Alliance, a bipartisan coalition of 24 governors, has recommitted itself to protecting the climate.[146]

"The U.S. Climate Alliance and its governors filled the void of leadership during [President] Trump's first term and Americans can be assured we're prepared to fill it again," said New York Governor Kathy Hochul, Co-Chair of the Alliance, in a statement. "Together, we'll tap every ounce of our experience and authority to protect America's progress and press forward."

"We're not alone in this fight – we stand shoulder-to-shoulder with hundreds of cities, Tribes, businesses and institutions that are fiercely committed to protecting our climate and delivering a better, healthier future for America," said New Mexico Governor Michelle Lujan Grisham, the Alliance's other Co-Chair. "Governors have a decades-long track record of advancing innovative, effective climate solutions, and we won't be deterred by the result of this or any other election. No matter the obstacles, our commitment will not waver, and our progress will not be stopped."

The U.S. Climate Alliance was launched on June 1, 2017, by the governors of Washington, New York and California to help fill the void left by the previous Trump administration's decision to withdraw the U.S. from the Paris Agreement. Consisting of the governors of 22 U.S. states, Guam and Puerto Rico, the Alliance represents nearly 55% of the U.S. population and 60% of the U.S. economy.

Several Alliance states, most notably California, Washington and New York, have pursued regulations to aggressively restrict HFC emissions, in some cases enacting rules that are stricter than those of the AIM Act. The North American Sustainable Refrigeration Council has published an interactive map showing the refrigeration initiatives of U.S. Climate Alliance states.[147]

In October 2024, the Alliance released its annual report, "No Turning Back: America's Governors Confronting the Climate Crisis & Building a Brighter Future." Notably, the report said that between 2005 and 2022, Alliance members reduced collective net greenhouse gas emissions by 19%, while increasing gross domestic product by 30%.

Governors in the Alliance have pledged to collectively reduce greenhouse gas emissions by at least 26–28% below 2005 levels by 2025 and at least 50–52% below 2005 levels by 2030 and collectively achieve overall net-zero greenhouse gas emissions as soon as practicable, though no later than 2050.

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3.7 North American Market Data: Stores Using Natural Refrigerants

Total Addressable Market

In 2024, there were an estimated 61,626 supermarkets and grocery stores[148] and 152,396 convenience stores[149] in the U.S. and an estimated 8,936 supermarkets and grocery stores[150] and 9,432 convenience stores in Canada.[151] In total, there were approximately 70,562 supermarkets and grocery stores along with 161,828 convenience stores in North America for a combined 232,390 retail food stores.

The total number of food retail stores in North America increased by 0.4% (231,443 total store) from 2023 to 2024. In 2022, the total number of food retail stores in North America was 229,452, and in 2021 it was 193,180. From 2021 to 2024, the total number of supermarkets, grocery stores and convenience stores in North America has grown by 20%.

TRANSCRITICAL CO_2 RACKS

The Market Today

According to data collected by ATMOsphere, as of December 2024, there were approximately 4,100 food retail stores in North America using transcritical CO_2 systems, up 40% from 2,930 in 2023. Of these 4,100 food retail stores, 2,800 are in the U.S. and 1,300 are in Canada.

In the U.S., 93% of the CO_2 store systems were for new construction, according to manufacturers, with the remainder for retrofits/remodels in existing stores. In Canada, the figure was 74% new construction and 24% retrofits/remodels.

The market penetration of transcritical CO_2 systems in the estimated 70,562 North American supermarkets and grocery stores is 5.8%, up from 4.1% a year ago. When considering convenience stores as well, the market penetration out of 232,390 retail food stores in North America is 1.8%, up from 1.27% in 2022.

There were also 870 industrial sites using transcritical CO_2 in North America as of December 2024, for a total of **4,970** transcritical CO_2 sites. (See chapter 3.8 for more detail on industrial sites.)

Behind the Numbers

After years of a slow but steady rollout, the AIM Act and state regulations (see chapter 3.3) limiting the GWP of refrigerants used in commercial refrigeration systems has driven a surge in adoption of transcritical CO_2 racks in supermarkets and grocery stores.

A 2024 survey by the NASRC of 14 major U.S. food retailers – representing more than 28,000 store locations – found that the number of stores using transcritical CO_2 refrigeration systems is projected to grow by 176% from 2024–2028, with the number of secondary CO_2 systems (which include cascade systems) projected to increase by 620%.[152] The NASRC projects that 22% of the 28,000 stores will use transcritical and secondary/cascade CO_2 systems by 2028.

Manufacturers are responding to the regulatory developments by bringing new CO_2 products and components to the market. Carrier Commercial Refrigeration (CCR) announced in May 2024 that its transcritical CO_2 racks, heat pumps and condensing units would be available in North America[153]. Several manufacturers at the 2024 FMI Conference said they're bringing new CO_2 refrigeration systems and components to market, including condensing units.[154]

The market for CO_2 condensing units in commercial refrigeration appears ready for growth as more manufacturers enter the market. In addition to CCR, American manufacturer Zero Zone launched a CO_2 condensing unit at the 2024 IIAR Conference,[155] and Hussmann, a Panasonic subsidiary, announced in December 2024 that it would offer a 4HP CO_2 condensing unit that can support remote food retail display cases.[156]

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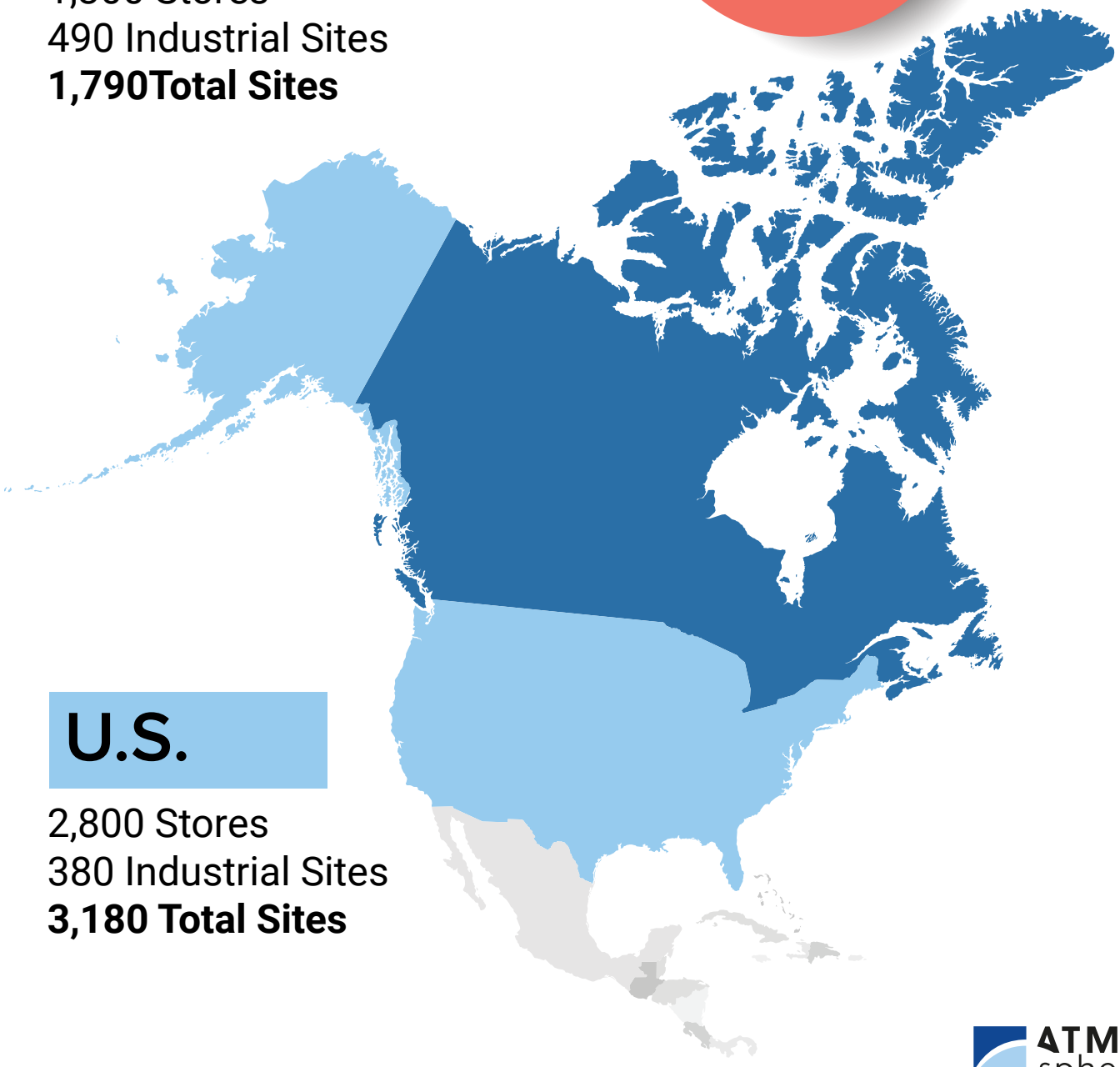
Figure 17: Transcritical CO_2 Installations in North America

(as of December 2024)

4,970
sites with transcritical CO_2

Canada

1,300 Stores
490 Industrial Sites
1,790Total Sites



U.S.

2,800 Stores
380 Industrial Sites
3,180 Total Sites

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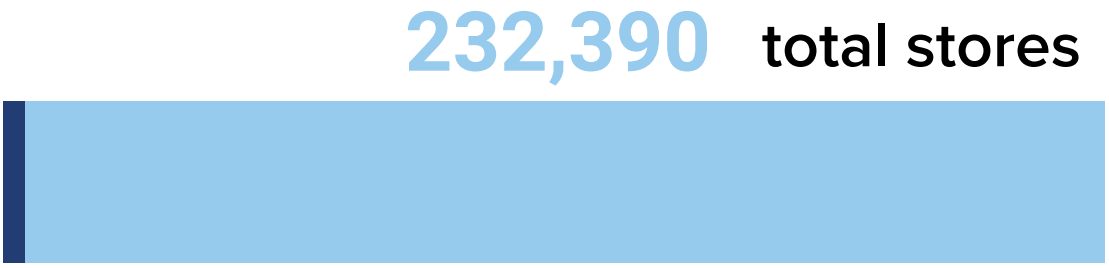
Figure 18: Transcritical CO_2 Commercial Refrigeration Market Penetration in North America



1.8% transcritical CO_2 stores

5.8% transcritical CO_2 stores

Figure 19: Transcritical CO_2 Installation Growth in North America

(stores)

2022	1,605
2023	2,930
2024	4,100

U.S.

2022	1,030
2023	1,850
2024	2,800

Canada

2022	575
2023	1,080
2024	1,300

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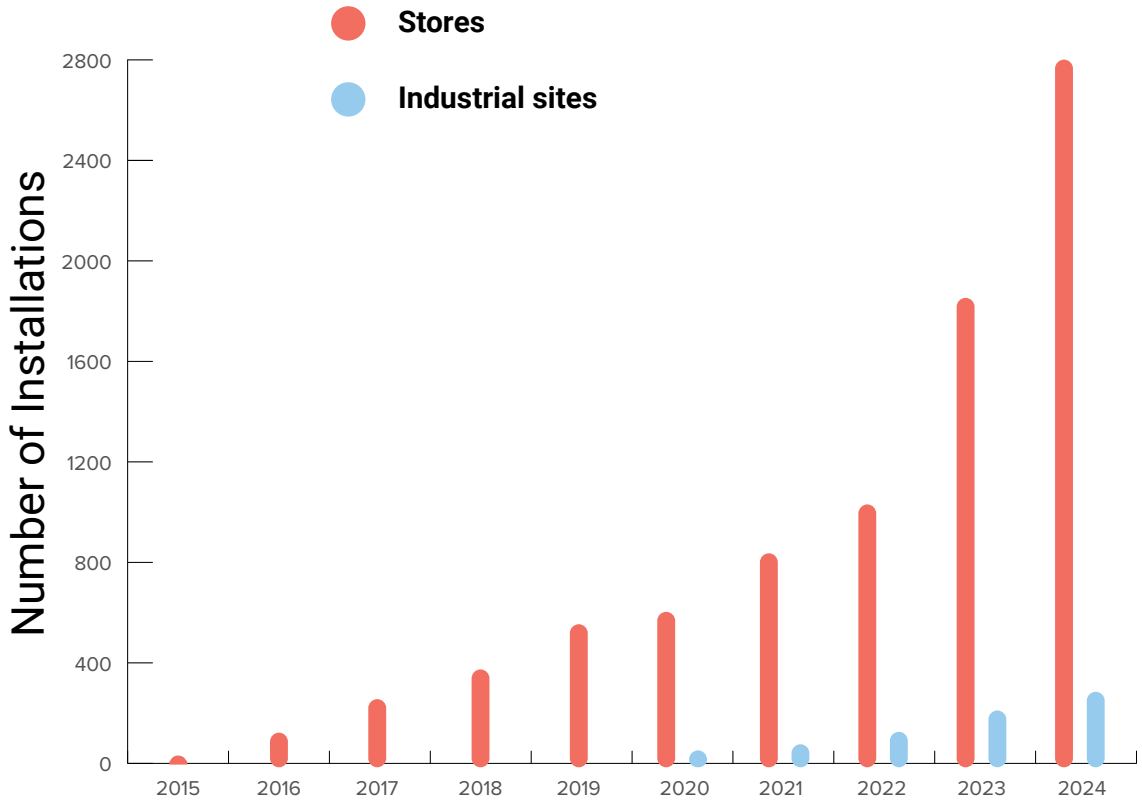
Figure 20: Transcritical CO_2 Installation Growth in the U.S.

(stores and industrial sites)



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

HYDROCARBON SELF-CONTAINED CASES

The Market Today

Using data collected from a survey of OEMs as well as insights from trusted industry sources, ATMOsphere estimated 3.8 million self-contained hydrocarbon (mostly R290) cases installed in U.S. food stores and 800,000 cases installed in Canadian food stores by December 2024. In total, there are an estimated **4.6 million** self-contained hydrocarbon cases installed in North American food stores.

This is a significant increase from the previous year when we estimated there to be 928,000 self-contained hydrocarbon cabinets installed in U.S. food stores; data was not gathered for Canada in 2023. This higher estimate is the result of better and more complete data, gathered from a combination of manufacturers, OEMs and trusted industry sources.

As the data gathered is historical, the increase from 928,000 to 4.6 million self-contained hydrocarbon cabinets in North America should not be interpreted as a year-over-year gain. It is our new baseline for Europe, and as such we do not refer to estimates from previous years in this report.

Our data collection process, as well as the model underpinning our analysis, is continually being refined. This year's iteration resulted in a more complete look at the global market for self-contained hydrocarbon cabinets, which were undercounted in previous reports.

Behind the Numbers

While the market for self-contained hydrocarbon cabinets in North America is not as developed as in Europe, the shift away from f-gases is already well underway. One trusted industry source told ATMOsphere that hydrocarbon cabinets have taken a 50% market share in the commercial cabinet sector in North America.

Moreover, R600a and R290 cabinets make up more than 90% of the EPA's Energy Star certified commercial refrigerators and freezers in both the U.S. and Canada.[157] The Canadian market for hydrocarbon self-contained cabinets was estimated to be 10–12% of the U.S. market.

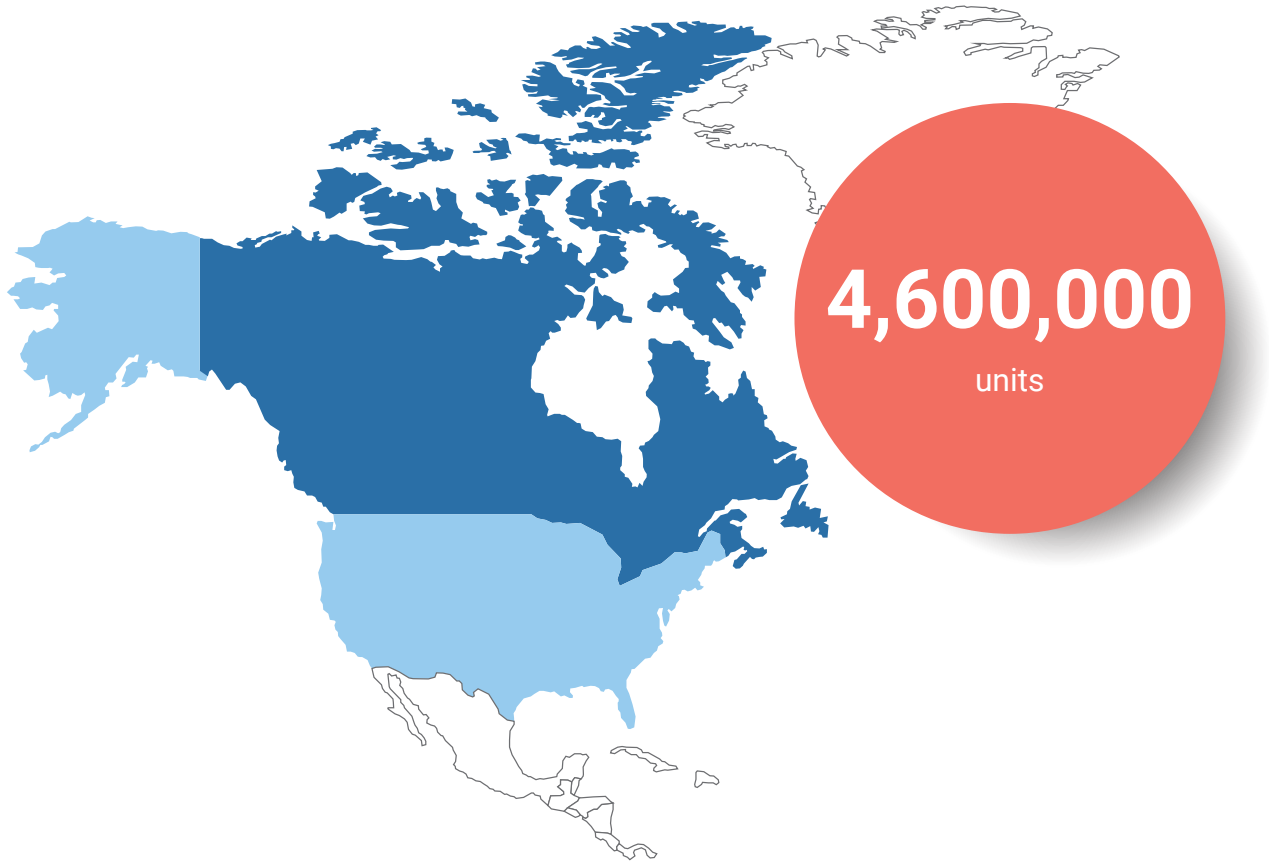
January 2025 marks the start of the EPA's requirement that new commercial cabinets use refrigerants with a GWP of less than 150, eliminating many f-gases from consideration over the next three years as inventories are cleared.[158] Some HFO blends with a GWP below 150 can still be used (R455A, GWP 145; R454C, GWP 148). However, these contain HFO-1234yf, which may ultimately be regulated as a PFAS; it degrades in the atmosphere into TFA, which is also a PFAS (see chapter 3.2).

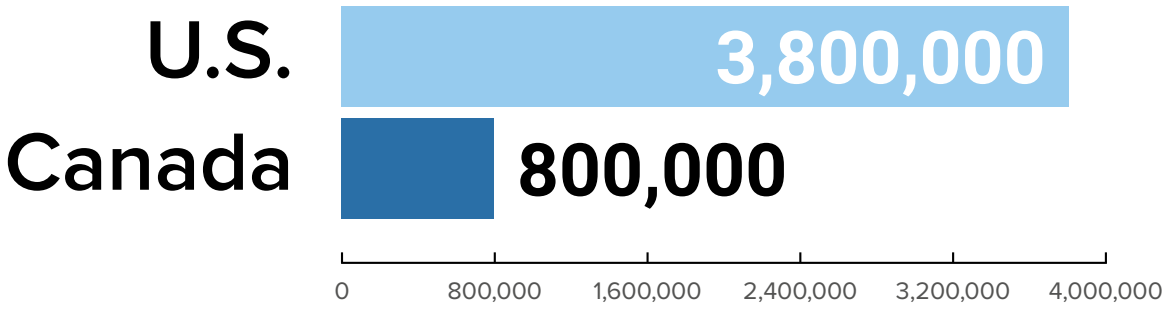
In May 2024, the EPA finalized the SNAP 26 rule (see chapter 3.5), raising the R290 charge limits for self-contained commercial cabinets from 150g to 300g for closed cases (those with doors) and to 500g for open cases (those without doors).

Given the three-year sell-through period for previously manufactured or imported cabinets using a refrigerant with a GWP of more than 150, the higher charge limits may not impact the number of hydrocarbon self-contained cases in stores in the short term. In addition, the larger charges would enable the production of larger cases, which could eventually reduce the number of installed cases, although the number of installed doors (another way of measuring case numbers) may remain unchanged.

Figure 21: Self-Contained Hydrocarbon Cabinets Installed in North America

(as of December 2024)





3.8 North American Market Data: Industrial Sites Using Natural Refrigerants

TRANSCRITICAL CO_2

The Market Today

As of December 2024, there were **870** industrial sites using transcritical CO_2 in North America, 17% of the total of **4,970** transcritical CO_2 sites. (See chapter 3.7 for more detail on store sites.) The 870 industrial sites, which represents a 74% increase from the 498 North American sites in 2023, consists of 380 in the U.S. (up from 208 in 2023) and 490 in Canada (up from 290 in 2023).

Behind the Numbers

Mathieu Cardinal, CEO of Canadian refrigeration systems manufacturer RefPlus, said during the 2024 IIAR Conference that demand for the industrial CO_2 racks is "booming" in the U.S.[159] Frédéric Houle, Sales Director at Evapco LMP, a Canadian subsidiary of the U.S.-based manufacturer Evapco, said in a September 2024 interview that the company is seeing a "big trend in demand" for industrial CO_2 refrigeration systems in North America.[160]

Industrial CO_2 condensing units are also growing in availability. Hussmann's recently launched 4HP CO_2 condensing unit supports warehouse unit cooler applications, and the company plans to bring a 10HP unit to market in 2025 to accommodate larger warehouses.[161] At the 2024 RETA Conference, RefPlus said it had installed its first industrial CO_2 condensing unit at a facility in Quebec.[162]

U.S. manufacturer Copeland launched the production of its Vilter-branded industrial CO_2 compressor unit, which uses single-screw compressors for transcritical applications, subcritical applications or both, in April 2024.[163] The large-capacity CO_2 compressors "reduce the complexity of industrial refrigeration operations by reducing the number of components required for larger systems."

LOW-CHARGE AMMONIA

The Market Today

As of December 2024, ATMOsphere estimates there were **1,230** industrial sites using low-charge (below 1.3kg/kW or 10.1lbs/TR) ammonia systems in North America, an increase of 17% over the number a year ago, including **152** with packaged units and **1,078** with central systems.

The 1,230 industrial sites equate to 842 sites (717 with central and 125 with packaged systems) in the U.S. and 388 (361 central and 27 packaged) in Canada.

As of December 2023, there were 1,045 industrial sites with installations of low-charge ammonia systems in North America, including 110 with packaged units and 935 with central systems. In the U.S. there were 715 industrial sites (627 with central and 88 with packaged systems), and in Canada there were 330 (308 central and 22 packaged).

Behind the Numbers

The year-over-year growth rate for packaged units was 38% compared to 15% for central systems. The growth of packaged units is reflected in the growth of Evapco, a leading manufacturer of low-charge ammonia systems. The company announced in February 2024 that it was expanding its Maryland headquarters by 45,000ft^2 (4,180m^2) and making 275 new hires.[164]

Evapco also announced a new product in 2024: an evaporator for its low-charge ammonia packaged refrigeration units that uses an ejector to raise the capacity and efficiency of a direct expansion (DX) evaporator almost to the level of a pumped liquid recirculation unit while offering the low charge and stable operation of a DX system.[165]

American manufacturer Frick Industrial Refrigeration, a subsidiary of Johnson Controls, released a packaged heat pump, SmartPAC, that piggybacks on an ammonia refrigeration system to provide up to 190°F (87.8°C) hot water.[166] SmartPAC is designed to replace boilers — typically used for heating water for industrial cleaning processes — by using the saturated ammonia leaving the refrigeration system's condensers as a refrigerant and heat source.

Figure 22: Growth of Transcritical CO_2 in North America

(industrial sites)

2022	290
2023	498
2024	870

U.S.

2022	120
2023	208
2024	380

Canada

2022	170
2023	290
2024	490

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Figure 23: Installations of Low-Charge Ammonia Systems in North America

(industrial sites as of December 2024)

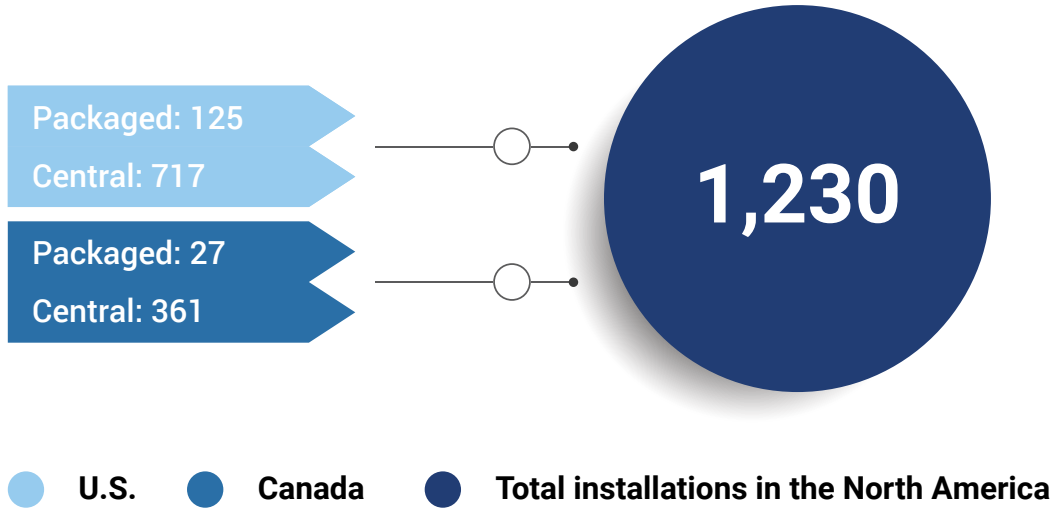
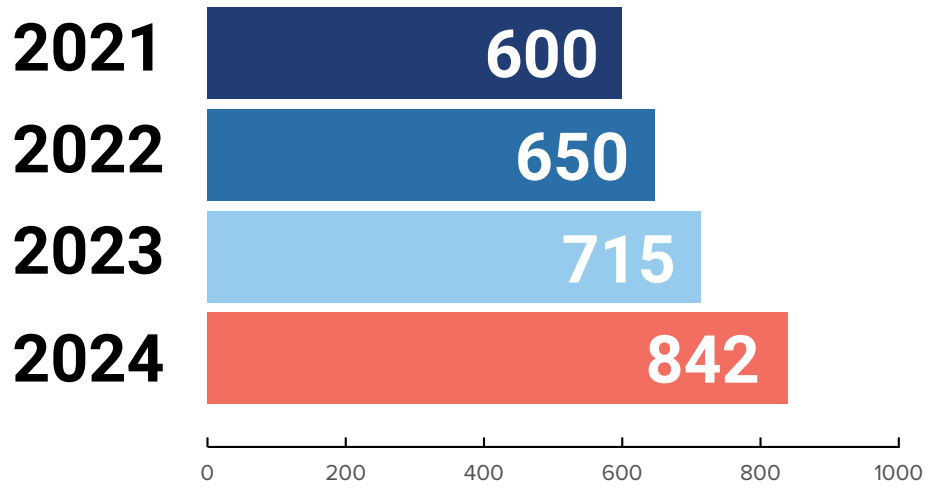


Figure 24: Growth of Low-Charge Ammonia in the U.S.

(industrial sites)



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CHAPTER 4

Japanese Trends

4.1 The Japanese Food Industry: Economic Outlook

Japan supermarket retail sales grew 3.5% from ¥15.15 trillion ($98 billion/€93.3 billion) in 2022 to ¥15.64 trillion ($100 billion/€95.2 billion) in 2023.[167] According to the country's Ministry of Economy, Trade and Industry Statistics Bureau, supermarket sales in September 2024 accounted for ¥1.3 trillion ($8.4 billion/€8 billion), representing a 2.1% increase in sales from September 2023.[168]

In 2023, supermarkets accounted for 44.9% of food retail sales in Japan, while convenience stores represented 29.1%; the rest came from department stores (5.9%), drug stores (9.6%) and the internet (10.9%).[169]

The demand for chilled and frozen foods in Japan continues to rise, fueled by all population segments. Frozen food and meal pack sales have climbed in supermarkets, drugstores and convenience stores. As a result, the diversity of frozen products has increased.

Drug store sales in Japan continue to increase due to adding food products, including fresh produce, ready-made meals, snacks and beverages. The number of convenience stores in Japan, called konbini, has also increased. In addition to building more stores, owners have increased the freezer space per konbini. The wide selection of ready-made meals and frozen foods makes it easier for on-the-go consumers to obtain food.

The Japanese cold chain logistics market is expected to grow from ¥3.93 trillion ($25.52 billion/€24.3 billion) in 2024 to ¥4.13 trillion ($26.8 billion/€25.5 billion) in 2029 at a CAGR of 5.0%.[170] As of April 2024, Japan's cold storage space is insufficient for the demand, with the facilities in several cities either filled or near capacity.[171]

Most cold storage facilities in Japan are owned and operated by major cold chain corporations, with only a small number available for lease. However, the demand for cold storage has led to the construction of multi-tenant facilities, with 20 such properties slated for completion by the end of 2026 in the Greater Tokyo and Osaka areas.

Roughly 54% of Japan's logistic facilities are more than 30 years old. Energy efficiency standards and HCFC restrictions will necessitate the redevelopment of some of these warehouses over the mid-to-long-term.[172]

Current labor shortages in Japan are driving the construction of facilities with automated warehouse processes. A new regulation that went into effect in April 2024 limiting truck driver hours could create the need for new cold storage locations between large cities. Other cold storage construction growth factors include advancements in biopharmaceuticals and the continued growth of e-commerce for frozen and chilled goods.

Figure 25: Japan Food Retail Sales, 2021-2023

(trillion Yen)

Source: Ministry of Economy, Trade and Industry, Statistics Bureau of Japan

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Energy Saving 20 - 40 %	Super Green is equipped with a high-performance compressor manufactured by Danfoss BOCK and BITZER of Germany, and all compressors are individually optimally controlled by an inverter to achieve energy savings of 20-40% per year compared to HCFC R22 refrigeration system.
Safety	CO_2 is odorless, non-toxic, non-flammable, and easy to handle. The amount of refrigerant stored inside is also minimized, and even if it leaks, there is no harmful effect on people and environment.
BCP	Super Green is air cooled system. The system can be returned to operation even under disaster once electricity is restored. The system is not affected by water outages.

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4.2 Increased Uptake of Subsidies Among SMEs

In the summer of 2023, the Japanese Ministry of the Environment (MOE) announced it would continue its natural refrigerant equipment installation subsidy project through the fiscal year 2027 with a budget of ¥7 billion ($48.7 million/€42.5 million) for the fiscal year 2023.[173] In addition, the MOE said it changed the program to make it more accessible to small- and medium-sized enterprises.

The changes included making the application process easier and relaxing the equipment installation schedule. The maximum subsidy available was also raised from one-third of the construction costs to one-half. The changes have had the desired effect, according to Teruo Kogu, Director of the Office of Fluorocarbons Control Policy at the MOE.[174]

Kogu, speaking at the ATMOsphere APAC Summit 2024, held in Tokyo in February, said the program saw a 10% increase in the number of SMEs receiving subsidies and a 10% increase in food retailer renovation projects. Kogu cited the increased maximum subsidy as the driving force behind the gains.

Convenience stores in Japan are already using natural refrigerants, particularly CO_2, according to Gaku Shimada, General Manager of the Condensing Unit Engineering Department at Panasonic.[175] Shimada said Japanese supermarkets are still resistant to the idea of adopting CO_2-based refrigeration systems, with costs being one of their biggest concerns. The government's subsidy program helps allay those fears by reducing the payback period for CO_2 systems.

"Without subsidies, the payback period for CO_2 systems is typically five–eight years," Shimada said. "With government support, the payback period can be almost zero. The Japanese government is positive about natural refrigerants and is always supporting us."

Requirements for Large Companies

Applicants classified as "large companies" by the MOE must meet more strenuous requirements than those classified as SMEs.[176]

All refrigerated and cold storage warehouses and food manufacturing plants must commit to only using natural refrigerant-based refrigeration and freezing equipment in the future. For food retail stores, the requirement is that natural refrigerant systems will be installed in more than 50% of new stores and stores that have been completely renovated and require the replacement of refrigerated units. The ratio of natural refrigerant equipment installed per store does not matter.

These goals for moving to natural refrigerant systems must be publicly announced.

In addition, large companies must meet at least one or more of the following evaluation criteria from the below two categories.

Initiatives to Utilize Renewable Energy:

- Introduction of renewable energy power generation equipment (for self-consumption)
- Purchase of renewable energy electricity
- The above (either alone or in conjunction) must cover 5% or more of the business's electricity consumption.
- Introduction of demand response for using renewable energy
- Introduction of storage batteries for using renewable energy
- Participating in the "100% Renewable Energy Declaration"
- Joining RE100, a global campaign where multinational companies commit to sourcing 100% of their electricity from renewable sources
- External publication of a voluntary declaration equivalent to any of the above

High-Level Energy Conservation Initiatives:

- Utilization of waste heat from freezers (refrigerated warehouses and food manufacturing plants)
- Improvement of heat insulation and heat shielding of facilities (refrigerated and freezer warehouses)
- Introduction of showcases with doors (food retail stores)

Project Results

There were two rounds of applications for the natural refrigerant subsidy project in 2023, with 157 applicants receiving funding for 426 projects.[177] There was just one application round in 2024, which saw 110 applicants receiving funding for 269 projects. Some of the funding recipients include AEON (11 projects), 7-Eleven (27 projects), Lawson (20 projects) and FamilyMart (76 projects). Many of the projects funded were for convenience stores.

4.3 Gains in the Cold Storage Sector

Japan's use of natural refrigerants in its cold storage sector has steadily increased since the country ratified the Kigali Amendment in 2018, according to information shared with the UN Environment Programme (UNEP) by Yutaka Matsuzawa, the country's Vice Minister for Global Environmental Affairs. As of January 2024, 43% of the country's refrigerated warehouses use natural refrigerants.[178]

At the ATMOsphere APAC Summit 2022, Japan's Association of Refrigerated Warehouses shared data showing that 40% of the warehouses operated by its members – which represent around 90% of the total sector – used natural refrigerants.[179] The share of the association's members using natural refrigerants increased to 51.4% in 2023[180] and has been rapidly growing every year since 2015.

While many Japanese cold storage warehouses still use HCFCs, such as R22, in their refrigeration systems, companies that have made the switch to natural refrigerants have seen notable benefits.

Marine Access, a frozen tuna producer, reported a 15% energy savings after replacing its R22- and R23-based refrigeration equipment with natural refrigerant-based systems provided by Japanese manufacturer Mayekawa.[181] Marine Access employed a combination of Mayekawa equipment, which included its air-cycle refrigeration system, ammonia/CO_2 secondary refrigeration system and transcritical CO_2 condensing unit.

Marine Access replaced the R22- and R23-based refrigeration systems at a cold storage warehouse with a nominal refrigeration capacity of 8,000TR (28,134kW) with seven air-cycle refrigeration systems and a low-charge ammonia/CO_2 system. At another cold storage warehouse with a nominal refrigeration capacity of 3,000TR (10,550kW), Marine Access replaced the R22- and R23-based refrigeration systems with three air-cycle units and a CO_2 condensing unit.

Frigo, a Japanese cold chain logistics service provider, said its distribution center in Sakishima uses 48% less energy than the 2030 efficiency target set by the JARW because of its CO_2 refrigeration system.[182] In addition to refrigeration, the CO_2 equipment also provides dehumidification, defrosting and hot water from heat recovery.

4.4 Japanese Market Data: Stores and Industrial Sites Using Transcritical CO_2

Total Addressable Retail Market

There were an estimated 55,692 convenience stores in Japan as of December 2024, a decrease of 0.18% from 2023 (55,790).[183] There were an estimated 21,261 supermarkets in Japan as of December 2024, an increase of 0.12% from the previous year (21,236).[184] Combined, this amounted to 76,953 food retail outlets in Japan in 2024, a decrease of 0.1% from the prior year (77,023).

The Retail Market Today

As of December 2024, there were **12,250** stores, including **11,500** convenience stores and **750** supermarkets, using transcritical CO_2 systems (mostly condensing units), up 46% from the 8,385 stores (7,800 convenience stores/585 supermarkets) reported in December 2023. With **470** industrial site installations, the total number of transcritical CO_2 installations in Japan was **12,720** sites.

In 2024, the convenience store sector's installations of transcritical CO_2 grew by 47% while the supermarket sector's installations increased by 28%.

The market penetration of transcritical CO_2 in convenience stores is 20%, an increase from 14% in 2023. The market penetration of transcritical CO_2 in supermarkets is 3.5%, up from 2.8% in 2023. The market penetration of transcritical CO_2 across all food retail stores in Japan is 16%, up from 10.9% in 2023.

Lawson continued to lead all convenience store chains with 6,800 stores using CO_2 systems[185]– an increase of 28% from 2023 – out of a total of 14,608 stores (46.5%).[186] FamilyMart reported 1,600 stores were using CO_2 systems in 2024[187] out of a total of 15,311 stores (10.5%).[188] 7-Eleven reported using CO_2 systems in 1,262 stores[198] out of a total of 21,651 stores (5.8%).[190] 7-Eleven said it is using CO_2 in approximately half of its new stores.

Behind the Numbers

Panasonic has supplied 23,000 CO_2 condensing units to the Japanese market since 2010 and estimates it has a 70% market share.[191] It is working with other manufacturers to increase the adoption of CO_2 in supermarkets, according to Gaku Shimada, General Manager of the Condensing Unit Engineering Department at Panasonic. Shimada said manufacturers are highlighting the reduced energy consumption of CO_2 versus HFC-based refrigeration equipment as well as government subsidies (see chapter 4.2).

Masafumi Okuda, Manager of the CSR (Corporate Social Responsibility) Department at multinational retailer AEON, called government subsidies "key" to Japan's adoption of natural refrigerants in February 2024. AEON operates 2,187 supermarkets in Japan as of December 2024, many of which use either CO_2 condensing units or R290 cases, or a mix.[192]

The Industrial Market Today

As of December 2024, there were an estimated **470** industrial sites (mostly cold storage facilities) using transcritical CO_2 systems (mostly condensing units) in Japan's industrial refrigeration sector, up 17% from the 400 reported in 2023.

Behind the Numbers

Nihon Netsugen Systems has installed 620 CO_2 condensing units at 220 sites as of December 2024, an increase of 90 units and 40 sites, respectively, from 2023. Mayekawa and Mitsubishi Heavy Industries also have a sizable presence in industrial transcritical CO_2 in Japan.

CO_2 refrigeration systems are most common in cold storage applications (73%) in the industrial sector followed by process cooling (20%), freezing (6%) and food processing (1%).

Natural refrigerants are the majority refrigerant in cold storage warehouses, according to the JARW. Its 2023 member survey showed that a total of 51.4% of cold storage facilities used natural refrigerants in 2023, and of these, 67.6% used ammonia/CO_2 systems, 18.9% used ammonia systems, 12.6% used transcritical CO_2 systems and 0.9% used air-based systems.

While ammonia/CO_2 secondary systems account for the lion's share of natural refrigerant installations in cold storage facilities, CO_2 systems represent a fast-growing segment while liquid-overfeed ammonia continues to decline.

During the past five years, the number of ammonia/CO_2 systems has remained relatively stable, with the number of ammonia systems dropping by around 10%. The number of CO_2 systems in use has grown every year during the past five years and has nearly quadrupled since 2019.

Nearly half of Japan's cold storage warehouses still use HFCs, CFCs and HCFCs, but natural refrigerant systems have shown strong growth in recent years. The use of natural refrigerant-based systems in cold storage warehouses among JARW members, just 23.1% in 2015, more than doubled to 51.4% by 2023. By contrast, the use of non-natural refrigerant systems either continues to fall precipitously (HCFC systems) or have seen their growth stagnate (HFC systems).

Figure 26: Transcritical CO_2 Installations in Japan

(as of December 2024)

11,500 Convenience Stores
750 Supermarkets
470 Industrial Sites

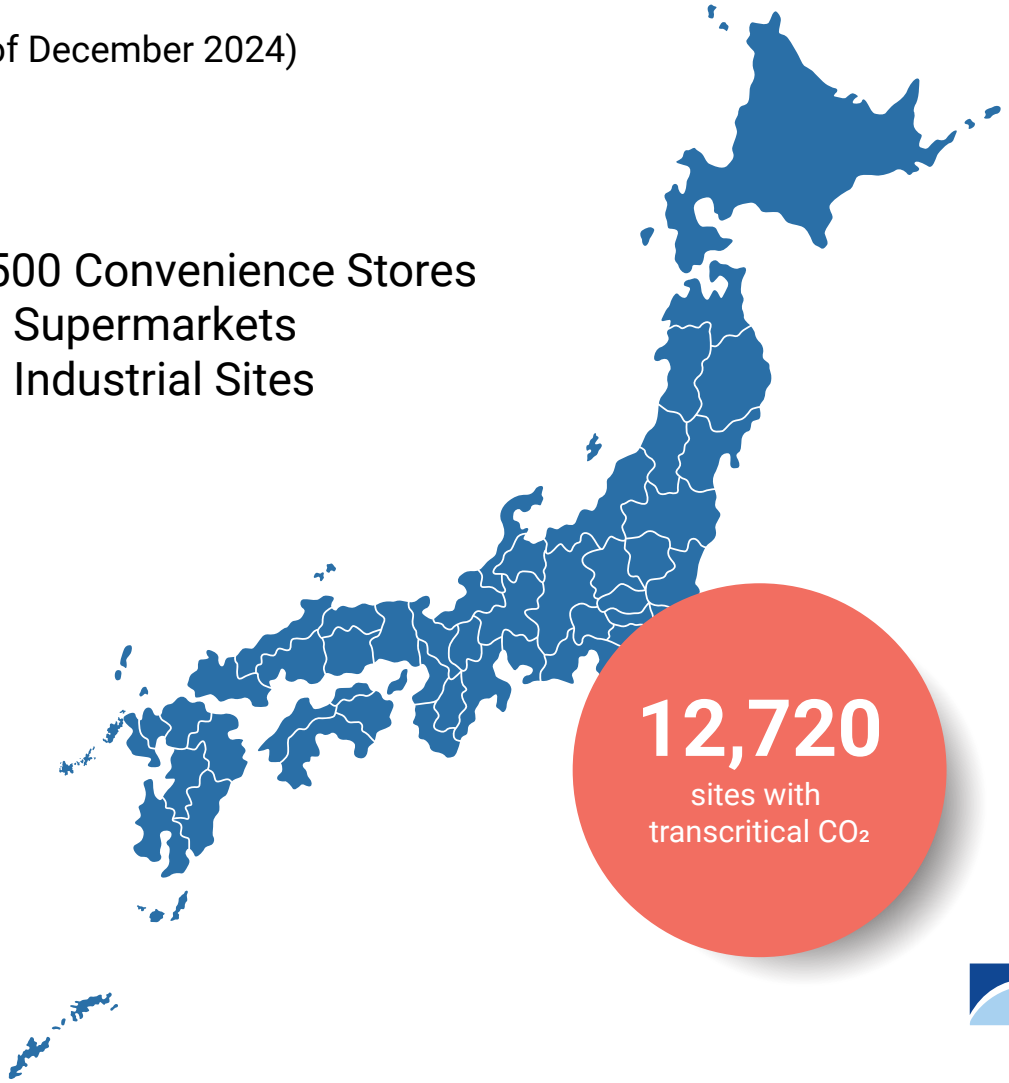

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Figure 27: Transcritical CO_2 Commercial Refrigeration Market Penetration in Japan

76,953 food retail stores

16% transcritical CO_2 stores (all)

55,692 convenience stores*

20% transcritical CO_2 convenience stores

21,261 supermarkets**

3.5% transcritical CO_2 supermarkets

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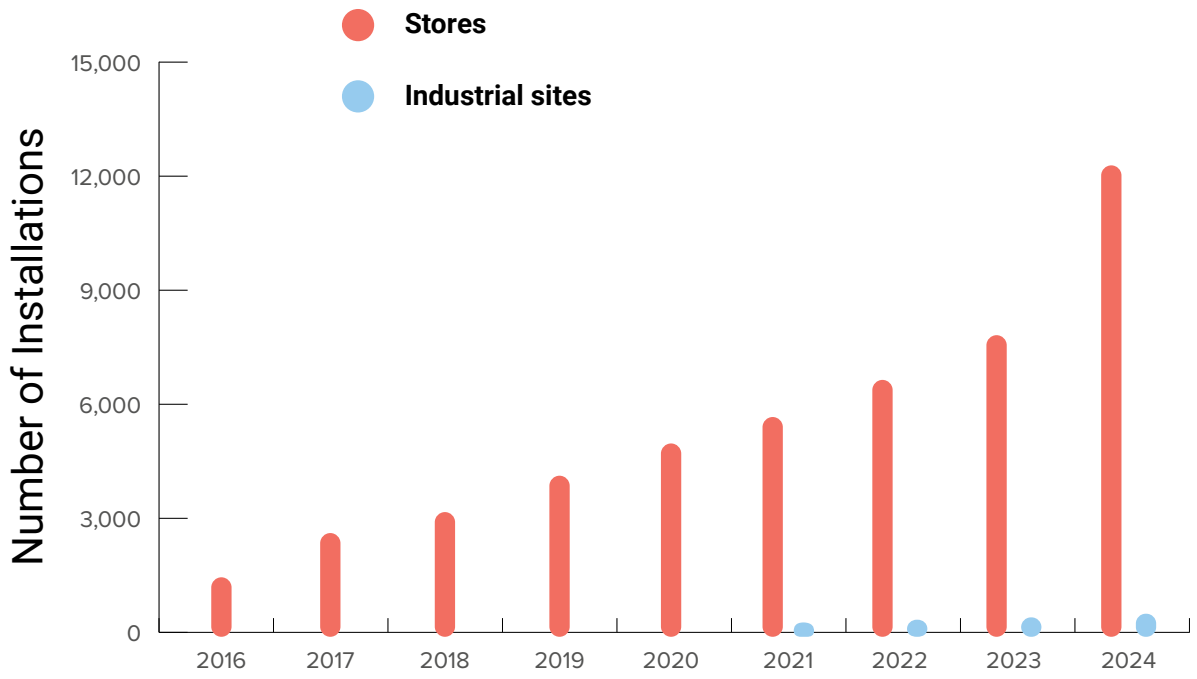
Figure 28: Transcritical CO_2 Installation Growth in Japan

(stores)

2021	5,800	2023	8,385
2022	6,630	2024	12,250

Figure 29: Transcritical CO_2 Historical Installation Growth in Japan

(stores and industrial sites)



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

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CHAPTER 5

Australian and New Zealand Trends

5.1 The Australian and New Zealand Food Industry: Economic Outlook

Australia

Australia is estimated to have 4,295 supermarkets and grocery stores as of mid-2023, with Aldi, Coles and Woolworths commanding more than half of the market share for supermarkets.[193] There is also a substantial presence of independent supermarkets, with the majority of those operated under a franchise model through the IGA brand. The floor size for the majority of supermarkets in Australia is 1,500–4,000m^2 (16,145–43,055ft^2).

The industry had an estimated revenue of US$131.7 billion (€125.3 billion) in 2024 and a CAGR of 0.7% from 2019–2024.[194] Of that, it is estimated that online grocery sales accounted for $9.1 billion (€8.7 billion) in revenue, a drop of 4.5% from 2024.[195] However, that drop comes on the heels of a 23.1% per year increase from 2018 through 2023. Revenue from frozen food was estimated at US$3.6 billion (€3.4 billion) in 2024, with an estimated CAGR of 4.81% from 2024–2029.[196]

Australia's total refrigerated warehouse capacity was estimated at 10.2 million m^3 (360.2 million ft^3) as of 2024,[197] the majority of which is located on the more-populous east coast. The market size in 2024 was estimated at US$5.1 billion (€4.9 billion),[198] with the pharmaceutical and food and beverage industries accounting for the majority of demand.

New Zealand

New Zealand is estimated to have 1,077 supermarkets and grocery stores as of December 2023, with supermarket operators Foodstuffs North Island, Foodstuffs South Island and Woolworths accounting for more than two-thirds of the market.[199] Independent and specialty supermarkets and convenience stores make up the remaining market.

Revenue was estimated at US$14.7 billion (€14 billion) as of the end of June 2023, with the industry seeing a CAGR of 2.5% from 2019–2024.[200] Online ordering is estimated to account for US$1.04 billion (€990 million) in revenue in 2024 with an estimated CAGR of 9.21% from 2024–2029.[201] Revenue from frozen food was estimated at US$900 million (€856 billion) in 2024, with an estimated CAGR of 4.10% from 2024–2029.[202]

The New Zealand Cold Storage Association lists 93 cold storage warehouses on its website as of December 2024.[203] The food industry is a primary driver of cold storage demand, with New Zealand exporting a significant amount of its food, with dairy products alone accounting for one fourth of all exports as of September 2023.[204]

5.2 Regulators Take Aim at R404A

In June, Australia's Department of Climate Change, Energy, the Environment and Water opened a public consultation period on policy options designed to reduce the use of HFCs in commercial refrigeration, particularly R404A, which has a 100-year GWP of 4,728 and a 20-year GWP of 7,208.[205] The DCCEEW noted that imports of R404A, as a percentage of total HFC imports, increased from 12.6% in 2016 to 16.3% in 2021, with condensing units and small racks helping drive demand.

The policy proposals directly and indirectly target R404A-based commercial refrigeration equipment. The direct measures include a ban on new imports of R404A or a restriction that the refrigerant only be used to service existing equipment. Controls on recycled R404A were proposed, too. The DCCEEW said it was considering exemptions for both the import ban and recycled refrigerant controls.

The indirect measures consist of GWP limits for refrigerants in commercial refrigeration equipment, with the proposed limits varying by equipment type. They are:

- A GWP limit of 150 for **self-contained and plug-in commercial equipment**, which includes refrigerated cabinets, ice makers, beverage coolers, self-contained blast chillers and refrigerated food lockers. The DCCEEW said small, self-contained refrigeration equipment in Australia primarily uses hydrocarbon refrigerants.
- A GWP limit of 1,500 for **medium-size commercial refrigeration equipment**, which includes slide-in/drop-in self-contained refrigeration units, chillers and condensing units. The GWP 1,500 threshold would apply to "most new equipment and condensing units in this category," with equipment that cools at or below −20°C (−4°F) subject to an initial GWP limit of 2,500 that would eventually decrease to 1,500. The DCCEEW said equipment in this segment primarily uses R404A.
- A GWP limit of 150 for **new large commercial refrigeration equipment**, roughly defined by the DCCEEW as refrigeration systems used in large supermarkets. For cascade systems, a GWP limit of 1,500 for the primary refrigerant is proposed.
- The DCCEEW declined to set GWP limits for **process and industrial refrigeration equipment**, stating that the segment "is understood to largely use refrigerants other than HFCs, primarily ammonia and CO_2."

The public comment period for the proposal closed on August 8, and as of this writing the DCCEEW has not announced next steps regarding the policy. There is some precedent for refrigerant GWP limits in Australia, with the country recently setting limits of the types of refrigerants that can be used in certain air-conditioning units.

In 2024, the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 was amended to prohibit the import and manufacture of "small synthetic greenhouse gas" air-conditioning equipment containing or using HFCs with a GWP over 750 without a license beginning July 1, 2024. Multi-head small synthetic greenhouse gas AC equipment – similar to split systems – falls under the prohibition beginning July 1, 2025. For both types of air-conditioning equipment, the ban only applies to those with a charge of 2.6kg of refrigerant or less.

At the local level, Paramatta City placed GWP limits on commercial refrigeration equipment back in 2022.[206] The city of 256,000[207] enacted a new regulation requiring new air-conditioning and refrigeration equipment to use refrigerants with a GWP of less than 10. It provides for exceptions if low-GWP equipment can't be supplied "on similar terms to conventional systems" and if costs are more than 10% higher than the market rate for conventional systems.

5.3 New Zealand Targets High-GWP Refrigerants in First Emissions Reduction Plan

New Zealand's Ministry for the Environment released its first-ever emissions reduction plan in 2022 with the goal of reducing its emissions from 290 metric tons of CO_2e in 2022–2025 to 240 metric tons of CO_2e in 2031–2035.[208] The plan contains a chapter on fluorinated gasses, which accounted for 2% of the country's gross greenhouse gas emissions in 2019.[209] New Zealand ratified the Kigali Amendment in 2019.

In the chapter, the MfE identified four "key actions" for reducing f-gas emissions:

- Build the capability to shift to alternative low-emissions refrigerants, which includes developing training and accreditation for handling alternative gases
- Prohibit the import of pre-charged equipment
- Investigate prohibiting f-gases with high GWP
- Introduce a mandatory product stewardship scheme for refrigerants

Training and accreditation for alternative gases

The Ministry of Business, Innovation & Employment (MBIE) developed a new licensing system for refrigeration, heating and air-conditioning technicians.[210] Technicians working on commercial and industrial systems that use "flammable, toxic or very high operating pressure [VHOP] refrigerants" will need to be licensed. Techs who only work on light commercial systems, which include refrigerated display cabinets and "small" drop-in packaged units, will not need to be licensed.

Licenses are based on both the type of refrigerant and the types of equipment:

- Refrigerant types: flammable, toxic (including ammonia), toxic (excluding ammonia) and VHOP
- System types: refrigeration, heat pump or air-conditioning; heat pumps and air-conditioning; transport refrigeration plant

As of this writing, the MBIE has not released an update on when the proposed regulations will be finalized.

Import Prohibitions

The MfE released a policy proposal for its prohibition of imported pre-charged equipment in November 2022, which would only apply "when and where alternatives are available."[211] The proposal defined low-GWP as refrigerants with a GWP below 150 and high-GWP as refrigerants with a GWP above 150. The MfE did not include a policy proposal for prohibiting the import of specific f-gases, stating, "We are currently considering a framework for this."

A public consultation period was opened between November and December 2022.[212] In October 2023, the MfE informed stakeholders it was rescinding the proposed import ban on pre-charged equipment as a result of the feedback.[213]

Mandatory product stewardship scheme

The MfE also released a policy proposal for a mandatory product stewardship scheme in November 2022, with a public consultation from November to December 2022. The scheme contained three elements:

- Participation obligation: Producers, sellers and distributors of refrigerants would be required by law to be in compliance with an accredited scheme to sell their products in New Zealand.
- Quality standards: A quality standard for end-of-life management and reporting requirements would be established to ensure best practices.
- Workforce competence: Workers would need to provide evidence of their ability to work with equipment that uses refrigerants or to buy bulk or pre-charged refrigerants.

The scheme has yet to be accredited by the government, although the MfE says that if accredited, the regulation could take effect starting in 2025 at the earliest.[214]

5.4 Manufacturers Offering Natural Refrigerants Training

Like other regions of the world, Australia and New Zealand are facing a shortage of technicians trained to work with natural refrigerant-based refrigeration systems. That shortage is being addressed in part by manufacturers like SCM Ref Australia, a subsidiary of Beijer Ref, which offers nationally certified training programs for both transcritical CO_2 systems and those using flammable refrigerants, including hydrocarbons.[215]

SCM Ref Australia, in partnership with the Superior Training Center and Danfoss, offers training in transcritical CO_2 system safety, repair and servicing. The company says it has delivered training to 148 technicians. The hydrocarbon training also focuses on safety, repair and servicing along with installing and commissioning systems.

The training is conducted online and in-person at the Beijer Ref Academy in Bankstown. The company also operates a mobile training facility for its flammable refrigerant program. SCM Ref New Zealand operated a mobile transcritical CO_2 training facility as of September 2023, which the company said has "reached over 200 contractors."[216]

Bitzer Australia also offers training in transcritical CO_2 systems at its Sydney and Melbourne facilities as well as offsite training.[217] In addition to safety, commissioning and maintenance skills, the training has also covered natural refrigerant legislation and end-user-specific controls.[218]

Advansor has provided training on transcritical CO_2 systems in Australia. In 2023, the company teamed up with The Natural Refrigerants Company, an HVAC&R contractor, to deliver onsite training for technicians at grocery stores throughout the state of South Australia.[219]

5.5 Australian Market Data: Stores and Industrial Sites Using Natural Refrigerants

Total Addressable Market

There were an estimated 4,295 supermarkets and grocery stores in Australia as of mid-2023. Data was not gathered for convenience stores because our survey respondents only reported on transcritical CO_2 installations in Australian supermarkets.

The Retail Market Today

As of December 2024, there were an estimated **330** supermarkets using transcritical CO_2 systems in Australia. The market penetration of transcritical CO_2 in the Australian supermarket sector is 7.7%. With **20** industrial site installations, the total number of transcritical CO_2 installations in Australia was **350**.

Three of Australia's biggest supermarket operators, Aldi, Coles and Woolworths, all have policies stating a commitment to installing transcritical CO_2 systems in new stores and in major retrofits when possible. Integrated designs are popular, with survey respondents reporting many of their transcritical CO_2 systems also provide domestic hot water, with a smaller percentage reporting that their systems can provide space heating and cooling.

In addition to transcritical CO_2 racks, survey respondents reported that smaller-format stores are using CO_2 condensing units and that CO_2 heat pumps are increasingly being looked at as a replacement for natural gas boilers. A small number of CO_2-based waterloop systems are also in use, including at an ALDI in Melbourne.[220] Hydrocarbon cases are in stores, although not in great numbers. The exception is ALDI, which exclusively uses R290-based freezers. Hydrocarbon chillers are also being trialed, too.

HFC/CO_2 cascade systems were first installed in Australian supermarkets in 2005, with the first transcritical CO_2 system for a grocery store commissioned in 2007.[221] As of December 2024, more than 700 supermarkets were estimated to use subcritical HFC/CO_2 cascade systems.

Behind the Numbers

Woolworths is one of the leading users of transcritical CO_2 refrigeration in Australia's commercial sector. In April 2024, the retailer celebrated the opening of its 100th transcritical CO_2 store, with the company's first such store opening in 2017. Woolworths began using CO_2 refrigeration in 2006 when it installed its first R134a/CO_2 cascade system.

As of December 2024, Woolworths confirmed to ATMOsphere that it operates approximately 1,150 stores (including convenience stores), with 125 using transcritical CO_2 systems (11%), 65 of which are integrated systems (43 space heating, 22 space heating and cooling). The company also has a CO_2 waterloop system in operation. Along with CO_2, Woolworths has installed 269 plug-in R290 cases and employs two R290 chillers. A total of 407 stores use HFC/CO_2 cascade systems (35% of stores).

Coles stated in its 2024 sustainability report that 78 of its supermarkets used natural refrigerants as of September 2024. The company also said it is trialing the reuse of waste heat from natural refrigerant-based refrigeration systems to provide space heating.[2022] In addition, Coles installed an experimental CO_2 system equipped with a dew point cooler to increase efficiency at a store in South Australia in 2023.[223]

Manufacturers are enabling the transition to transcritical CO_2 through local production. Bitzer Australia entered the CO_2 refrigeration systems market in 2004.[224]

End users looking for local systems gained another option in June 2024 when SCM Ref Australia, launched a new transcritical CO_2 rack designed for small- and medium-sized stores.[225] Optional add-ons include heat recovery, air-conditioning load and ejectors for added system efficiency.

The government is also showing support for natural refrigerant-based systems. In 2024, Japanese

manufacturer Itomic announced that its air-to-water CO_2 heat pump was eligible for state rebates in New South Wales and Victoria when it replaced a gas boiler or electric resistance element hot water system.[226] Automatic Heating, the heat pump's local distributor, reported that 10 supermarkets installed the units in 2023.

The Industrial Transcritical CO_2 Market Today

As of December 2024, there were an estimated **20** industrial sites using transcritical CO_2 systems in Australia's industrial refrigeration sector. One survey respondent reported that industrial transcritical CO_2 systems are mostly found in smaller cold storage facilities.

Behind the Numbers

Transcritical CO_2 is still finding its footing in Australia's industrial refrigeration sector, with Inderpal Saund, Business Development Director APAC for Beijer Ref Australia, noting at ARBS 2022 that ammonia systems are providing stiff competition.[227] Of the 20 transcritical CO_2 sites, one is a warehouse operated by a food wholesaler in New South Wales, which opened in 2021.[228] Its system has 11 compressors and a total capacity of 256kW (72.8TR), including 108kW (30.7TR) low-temperature capacity at −25°C (−13°F), and 148kW (42.1TR) medium-temperature capacity at −7°C (−19°F).

The Industrial Low-Charge Ammonia Market Today

As of December 2024, there were an estimated **60** industrial sites using low-charge ammonia systems in Australia's industrial refrigeration sector. Survey respondents indicated that the majority of low-charge ammonia installations are for central systems.

Behind the Numbers

Scantec Refrigeration Technologies is one of the leading providers of low-charge ammonia systems in Australia, offering both central and packaged systems. Managing Director Stefan Jensen said in May 2024 that Scantec has "a full order book for the 2024–2025 financial year and a little beyond" for its low-charge ammonia systems.[229] He noted that the company can roughly produce 8 to 25 low-charge ammonia systems per year, depending on the project size.

GEA is also seeing increased demand for low-charge ammonia in Australia. Greg Clements, Head of Sales – Compression at the German manufacturer, said at ARBS 2024 that the industrial refrigeration sector "boomed" during the pandemic.[230] "If you look at what's happened in the last two to three years, low-charge ammonia is at the forefront, no question," he said.

Jensen said in 2021 that one of the main barriers to the increased uptake of natural refrigerants in the Australian industrial sector is "an environment where the lowest capital cost is often installed to the detriment of energy efficiency."[231] He added two new roadblocks in 2024: a lack of policy direction for HFO refrigerants that degenerate into PFAS and a lack of properly trained personnel.[232]

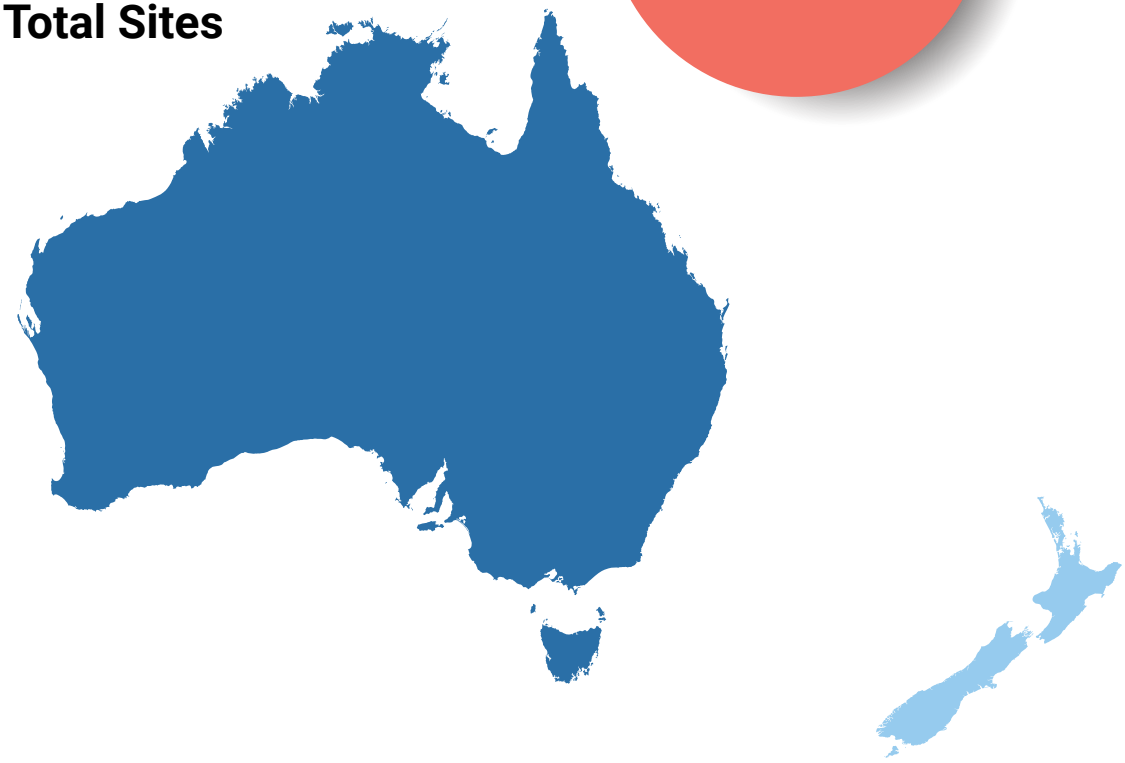
Figure 30: Transcritical CO_2 Installations in Australia and New Zealand

(as of December 2024)

Australia

330 Stores
20 Industrial Sites
350 Total Sites

650
sites with transcritical CO_2



New Zealand

240 Stores
60 Industrial Sites
300 Total Sites

ATMO sphere

Figure 31: Transcritical CO_2 Commercial Refrigeration Market Penetration in Australia

4,295 total stores

7.7% transcritical CO_2 stores

5.6 New Zealand Market Data: Stores and Industrial Sites Using Natural Refrigerants

Total Addressable Market

There were an estimated 1,077 supermarkets and grocery stores in New Zealand as of December 2023. Data was not gathered for convenience stores because our survey respondents only reported on transcritical CO_2 installations in New Zealand supermarkets.

The Retail Market Today

As of December 2024, there were an estimated **240** supermarkets using transcritical CO_2 systems in New Zealand. The market penetration of transcritical CO_2 in the New Zealand supermarket sector is 22%. With an estimated **60** industrial sites, the total number of transcritical CO_2 installations in New Zealand was **300** as of December 2024.

Behind the Numbers

New Zealand has three major supermarket chains: FoodStuffs North Island, FoodStuffs South Island and Woolworths New Zealand.

FoodStuffs said in its 2024 sustainability report that it is transitioning from synthetic refrigerants to CO_2 systems in its stores.[233] In the fiscal year 2024, FoodStuffs said 49% of its Pak'nSave-branded stores and 37% of its New World-branded stores moved to CO_2 refrigeration systems. In the fiscal year 2025, the company said it aims to increase those figures to 73% and 51%, respectively. As of December 2023, FoodStuffs operated 58 Pak'nSave (28 CO_2 stores) and 105 New World stores (38 CO_2).

FoodStuffs' history with natural refrigerants dates back more than a decade. FoodStuffs North Island said in 2012 it became "the first company in the southern hemisphere to trial CO_2-based refrigeration in preference to synthetic gas."[234] Since 2014, the company said it's installed CO_2 systems in all new supermarkets and "major store refits."

Woolworths operates 191 supermarkets in New Zealand as of April 2024, with 32 of those equipped with transcritical CO_2 refrigeration systems.

In addition to racks, transcritical CO_2 condensing units are also in the commercial market, with Panasonic reporting that it sold 100 units in the Oceania region as of July 2022, the majority of which were installed in small supermarkets in New Zealand.[235]

The Industrial Transcritical CO_2 Market Today

As of December 2024, there were an estimated **60** industrial sites using transcritical CO_2 systems in New Zealand's industrial refrigeration sector. Survey respondents did not share data on the number of low-charge ammonia systems.

Behind the Numbers

One of the 60 industrial sites using transcritical CO_2 is a cold storage facility operated by Dutch shipping conglomerate Maersk. The 45,000m^2 (484,376ft^2) facility, located in Hamilton, opened in 2023 and has space for 21,000 pallet positions. It uses seven transcritical CO_2 racks supplied by Danish manufacturer Advansor with a total capacity of 6.8MW (1,933TR). The system also provides space cooling and heating.[236]

One unique opportunity for CO_2 in the industrial sector is in dairy industry. New Zealand is the world's seventh-largest producer of milk, 95% of which is exported.[237] Raw milk must be cooled to prevent the growth of bacteria, and CO_2 chillers equipped with heat recovery can both cool milk and provide hot water for cleaning equipment.

Figure 32: Transcritical CO_2 Commercial Refrigeration Market Penetration in New Zealand

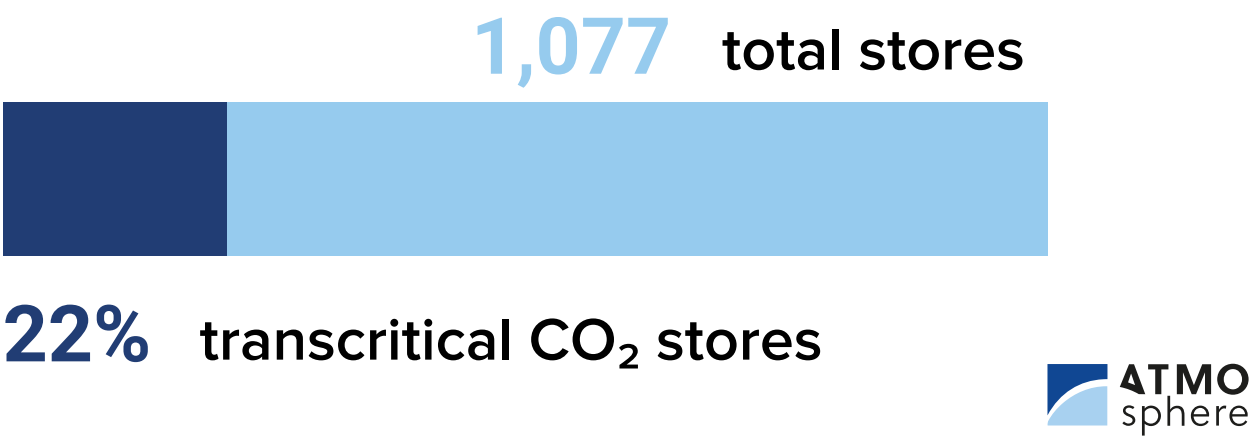
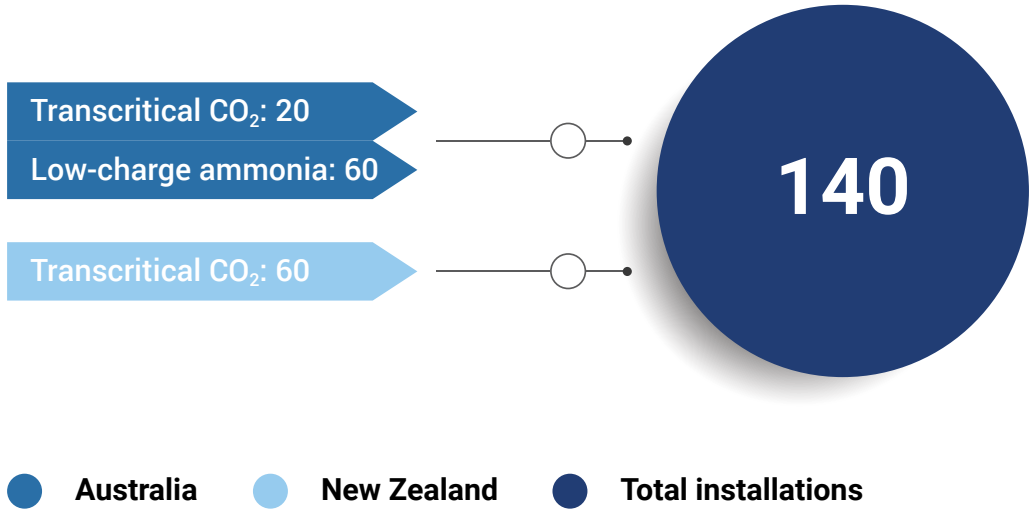


Figure 33: Industrial Installations of Transcritical CO_2 and Low-Charge Ammonia Systems in Australia and New Zealand



CHAPTER 6

Latin American Trends

6.1 A Snapshot of Natural Refrigerants in Latin America

This chapter provides an overview of the use of natural refrigerants in commercial and industrial refrigeration in Latin America. The region as we've defined it consists of 20 countries divided into three sub-regions: Mexico, Central America and South America.

Central America

- Belize
- Costa Rica
- El Salvador
- Guatemala
- Honduras
- Nicaragua
- Panama

South America

- Argentina
- Bolivia
- Brazil
- Chile
- Colombia
- Ecuador
- Guyana
- Paraguay
- Peru
- Suriname
- Uruguay
- Venezuela

Every country in the region except Guyana and Suriname have ratified the Kigali Amendment to the Montreal Protocol.[238] In addition to ratifying the Kigali Amendment, some countries have taken further steps to promote the use of natural refrigerants.

Chile's Ministry of the Environment, with funding from the Climate and Clean Air Coalition and assistance from the United Nations Development Programme (UNDP), led a project to install the country's first transcritical CO_2 system in a supermarket back in 2017.[239]

In Peru, the Ministry of Production and the UNDP teamed up in 2021 to train 165 refrigeration and air-conditioning technicians in the safe handling of "alternative gases."[240]

Panama has included the development of safety standards for natural refrigerants in its national cooling action plan, labeling it a high-priority initiative.[241]

Mexico's Ministry of Energy has issued energy efficiency requirements for domestic and commercial equipment, including those that use natural refrigerants, and Brazil, Chile and Argentina were all developing regulations as of July 2024 for the safe handling and use of refrigerant gasses, including natural refrigerants.[242]

A Snapshot for 2024

These are minimum estimates for the number of food retail stores and industrial sites using natural refrigerant systems. This report provides a foundation for our understanding of natural refrigerants in Latin America, one ATMOsphere intends to build upon in the coming years.

However, the data we have gathered provides numerous insights into the state of natural refrigerants in commercial and industrial refrigeration in Latin America. While these individual observations are explored in the subsequent chapters, collectively, they show that natural refrigerants have arrived in Latin America and established a strong presence in several countries throughout the region.

6.2 Latin American Market Data: Stores Using Natural Refrigerants

TRANSCRITICAL CO_2 RACKS

The Market Today

As of December 2024, there were a minimum of **580** supermarkets and grocery stores using transcritical CO_2 systems in Latin America. With at least **100** industrial site installations (see chapter 6.3), the total number of transcritical CO_2 installations was a minimum of **680**. In addition to transcritical CO_2, cascade R134a/CO_2 systems are also used in relatively large numbers in Brazil, with an estimated **863** supermarkets employing them.

There were an estimated **125** supermarkets and grocery stores in Ecuador, **80** in Colombia and **70** in Argentina using transcritical CO_2 systems.

In Ecuador, there were an estimated 919 supermarkets and grocery stores as of May 2024, making the market penetration of transcritical CO_2 in the country's supermarket sector 13%.[243]

In Colombia, there were an estimated 4,613 supermarkets and grocery stores as of 2023,[244] giving transcritical CO_2 a market penetration of 1.7%. In addition to supermarkets and grocery stores operated by large brands, small neighborhood grocery stores are also popular and commanded 44% of food retail sales in 2023.

In Argentina, there were an estimated 3,272 supermarkets and grocery stores as of 2025, giving transcritical CO_2 a market penetration of 2.1%.[245]

Along with transcritical CO_2 and cascade systems, there are also an estimated 81 supermarkets in Brazil using propane chillers, which can provide cooling via a glycol propylene loop or a subcritical CO_2 system.

Behind the Numbers

While the market for transcritical CO_2 systems is still in its infancy, several manufacturers have established strong footholds in Latin America, such as Colombia's Weston. The company installed Colombia's first transcritical CO_2 system in 2017.[246]

Richard Osma, General Manager at Weston, said in 2022 that the market for transcritical CO_2 in Latin America would be "exploding in the future." He added that Bogotá, at an elevation of 2,640m (8,661ft) and with ambient temperatures ranging from 10 to 20°C (50 to 68°F), was very well-suited for CO_2 refrigeration. Systems able to operate in subcritical mode 99% of the time.

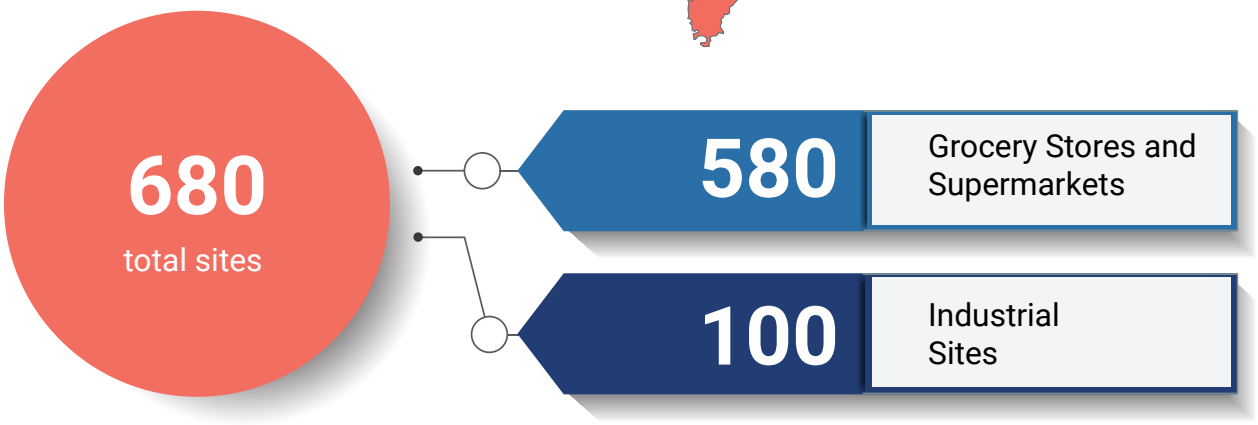
In 2019, Weston formed a partnership with German manufacturer TEKO, creating TEKO Américas.[247] As of December 2023, the partnership had led to the installation of 100 TEKO transcritical CO_2 systems in Latin America. The majority are in Colombia, Chile and Peru, with Mexico seeing some subcritical CO_2 system installations.

Arneg has also established itself in Latin America, with Arneg Central America operating out of Panama City. Rolando Bissot, Engineering and Maintenance Manager at Arneg Central America, said in 2020 that the Italian company had installed two transcritical CO_2 systems at two Mi Comisariato stores in Guayaquil, Ecuador, and stated that the largest supermarket chains in Ecuador only choose CO_2 refrigeration for new stores. "They have experienced the energy savings and do not want to turn back," he added.

Italian manufacturer Epta also has a big presence in Latin America and has installed 42 transcritical CO_2 systems in Argentina and 39 in Ecuador as of December 2023.[248] After installing an Epta transcritical CO_2 system in a supermarket in 2018, the Argentinian chain La Anónima decided to use transcritical CO_2 systems for all of its new stores and retrofits, with 17 stores using the Epta technology as of December 2023. The company operates 170 supermarkets in Argentina as of March 2024.[249]

Figure 34: Transcritical CO_2 Installations in Latin America

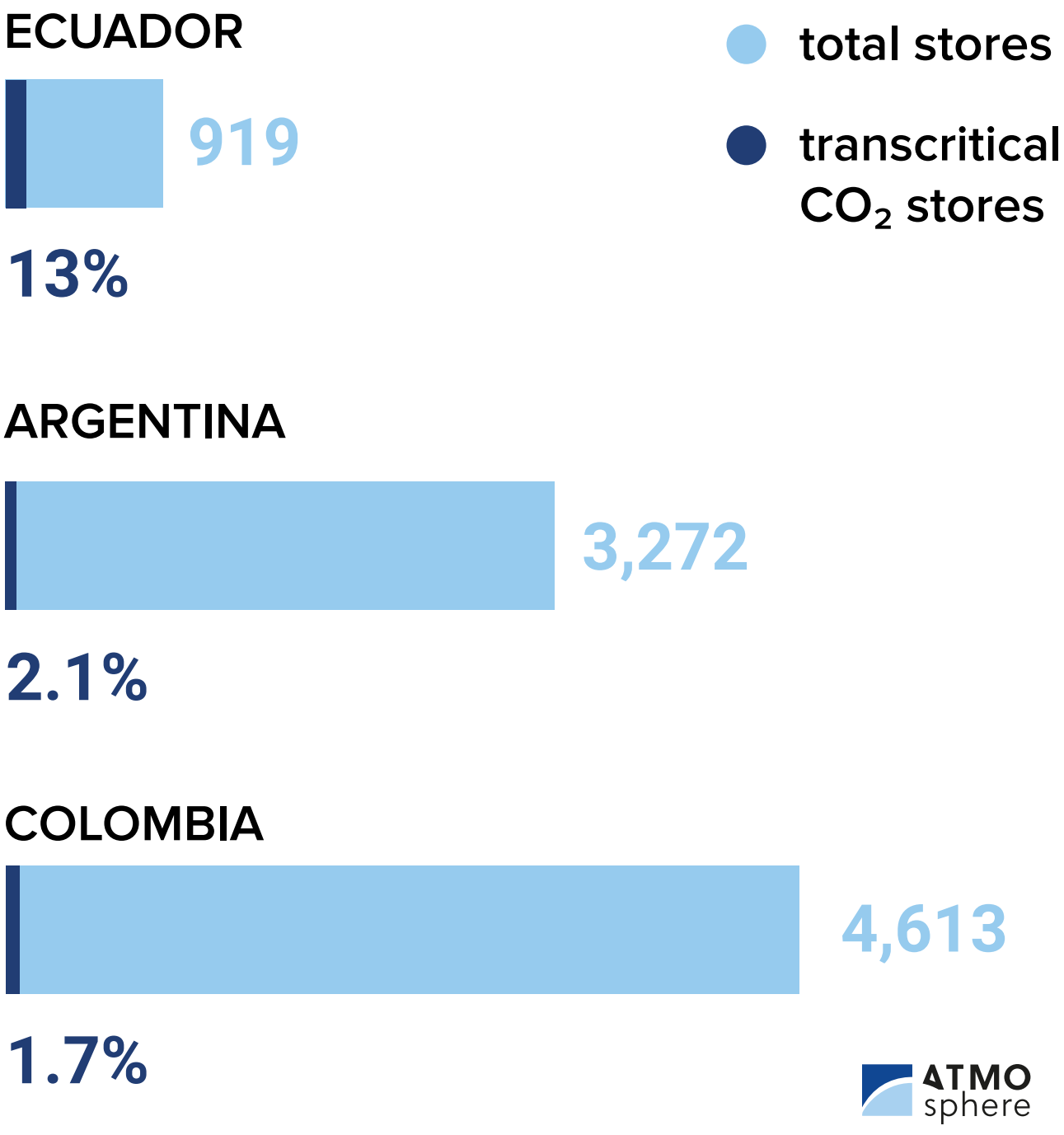
(as of December 2024)



ATMO sphere

Figure 35: Transcritical CO_2 Commercial Refrigeration Market Penetration

(in three leading markets, as of December 2024)



HYDROCARBON SELF-CONTAINED CASES

Using data collected from a survey of OEMs as well as insights from trusted industry sources, ATMOsphere estimated **8.5 million** self-contained hydrocarbon (mostly R290) cases installed in food stores in Latin America by December 2024. Of those, there were an estimated **2.6 million** cases installed in Mexico and **5.9 million** cases installed in Central and South America combined.

Behind the Numbers

Unlike in other regions of the world, regulation is not driving demand for self-contained hydrocarbon cases in Latin America – at least not directly. Local case manufacturers are undoubtedly following regulatory developments in the U.S. and EU to ensure their products are compliant for those markets. However, manufacturers in the region have been building self-contained hydrocarbon cases before these regulatory developments.

In 2017, commercial freezer manufacturer Frío Perú partnered with Embraco, which is headquartered in Joinville, Brazil, to transition its freezers to R290 compressors. By 2019, all of its compressors were using propane refrigerant.[250] Weston began manufacturing R290 cases in 2021,[251] and Brazil-based manufacturer Eletrofrio Refrigeração also builds self-contained hydrocarbon cabinets and R290 chillers.

In 2019, Eletrofrio provided a propane/glycol chiller and an propane/glycol/CO_2 cascade system for a new Supermercado Condor in Curitiba, Brazil. This was Condor's first store using all natural refrigerants, and the store produced energy savings of 3.5% compared to an identical location in the same city using an R134a-based refrigeration system.[252]

In 2021, Embraco announced a $21 million (€20.3 million) investment in its Joinville plant to increase production of its EM2 and EM3 compressors by 2.5 million units annually.[253] The EM2 and EM3 compressors use R290 and R600a and are used in residential and light commercial applications.

In addition to being energy efficient, self-contained hydrocarbon cases have a small footprint, making them a good fit for small-format stores. In addition to small neighborhood markets, larger retailers are also opening up smaller stores in high-traffic areas throughout Latin America to cater to shifting consumer preferences.[254]

Copeland has a strong presence in Latin America and operates distribution centers and technical facilities in Argentina, Brazil, Chile, Colombia and Mexico. Carlos Obella, VP of Engineering Services and Product Management for Copeland Latin America, said in 2023 that supermarkets in the region are moving to a smaller format, which creates opportunities for micro-distributed units and self-contained R290 cases.[255]

Arneg operates factories in Argentina, Brazil and Colombia and offers self-contained hydrocarbon cases, among other natural refrigerant systems.[256] Rolando Bissot of Arneg Central America said in 2023 that the company is developing new natural refrigerant technologies for use in stores with small sales floors.

Figure 36: Self-Contained Hydrocarbon Cabinets Installed in Latin America

(as of December 2024)

Mexico — 2.6 million

Central & South America — 5.9 million

ATMO sphere

6.3 Latin American Market Data: Industrial Sites Using Natural Refrigerants

TRANSCRITICAL CO_2

The Market Today

In December 2024, there were **100** industrial sites using transcritical CO_2 in Latin America, 14% of the total **680** transcritical CO_2 sites. (See chapter 6.2 for more detail on store sites.) Of the 100 industrial sites, 50 are in South America, 35 are in Mexico and 15 are in Central America.

Behind the Numbers

Industrial transcritical CO_2 is still in its early days in Latin America and is competing with both synthetic refrigerants and ammonia, the dominant natural refrigerant in the sector, for market share. There are some early signs of encouragement for transcritical CO_2 from a major end user and many manufacturers, though.

Mexican multinational baked goods company Grupo Bimbo is one of the strongest proponents in Latin America of natural refrigerants in the industrial sector. The company operates 14 bakeries in Central and South America and six in Mexico and uses transcritical CO_2 and CO_2/ammonia cascade systems in its freezing operations.[257] Natural refrigerants represented 60% of its total refrigerant charge as of July 2023, and more than 20% of its sites were expected to fully use natural refrigerants by 2024.[258]

Advansor is one of the manufacturers leading the charge on industrial transcritical CO_2 in Latin America. The company said in November 2023 that it had installed 48 industrial transcritical CO_2 systems in the region, including at cold storage warehouses and distribution centers in Mexico, Chile, Ecuador, Peru and Uruguay.[259]

Mauricio Baena, Advansor's Regional Sales Manager, said reduced energy consumption, capital and operational costs are driving demand for transcritical CO_2 in Latin America's industrial sector. Integrated systems are also stoking interest.

SCM Frigo shared data showing that its industrial transcritical CO_2 systems were more energy efficient than comparable R404A systems.[260] The company saw a 33% gain in the coefficient of performance (COP) at a distribution center in Bogota where a transcritical CO_2 system with parallel compression was installed. An automated logistics warehouse in Santiago, Chile, with a transcritical CO_2 system featuring a vapor ejector, adiabatic cooler and satellite compressors, saw a 23% improvement in COP.

Transcritical CO_2-based refrigeration systems have been found to be up to 18.6% more efficient than R404A alternatives in hot climates, according to German OEM Güntner.[261] While the company found that a R404A-based system in Monterrey, Mexico, marginally outperformed a transcritical CO_2 system with adiabatic cooling and parallel compression in ambient temperatures of 21–27°C (69.8–80.6°F), CO_2 was significantly more efficient in ambient temperatures up to 20°C (68°F) and above 28°C (82.4°F).

Spanish OEM Tecnac confirmed a rising demand for industrial CO_2 in Latin America at Chillventa 2024.[262] "[CO_2 systems] are starting to come up in the industrial and supermarket sectors, especially in Colombia," said Sales Executive Juan Bortone.

LOW-CHARGE AMMONIA

The Market Today

As of December 2024, ATMOsphere estimates there were **60** industrial sites using low-charge (below 1.3kg/kW or 10.1lbs/TR) ammonia systems in Latin America. Mexico has an estimated 30 sites, South America 20 and Central America 10.

Behind the Numbers

Coca-Cola installed a low-charge ammonia refrigeration and air-conditioning system at a plant in Guanacaste, Costa Rica, in 2021.[263] A year prior, Hillphoenix installed packaged low-charge ammonia units at a multinational poultry company's distribution center in Costa Rica.[264]

While low-charge ammonia systems have a presence in Latin America's industrial sector, they face stiff competition for market share not just from synthetic and transcritical CO_2 systems share but also with ammonia/CO_2 cascade and conventional ammonia systems.

Frialsa, a Mexico-based operator of distribution centers, said in November 2023 that 14 of its 28 distribution centers – 26 in Mexico and two in Peru – used ammonia, and 10 used ammonia/CO_2 cascade systems.[265] The four distribution centers that don't use natural refrigerants use R404A. Frialsa said it found R404A compressors to use 25% more energy than ammonia ones.

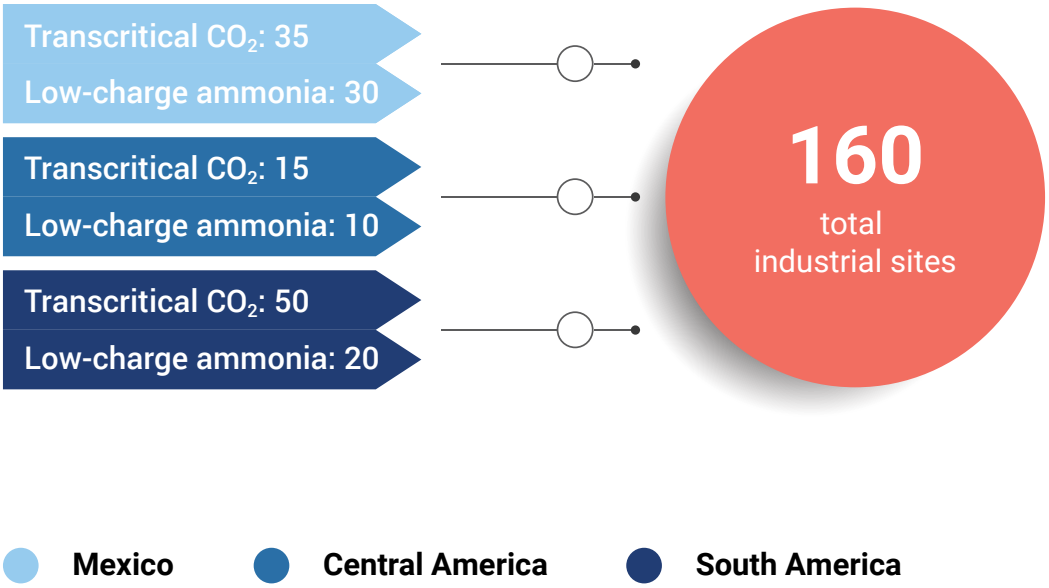
Emergent Cold, a subsidiary of Lineage Logistics and a leading logistics company in Latin America, said in November 2023 that 82% of its refrigerant stock is made up of ammonia and CO_2.[266]

Vilter, which is owned by Copeland, has been part of more than 500 industrial projects in Latin America,[267] including a 23,296m^2 (250,756ft^2) distribution center built in 2023 with a centralized ammonia refrigeration system with a 25,000kg charge.[268]

Another manufacturer that's shown strong support for ammonia is FB Industrial. The Mexican company manufactures ammonia, CO_2 and propane refrigeration systems. It began working with natural refrigerants in 2016 when it created a division focused on ammonia industrial refrigeration.[269] The company's current offerings include transcritical CO_2 racks and condensing units, R290 chillers and ammonia chillers along with components. FB Industrial has four factories, three in Mexico and one in Chile, and more than 1,500 employees as of August 2024.[270]

Figure 37: Industrial Installations of Transcritical CO_2 and Low-Charge Ammonia Systems in Latin America

(as of December 2024)



ATMO sphere

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