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2016

GUIDE TO NATURAL REFRIGERANTS IN JAPAN

— STATE OF THE
INDUSTRY



2016 GUIDE TO NATURAL REFRIGERANTS IN JAPAN

– STATE OF THE INDUSTRY

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Contributing to stores and the Earth, CO₂ Refrigeration System

We keep working for Freon free for the Earth environment and ecology

Panasonic targets next condensing unit global standard with Non-Freon condensing unit, adopting low Global Warming Potential (GWP) and zero Ozone Depletion Potential (ODP) CO₂ refrigerant.

Eco friendly **CO₂ refrigerant** having 1 GWP

GWP

About **1/4000**,^{※1}

ODP

0
(Zero)

CO₂ exhaust

58% reduction

^{※2} Estimation condition

^{※1} As compared to that of R404A refrigerant

^{※2} (Estimation condition) Sales area: 1200m², Condensing unit output: 90kW, R404A model: Inverter multi-type, Refrigerant leakage rate: 16% (From METI "Re-examination of condensing unit and air-conditioner CO₂ emission in their operation" 7th, March 2009)



10HP, for
refrigerator



10HP, for
refrigerator & freezer



15/20HP, for
refrigerator & freezer

CO₂ Refrigeration System

Pressure adjust control type

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About this GUIDE

A short overview



Chapter 1 – About this GUIDE – This chapter serves as a simple introduction to the world of natural refrigerants and the topics covered in this GUIDE. The chapter begins by detailing the ‘natural five’ refrigerants: ammonia, carbon dioxide, hydrocarbons, water and air. This section provides information regarding their chemical, physical, technical and environmental properties.

Chapter 2 – Application of Natural Refrigerants in Japan TODAY – Through independent research, surveys and interviews, this chapter offers a comprehensive evaluation of Japan’s current natural refrigerants market. It focuses on key drivers emerging in Japan in three different spheres: the market for natural refrigerants, technological developments, and the current policy climate.

The current state of the Japanese market for natural refrigerants is explored in three ‘ecosystems’: City & Buildings; Industry, Special Applications and Sports, and the Food Chain. The purpose of the ‘ecosystems’ is to highlight the variety of natural refrigerant products and technologies currently in use in Japan and the huge scope for their further adoption. In addition, an ecosystem showcasing natural refrigerant applications outside Japan highlights potential areas of future growth.

Chapter 3 – Outlook for Natural Refrigerants in Japan

TOMORROW – This chapter looks at the future of Japan's natural refrigerant market, with exclusive insights drawn from an industry survey and interviews with industry experts. It helps to put together a blueprint of an industry plan for the future provision and use of natural refrigerants. The survey provides clear indications of expectations regarding future market share in 2020 and beyond for different natural refrigerant applications and other important factors that will drive the market.

Chapter 4 – Overview of Key Applications in the Japanese Market

This chapter focuses on the four major applications for natural refrigerants in the Japanese market: light commercial refrigeration, commercial refrigeration, industrial refrigeration and CO₂ heat pumps. It also looks at worldwide use of naturals for these applications, and analyses global policy and market trends.

Light commercial refrigeration – Thanks to the committed development plans of global consumer brands, the world is getting used to the sight of hydrocarbon and CO₂ light commercial refrigeration equipment such as drinks cabinets and in Japan, vending machines. This chapter looks into the key market trends and policies that are strengthening this trend both in Japan and beyond.

Commercial refrigeration – CO₂ transcritical stores have grown in the last two years, as shown by the installation map included in this chapter. The chapter goes on to describe how market uptake has quickened with increasingly conducive policies and technologies being developed to make transcritical solutions available for all climates.

Industrial refrigeration – As Japan weans itself off an R22-dominated industrial refrigeration sector, this chapter examines the growing use of innovative solutions such as NH₃/CO₂ secondary and cascade systems. It explores which policies have helped to deliver this change, and looks at potential technology exports and the worldwide situation for natural refrigerants in industrial refrigeration.

CO₂ heat pumps – Japan is a world leader in the use of natural refrigerants in heating with its ubiquitous deployment of CO₂ 'EcoCute' heat pump models. This chapter assesses market penetration of this technology, as well as looking at how Japanese best practice has inspired similar action abroad.

About natural refrigerants

As a general differentiation, 'natural refrigerants' are substances that exist naturally in the environment, while 'non-natural refrigerants' or 'synthetic refrigerants' are man-made chemicals. The most commonly used natural refrigerants today are ammonia (NH_3 , R717) carbon dioxide (CO_2 , R744), and hydrocarbons (HCs), such as propane (R290), isobutane (R600a) and propylene, also known as propene (R1270).

The precision of the term 'natural refrigerants' is sometimes debated, given that, to be used as refrigerants, ammonia, carbon dioxide, and hydrocarbons also undergo an industrial purification and manufacturing process. However, today there is a well established distinction between substances whose chemical properties and safety aspects have been studied in their entirety and those fluorinated gases, which, given their chemical complexity and comparatively short period of usage, have confirmed and/or have unknown negative effects on ozone depletion, global warming and ecological safety, and therefore, are subject to continued debate.

The most commonly used natural refrigerants today are ammonia (NH_3 , R717), carbon dioxide (CO_2 , R744) and hydrocarbons (HCs), such as propane (R290), isobutane (R600a) and propylene, also known as propene (R1270).

Mixtures of ammonia and dimethyl ether (R723) have been developed, as well as various hydrocarbon blends with optimised performance and safety properties (isobutane/ propane; R441 etc.). Water as a refrigerant has been used especially in absorption and absorption chillers. The use of air is less common, but has been developed for deep-freezing applications.

In addition to their wide availability, their non toxicity, non-flammability and their unbeatable environmental credentials, water and air have shifted into the focus of R&D activities. Natural refrigerants no longer in use are sulphur dioxide (SO_2) and methyl chloride (CH_3Cl).



Carbon dioxide (ODP= 0; GWP= 1)

Carbon dioxide (chemical symbol CO_2 , refrigerant designation R744) is colourless, odourless and heavier than air. With a Global Warming Potential (GWP) = 1, CO_2 is the reference value for comparing a refrigerant's direct impact on global warming.

Carbon dioxide carries an A1 safety classification (the same as most fluorocarbon refrigerants), indicating that it has low toxicity and is non-flammable. CO_2 as a refrigerant is sourced as a by-product from a number of production methods. Although it is nontoxic, if enough carbon dioxide builds up in an enclosed space, it will begin to displace oxygen. Over a certain period of time, this can cause asphyxiation of those present. With a long atmospheric lifetime, CO_2 does not lead to any byproduct formation or decay products with serious environmental impact.

When used as a refrigerant, carbon dioxide typically operates at a higher pressure than fluorocarbons and other refrigerants. While this presents some design challenges, they can be overcome in systems designed specifically to use carbon dioxide. Carbon dioxide is compatible with some, but not all, commonly used refrigeration system lubricants. In particular, it is not suited for use with polyol ester (POE) and poly vinyl ether (PVE) lubricants and it only has limited applications with poly alkaline glycol (PAG) lubricants. It is generally regarded as a cheap and easily available refrigerant.



Ammonia (ODP= 0; GWP= 0)

Ammonia (chemical symbol NH_3 , refrigerant designation R717) is a colourless gas at atmospheric pressure. With zero ozone depletion and global warming potential, as well as a short atmospheric lifetime, it does not form any by-products or decomposition products with negative environmental impact. It is compatible with some, but not all, commonly used refrigeration system lubricants. In particular, it is not suited for use with polyol ester (POE) and poly vinyl ether (PVE) lubricants, and it only has limited applications with poly alkylene glycol (PAG) lubricants.

Despite its undisputed energy efficiency benefits, the use of ammonia is restricted in certain applications and geographic regions, due to its toxicity. As a result, R717 is effectively prohibited from use inside occupied spaces but can be used in unoccupied areas or outside.

However, many advances have been made in recent years to minimise risks for human health, particularly for ammonia installations in populated areas. These advances include using ammonia in conjunction with other refrigerants, such as in secondary systems, in order to reduce and isolate an ammonia charge, using advanced safety equipment, deploying containment casings, or using ammonia absorption systems.

It is important to note that ammonia has a strong odour, making leaks easy to detect.



Hydrocarbons (ODP= 0; GWP< 4)

With zero ozone depleting characteristics and an ultra-low global warming impact, the group of hydrocarbons (HCs) does not form any by-products or decomposition products in the atmosphere.

HC refrigerants can be applied either in systems designed specifically for their use, or as replacements in a system designed for a fluorocarbon refrigerant.

This makes them a cost-competitive solution, and an optimal for developing countries. If a hydrocarbon refrigerant is to be used in a system designed for a different refrigerant, it should be noted that modifications are probably required to ensure compatibility. Lubricant compatibility and the issues associated with hydrocarbons' flammability have to be addressed. However, the greatest potential for hydrocarbon refrigerants lies in new systems.

Hydrocarbon refrigerants are flammable and, as a result, carry an A3 safety classification, which means they have a low toxicity but are in the higher range of flammability. HCs are often subject to stricter safety requirements concerning the quantities permitted in occupied spaces.

Hydrocarbon refrigerants are fully compatible with almost all lubricants commonly used in refrigeration and air conditioning systems. One major exception to this rule is lubricants containing silicone and silicate (additives which are commonly used as antifoaming agents).



Water (ODP= 0; GWP= 0)

Water (chemical symbol H_2O , refrigerant designation R718) is one of the oldest refrigerants used for refrigeration applications. Also known as dihydrogen monoxide, water or water vapour is one of the earth's most abundant elements. Water has been extensively used as a process fluid (distillation, drying processes), as a heat transfer or energy storage medium (central heating, system cooling, ice storage systems) and as a working fluid in the Rankine power generation cycle. R718 is an environmentally safe refrigerant with zero ozone depletion potential and zero global warming potential. It is odourless, colourless, nontoxic, non-flammable, non-explosive, easily available, and it is one of the cheapest refrigerants.

In refrigeration applications, water requires state-of-the-art technology. Its use as a refrigerant has been mostly limited to compression chillers with steam injection compressors, absorption systems built around a binary fluid comprised of lithium bromide as the absorbent, and adsorption systems using water as the refrigerant and the mineral zeolite as the adsorbent.

From an environmental and thermodynamic point of view, water is an ideal refrigerant for applications above $0^{\circ}C$. R718 has a higher latent heat of evaporation (2,270 kJ/kg) than other natural refrigerants. R718 absorbs significantly larger amounts of energy, in the form of heat, during a change of phase, from liquid to gas, without a change in temperature. An obvious limitation is the high freezing rate at atmospheric pressure. Water leads to corrosion and oxidation of many metals. Water is more reactive than other refrigerants and choosing the right materials or the R718 system during the design phase requires special attention.



Air (ODP= 0; GWP= 0)

Air (refrigerant designation R729) is a refrigerant that is environmentally benign, cheap, totally safe and nontoxic. Environmental concerns about ozone depletion, global warming, and increasingly stringent legislation have renewed the interest in alternative refrigeration technology, globally. However, the use of air-cycle refrigeration systems is not new. It was used on refrigerated cargo ships around the turn of the 20th century.

Air cycle refrigeration works on the reverse Brayton or Joule cycle. Air as a refrigerant does not undergo phase change (condensation/evaporation) at the temperature levels encountered in conventional refrigeration applications. The COP value of air is low because of its light weight, but air-cycle cooling systems can provide relatively high temperature heat recovery without the efficiency set back experienced by vapour compression systems. Air cycle units, compared to vapour-compression units, can also produce a much higher temperature difference between the hot and cold sides. As a result, very cold air can be produced for near cryogenic processes. The performance of an air cycle unit does not deteriorate as much as that of a vapour-compression unit, when operating away from its design point.

When operating in a refrigeration cycle, an air cycle unit can also produce heat at a useful temperature. Air has been used commercially for aircraft cooling for a long time. In spite of the low COP, air is used because of the specific operating conditions of aircraft (e.g., availability of compressed air and ram effect) and stringent specifications (e.g., low weight, small size, absolute safety, zero toxicity, etc.). Air has also been used as a refrigerant for residential and automobile air conditioning and cooling. In some refrigeration plants, air is used in the quick freezing of food products.

Refrigerants	Ammonia	Carbon dioxide	Propane	Isobutane	Propylene	Water	Air
Refrigerants number	R717	R744	R290	R600a	R1270	R718	R729
chemical formula	NH ₃	CO ₂	C ₃ H ₈	C ₄ H ₁₀	C ₃ H ₆	H ₂ O	-
GWP (100 years)	0	1	3.3	4	1.8	0	0
ODP	0	0	0	0	0	0	0
normal boiling points (°C)	-33.3	-78	-42.1	-11.8	-48	100	-192.97
critical temperature (°C)	132.4	31.4	96.7	134.7	91	373.9	-
critical pressure (bar)	114.2	73.8	42.5	36.48	46.1	217.7	-
Safety group	B2	A1	A3	A3	A3	A1	-
molecular weight (g/mol)	17.03	44.0	44.1	58.12	42.08	18	28.97

Application of natural refrigerants in Japan TODAY

Introduction

The Japanese market has some of the greatest success stories for natural refrigerants worldwide, as well as key sectors possessing large potential growth for natural refrigerants. The benefits of heat pumps have been extolled for years now, but other sectors are beginning to attract praise of their own, especially the accelerated uptake of CO₂ transcritical solutions in commercial refrigeration.

In addition to this, great strides have been made to help win market share for CO₂ and hydrocarbons in light commercial refrigeration. This is especially prevalent in vending machines with a small niche role for plug-in units in supermarkets emerging. After many years of dominance by fluorinated gases, industrial refrigeration has begun to throw off the shackles and adopt innovative natural refrigerant-based solutions.

The main drivers of these great strides in adoption are an increased role for government in steering the market away from fluorinated gases through subsidies and information dissemination, and the energy-efficiency benefits of natural refrigerants. While government has moved forward in certain areas, gaps remain that must be addressed to allow for full proliferation of natural refrigerant solutions in Japan.

4 current market trends

FOCUSED GROWTH OF CO₂ IN COMMERCIAL REFRIGERATION

The strongest trend that has emerged in Japan in the last three years has been the uptake of natural refrigerants within the commercial refrigeration sector, almost exclusively within convenience stores (CVS). This growth has been encouraged by the government through the use of subsidies to help reduce initial costs, which allows companies to make decisions based on long-term factors as opposed to potentially short-sighted ones.

This has allowed key CVS stores such as Lawson and 7-Eleven to begin changing the standard refrigerant in their refrigeration systems. However, this trend does not extend to larger supermarkets due to regulations in place that restrict the use of larger capacity package systems or 'rack' systems as found in Europe and North America. This limitation makes the use of CO₂ refrigeration difficult in larger stores.

VENDING MACHINES CONTINUE TO BROADEN MARKET FOR NATURAL REFRIGERANTS

The use of natural refrigerants is also growing in the light commercial refrigeration sector, namely in vending machines. As both a cultural institution and a large market in Japan, the use of natural refrigerants in vending machines is a key and symbolic area for natural refrigerant growth within Japan. Over 1.35 million Japanese vending machines use either CO₂ or hydrocarbons, out of a potential 2.5 million.

While the use of natural refrigerants in vending machines is clearly making an impact, the same cannot currently be said of small plug-in units. While European manufacturers have managed to penetrate the market to a certain extent, smaller self-contained units that typically use hydrocarbons are still minimal but their number has the potential to rise in the future as education and future supply improve.

INDUSTRIAL REFRIGERATION BEGINNING TO TURN CORNER

Due to safety concerns that took hold in Japan in the 1970s with regard to the use of ammonia in large industrial refrigeration systems, this sector has typically been the territory of fluorinated gases. However, alongside other advanced regions such as the EU and North America, Japan has seen a growing number of 'next generation' industrial refrigeration installations. Safety concerns are being mitigated through the use of NH₃/CO₂ secondary systems while also ensuring efficiency. As with other regions, these state-of-the-art technologies are only just beginning to penetrate the market, but the future looks promising for solutions such as CO₂ transcritical, low-charge ammonia and NH₃/CO₂ secondary and cascade systems globally.

CO₂ HEAT PUMPS: A CLEAR EXAMPLE OF NATURAL REFRIGERANT BEST-PRACTICE

As other areas continue to grow, they will surely hope to emulate the success of CO₂ heat pumps in Japan. The country remains the world leader by far in terms of using natural refrigerants in domestic water heating, while the number of CO₂ heat pumps is growing by hundreds of thousands of units annually. A generous and long-serving government subsidy for CO₂ heat pumps has allowed for the introduction of the technology with a reduction in the initial cost premium thanks to economies of scale.

The rest of the world has something to learn from Japan in promoting environmentally friendly and energy-efficient technology, with efforts to replicate this success ongoing in North America, Europe and China. The next step for Japan is to introduce the technology for more commercial and industrial applications.

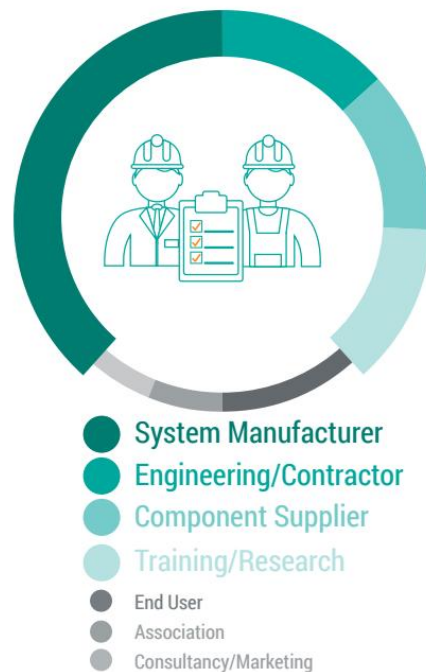
Japanese survey about natural refrigerants

In order to provide an accurate current market share of natural refrigerants in Japan as well as the future outlook for the use of natural refrigerant-based technology, shecco conducted an online survey among hundreds of experts in the Japanese HVAC&R sector.

The GUIDE survey asked key stakeholders for their opinions on subjects such as the state of the market, the potential drivers and barriers for wider uptake of natural refrigerant-based technology and the effectiveness of current relevant policy, as well as the perceived effect of potential upcoming policy changes. These results add to increasingly dense knowledge of the Japanese natural refrigerant market.

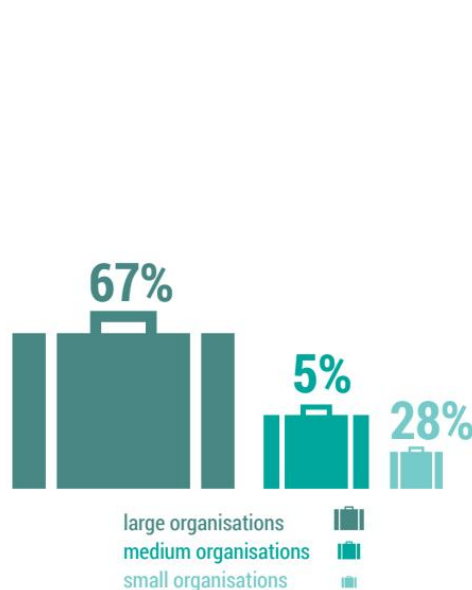
To further improve the accuracy of our findings, the GUIDE survey tailored the questions to the respondent's area of activity, focusing on light commercial, commercial and industrial refrigeration as well as CO₂ heat pumps, which have seen the most dynamic developments for innovative natural refrigerant technologies. Those active, for example, in industrial refrigeration were asked their opinions on relevant policy for this sector, as well as key technological advancements. By including this division, the GUIDE is able to provide supplementary data to the key market, policy and technological trends for natural refrigerants in these key sectors.

The make-up of the survey respondents can be seen in the graph on the right.



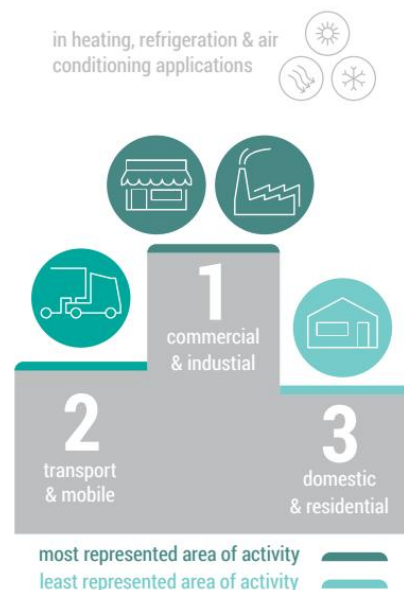
Big industry turnout

The GUIDE Survey asked respondents to identify the type of organisation they represent or are active in. System manufacturers comprised by far the biggest group of respondents, with 52.4% identifying themselves with this category. The other category types were mostly equally split, with engineers/contractors, training/research, component suppliers and end users all receiving between 15.9-18.3%, and associations and consultancy/marketing having 8.5% and 7.3% respectively.



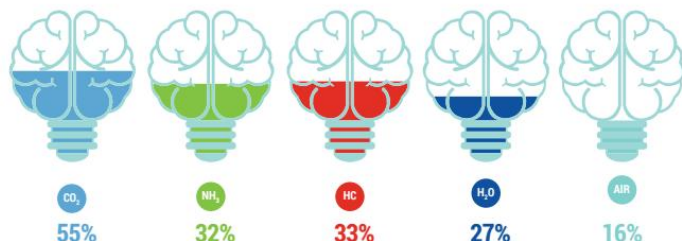
Size of companies shows an open industry

The GUIDE Survey also sought to find out the size of the companies surveyed and clearly, it captured a large percentage of the market, with 67.1% of respondents working for 'large' firms (500 employees or more). The remaining respondents typically worked in 'small' firms (less than 99 employees) while a small percentage worked for medium sized organisations (between 100-499 employees).



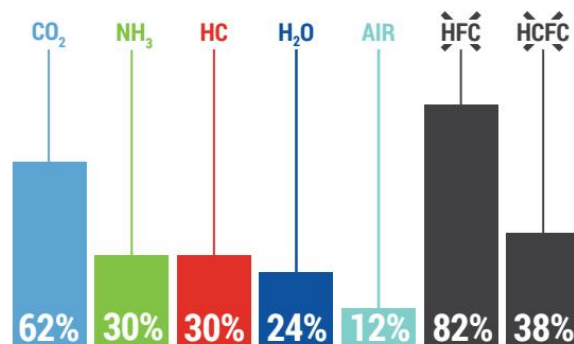
Commercial and industrial applications prevail

To better understand the division of applications that are represented in the responses, the GUIDE Survey asked respondents to identify the applications they are active in. Refrigeration as a whole was the most common choice. Commercial refrigeration had the highest proportion, with 65.9%, followed by light commercial and industrial refrigeration, which was chosen 51.2% and 48.8% of the time. Transport and domestic refrigeration, however, were not so common, with 25.6% and 20.7% respectively.



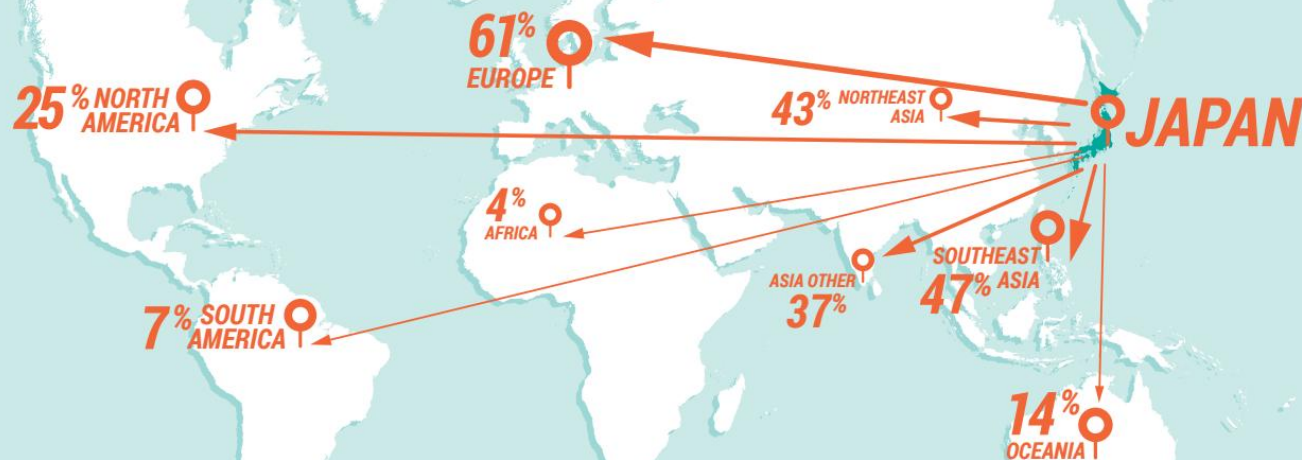
Carbon dioxide lead the NR group in terms of industry familiarity

When asked which natural refrigerant the respondents were most familiar with, unsurprisingly, as the most prevalent refrigerant in Japan with high adoption rates for both heat pump water heating and commercial refrigeration, CO₂ had the highest level of familiarity. Unlike in North America, Europe and China, there is a greater emphasis on both water and air as refrigerants in Japan, and this too is reflected in the levels of familiarity. While the level of familiarity for ammonia and hydrocarbons is also high, this may be a result of negative publicity, as both ammonia and hydrocarbons have been marginalised in the past due to safety concerns.



CO₂ edges closer to widespread usage closing gap with HFCs

To better understand the current market, the survey investigated which refrigerants the organisations work with. The strong presence of HFCs and HCFCs is not surprising as the transition to more environmentally friendly refrigerants takes time. As for natural refrigerants, it is clear that CO₂ is the most used refrigerant, with ammonia and hydrocarbons each taking an equal slice of the cake. Water and air, while used more extensively in Japan than elsewhere, still remain somewhat limited in their scope and adoption.



Japanese natural refrigerant industry has a global reach

Japan is one of the world's major producers of HVAC&R equipment, and as such is a valuable exporter. The map shows that Europe is a major recipient of exported Japanese natural refrigerant-based goods, with nearly two-thirds of respondents shipping their products to Europe. Technology exchange is also common with nearby regions such as North-East and South-East Asia, where demand for natural refrigerant products is also growing – with several Japanese companies operating in countries such as China and Indonesia. The exchange with North America is rather less emphatic. However, as the North American market matures in the coming years, the relationship is expected to grow.



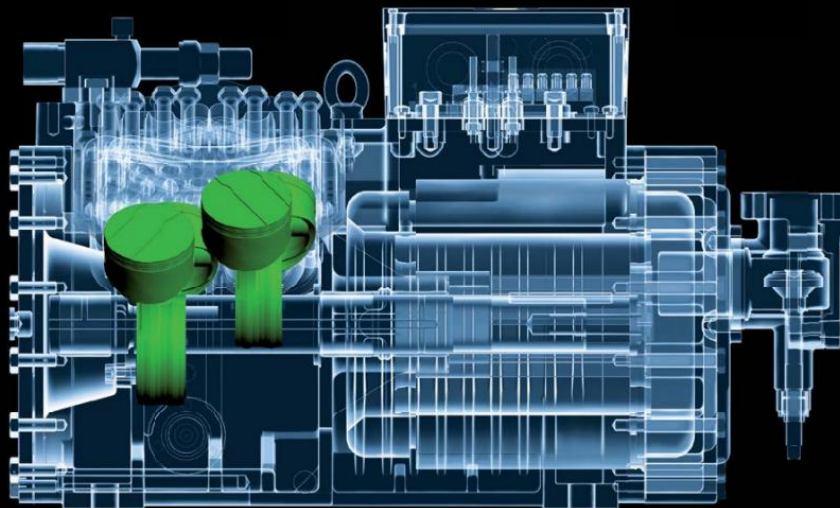
Considerations about legislation, efficiency and environmental impact drive market

The standout reason for the use of natural refrigerant-based products and services is its lack of negative environmental impact, followed in second place by efficiency and performance. These factors allow companies to save both on emissions and energy usage and are a part of a growing global trend to help meet compliance with current and future legislation, which is placed third. Compared to other regions, the place of financial assistance and incentives is notably higher than usual, showing the impact that the government's attempts to stimulate the industry is having.

The provision of subsidies is particularly helpful, as it is clear that capital and overall lifecycle costs are not pulling the market towards natural refrigerants, as shown by the place of these two factors in the bottom three.



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CO₂ AS A REFRIGERANT?
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THE HEART OF FRESHNESS

Overview of policy trends in Japan

The role of natural refrigerants in Japan is heavily influenced by a vast array of government policies and initiatives that have dramatically accelerated the introduction of natural refrigerant-based technologies and mitigated the growth of other environmentally-friendly solutions.

The Japanese Ministry of Environment (MOE) has attracted praise for subsidising the introduction of technologies such as CO₂ heat pumps and more recently, subsidising CO₂ transcritical refrigeration in convenience stores and energy-efficient industrial refrigeration systems, such as NH₃/CO₂ secondary systems.

However, while these initiatives have undoubtedly had a major impact on the market, Japan also has restrictive policies in place such as the High Pressure Safety Gas Act, which limits the potential growth of technologies such as CO₂ transcritical rack systems in larger supermarkets and industrial applications. Some manufacturers consider these policies to be out-dated, and are urging stakeholders to come together to push through changes facilitating the uptake of a wider variety of technologies in Japan.

JAPAN PROMOTES INTRODUCTION OF LOW-GWP ALTERNATIVES GLOBALLY

The Act on the Protection of the Ozone Layer through the Control of Specified Substances is making an effective contribution to phasing out the production and consumption of CFCs and HCFCs. In addition, the HCFC phase-out target for 2020 is pushing supermarkets and cold storage warehouses to convert their facilities from R22 to natural refrigerants such as CO₂ and low-charge NH₃ through the wider adoption of NH₃/CO₂ secondary systems.

In view of the discussions regarding a global phase-down of HFCs, Japan considers that

the Montreal Protocol needs amending to protect the Earth's environment. The government also provides support for implementing projects in developing countries through Japan's Joint Crediting Mechanism (JCM). The energy savings and f-gas emission reductions achieved by such projects translate into emission reduction credits under Japan's Joint Crediting Mechanism (JCM) and count towards meeting the country's greenhouse gas reduction targets. One project sanctioned under the scheme is bringing CO₂ transcritical refrigeration technology to Indonesia.



Government subsidies create immediate opportunities for natural refrigerants

A survey distributed among industry experts investigated the impact of a variety of regulatory and non-regulatory factors on the adoption of natural refrigerants in Japan. Respondents unanimously believe that financial subsidies for end-users have the greatest influence in accelerating the uptake of HFC-free technology. The acceleration in use of CO₂ in commercial refrigeration and CO₂ in hot water heat pumps clearly supports this. The second most important factor is whether there is a global agreement on a HFC phase-down. With advances at international level amid discussions on amending the Montreal Protocol to incorporate HFCs, this could soon become a reality. The provision of subsidies for manufacturers to conduct R&D on natural refrigerant-based technology is also seen as a major factor that could help cut the initial premium for these technologies. Japan's own F-Gas laws rank as an important but not the most significant factor.

REVISION OF F-GAS LAWS BRINGS GREATER IMPETUS FOR NATURAL REFRIGERANTS

In April 2015, new policy measures for reducing emissions of fluorinated gases were introduced by the Japanese Government. The main driver of the revision of the regulations was the steep increase in emissions of fluorinated gases as well as concrete evidence of high leakage rates from commercial air conditioning and refrigeration equipment. With the revised F-Gas Law, the Japanese government expanded the scope of f-gas measures from their previous focus on recovery and destruction to the whole lifecycle, including f-gas manufacturing, maintenance and leak checking, the promotion of low-GWP/non-fluorocarbon refrigerants in designated products, and destruction and recycling.

Manufacturers and importers of certain refrigeration and air conditioning systems will be requested to reduce the climate impact of their equipment by deploying non-fluorinated gases or other refrigerants with a lower Global Warming Potential (GWP) by certain target years depending on the product category. Weighted average GWP values of entire production and imports are taken into account to measure compliance by manufacturers.

Designated products		Present refrigerant (GWP)	Target value (GWP)	Target year
Room air conditioning		R410A (2090), R32 (675)	750	2018
Commercial air conditioning (offices & stores)		R410A (2090)	750	2020
Condensing units and refrigeration units (> 1.5kW)		R404A (3920), R410A (2090), R407c (1774), CO ₂ (1)	1500	2025
Cold storage warehouse (> 50.000m ³)		R404A (3920), NH ₃ (0)	100	2019
Mobile air conditioning		R134a (1430)	150	2023

THE ACT ON THE RATIONAL USE OF ENERGY

The Act on the Rational Use of Energy (ARUE) was established in 1979 to help tackle the oil crises and is now considered one of the most important measures driving the reduction of greenhouse gas emissions as well as improving energy security. Under the ARUE, products that have the greatest impact on energy consumption, such as air conditioners, refrigerators and vending machines, are obliged to meet updated Top Runner targets.

TOP RUNNER PROGRAMME DRIVING ENERGY EFFICIENCY

Japan's Top Runner Programme, introduced in 1999, is a set of energy efficiency standards for energy-intensive products, such as smaller appliances and motor vehicles.

As of 2015, the programme includes 21 product categories eligible for a 'Top Runner' label. The scheme encourages companies to develop more efficient models to compete for the 'Top Runner' award.

HIGH PRESSURE GAS SAFETY ACT LIMITS USE OF CO₂ IN BIGGER SYSTEMS

The High Pressure Gas Safety Act regulates the production, storage, sale, transportation and other matters related to the handling of high-pressure gases. The outdated classification of CO₂ as an "active gas" under the Act limits the availability of large capacity systems and increases the cost of CO₂ solutions for supermarkets and industrial refrigeration applications.

To meet these targets, various applications have taken the initiative in adopting energy-efficient natural refrigerants to help reduce energy consumption. One key example of how this has pushed the market towards natural refrigerants is the introduction of isobutane for domestic refrigerators, which is now a standard in Japan. Hot water heat pumps are another clear example of how this initiative benefits natural refrigerants, as the application was included under the scope of ARUE in 2013.

This award of status is countered by the ability of Japan's Ministry of the Environment (MOE) to disclose the names of companies that fail to meet energy efficiency targets, as well as issue recommendations, orders and fines. However, as of yet, no enforcement actions have been taken as targets have been either met or exceeded.

Although exemptions for fluorinated refrigerants and ammonia exist, the regulations governing the use of CO₂ and hydrocarbons are more stringent. This means that official permission must be obtained to install equipment with a capacity above 40~50 horsepower, thereby imposing a significant barrier on end-users.

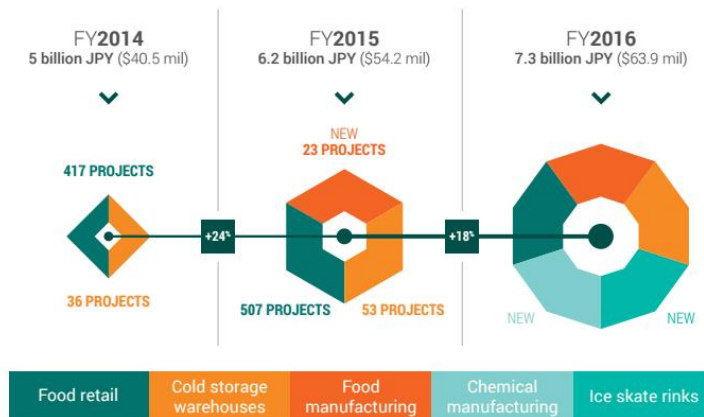
MOE SUBSIDY SCHEME – KEY DRIVER FOR NATURAL REFRIGERANTS

Starting from 2005, the Ministry of Environment (MOE) initiated a subsidy scheme for commercial and industrial projects using natural refrigerants. In the period 2005-2013, the scheme was available to renovation, earthquake reconstruction and advanced technology projects, aiding a total of 242 projects in this phase.

As of 2014, the subsidy scheme has undergone a substantial revision coupled with a funding increase, resulting in a dramatic upturn in the number of projects aided. Since 2014 the subsidy has been the major driver of growth in the number of CO₂ stores in Japan as well as NH₃/CO₂ cold store facilities.

This subsidy aided 583 projects in 2015, most of which were in food retail. The scope of the scheme has been broadening, with the food manufacturing sector added in 2015, and chemical manufacturing and ice rinks included as of 2016. In addition, the budget allocated for the subsidy has been growing year-on-year. It was increased by 24% in 2015 and by an additional 18% in 2016. The 2016 budget of 7.3 billion yen bodes well in terms of both the number of projects to potentially be aided and the market for natural refrigerant technology in Japan.

Japan's subsidy growing in scope and budget



TOKYO SUBSIDIES AIM TO HELP SMALLER BUSINESSES

Tokyo has the largest concentration of refrigeration equipment in Japan, and as such is a key area to target for increasing uptake of environmentally-friendly equipment. This growing need for environmentally-friendly technology has been recognised by the local government, the Tokyo Metropolitan Government (TMG), which is looking to promote natural refrigerants in Tokyo.

However, while the MOE subsidies target all companies, TMG funding is aimed at small, mid-sized or solo business operators. The TMG subsidy targets energy-efficient showcases using natural refrigerants and provides up to 1/3 of the cost of installation (including the construction cost).

The TMG subsidy scheme was allocated 200 million Yen for 2014/2015. As well as attempting to help smaller businesses, it also aims to inform customers of the use of natural refrigerants. It does this via a sticker displayed on showcases.

Other initiatives involving the TMG include the provision of information to site supervisors.





Industry viewpoint

ON MOTIVATION TO ADOPT NATURAL REFRIGERANTS...

Tsutomu Saito - Manager of the Environmental Policy Promotion Group, COOP Mirai

"The reason for introducing CO₂ is that global warming is something we need to address, as well as improving energy efficiency."

Shinichirou Uto - Energy Manager, Lawson

"We were surprised to learn that CO₂ systems were highly energy efficient and that leakage of f-gases actually has a profound impact on the environment because of their potent global warming potential. Realising that we could make a far more positive impact on the environment by replacing f-gas refrigerants than taking energy-saving measures, we launched a study group to further look into CO₂ as a refrigerant.

Instead of taking multiple measures, we want to leapfrog [HFCs], and this is why we have decided to adopt CO₂ technology."

Junya Ichikawa - President, SANDEN Environmental Products Corporation

"The passion to use natural refrigerants is the most important element for us to be able to save our Earth for coming generations. We have to have the passion to promote and to use natural refrigerants. In SANDEN's case, we have chosen CO₂."

ON SAFETY AND ENERGY EFFICIENCY...

Yoshiaki Kenjo - Construction Manager, Save On

"The fact that propane is widely used in Europe proves its safety. The approved charge limit for propane is 150g, which our systems adhere to. Within this limit, we believe its safety is guaranteed."

Shinichirou Uto - Energy Manager, Lawson

Although people say that CO₂ systems are not suited to reduce energy consumption in tropical regions, we have actually been able to save energy by implementing Japanese technology.

Tetsuji Okada - Executive Director, Japan Refrigeration & Air Conditioning Industry Association (JRAIA)

"We do offer training programmes on how to install and maintain CO₂ equipment. It's a two-day training course that we restarted two years ago. During the first day, technicians are given theoretical studies in the classroom and in the second day they are given practical experience of installing machines."

Shinichirou Uto - Energy Manager, Lawson

"It has been a long road and we have overcome many challenges. The biggest problem was the lack of training, so we had to provide training to Lawson's refrigeration technicians, for which we received the cooperation of the system manufacturers."

ON BARRIERS...

Jurgen Brenneis - Global Purchasing Manager, Red Bull

"We would like to fulfill our HC policy in Japan but we are struggling to find and get components for R600a."

Shinichirou Uto - Energy Manager, Lawson

"We face the challenge of high cost of new systems, and without government support it would be difficult for us to install this many systems."

ON REGULATIONS...

Motoyuki Kumakura - Director, Office of Fluorocarbons Control Policy, Ministry of Environment

"Technology using natural refrigerants has been improved in efficiency and safety, but not yet spread widely. To address this situation, the Ministry of Environment financially supports installations of high-efficiency equipment with natural refrigerants."

Satoshi Narisawa - Director, Environmental Protection Section, Tokyo Metropolitan Government (TMG)

"We are making sure that it will be easier for consumers to use and understand environmentally friendly equipment – therefore we are promoting the labelling of equipment saying it is environmentally friendly."

ON COST...

Yukio Yamaguchi - General Manager, Sales and Marketing Dept., SANDEN

"Going forward we are expecting to see further impact as the volume increases, so the cost parity with HFCs can be achieved."

Hiroaki Suzuki - Manager of Sustainability, Corporate Citizenship Dept., AEON

"We would like to move towards using CO₂ as a standard in stores, but one of the main hurdles has been cost. For this reason, support from the Japanese government is important."

An ecosystem approach

The purpose of the “ecosystems” is to highlight the recent developments in a variety of natural refrigerant-based products and technologies currently in use in Japan. The examples mentioned aim to provide insights into the experiences of a range of Japanese manufacturers, suppliers and contractors, as well as end users, that drive the adoption of natural refrigerant-based technology. The cases highlighted also allow for a deeper analysis of the different business models currently used in various HVAC&R in Japan.

In addition to ecosystems highlighting the progress of Japan, the chapter also provides an international perspective. The “outside Japan” ecosystems looks to elucidate areas of potential growth for Japan through the use of successful examples from around the globe.

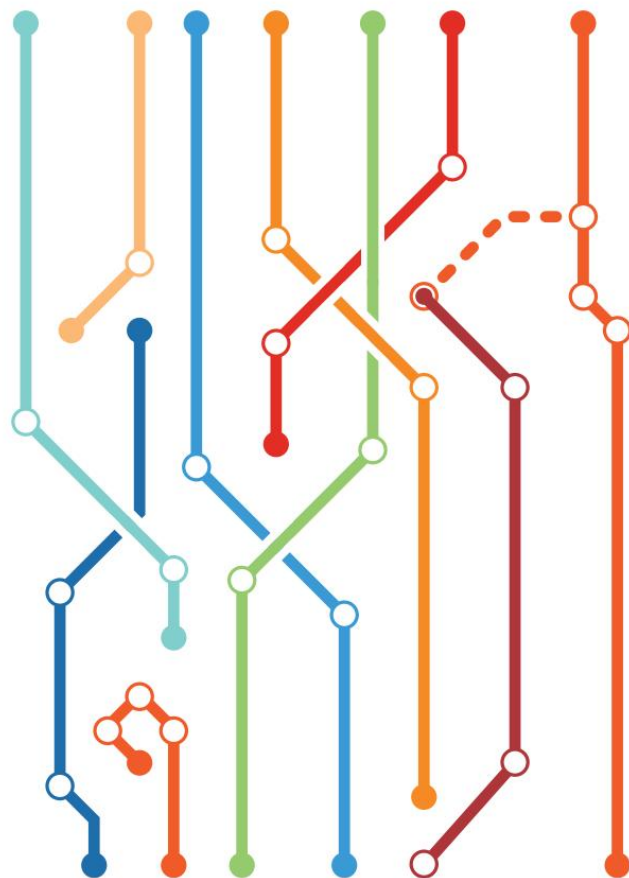
The four ecosystems for inside and outside are categorised into the following sections:

CITY & BUILDINGS: Natural refrigerants can be used in a variety of applications in public and commercial buildings, data centres, district heating and cooling and private residential housing.

TRANSPORT APPLICATIONS: The use of natural refrigerants in Japanese transport applications is not so prominent. However, developments elsewhere show the distinct possibility of an all-natural food chain.

INDUSTRY, SPECIAL APPLICATIONS & SPORTS: Natural refrigerants are also applied in larger scale applications such as industry processing in laboratories, pharmaceutical, petrochemical industry, agriculture and power plants. Sports facilities such as ice rinks and curling halls in Japan also present themselves as opportunities for natural refrigerants.

FOOD CHAIN: Natural refrigerants are widely adopted in food and beverage storage, distribution, production and processing, and supermarkets. This section highlights different examples across the entire food chain that use natural refrigerants.



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City & buildings

PUBLIC AND COMMERCIAL

CO₂

In Japan, over five million EcoCute CO₂ heat pump water heaters were in operation as of February 2016. Annual sales are now reaching 400,000-500,000 units, representing a market share of 98% of all new heat pump water heaters. The Japanese Government aims to reach 10 million EcoCute CO₂ heat pump water heaters by 2020.

In 2009, the Tottori Green Hotel Morris was built according to the 'all-electric' principle, using a commercial CO₂ EcoCute system for hot water production in addition to small electric water heaters, air-source heat pump chillers and room air conditioning, as well as all-electric kitchen appliances. The EcoCute system achieves CO₂ emission savings of 48.7% (91.1 tonnes CO₂/year) compared to a gas boiler hot water system (139.8 tonnes CO₂/year). Running costs are around €14,000 per year, compared to €45,270 for a boiler system.

Sagahihara Heart Disease hospital installed a commercial EcoCute CO₂ heat pump water heater to save energy and enhance business sustainability. EcoCute technology achieves

large energy savings and helps to reduce fuel consumption. Compared to the gas boiler previously used by the hospital, the EcoCute heat pump delivers energy savings of 43%.

Fujiginkei Hotel in front of Kawaguchi Lake (the nearest hot spring hotel to Mount Fuji) invested in a commercial EcoCute CO₂ system to reduce energy costs and contribute to environmental protection. The EcoCute system heats water for hotel room showers and produces hot drinking water, complementing the traditional boiler (which heats water from the spring). Thanks to EcoCute technology, the hotel was able to save 30% on energy costs.

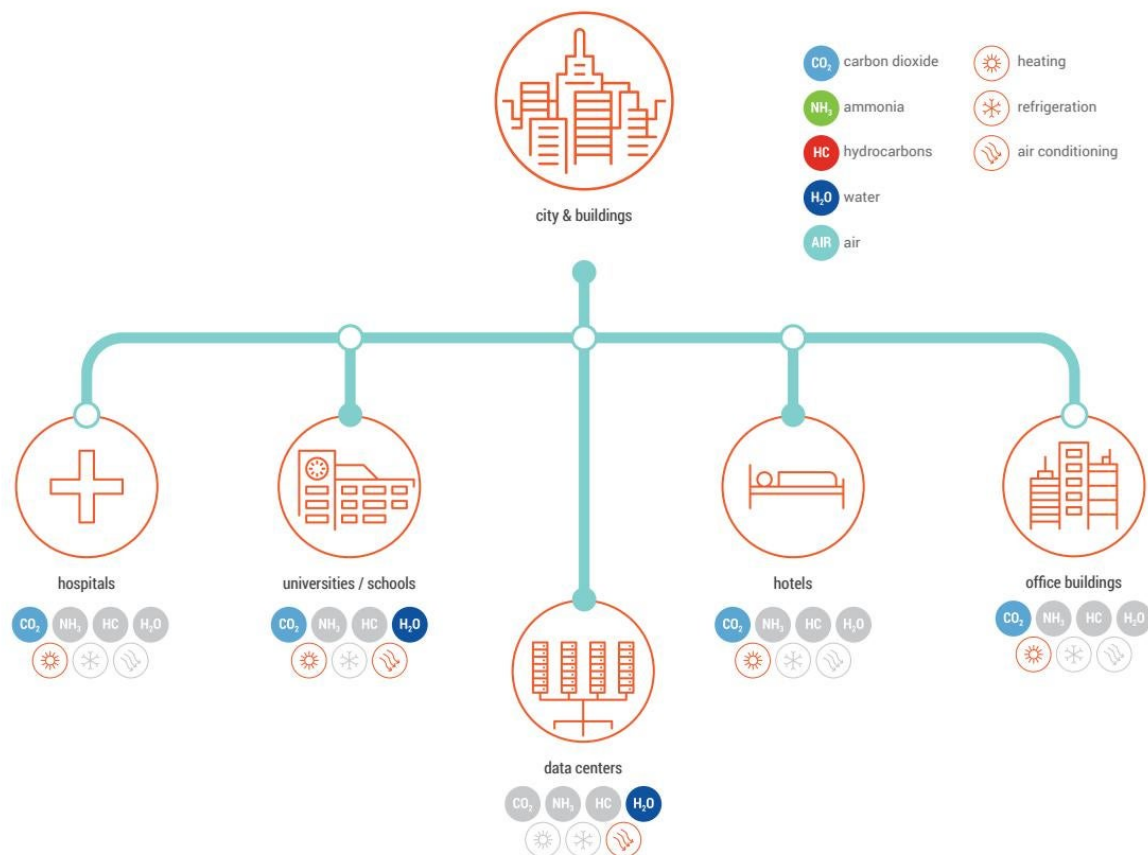
H₂O

Waseda Setsuryo Junior High School and the High School of Waseda University Group introduced a cooling and heating air conditioning system based on a newly developed absorption freezing machine that uses solar heat as the heat source. In summer, the system provides dry and cool air without drafts and in winter, it provides warm air. The installation helps contribute to emissions reductions of 51 tonnes CO₂/year.

DATA CENTER

H₂O

The Riken Advanced Institute for Computational Science installed two types of chillers: four absorption refrigeration chillers and three centrifugal water chillers. In addition, there are two cogeneration systems with gas turbines that can generate electricity (maximum 5 MW) and steam for the absorption chillers. The largest priority in selecting the system was to stabilise 'Kyo', the facility's supercomputer system, which consumes an enormous amount of electricity.



RESIDENTIAL

CO₂

Japan is focusing on smart and energy-efficient housing, pursuing the concept of zero-emission houses. These houses usually feature energy-saving household appliances such as EcoCute heat pumps. In an all-electric house, EcoCute can utilise and store electrical energy generated from solar photovoltaic (PV) panels. Solar PV not only helps to reduce utility bills but also acts as a back-up energy generation system in case of power outages caused by natural disasters. Extracting energy from outside air, EcoCute heat pumps use renewable energy to provide hot water with high-energy efficiency.

In under-floor heating, warm water is circulated through a series of heating pipes. EcoCute is particularly suitable for under-floor heating due to its high efficiency in water heating and its use of night-time energy to store heat for use during the daytime (when energy is more expensive). Running costs of the EcoCute under-floor heating system are a third lower than those of a gas-powered system.

The Shikoku power company has developed a small-scale commercial EcoCute system for deployment in barber shops, beauty salons or family houses, whose hot water demands exceed the capacity of domestic heat pump water heaters, yet are too small for the standard commercial model. These new small-scale commercial CO₂ heat pump water heaters are available in capacities of either 740 litres or 920 litres.

HC

Hydrocarbons for domestic refrigeration have been used in Japanese refrigerators and freezers since 2002 and now dominate the market, with R600a being used in 99.8% of new domestic refrigerators – equating to nearly 4 million units per year.

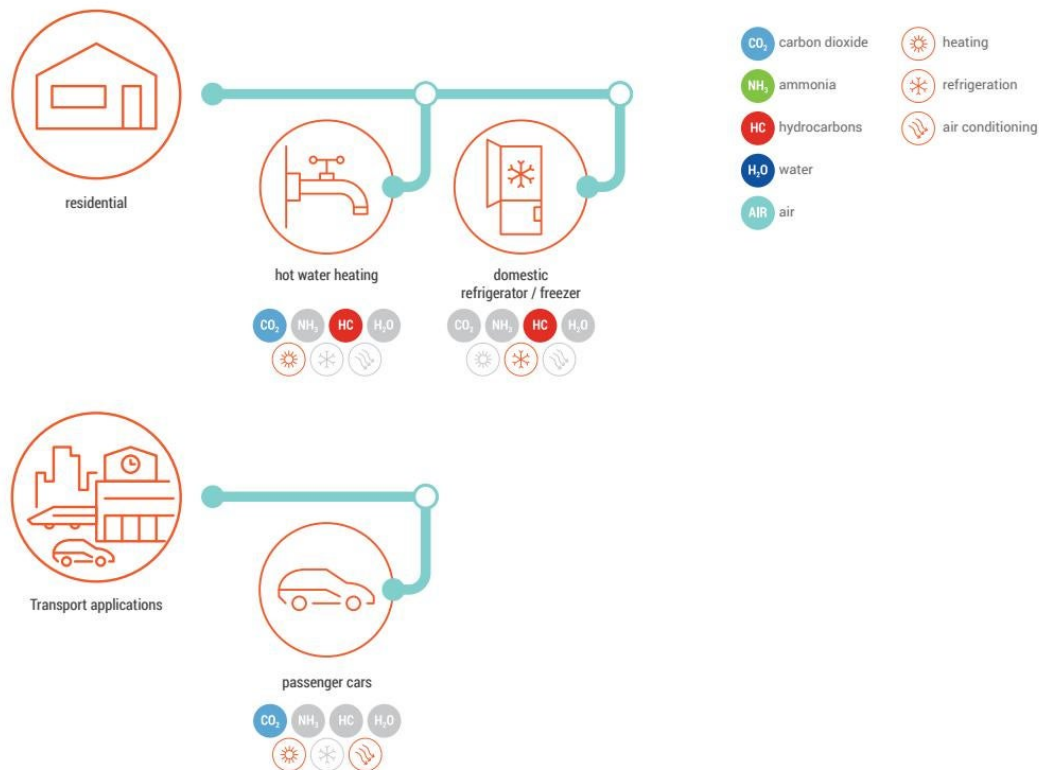
In 2013, Noritz, a Japanese manufacturer of household water heaters, released the first Japanese R290 hybrid water heating system, designed to cover the hot water supply and space heating needs of Japanese households. The system combines heat pump technology (using propane as a refrigerant) and a gas heater. Hot water is supplied by the heat pump, which has a heating capacity of 2.2kW, and is stored in a 90l storage tank. The heat pump unit is charged with 220g of propane refrigerant. The unit's small footprint, with a depth of 300mm, enables easy installation in urban residences with limited space. The primary energy efficiency of the new hybrid system is 50% higher than a previous model of gas water heater and 18% higher than a heat pump with an Annual Performance Factor of 3.2. These efficiency gains can lead to annual utility expense savings of 60,000¥ (€450). This equates to an approximate 45% reduction in annual CO₂ emissions in comparison with previous gas water heaters.

Transport applications

PASSENGER CARS, BUSES, TRAINS

CO₂

The first CO₂ mobile air conditioning (MAC) system was designed and implemented in Japan. The CO₂ MAC system was used in the Toyota FCHV-4. The fuel cell hybrid vehicle was launched in December 2002.



Industry, special applications and sports

INDUSTRIAL PROCESSES

HC

A polypropylene production plant in Oita Prefecture installed a propylene system with 612 kW cooling capacity to enhance energy efficiency and replace a 30-year-old absorp-

tion freezing unit. The propylene system includes a cooling tower, a cooling water pump, a water-cooling propylene chiller unit and a cooling water tank. The system reduces CO₂ emissions by 17.1 tons compared to the refrigerant leakage of other systems and achieves 312 tonnes of electricity savings (0.472kg-CO₂/kWh).

SPORTS FACILITIES

CO₂

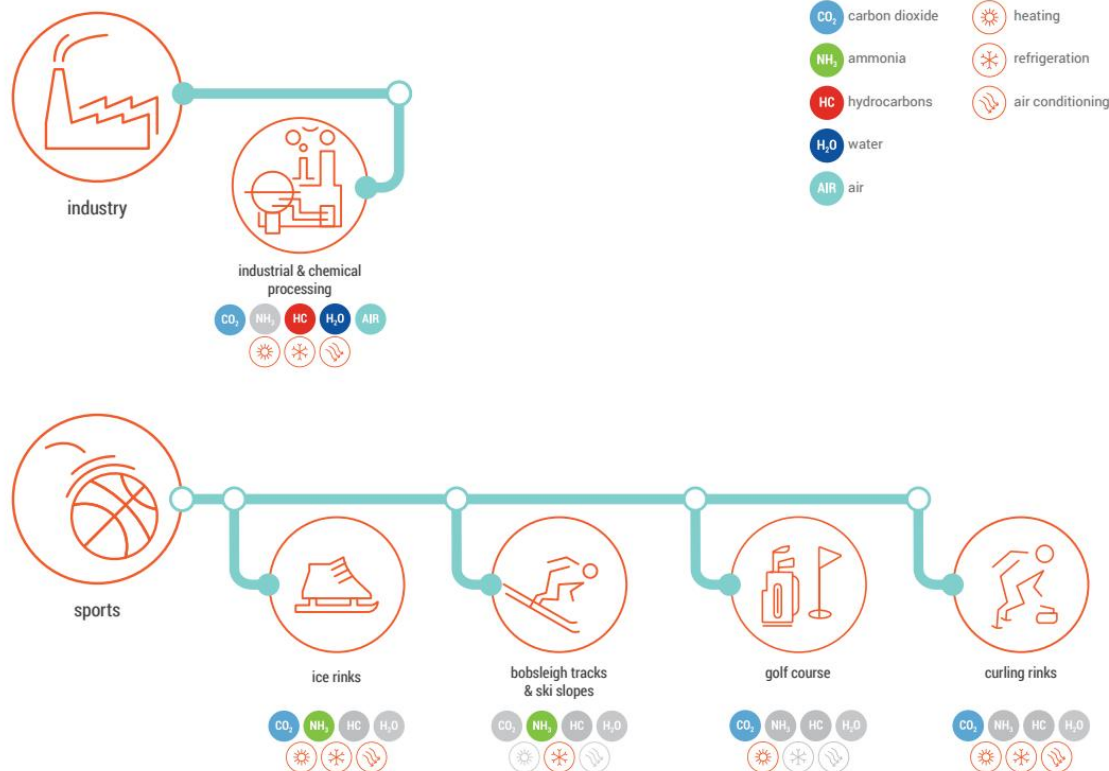
In 2012, Tateyama Country Club and golf course in the city of Tateyamay (Chiba Prefecture) installed a commercial CO₂ EcoCute system to save energy and increase the safety of its heating installation. The traditional water boiler required three staff members to manage two boilers, resulting in high inspection costs. The EcoCute CO₂ system helped to save costs and improved overall system efficiency.

NH₃

In 1996, the bobsleigh, luge and skeleton track was built for the 1998 Winter Olympics in the north of Nagano, Japan. Three indirect ammonia refrigeration systems were installed along the track, limiting the amount of ammonia to less than 800 kg (1764 lbs).

CO₂/NH₃

The Kazakoshi Park in Karuizawa uses two CO₂ and six NH₃ refrigeration systems to cool a curling hall opened in 2013. Compared to a conventional brine refrigeration system, the new system reduces energy consumption by 45-50%. Also due to the cooling properties of CO₂, the system can evenly cool the ice surface and therefore the ice quality has improved, leading to favourable impressions among athletes.



Food chain

FOOD PROCESSING

NH₃/CO₂

AQLI Foods installed a refrigeration system using ammonia in its food-processing factory in Hokkaido Prefecture. CO₂ is also used as a secondary refrigerant to achieve safe and highly efficient cooling. The new technology achieved energy savings of 246.343 kWh and reduced CO₂ emissions by 204.7 tonnes per year.

Kobeya Baking Company converted the R22 refrigeration system to a NewTon F600 NH₃/CO₂ solution at its 7,034m² Chiba frozen dough production facility (located in the Kanto area of Japan). The new system delivered average energy consumption savings of 38%-48% in summer and 25% in winter, due to the innovative system design and in particular, an inverter-driven air compressor. The switch to an air-driven inverter system, with one operating at 15kW and two at 11kW, achieved 27% power savings.

FOOD STORAGE & DISTRIBUTION

NH₃/CO₂

In the 18,118m² logistics centre of the Japanese Consumers' Cooperative Union (CO-OP) (Hiroshima Prefecture), a freezing system based on NH₃/CO₂ was installed. The system achieved energy savings of 374,024 kWh per year and a CO₂ emission reduction of 234.9 tonnes per year (0.555kg-CO₂/kWh).

Yokorei Co., Ltd installed a NH₃/CO₂ refrigeration system in its 27,000 tonne capacity logistic centre in Osaka. The system achieves energy savings of 570,000 kWh per year and reduces CO₂ emissions by 413.3 tonnes per year (0.555kg-CO₂/kWh). One of the largest cold stores in Japan, the 200,000m³ cold storage facility in Kawasaki, installed 11 NH₃/CO₂ packages for frozen food and loading rooms (which require temperatures as low as -25°C). The system consumes less energy than conventional technologies and is one of the most energy-efficient cold storage facilities in Japan, reducing energy consumption by nearly 40% compared to a R22 system.

Air

An air-based freezing system was installed in the Fukazawa Reizo K.K. refrigerant warehouse in Shizuoka Prefecture. The system contributed to delivering 34% energy savings compared to conventional technologies. It reduced CO₂ emissions by 559 tonnes per year, with direct savings from reduced electricity consumption of 380 tonnes CO₂ per year and 179 tonnes CO₂ emission reductions caused by more efficient refrigeration leakage than with conventional refrigerants.

WINERIES & BREWERIES

NH₃

Asahi Beer was the first company in Japan to introduce a completely fluorocarbon-free factory in Nagoya. The company installed a highly efficient NH₃ refrigerant cooling system combined with a brine (antifreeze) cooling system. In order to cool the heated brine, two NH₃-

based cooling units were installed in a cascade system. The company also introduced highly efficient ammonia refrigeration in its Ibaraki factory. The system saves 1,146,955 kWh per year and achieves a CO₂ emission reduction of 786 tonnes per year (0.555 kg-CO₂/kWh).

NH₃/CO₂

Hakutsuru Sake Brewing, a Japanese sake producer founded in 1743, uses CO₂ and ammonia refrigerants for sake storing (and in the bottling process) in its factory based in Kobe. The factory combines traditional sake brewing techniques and the latest energy saving technologies. In sake processing, heating is needed for sterilisation right before bottling. Moreover, the product has to be cooled immediately after bottling. The system uses a

CO₂ heat recovery pump capable of simultaneously producing hot and cold water for the bottling process. The EcoCute system reached a coefficient of performance as high as 5.7. Also to cool sake storage tanks, an ice storage system equipped with an ammonia-based chiller was installed. Ice storage allows for the utilisation of cheap night-rate electricity and contributes to reducing the electric power load.

SUPERMARKETS**CO₂**

In 2009, retailer AEON introduced natural refrigerants in Japanese supermarkets for the first time. After successful pilot installations, AEON introduced natural refrigerant solutions to additional stores. A larger store in Makuhashi Shintoshin uses 20 CO₂ systems to refrigerate 144 CO₂ cabinets. This system reduced energy consumption by roughly 20% compared to the previous R404 refrigeration systems. The system also reduced CO₂ emissions by more than 813 tonnes.

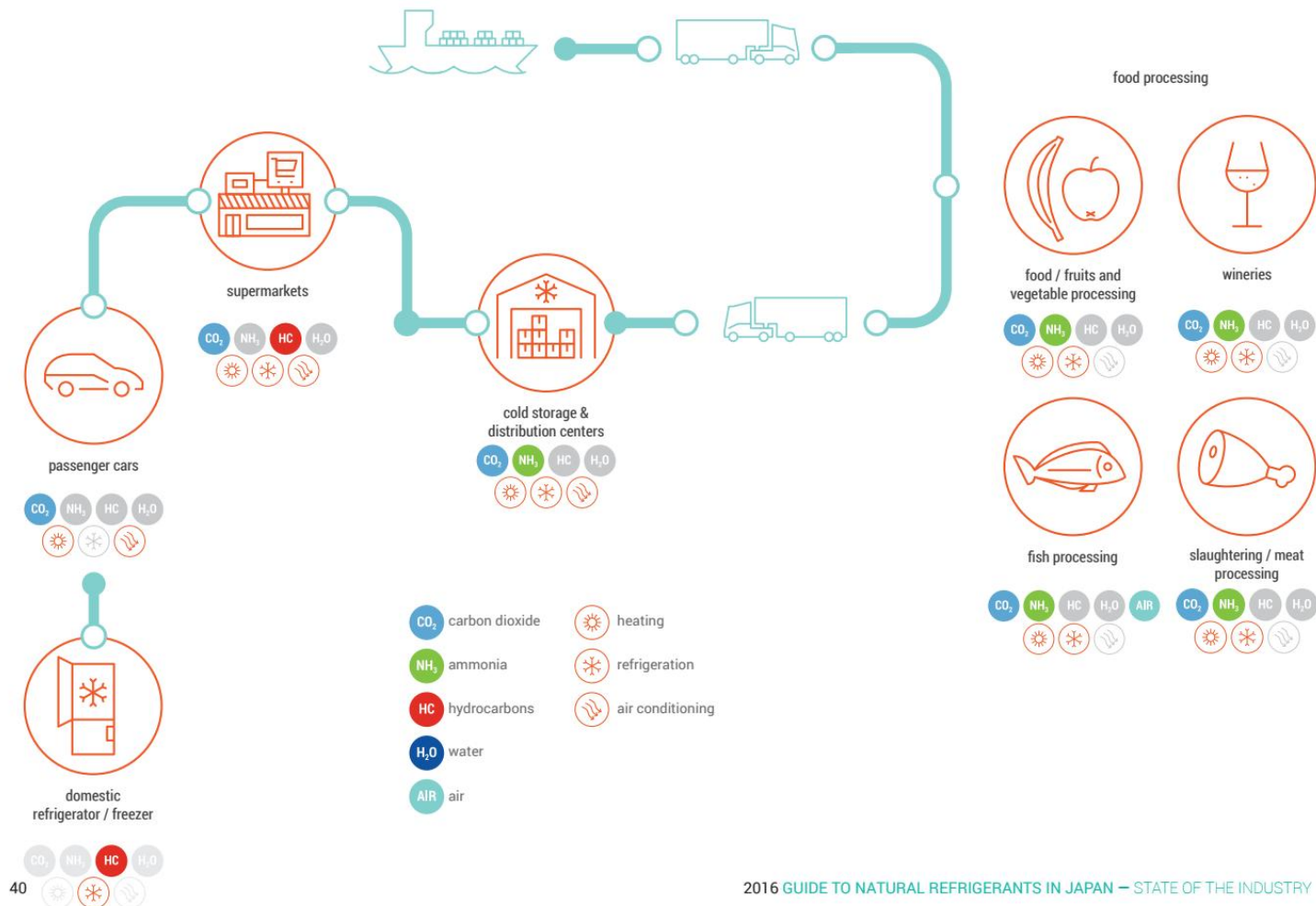
Lawson, another Japanese retailer, aims to become the number one food retailer using natural refrigerants. It is planning to install CO₂-based refrigeration systems in all new stores and reduce electricity consumption by 20% (across all stores and when compared with 2010 FY [Fiscal Year]). Lawson, which operates 12,000 stores, adopted CO₂ refrigeration as its standard technology for all new stores in 2014. The retailer currently has 1,300 climate-friendly systems in operation.

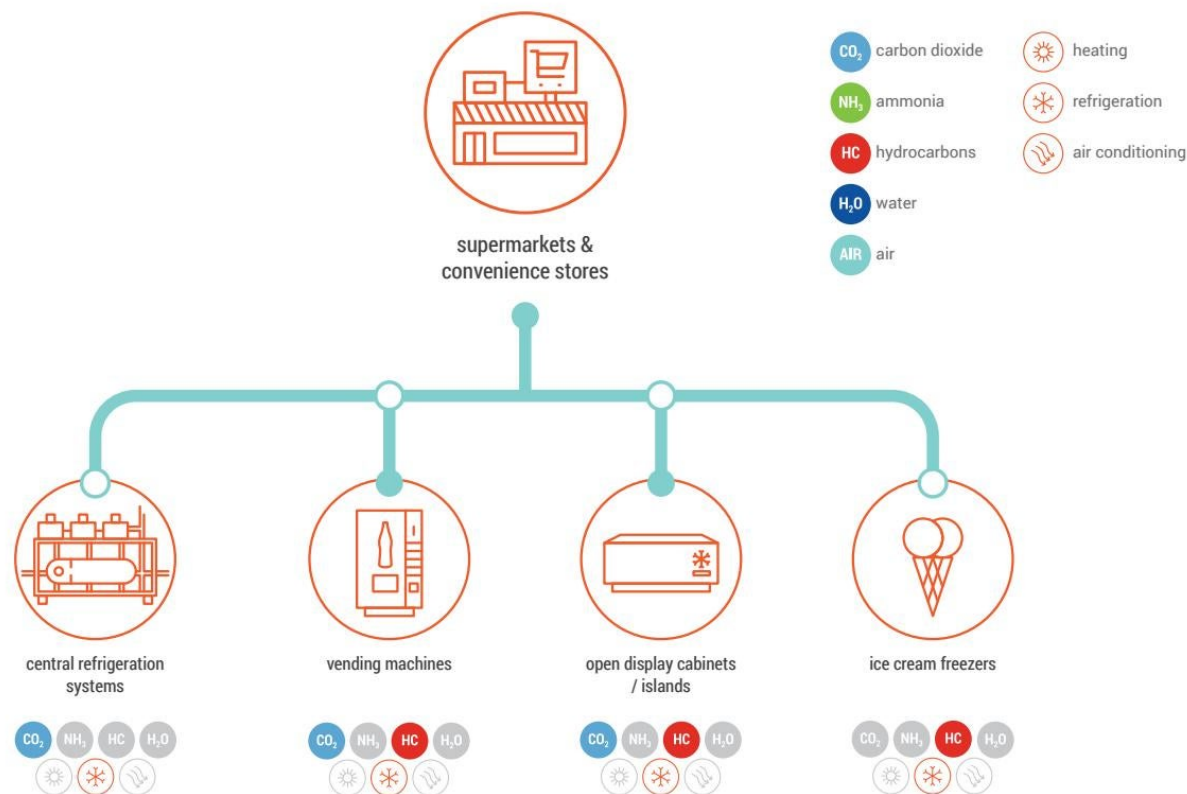
LIGHT COMMERCIAL REFRIGERATION**HC**

SAVE ON, a convenience store chain and part of the Besia Group in Japan, has opened its first store to only use natural refrigerants. The store contains Panasonic wall-side remote-type cases using CO₂ and one cooling plug-in case using R290. The technology achieved significant energy savings and reduced running costs when compared to the old conventional three-phase 200V showcase. Currently, SAVE ON has 30 stores using R290 showcases. In Okinawa, SM chain Union equipped 10 stores with a total of 50 R290 plug-in cases using a MOE subsidy from 2015. The self-contained unit helps reduce energy consumption by roughly 50% compared to traditional R404A models.

CO₂

Coca-Cola Company use a green CO₂ 'peak shift' technology for a growing percentage of their vending machines in Japan. The technology cuts daytime power consumption by up to 95%, as it is able to function without any cooling for a maximum of 16 hours. Insulation was improved by employing vacuum insulation materials, which are 10 times smaller and 10 times more efficient than the polyurethane foam materials used in conventional vending machines. Since 2013, the Coca-Cola Company has installed 100,000 CO₂ 'peak shift' vending machines in Japan.





Natural refrigerants used outside Japan

While the ecosystems on previous pages show the increasing number of applications that are beginning to use natural refrigerants as well as those that have already fully embraced them, there still remains room for improvement. The “outside Japan ecosystems” section gives concrete areas where natural refrigerants have not been deployed in Japan or only to a small extent, but where there exists significant growth potential for natural refrigerants. This section, using the example of success stories from other regions serves as an indication as to where the use of natural refrigerants may be expanded in Japan in the future.

City & buildings

PUBLIC AND COMMERCIAL

CO₂

Shipping company Hurtigruten's terminal in Bergen, Norway uses the natural refrigerant CO₂ for cargo storage. The CO₂ refrigeration system has been especially adapted to Hurtigruten's needs, as well as those of other ships using the terminal – including Troms Fylkes Damskipsselskap, Lofoten og Vesteralens Damskipsselskap and Nor-Cargo. The refrigeration system is 100% CO₂, and was chosen as an alternative to the environmentally harmful R22.

NH₃

A commercial office building in Slough, United Kingdom is one of the first in the country to install an NH₃ heat pump for heating and cooling. The installation of an energy-efficient ammonia heat pump, which took place in 2015, has reduced operating costs by 96% compared to a conventional chiller/boiler combination.

London's Heathrow Airport has a central chilling plant with four energy-efficient chillers, each with a cooling capacity of 6.6 MW, or 1,875 tonnes. The units, powered by high-voltage electricity, use twin compressors which ensures efficient part load performance, while the 11 kW motors reduce transformer losses. Since the large-scale R717 chillers deliver higher efficiencies than smaller local chillers, they are expected to reduce energy consumption by at least 30% and possibly more from the chilled water store benefit.

HC

As the Aarhus University Hospital Skejby in Denmark has gradually expanded over the years, the facility's heating and cooling capacity has become insufficient. As a result, not only have new hydrocarbon chillers been installed to replace out-of-date R22 chillers, but hydrocarbon heat pumps have also been put in place. The first hydrocarbon chillers were installed in 2003 and, as the hospital gradually expanded, additional hydrocarbon chillers have since been installed. The larger chiller system uses nine air-cooled propane (R290)-based chillers, each with a cooling capacity of 250 kW and a coefficient of performance (COP) of 4.5, and using a total of about 210 kg R290.

H₂O

The Reichstag building in Germany, which covers a total floor area of approximately 240,000 m², uses three absorption chillers during the summer for cooling purposes. The surplus heat resulting from operation of the motor-driven cogeneration plants is stored as hot water in an aquifer deep below ground. This water can either be pumped up to heat the building or used to drive an absorption cooling plant (to produce chilled water). The system includes an 850 kW absorption device to provide cooling during July or August if needed, and which can function as a heat pump. Thanks to the chillers and other green technologies, the building's energy requirements are so small that it produces more energy than it consumes, allowing it to act as a mini power station supplying nearby government buildings.

DATA CENTER

CO₂

In September 2014, Bell Canada's Ottawa facility became one of the first data centres to use an all-CO₂ cooling system to protect business-critical information. The new 105 kW system was developed to replace an R22 system. Energy use at the facility has been cut by about 70%, partly through an innovative 'free cooling' process (patented as Aquilon), which uses cool outdoor air to cover some of the load. The technology has won numerous awards.

HC

A cooling unit using propane was installed in Lübbecke's public utilities building in Germany. The R290 system satisfies cooling demand for the building's air-conditioning and for cooling the server room, while at the same time helping to reduce operating costs.

DISTRICT HEATING AND COOLING

CO₂

In China, thirty CO₂ heat pumps were installed in a military base in the city of Kunming. A lack of coal in the region had made heating a major issue for the military. The CO₂ heat pumps have successfully solved the heating issue for the 25,000m² military base.

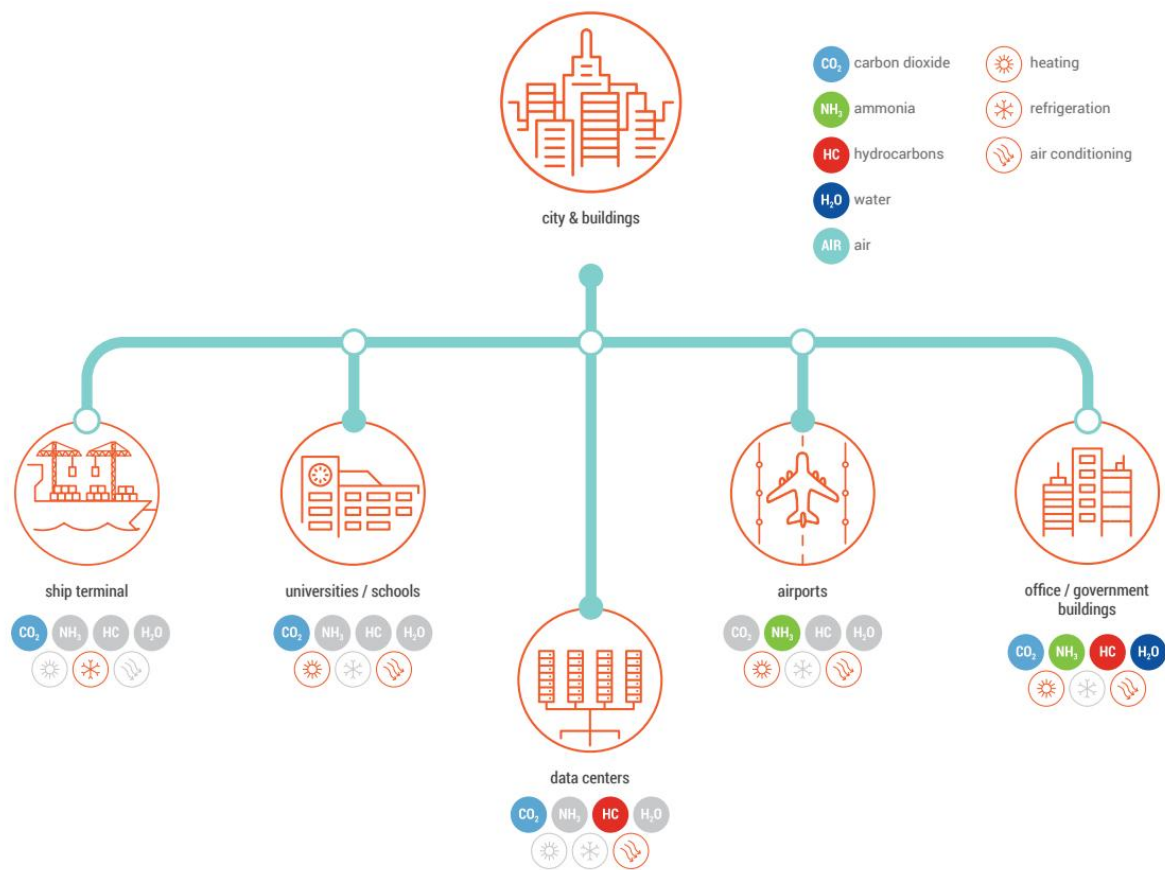
H₂O

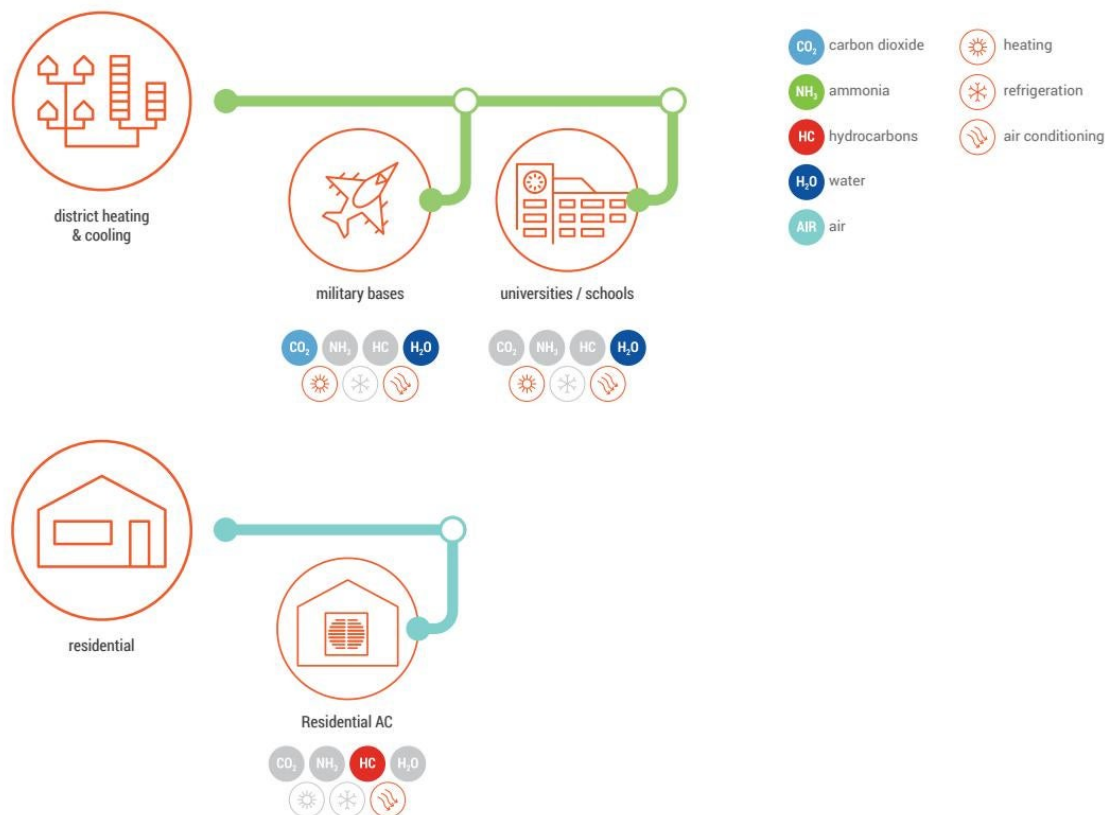
Carnegie Mellon University's Intelligent Workplace, located in Pittsburgh, provides 600m² of offices, meeting rooms and workspace for students and faculty. The energy supply system uses solar thermal energy and renewable fuel bio-diesel oil to drive a pair of 16 kW absorption chillers using water as a refrigerant to provide electrical power, cooling, heating and ventilation with temperature and humidity control.

RESIDENTIAL

HC

Thanks to increased policy support from the Chinese Government and external parties, the integration of R290 into China's room air conditioning (RAC) sector is quickly becoming one of the key potential markets for the development of natural refrigerants in China. Three R290 RAC production lines have already been converted, with an annual production capacity of 400,000 units. Currently 20 RAC lines are being converted, as well as four compressor lines. As a global supplier of RAC equipment and with 85% of global RAC units being manufactured in China, this conversion could have reverberations worldwide. The conversion of production lines could make China a leader in R290 RAC production with an annual capacity of 4.5 million units.





Transport applications

PASSENGER CARS, BUSES

CO₂

Régie des transports de Marseille (RTM) is moving to phase out R134a in its mobile air conditioning, running tests using CO₂ on two of its new buses in 2015. As well as trialling 100% electric buses in 2015, the transport authority RTM, which governs the bus, train and tram networks in Marseille, has turned to the environmentally friendly refrigerant CO₂ to increase

energy efficiency and reduce its carbon emissions.

CO₂ mobile air conditioning systems have also been installed in trains. Deutsche Bahn, a German railway company, began field trials of this equipment in 2011.

REFRIGERATED TRANSPORT

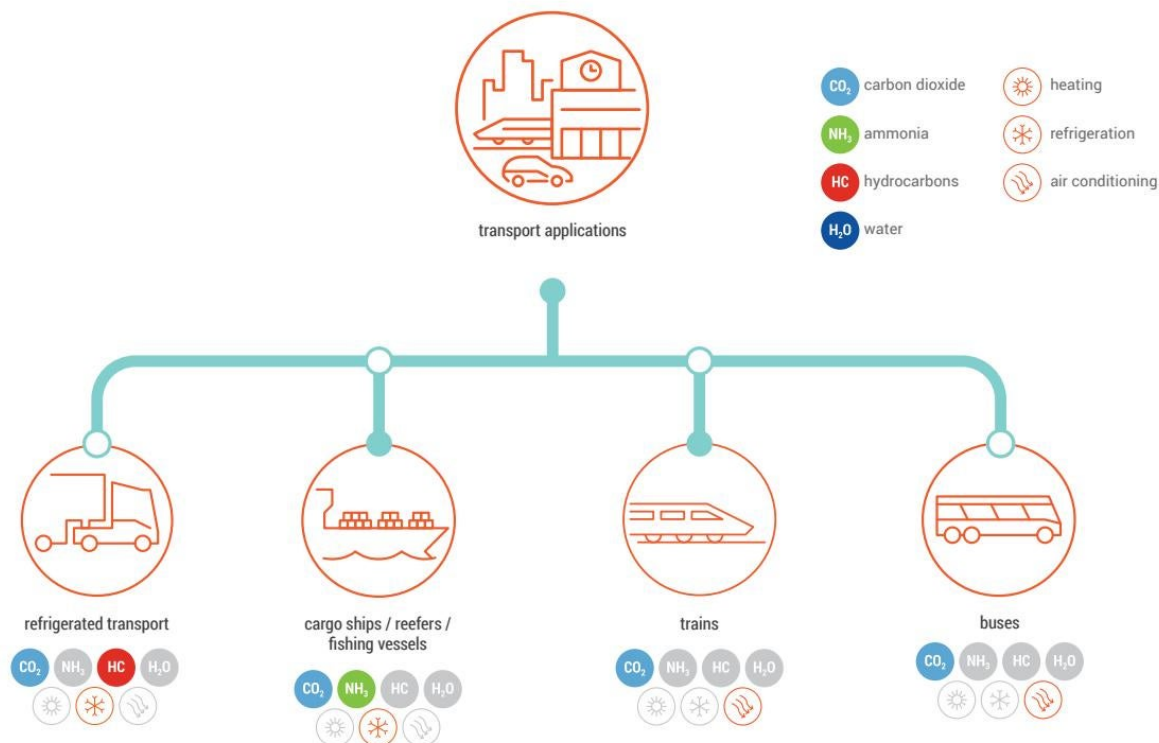
CO₂

A CO₂-refrigerated shipping container has been modified for use in road transport refrigeration. The container was mounted to a box trailer and transported on land. Sainsbury's, a leading UK food and beverage retailer, has been testing the unit for over a year across Greater London, with the system receiving a RAC cooling Industry Award in 2014 for refrigeration innovation. These units reduce CO₂-equivalent emissions by up to 35% compared to the previous equipment. Sainsbury's hopes they will save over 70,000 tonnes of CO₂ emissions compared to its current refrigerated trailer fleet.

CO₂ transcritical refrigeration systems have been installed in fishing vessels in Europe. The cooling and freezing compressors are mounted on one frame that includes oil systems, tanks, pumps and everything else needed, allowing for instant freezing on the vessel through its plate freezers. The plate freezers, which use CO₂, provide a high freezing rate in addition to shorter freezing times, saving energy. They also bring the added benefit of preserving the natural quality and freshness of the fish.

HC

A pilot project on hydrocarbon technology involving Transfrig and Tshwane University has been launched to develop a climate-friendly technology for refrigerated trucks. The R290 prototype was built at the end of May 2015 and is currently undergoing testing (including for leakage and safety). From January to April 2016, the prototype will undergo a field trial. Compared to the R404A system, R290 refrigeration technology has a GWP of just three. In order to address R290 flammability issues, the charge size was significantly reduced from 3.5 kg to 0.65 kg. Direct emission reduction of greenhouse gases was achieved from the previous 6.9 tCO₂eq to just 0.001 tCO₂eq. Estimated fuel consumption is also more advantageous for the R290 system, at 1.0 L/h (compared to 1.2 L/h for R404A unit).



Industry, special applications & sports

CO₂

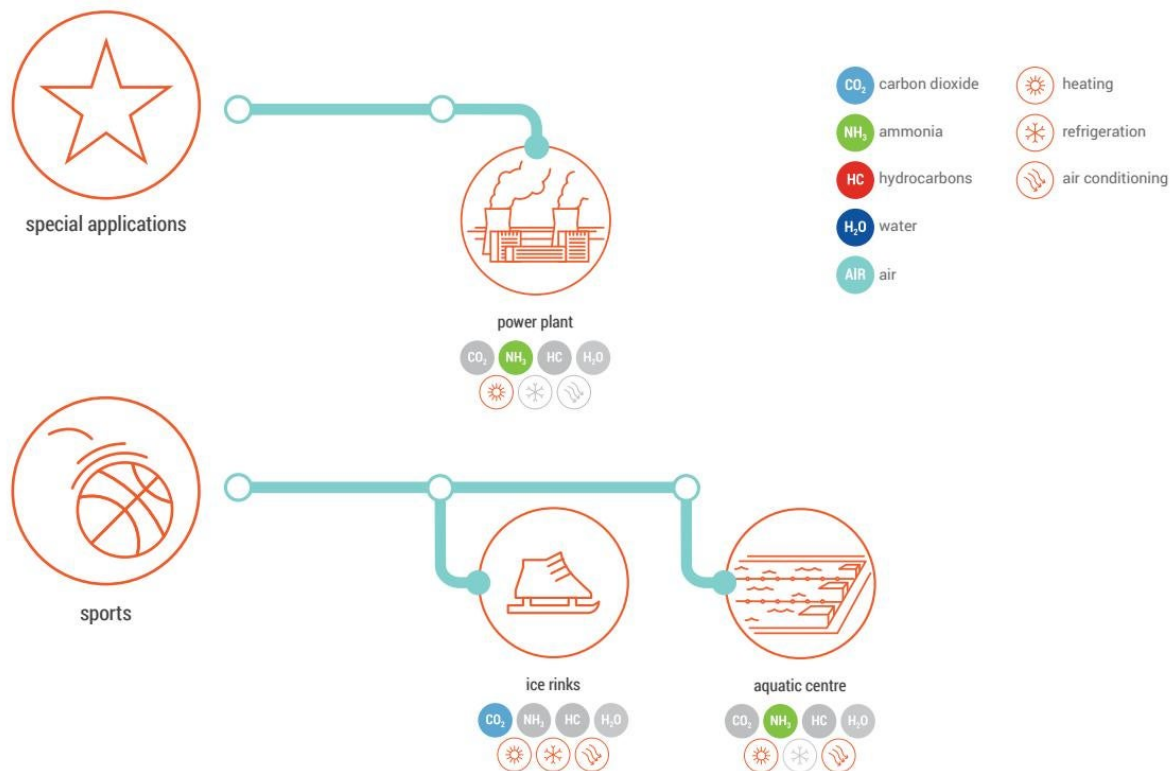
Following a nine-month renovation and the installation of a CO₂-based ice rink refrigeration system, ice skaters and ice hockey players at the Harry J. McDonald Recreational Center in Anchorage (Alaska) now enjoy ice skating in the U.S.'s first ice rink cooled with a CO₂ transcritical system. The new system improved ice quality and pump power savings of up

to 90% compared to traditional systems. Waste heat recovery provides a heating source for the entire facility including indoor areas, locker rooms and utility water. The ice rink is already seeing savings, with the owners' expecting savings of between 25-40% compared to the previous R22 system.

NH₃

Following a recommendation by the Commission for a Sustainable London 2012 (responsible for assuring sustainability across the London 2012 Olympic and Paralympic Games), the cooling system of the Aquatic Centre was converted to an ammonia-based system, reducing its climate change impact. The large-scale Olympic Energy Centre also features ammonia chillers and provides efficient and low-carbon power by using new technology, including biomass boilers and a trigeneration plant (delivering power, heating and cooling), which captures heat generated as a by-product of electricity production. As well as being at the heart of the Olympic power infrastructure, the primary Olympic Park Energy Centre can lay claim to being one of the largest combined cooling, heating and power generating facilities built in the UK.

Off the coast of Hainan in southern China, an ocean thermal energy conversion (OTEC) power plant is being constructed, with an expected completion date of 2017. OTEC represents a sustainable and continuous energy source that is capable of producing high levels of electricity. To do so, it utilises the temperature difference between the warmer water found at the surface and the cooler water found lower down. The power plant will be configured as a closed-cycle system and will be the world's largest OTEC facility. Without using fossil fuels, and using ammonia as a refrigerant, the system meets electricity demand by harnessing solar energy that the seawater has absorbed. The completed power plant will generate electricity to supply a resort built by the Reignwood Group on Hainan Island.



Food Chain

FOOD PROCESSING

CO₂/HC

A meat processing plant in Osnabrück (Germany) has installed a propane-CO₂ cascade system for refrigeration and deep freezing in processing and cold storage applications. The technical and constructional innovation of this system is the combination of propane

(R290) and CO₂ in a single loop. The new, integrated solution reduces the amount of space required as well as installation costs.

WINERIES/BREWERIES

CO₂

Since 2010 Somerston Wine Co., producer of Highflyer, Priest Ranch and Somerston wines, has been using an integrated EcoCute CO₂ refrigerant heat pump system that is 360-400% more efficient than conventional systems while performing heating and cooling functions at the same time. By combining the hot water heating system with the glycol cooling system using the heat pump unit, a high COP (Coefficient of Performance) is achieved, unlike when using separate systems. The system delivers energy savings of 22% compared to a more traditional system.

NH₃

De Bortoli Wines, one of Australia's largest privately owned companies, installed a centralised refrigeration unit that uses ammonia at its headquarters in New South Wales, along with the installation of the largest solar panel array of any Australian winery at the time. This new system – which used brine as a secondary refrigerant – replaced an old Froen refrigeration plant, with the resulting energy consumption falling by 17.3% over a year-long analysis. Due to the impressive performance of the ammonia system, De Bortoli Wines is considering using one in another plant located in Victoria's Yarra Valley.

FOOD STORAGE/ DISTRIBUTION

CO₂

Matthies & Söhne Fruchthand GmbH in Braunschweig, Germany opted to equip a banana ripening facility with a CO₂ transcritical system with a capacity of 300kW to control the climate of its six ripening chambers, 18 cold storage rooms and seven consignment rooms. The system features waste heat reclaim and a heating capacity of 300kW. The system is proof that CO₂ technology is reliable and efficient and achieves energy savings of 25%.

NH₃

Walmart opened a new 42,000m² distribution centre in 2015 that uses ammonia. The distribution centre, located in the state of Minnesota, uses 15,400kg of ammonia to cool the two million cases of cold and frozen foods shipped every month. The 15,400 kg of ammonia is circulated throughout the distribution centre through five 1908 kW compressors that allow the refrigerant to flow throughout 14,000 linear feet of refrigeration piping.

SUPERMARKET

CO₂

Sprouts, a grocery chain focusing on fresh and healthy foods with over 200 locations in the United States, opened its first store near Atlanta, Georgia, in July 2014. By adopting a CO₂ transcritical booster system for its refrigeration needs, the company proved that this technology is equally effective in warm ambient temperatures. Since the installation of the CO₂ transcritical booster system in Sprouts' Atlanta location, the company has operated its store efficiently and effectively. This success story is testimony to the potential for using CO₂ as a refrigerant in warmer climates.

CO₂ / NH₃

Piggly Wiggly, a supermarket chain located in the U.S., installed a CO₂/NH₃ cascade refrigeration system in one of its new stores in September 2015. The total amount of ammonia used equates to 26.7 kg, all of which is confined to the roof of the supermarket. As well as being environmentally friendly, this logistical placement eliminates the requirement for on-site engineers to monitor the system, lowering overall costs for maintenance. In addition to the improvements in safety and maintenance costs, the cascade system will also provide Piggly Wiggly with higher energy savings than a traditional HFC system. Given the negligible global warming potential (GWP) of CO₂ and ammonia, the Piggly Wiggly store has been able to reduce its emissions by over 99%.

HC

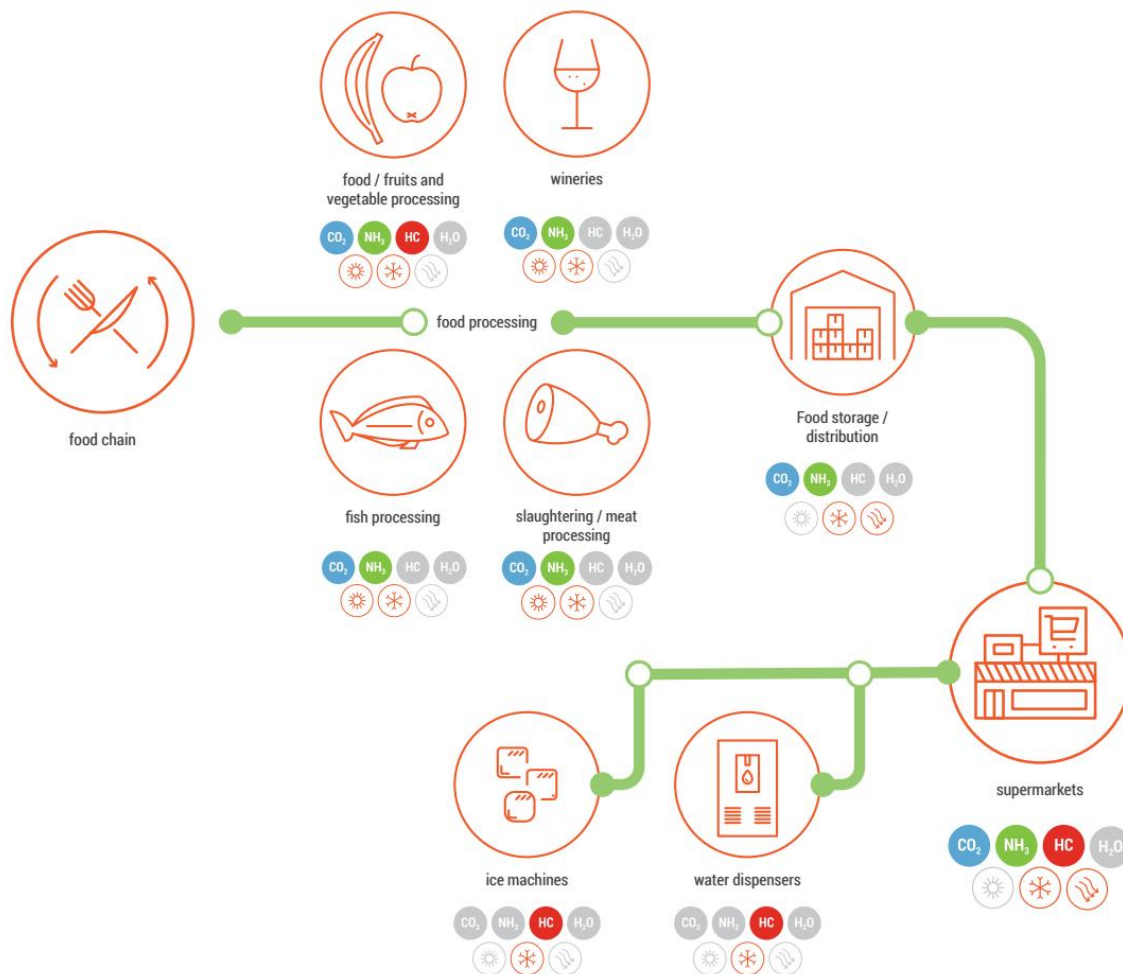
The Colruyt Group, a Belgian supermarket group, announced plans to reduce its overall emissions by replacing their current DX-cooling systems (which primarily use R507) with an unprecedented shift to R290 chillers in all of its stores. 2-4 compact chillers will be installed in each of the Colruyt Group's 360 stores with a cooling capacity of between 25kW-40kW per chiller. The new R290 chillers use between 1.4kg and 1.7kg of refrigerant and are placed outside the store. An important benefit of this installation is the possibility to exchange the compact chiller in the event of a defect without having to work on the refrigerant side on-site.

In August 2014, the American Classic ice cream company tested Priority Cool hydrocarbon refrigerant (HC12a/134+) in a 7kW freezer, with the objective of saving energy during the peak New York summer months. An initial 28% decrease in compressor amperage was recorded, while keeping the freezer almost 10°C cooler than the previous refrigerant used (R408A).

Light commercial refrigeration (water coolers, drink dispensers and ice machines)

HC

In Europe, R290- and R600a-cooled water coolers and fountains are widely used. Moreover, the use of hydrocarbons in domestic and commercial ice machines is steadily growing in Europe. However, in the U.S., hydrocarbons are not yet approved for use in water coolers and domestic and commercial ice machine applications under the SNAP Program.



Each Nation and each Industry Sector bears an individual responsibility in the fight against climate change.

The refrigeration, heating and cooling industry recognises the role it can play to reduce direct and indirect emissions of greenhouse gases.

The Organisations who endorse this statement call upon the National Governments to responsibly shape today the climate opportunities of tomorrow, and acknowledge the potential of Natural Refrigerants.

Support the statement today on

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Outlook for natural refrigerants in Japan TOMORROW

Introduction

As the market for natural refrigerants continues to grow in Japan, let's turn our attention to the future to see which areas are anticipated to be the most prosperous and where market uptake for natural refrigerants may be less immediate.

The industry survey results reveal that the overall market for natural refrigerants is expected to continue to grow, particularly as companies that are not currently providing or using natural refrigerant-based solutions enter the market. Moreover, 83% of respondents who are already active in natural refrigerant markets are looking to increase their R&D expenditure by 2020.

Migration to the natural refrigerant market will be further fuelled by more stringent policy at both supranational and national level, in the form of a HCFC phase out and national f-gas laws respectively.

To help provide more in-depth analysis, we provide market expectations for the clearest areas of growth – CO₂ in commercial refrigeration, ammonia in industrial refrigeration, and hydrocarbons in light commercial refrigeration – in Japan through to 2020, 2025 and 2030.

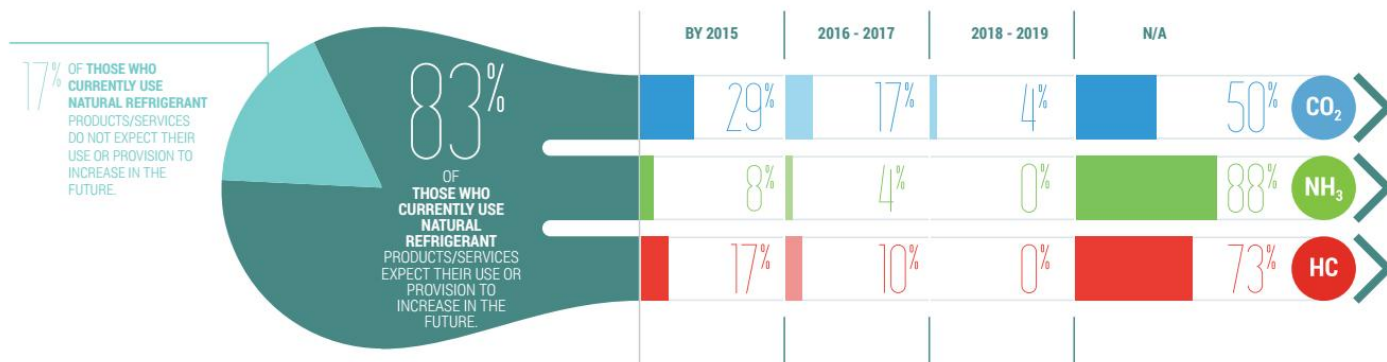
Coupled with these findings are insights from leading stakeholders in the Japanese HVAC&R industry about their thoughts on the future of natural refrigerants within Japan.

Future trends for natural refrigerants

INDUSTRY ALSO IN COMPLETE HARMONY IN EXPECTATION FOR NATURAL REFRIGERANT INCREASE

Of those who already provide or use products or services with natural refrigerants, 83% forecast they will increase this provision or usage as both domestic and global policy steer the industry away from f-gases to the more consistent adoption of natural refrigerants across Japan. The increasing focus on fluorinated gases will mean that this trend will not remain localised to Japan but will also spread across the global market.

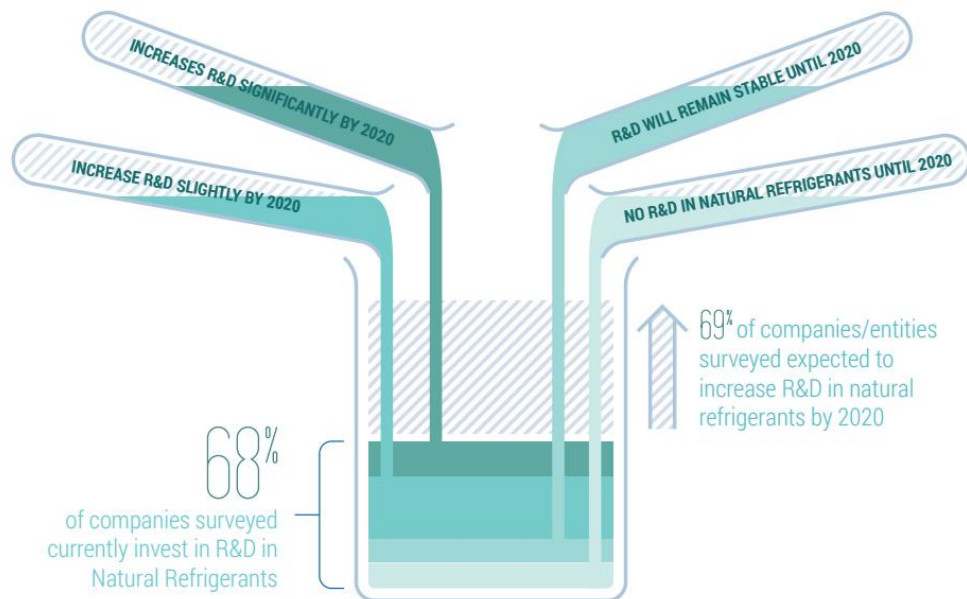
The survey responses show that the industry is looking to adopt natural refrigerants but there is not a clear indication of when this will occur per refrigerant. CO₂ is clearly preferred in the immediate future, which could be sparked by increased government subsidies for using R744 in both commercial and industrial applications. With the f-gas law stating 2025 as the year for adherence to a target value of average GWP of 1,500 for condensing units and commercial refrigerated cabinets, the potential for early adoption of CO₂ is encouraging. Undecided cold storage warehouse end users are likely to be influenced by the f-gas law setting a target for reaching an average GWP value of 100 by 2019.



OVER 2/3 OF SURVEYED ORGANISATIONS INVEST IN R&D IN NATURAL REFRIGERANTS

Currently, nearly one third of respondents noted that their organisation does not conduct R&D activities related to natural refrigerants. The remaining two thirds had a fragmented response to how much they spend in R&D compared to non-natural refrigerant-based technology or services. Over 20% indicated that they put more than half of their R&D expenses into natural refrigerants. However, nearly a third noted that they spend 1-10% on natural refrigerant R&D. The remaining 17% fell between 11%-50%.

This is set to improve in the future with only 18% not looking to conduct R&D into natural refrigerants by 2020 and 69% expecting their R&D expenditure to increase by 2020. While a small share of respondents indicated that their expenditure would not change, nobody thought it would decline. Again, as policy becomes more favourable for natural refrigerants in some respects – for example, thanks to government subsidies – and less favourable for fluorinated gases, this trend is expected to continue as the price differential between the two shrinks. No respondents who currently conduct R&D in natural refrigerants expect their R&D to decrease.

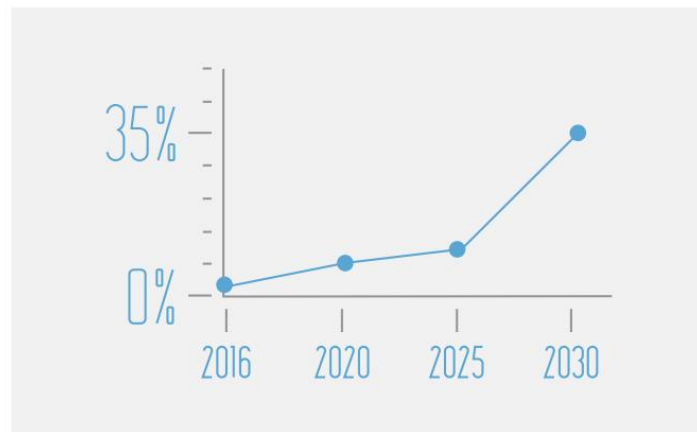


Applications to watch out for in the future

While the overall market for natural refrigerants is expected to grow in the near future, there are even greater growth expectations in certain developed or expanding sectors. The following chart shows key areas and expectations for 2020, 2025 and 2030:

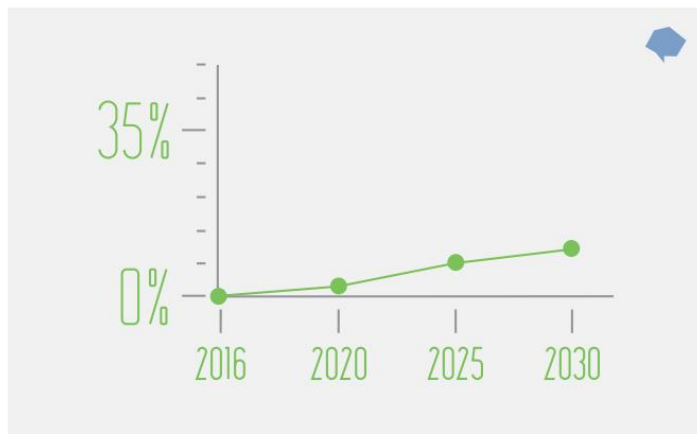
MARKET SHARE OF CO₂ IN COMMERCIAL REFRIGERATION SET TO RISE

With over 1,500 CO₂ installations already in commercial refrigeration, the future of R744 in this application looks to be as auspicious as it has been in the last couple of years. However, a large market share is not immediately expected, with 77% of respondents expecting a share between 5 and 10% by 2020. This could be due to limitations to the adoption of larger capacity rack systems for supermarkets in Japan as a result of the High Pressure Gas Safety Act. However, respondents envisage seeing a greater share in 2030, with almost 30% expecting between 11-25% and 32% seeing a market share of 26-50%.



WORK STILL REQUIRED FOR GROWTH OF HYDROCARBON PLUG-IN UNITS

The use of hydrocarbons in light commercial refrigeration is not so directly positive. Currently the use of hydrocarbons in stand-alone units is not well established and even though small steps are being taken by some suppliers to introduce the technology, hydrocarbons are not expected to attract a market share above 5% by 2020. However, there could be reverberations felt by 2025 when a greater amount of respondents saw 6-10% and 11-25%. Again, in 2030, there is also a divergence away from a minimal share, showing confidence that the market will grow but at a slower rate than other natural refrigerant-based technology.



SHIFT BACK TO AMMONIA FROM HCFCs IN INDUSTRIAL REFRIGERATION WILL CONTINUE

The use of ammonia in industrial refrigeration is expected to remain muted throughout 2030. While the use of ammonia alone is predicted to remain low, ammonia is increasingly used in secondary systems along with CO₂. The use of secondary systems alleviates concerns about the safety of ammonia, which is of great importance in Japan. Government subsidies have already helped 113 new projects using innovative new industrial refrigeration systems as of 2015. Therefore, ammonia is likely to take up the mantle as R22 is phased out by 2020.



Why CO₂ Technology?



CO₂ compressor

natural
harmless
safe
efficient



SANDEN
Delivering Excellence

SANDEN, In Partnership with Nature



www.sanden.co.jp

SANDEN Forest-Akagi plant
best sustainable manufacturing practice recognized by OECD

Industry viewpoint

ON THE GROWTH OF NATURALS...

Christophe de Bassompierre - Deputy Head of Mission, Belgian Embassy in Tokyo

"Innovation is crucial for the future of our society and our businesses. The market for natural refrigerants is moving in Japan, thanks to government support, in particular a subsidy for the introduction of natural refrigerants, and thanks to innovation from suppliers from Japanese Industry. The market is also growing for international companies. With the Olympics fast approaching, the eyes of the world will be on Tokyo, and this will be a golden opportunity to showcase Japan's natural refrigerant technology to the world."

ON THE FUTURE...

Emiko Iida - Operation Officer of the Overseas Department, Patine Leisure

"It is obvious that the NH₃/CO₂ rink system is the direction to go if we can reduce energy consumption, there is very big potential in Asia."

Tadashi Maekawa, President, Mayekawa

"We have an ambition to embark into new markets such as commercial refrigeration and industrial air-conditioning [...] and bring them into markets we haven't addressed before. We are planning to develop NH₃/CO₂ systems for supermarkets and convenience stores [in 2016]."

Junya Ichikawa, President, SANDEN Environmental Products Corporation

Our vision is to create corporate value from the environment," he said. "In order to achieve that vision we [would] always [like] to have more friends in order to promote natural refrigerants. Without [increased] CO₂ technology on the market we cannot grow."

Kazuhiro Takahashi - Director, Global Environment Division, Japanese Ministry of Foreign Affairs

"Natural refrigerants have an important role to play in tackling global environmental challenges."

Yoshiaki Kenjo - Construction Manager, Save On

Moving forward, our ultimate goal is to achieve a 100% adoption with R290 showcases, but we are also interested in CO₂ systems. Combining these two, we aim to go all natural at 10% of our new stores within the next five years.

ON DRIVERS...

Junya Ichikawa - President, SANDEN Environmental Product Corporation

"The most important driver is the end users' policy. For example, the Coca-Cola Company has committed to use CO₂ as its refrigerant of choice and therefore they buy CO₂ coolers globally, regardless of the region, including in Mexico, Asia and China. End users' policy can make this world better.

We talk to end users, as well as system manufacturers. The reason is simple: if the end users acknowledge the benefits of SANDEN CO₂ technology, then we can work together with their system suppliers to offer CO₂ solutions. SANDEN is determined to promote CO₂ refrigerant, regardless of regulations. In the future all refrigerants will be switched to natural refrigerants. It's just a matter of time."

Tetsuro Homma - President, Panasonic

"We operate several stores in cooperation with our customers and officials, and we already have evidence that CO₂ refrigeration systems' power consumption is lower than other refrigerant technologies. We trust CO₂ is very effective for customers' costs."

Key applications for natural refrigerants in Japan

Introduction

The following chapter focuses on four key sectors that are at the forefront when it comes to adoption of natural refrigerants in Japan. Commercial refrigeration, industrial refrigeration, vending machines and heat pumps are sectors that have registered the most significant shift to natural refrigerants, serving as a good practice example for other world regions looking to reduce their reliance on fluorinated refrigerants. The chapter analyses the current status of HFC-free equipment, while evaluating the drivers and barriers as well as future potential for the technology to further penetrate the Japanese market.

In addition, the chapter takes a close look at policies that allow for a greater role of natural refrigerants in the highlighted sectors. While outlining the achievements of the industry, the chapter also highlights areas that can be improved in terms of market uptake and regulatory environment.



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Light commercial refrigeration

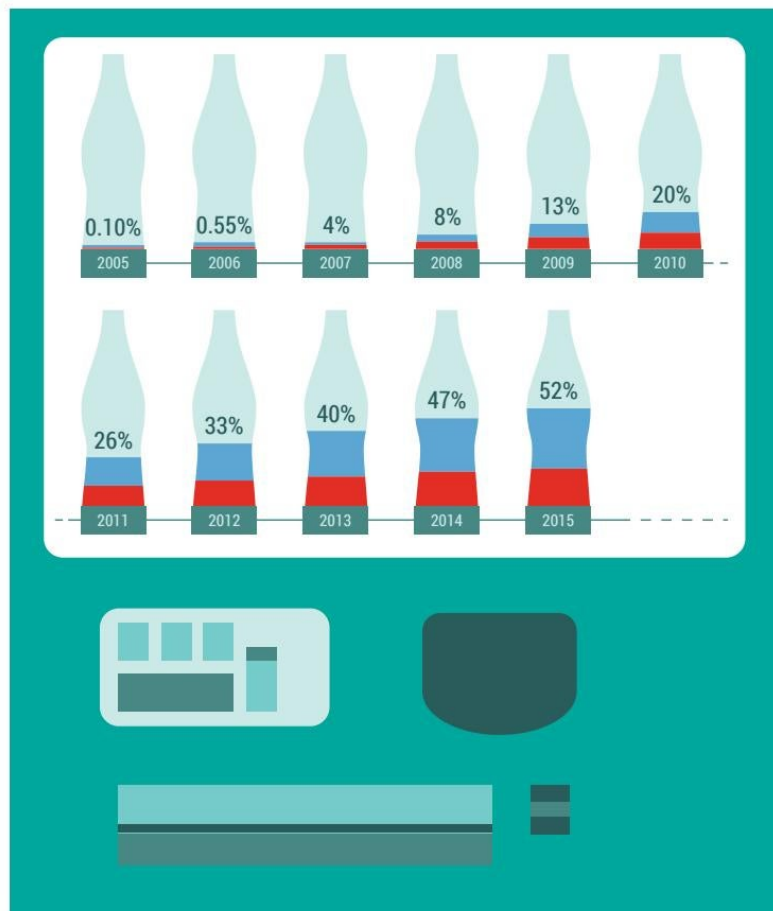
Introduction

The Japanese market for light commercial refrigeration is dominated by beverage vending machines – with more vending machines per capita than any other country in the world. Hence, the use of natural refrigerants in these ubiquitous systems has a significant impact on the overall market for natural refrigerants in Japan.

Currently, the beverage vending machine market is fragmented with R600a, R744 and R1234yf all commonly used as a refrigerant in Japan. A phase-out of other common vending machine refrigerants such as R134a is on the horizon and the displacement of these machines will reveal which low-GWP refrigerant is likely to gain a larger market share.

Although there is competition from unsaturated HFCs (HFOs), the use of natural refrigerants in light commercial refrigeration units – in Japan just as in the rest of the world – is propagated by environmental commitments that large global consumer brands have made. As companies try to communicate their environmental consciousness through their point-of-sale refrigerated units, the use of natural refrigerants in vending machines is only expected to grow.

In addition to vending machines, the use of hydrocarbon plug-in units – typically for freezing – is also growing in Japanese supermarkets, with European manufacturers supplying rising demand for versatile and efficient stand-alone units.



Currently 1.35 million beverage vending machines in Japan use either hydrocarbons or CO₂ to keep drinks cool. With 2.5 million beverage vending machines in Japan, natural refrigerants make up over 50% of the market.

	CO ₂	HC
2005	2,000	1,000
2006	4,000	8,000
2007	23,800	53,800
2008	62,600	42,000
2009	87,600	60,000
2010	98,000	63,000
2011	108,000	53,200
2012	118,000	70,700
2013	118,000	54,400
2014	106,000	67,200
2015	94,000	41,700
TOTAL	840,000	511,000

NATURAL REFRIGERANTS INDISPENSABLE TO VENDING MACHINES

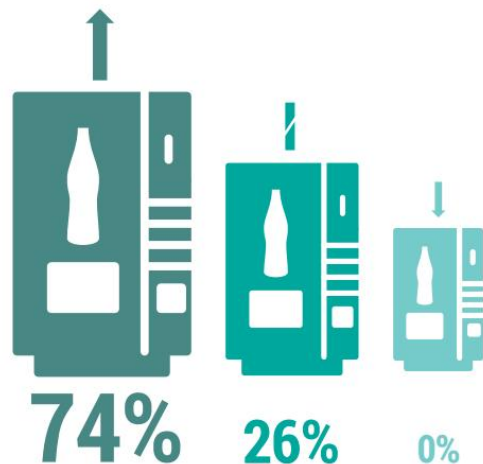
Over two and a half million beverage vending machines line the streets of Japan, offering valuable opportunities for natural refrigerants. Typically, R600a, R744 and R1234yf are the new refrigerants of choice, while a large portion of existing equipment uses R407C and R134a.

This represents a significant opportunity for the complete takeover of the market by natural refrigerants, which already account for close to 60% of the market as approximately 1.35 million as of February 2016 beverage vending machines use either hydrocarbons or CO₂.

The current market penetration rate reveals a clear role for natural refrigerants which has grown year after year, despite the total number of vending machines remaining roughly the same.

The growth of CO₂ is reflected in the Coca-Cola Company's decision to shift to R744-only vending machines in 2009, after having begun testing the equipment in 2000. The use of R600a vending machines in Japan is still strong, however, with roughly nine companies deciding to use hydrocarbons in their vending machines.

With the Coca-Cola Company – which has the largest market share in the industry – on track to convert nearly 1 million vending machines to CO₂ by 2020, the market will continue to prosper.



...of respondents expect, in light commercial refrigeration, the use of natural refrigerants will...

increase by 2020

remain the same
by 2020

decrease by
2020

Natural refrigerants in light commercial expected to grow until 2020

The survey found that there is a clear expectation that natural refrigerants in light commercial refrigeration will continue to grow until at least 2020. It was also apparent that no respondents expected the use of natural refrigerants to decrease by 2020. The increased use of both hydrocarbons and CO₂ in beverage vending machines as well as self-contained units explains this clear optimism for the future.

GROWING USE OF SELF-CONTAINED UNITS USING HYDROCARBONS AND CO₂ IN JAPAN

As well as the consistently growing use of CO₂ transcritical systems in supermarkets, the use of natural refrigerants in smaller plug-in units is also an emerging trend.

The Japanese market for hydrocarbon-based self-contained units has traditionally been non-existent, with concerns over flammability representing a clear barrier to potentially vast market penetration. This lack of growth is rather perplexing given that the use of R600a is seen as standard in Japan for domestic refrigeration, and hydrocarbons are also commonly used in beverage vending machines.

However, with self-contained freezers and cooling cabinets having used hydrocarbons in Europe for over ten years, these lessons are gradually beginning to filter through to Japan,

ENERGY EFFICIENCY IS ALSO A CLEAR TARGET

With consumer brands having already begun the conversion to natural refrigerants – which are naturally energy efficient – the next step is to reduce energy consumption further by introducing extra-energy efficient vending machines.

Coca-Cola Japan has a nationwide goal of ensuring that its 'Peak Shift' vending machines account for 50% of its fleet by 2020, and currently estimates that over 100,000 units are already on the market. 'Peak Shift' models can adjust the hours that vending machines use electricity from daytime to nighttime, when supply-demand is considerably lower.

Therefore the vending machines can supply beverages for 24 hours without using any cooling for a maximum of 16 hours between 7am-11pm. While the technology is not new –

with both Chinese and European manufacturers entering the Japanese market. The availability of MOE funding for the use of hydrocarbon-based cooling equipment in supermarkets has allowed the market to grow in the last year, with 150 hydrocarbon-based self-contained units currently in operation in Japan.

One example of this is Union, a small supermarket chain that has been receiving subsidies to implement R290 plug-in units in 10 of their stores in 2015. Save-On is another prominent supermarket investigating the use of R290 plug-in units and is looking to increase the number of stores installed with R290 units by 20-30 every year – with the end goal being 100% adoption of R290 self-contained units in their stores.

The Coca Cola Company first introduced the technology in 1995 – it is incredibly efficient and cuts daytime energy power consumption by up to 95%.

As the MOE promotes these extra-efficient vending machines along with other natural refrigerant technologies through its 'Cool Choice' national campaign, which began in July 2015, it is clear that the industry will continue to innovate to ensure market share in this large refrigeration segment.

Policy drivers for natural refrigerants in light commercial refrigeration

TOP RUNNER PROGRAMME HELPS ENCOURAGE ENERGY EFFICIENCY

The Top Runner Programme serves as a direct impetus for the beverage vending machine industry. The programme seeks to aid the environment by ensuring that companies are aiming for the highest energy efficiency possible. Those that meet specified targets are given the Top Runner label.

Due to the inherently efficient performance of natural refrigerants, they are generally seen as a clear replacement to ensure adherence to the Top Runner Programme. As can be seen previously with Coca-Cola's 'Peak Shift' model, the programme continues to ensure top energy performance.

From 2000-2005, the Top-Runner Programme has recorded an improvement in energy con-

sumption efficiency of approximately 37.3% for vending machines for canned/bottled beverages. From 2005-2012, efficiency was improved by about 48.8% compared to 2005. Since 2012, vending machines servicing cold canned or bottle beverages were set the following target, based on a formula calculation of standard energy consumption efficiency:

$$E=0.218V+401$$

Where:

E: Standard energy consumption efficiency (in kWh per year)

V: Actual internal volume (indicates the numeric value calculated from the internal dimensions of the goods storage area - in litres)

ACT ON PROMOTION OF GREEN PURCHASING

In order to help companies make the shift towards eco-friendly goods and services, the Japanese Ministry of Environment actively facilitates both the supply of eco-friendly technologies and demand for them through its own internal purchasing. It hopes that by internally prioritising the purchasing of eco-friendly goods and services, the markets will be boosted.

Therefore, each fiscal year, each institution of the government formulates and publishes a green purchasing policy based on Article 7, "Act on Promotion of Procurement of Eco-friendly Goods and Services by the State and Other Entities".

This has had a direct impact on the installation of beverage vending machines, with public institutions purchasing energy efficient, natural refrigerant-based units. This is because the evaluation criteria for the 'Green Purchasing' of vending machines prohibits the use of HCFCs and HFCs as well as ensuring that energy efficiency does not exceed the amount of energy consumption efficiency stated above. Therefore, two of the three clear recommendations for Green Purchasing of vending machines are CO₂ and hydrocarbons.

Light commercial refrigeration outside Japan

The use of natural refrigerants in light commercial refrigeration outside of Japan is a strong trend in most economies. Through the innovation and dedication of large consumer brands, vending machines, ice cream freezers, bottle coolers and refrigerated cabinets all around the world are increasingly cooled by CO₂ and hydrocarbons. The use of natural refrigerants is advantageous in that it contributes to lowering emissions, which helps companies to achieve corporate sustainability report objectives.

First, companies are able to cut emissions by replacing fluorinated gases with refrigerants such as R600, R290 and R744 which have zero ozone depleting potential (ODP) and a negligible global warming potential (GWP). Second, these refrigerants are characteristically more energy efficient than traditional fluorinated refrigerants in light commercial refrigeration equipment. In some cases, natural refrigerants can register savings of up to 33% in energy use.

CONSUMER BRANDS WORKING TO ENSURE NATURAL REFRIGERANTS ARE THE GLOBAL CHOICE FOR LIGHT COMMERCIAL REFRIGERATION

Some of the biggest brand names that can be found on the shelf are committing their long-term refrigeration purchasing to natural refrigerants. The group Refrigerants, Natural-ly contains five multinational companies who are taking individual action against global warming and ozone depletion by replacing fluorinated gases with natural refrigerants in their refrigeration equipment.

Their profiles show how their individual actions and overall goals together amount to over 4.5 million point-of-sale units using R744 or hydrocarbons worldwide.



Reduce the carbon footprint of "the drink in your hand" by 25% by 2020.

"We are reaching an inflection point in our HFC-free global system adoption. We are at the phase where CO₂ is the technology that fits our portfolio of equipment."

Founded: 1886

Headquarters: ATLANTA, USA

Global fleet that uses natural refrigerants: 1.8 MILLION UNITS



Complete 100% global procurement of hydrocarbon eco-coolers

"As early adopters of this technology, we have seen a significant decrease in energy usage. Less harm to the planet while increasing profit to our accounts' business is clearly a win/win. Our hope is that as our use of this technology grows, the overall light-commercial refrigeration market will convert with us."

Founded: 1987

Headquarters: FUSCHL AM SEE, AUSTRIA

Global fleet that uses natural refrigerants: > 500,000 UNITS





Cut the environmental footprint of making and using its products by 50% by 2020

"Nearly 2 million cabinets [with hydrocarbons] running all over the globe, which is ahead of formal targets. In the United States, hydrocarbons were prohibited and Unilever succeeded in gaining formal approval."

Founded: 1929

Headquarters: ROTTERDAM, NETHERLANDS & LONDON, UK

Global fleet that uses natural refrigerants: 2.2 MILLION UNITS



All point-of-sale equipment to be HFC-free by 2020.

"I believe all of us need to take action now. PepsiCo has already taken actions in our operations and throughout our supply chain to 'future-proof' our company—all of which deliver real cost savings, mitigate risk, protect our license to operate, and create resilience in our supply chain."

Founded: 1898

Headquarters: NEW YORK, USA

Global fleet that uses natural refrigerants: 240,000 UNITS



Source 100% HFC-free fridges by 2020

"It is more important than ever that we demonstrate how business can make a meaningful contribution to reducing the impacts of climate change"

Founded: 1895

Headquarters: LONDON, UK

Global fleet that uses natural refrigerants: < 90,000 UNITS



WOULD YOU LIKE SUSTAINABILITY WITH THAT? MCDONALD'S AND STARBUCKS LOOK TO INTEGRATE HYDROCARBONS INTO THEIR EQUIPMENT

It is not just point-of-sale cabinets in supermarkets that are experiencing upheaval in terms of equipment and company branding worldwide. Food service companies are also increasingly involving natural refrigerants in their food outlets.

McDonald's has already deployed over 13,000 pieces of natural refrigerant-based equipment in its European restaurants, including a restaurant in Denmark that has been running completely HFC-free for over 10 years. This model of deployment is something that McDonald's has indicated it wishes to follow in North America. As a franchise, McDonald's has noted that in terms of co-ordination, this type of mass installation will take time.

Other multinational companies such as Starbucks are investigating the role natural refrigerants can play in their operations. Starbucks has begun trialling the use of R290-based refrigeration units in its coffee shops. If big brands can drive installation and as a result lower the price for hydrocarbon based-equipment, this will create a second brand revolution – the first being point-of sale equipment – involving natural refrigerants in the light commercial refrigeration sector.



Current status: Trialing equipment in the U.S.

"Natural refrigerants make business sense and it's the right thing to do for the environment."

Founded: 1940

Headquarters: ILLINOIS, U.S.

Global fleet that uses natural refrigerants: >11,000 UNITS

Placements in North America: N/A



Current status: R&D and testing

"Rapid growth in the 2000s are leading to the end of life of a significant number of units and the 2014 EPA ruling on naturals enabled suppliers to tool up for supply and support of natural refrigerants."

Founded: 1971

Headquarters: SEATTLE, WA

Global fleet that uses natural refrigerants: N/A

Placements in North America: N/A



USE OF HYDROCARBON PLUG-INS ANSWERS QUESTIONS ABOUT CHANGING FACE OF SUPERMARKETS

As Japan becomes more acquainted with the use of systems designed for CVS super-market formats, both Europe and North America are beginning to notice subtle shifts in consumer behaviour that are leading to the reconstruction of the 'typical' supermarket. Paul Anderson, head of refrigeration for Target, noted that the days of the large suburban store are dying out, whilst new, smaller, centrally located stores are on the rise.

These stores are being primed to incorporate self-contained cases, which can easily be installed, moved around and serviced if required. While the type of equipment that will be employed in these 'stores of the future' is generally accepted, discussion is ongoing as to which natural refrigerant is the most beneficial in terms of efficiency and annual savings, with hydrocarbons typically being favoured. Target's findings indicate that the use of propane cases can cut a store's energy bill by more than \$40,000 per year.

Target's comparison of annual savings with natural refrigerants

Natural Refrigerant	Efficiency	Savings per year**
R290 HC	53%	\$42,920
R744 CO ₂	25%	\$20,150

*Baseline R134a

** Based on 100 stores with 10 cases per store

Policy drivers for natural refrigerants in light commercial refrigeration outside Japan

Outside of Japan momentum is growing for the use of natural refrigerants due to increasingly stringent policy, which looks to discourage the use of fluorinated gases.

UNITED STATES USES TWO-PRONGED APPROACH TO EASE TRANSITION TO NATURAL REFRIGERANTS

The United States has two powerful organisations at its disposal to influence the HVAC&R industry. First, the Environmental Protection Agency (EPA), which under the Significant New Alternatives Policy (SNAP) programme has the capacity to both approve and ban refrigerants based on their environmental impact. And second, the Department of Energy, which can post legislation establishing the minimum level of efficiency at which individual machinery must operate. Both of these organisations are working in tandem to target high-GWP fluorinated gases. The DOE sets minimum energy efficiency requirements for certain types of energy-consuming equipment.

EU F-GAS REGULATION DRIVES NATURALS IN AND OUTSIDE EU

Besides voluntary initiatives from global consumer brands, legislative action in different regions is driving the manufacturing industry to natural refrigerants in light commercial refrigeration – and not just in the intended region. In particular, the EU F-Gas Regulation that came into effect in 2015 will have a huge effect on the global HVAC&R industry.

The Regulation foresees a ban on the use of fluorinated gases (defined as GWP > 150) in stand-alone commercial refrigeration equipment as of 2022. Moreover, starting in 2017, HFC pre-charged equipment imported into the EU will need to be accounted for under the HFC phase-down, which will reduce the amount of HFCs placed in the EU by 79% by 2030 compared to 2009-2012 levels. With global trends towards environmentally friendly solutions and increasing demand from the EU and the U.S. in the future, manufacturers are expected to adapt to maintain a competitive edge in a more sophisticated market.



Energy efficiency target gives boost to hydrocarbons in the United States

Most recently, energy saving standards were adopted for icemakers and self-contained refrigeration units, which will enter into force in 2018 and 2017 respectively. This energy efficiency reduction target has already seen major manufacturers develop alternatives that use hydrocarbons for icemakers. A key manufacturer noted that the switch from using R404A to R290 reduced daily energy consumption by nearly 40%. The same can be said for self-contained units and display cases, which are migrating to hydrocarbons and CO₂ to help meet the 2017 targets. A leading manufacturer noted that the use of a R290 glass-door self-contained unit would improve energy efficiency by 28% compared to a R134a model.

Application / type of equipment	HFCs listed as unacceptable	New equipment	Retrofits	Natural refrigerants approved under SNAP
Vending machines	R134a, R507, R404A and other high-GWP HFCs	as of Jan 1, 2019	1 year from publication of the final rule in the federal register	CO ₂ , R290a, R441A, R600a
Supermarket systems	R404A, R507A and other high-GWP HFCs	as of Jan 1, 2017	1 year from publication of the final rule in the federal register	CO ₂ , NH ₃ vapor compression with secondary loop
Remote condensing units (supermarkets)	R404A, R507A and other high-GWP HFCs	as of Jan 1, 2018	1 year from publication of the final rule in the federal register	CO ₂
Stand-alone units	R404A, R410A, R134a, R407F and other high-GWP HFCs	as of Jan 1, 2019 or Jan 1, 2020 (depending on compressor capacity)	1 year from publication of the final rule in the federal register (only applicable for R404A, R507A)	CO ₂ , R290, R600a, R441A
Mobile air conditioning	R134a	as of model year 2021 (except where allowed under a narrowed use limit through model year 2025)	N/A	CO ₂

EPA SNAP delisting furthers the case for natural refrigerants

At the beginning of July 2015, the EPA announced the delisting of the use of R134A, R404A, R507A and other high-GWP HFCs in several major applications as of 2017 or later. While the initial proposal indicated that the market might delist these fluorinated gases as early as 2016, ultimately this was not the case and there is instead a staggered delisting, giving companies ample time to make the switch to naturals. Each application that has delisted HFCs also has approval for the use of natural refrigerants, so there is the case that companies can make the direct switch to these with new machinery.



Economy and ecology combined in SWEP heat pump solutions

Around the world, we are joined in a common challenge: enabling a growing urban population to live in sustainable comfort. This requires more energy-efficient and climate-friendly systems, and the increased use of renewable energy sources.

Heat pump and refrigeration systems using CO₂ are already part of the solution. This natural refrigerant reduces greenhouse gas emissions and improves safety. A SWEP brazed plate heat exchanger will further enhance the system's energy efficiency and reliability.

SWEP's complete CO₂ range is well proven in transcritical applications worldwide. The heat exchangers withstand extreme pressures, have excellent thermal performance, and offer high capacities in a compact design. This is our contribution to sustainable solutions for the future.



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Email: info.jp@swep.net

SWEP
A **DOVER** COMPANY

Commercial refrigeration

Introduction

The use of natural refrigerants in commercial refrigeration has escalated greatly in the past two years all across the globe, however the biggest acceleration has been in Japan. From only 190 systems in March 2014, the market now boasts over 1,500 stores using CO₂ transcritical solutions. This leap was achieved thanks to an astute combination of end-user empowerment, technological advancements and subsidies from the Japanese government.

This trend is consistent with the rest of the world. Globally, the use of CO₂ transcritical systems is becoming more widespread, with increasingly innovative solutions making CO₂ viable in all regions. However, while Japan has raced ahead in its use of CO₂ refrigeration systems, the vast majority are employed in small convenience store formats with an almost complete absence from larger supermarkets.

It is possible that the technological advancements Japan has made could well be exchanged for European and North American skills in larger store formats, if and when regulations become less stringent regarding the utilisation of CO₂ in larger capacities.

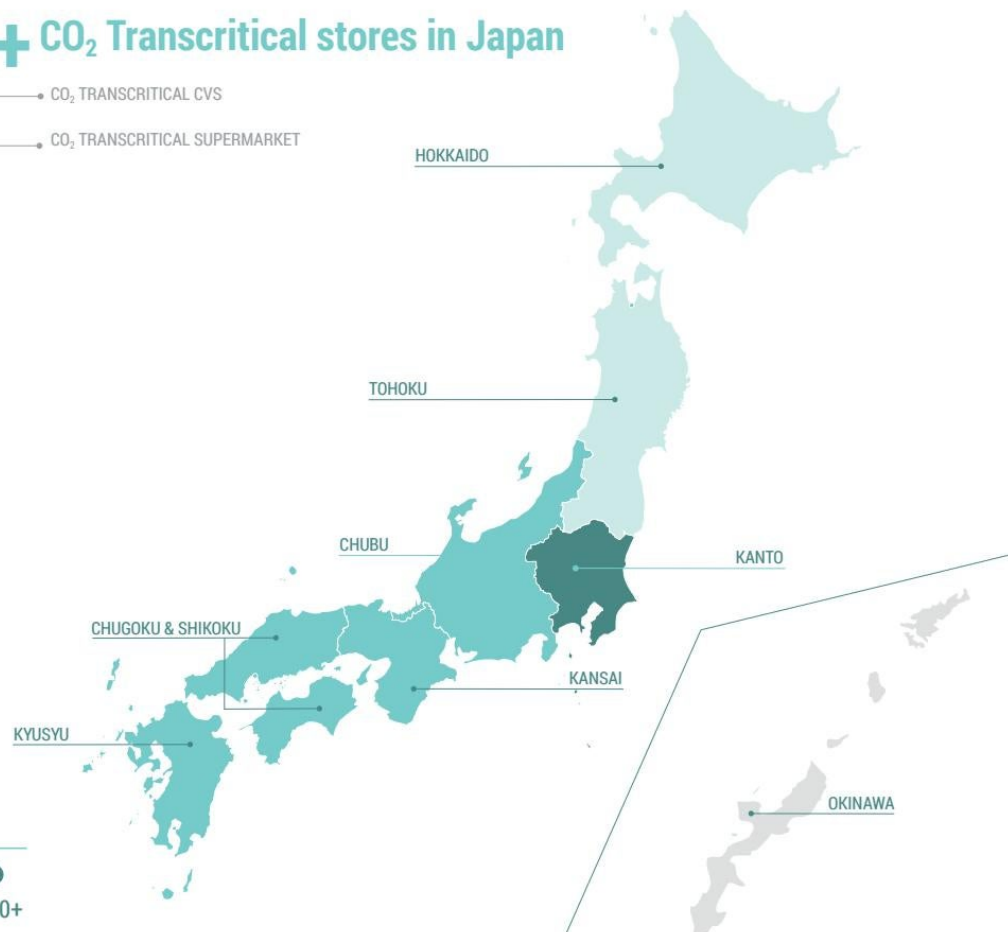
1,500+ CO₂ Transcritical stores in Japan

1,463 / 72

• CO₂ TRANSCRITICAL CVS

• CO₂ TRANSCRITICAL SUPERMARKET

KEY/LEGEND



CVS – A ONE-STOP SHOP FOR NATURAL REFRIGERATION

Convenience stores (CVS) are a regular sight in Japan, with over 55,000 dotted throughout the country. These small stores have benefitted from a massive overhaul in terms of refrigeration over the last two years. In March 2014, Japan had 190 stores using CO₂ transcritical systems. Fast-forward to February 2016, and this number has increased nearly sevenfold.

The main motivator of this has been the adoption of CO₂ solutions in CVS.

The three largest convenience store franchise chains, Lawson, 7-Eleven and Family Mart, all have CVS that use CO₂ technology, collectively accounting for 1,463 installations out of the three chains' total of 41,085 CVS across Japan. While this amounts to just under 4% of the stores the three chains possess, the future will see this number increase dramatically.

The largest concentration of installations is in the Kanto region – home to 20,040 CVS stores – which is not surprising as this is the region in which Tokyo lies. It is also the most heavily populated region by quite some distance. The Kansai region is the next most

populous but only contains half the number of residents as that of the Kanto region. The lower numbers of installations in regions such as Hokkaido and Tohoku in the south can be attributed to their low populations and harsh climate. Kyushu is subject to a subtropical climate, which could affect the efficiency of CO₂.

The future will undoubtedly bring further leaps in installation numbers, with Lawson having made CO₂ refrigeration a standard for their stores as of September 2014. Their impressive rollout in two years shows that this number could quickly escalate. Other prominent groups in Japan have also committed to converting their CVS to CO₂ refrigeration – such as AEON under its Ministop brand – further strengthening the future growth potential. In addition 7-Eleven, which has over 18,000 stores in Japan and installs around 1,500 CVS annually including remodelled stores, has also spoken of the possibility of installing CO₂ refrigeration in all of its model store showcases in the future.



LAWSON

Founded: 1975
Headquarters: SHINAGAWA, TOKYO
Type of store: CVS
Number of Stores: 12,164
Number of CO₂ stores: 1,376



Founded: 1973
Headquarters: TOKYO, JAPAN
Type of store: CVS
Number of Stores: 17,491
Number of CO₂ stores: 120



Founded: 1972
Headquarters: TOKYO, JAPAN
Type of store: CVS
Number of Stores: 11,352
Number of CO₂ stores: 56



Founded: 1980
Headquarters: TOKYO, JAPAN
Type of store: CVS
Number of Stores: 2,149
Number of CO₂ stores: 10

LEGISLATION COMPLICATES CVS-STYLE GROWTH IN LARGER STORES

While the use of CO₂ is growing in CVS, similar progress is notably absent from supermarkets. Of the 20,015 supermarkets in Japan, only 72 use CO₂ refrigeration systems and most of these were only introduced in 2014/2015 – although the first was installed in 2009 by AEON. While the innovation of the CO₂ system used by Lawson and other CVS works well in small store formats, the large number of such units that would be required for larger supermarkets is ineffective both economically and in terms of time required for installation.

While supermarkets in Europe and North America can have CO₂ systems that operate upwards of 200kW, the 'High Pressure Gas Safety Act' in Japan makes the use of similar equipment difficult due to safety concerns related to CO₂'s high-pressure properties, which are genuinely seen as outdated: especially given that technology has moved on greatly since the act was formed. Therefore, to use CO₂ systems, supermarkets would have to employ multiple systems to gain the desired cooling capacity. As such, uptake is minimal.

While there is a degree of ennui in supermarkets compared to CVS stores in terms of natural refrigerant adoption, this could change in the future. The aforementioned AEON is one of those who give cause for optimism for the future. Even though AEON is still steeped in difficult regulatory constraints, they are attempting to use CO₂ in supermarkets. AEON's 21,500m² General Merchandising Store (GMS) in Chiba City serves as a great example of how the company is able to meet the High Pressure Gas Safety Act policy, as 20 separate CO₂ refrigeration systems are employed to provide cooling to the 144 R744 showcase units in the store.

Despite the need for a large number of systems, AEON has posted energy savings of 23% (186,971 kWh per year) for this supermarket alongside a reduction of CO₂ emissions by 857t per year. These figures show both the business and environmental case for using CO₂ refrigeration within supermarkets. However, due to outdated regulations, the level of adoption is not likely to reach the levels of CVS.



Founded: 1963
Headquarters: TOKYO, JAPAN
Type of store: Supermarket
Number of Stores: 345
Number of CO₂ stores: 4



Founded: 1965
Headquarters: HOKKAIDO, JAPAN
Type of store: Supermarket
Number of Stores: 108
Number of CO₂ stores: 9



Founded: 1982
Headquarters: MIYAGI, JAPAN
Type of store: Supermarket
Number of Stores: 48
Number of CO₂ stores: 5



Founded: 1929
Headquarters: CHIBA, JAPAN
Type of store: Supermarket
Number of Stores: 2,828
Number of CO₂ stores: 10

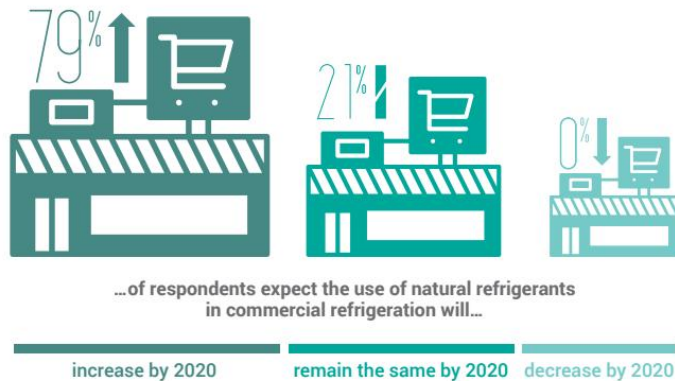
INNOVATION IS AT THE HEART OF CO₂ REFRIGERATION ACCELERATION IN JAPAN

Japan has strict rulings on the use of CO₂ and as such, the creation of a standardised package system that could utilise CO₂ under a 15kW (20HP) cooling capacity has swiftly helped to trigger a considerable number of installations. Panasonic's (responsible for over 90% of CO₂ installations in Japan) 8kW CO₂ outdoor unit fuels the showcases in the CVS while a smaller 1kW CO₂ outdoor condensing unit keeps their freezers frozen.

Lawson noted that the "next-generation" CVS now contains an 11kW outdoor unit and two 1kW units for the freezers. By replacing their previous HFC units with Panasonic's, Lawson notes that they were able save 27% in energy consumption while remaining within the regulatory framework.

The innovation of the Panasonic system used by Lawson has led to attempts to broaden use of this technology beyond Japan's shores. One such project, the Indonesian Eco-Project, has led to Panasonic's technology being used in 13 Alfamidi – an Indonesian retailer – and Lawson stores in Indonesia. The project, which is supported by the Japanese government, shows the desirability and applicability of the Japanese technology used in CVS. Moreover, first CO₂ booster systems are starting to be supplied by Nihon Netsungen Systems to a CVS brand in Japan.

The wider question of whether there is a place for this technology outside of Asia has been raised, with European and North American retailers curious about such innovations as the trend for ever smaller stores in the West continues and the results boasted by Japanese retailers pique interest.



Survey reveals great expectations for future of CO₂ refrigeration

It is clear from growing numbers and an increased government subsidies budget that uptake of natural refrigerants for Japanese commercial refrigeration will increase, most notably in the use of CO₂. Therefore, it is no surprise that the GUIDE survey reveals that the industry as a whole is also expecting natural refrigerant use to continue to grow until 2020. The 21% of respondents expecting the market to remain the same may have been influenced by the current hurdles that larger stores must overcome for CO₂ installation.

INCREASE YOUR VISIBILITY TODAY.

YOUR INDUSTRY NETWORK FOR NATURAL REFRIGERANTS

The world's only industry websites for the natural refrigerants carbon dioxide (CO_2 , R744), hydrocarbons (HCs, R600a, R290 etc.), ammonia NH_3 , R717) and water (H_2O , R718). From the number one publisher of natural refrigerant information, our websites feature a unique mix of News, Products, and Events, attracting 10,000+ regular readers, including CEOs, Technical Directors, Refrigeration Engineers, End Users, Marketing and Sales Managers, Policy Experts and more.

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Policy drivers for natural refrigerants in commercial refrigeration

NEW F-GAS LAWS LEAD TO STRONGER CASE FOR NATURAL REFRIGERANTS

Japan's revised F-Gas laws, which came into effect in April 2015, have created a greater impetus for the uptake of natural refrigerants within the commercial refrigeration sector. The GWP target for condensing units and refrigerating units is 1,500 by 2025. This means that the most common refrigerants such as R404A, R410A and R407C will be gradually replaced, as their GWPs are 3,920, 2,090, and 1,774 respectively.

MOE SUBSIDIES GREATLY AID GROWTH OF CO₂ REFRIGERATION

The Japanese Ministry of Environment (MOE) is taking various steps to actively combat rising HFC emissions in the retail refrigeration sector. The main way this is achieved is by providing subsidies for food retail refrigeration systems and showcases.

This allowance from the MOE is to help boost uptake of natural refrigerant technology, which they believe is not used widely enough:

"Technology using natural refrigerants has been improved in efficiency and safety, but not yet spread widely. To address this situation, the Ministry of Environment financially supports installations of high efficiency equipment with natural refrigerants" – MOE

This leaves the door open for lower-GWP solutions. However, the introduction of the 'Act on the Rational use and the Proper Management of Fluorocarbons' in April 2015 pushes the market further towards natural refrigerants. The Act obliges equipment users to conduct checks on refrigerant leaks from their showcases. However, the environmentally friendly nature of natural refrigerants exempts them from the Act, entirely eradicating both costs and time spent on inspection and administration.

In 2014, the budget was ¥5 billion (US\$42.7 million). It was increased to ¥6.3 billion (US\$53.9 million) in 2015 and further increased to ¥7.3 billion (US\$64.73 million) in 2016. This large allowance helped 557 individual commercial refrigeration installations in 2015, an increase from 409 in 2014. The number of companies helped was 23 and 24 in 2014 and 2015 respectively.

As the number of stores using CO₂ refrigeration in Japan is just over 1,500, it is clear that this funding has been used for the majority of installations since 2014, highlighting once again the role that the Japanese government plays in accelerating the market for natural refrigerants.

HIGH PRESSURE GAS SAFETY ACT REQUIRES REVISION TO ABSORB BENEFITS OF CO₂ REFRIGERATION

The uptake of CO₂ refrigeration in supermarkets is seen as more difficult than in CVS. The High Pressure Gas Safety Act is seen as a barrier to larger scale introduction of CO₂ for Japanese supermarkets. The High Pressure Gas Safety Act regulates the production, storage, sale, transportation and other matters related to the handling of high-pressure gases.

Although the classification of CO₂ as an “inactive gas” puts it in the same category as non-flammable fluorocarbons under the High Pressure Gas Safety Act, exemptions for certain refrigeration capacity ranges of equipment using fluorocarbons and ammonia are allowed. However, CO₂ is excluded from the exemption list, just like hydrocarbons. The list

is seen as out-dated, with many key players asking for it to be revised. Without a revision, the policy will limit the availability of larger capacity systems and increase the cost of solutions for supermarkets.

To solve this issue, collaboration between relevant stakeholders is seen as a necessity, which would open up the Japanese market to either imports or the creation of larger rack systems. Options that have been put forward include trimming the weight of high-intensity steel pipes.

EFFORTS BY TOKYO METROPOLITAN GOVERNMENT TARGET SMALL TO MEDIUM-SIZED BUSINESSES

The Tokyo Metropolitan Government (TMG) is committed to supporting the installation of refrigeration systems using natural refrigerants. Through its actions and support, the TMG is able to lower the initial cost of installations – through subsidies and also through increased production – and raise awareness of the dangers of fluorinated gases.

The TMG’s subsidy scheme is in place to help promote natural refrigerant equipment in Tokyo, where HFC emissions have risen nearly 300% since 2001. The target of the subsidy

is to assist small and medium-sized business operators with purchasing energy-efficient showcases that use natural refrigerants. The conditions of the subsidy are that it should replace f-gas equipment and that there should be a posting of a non-Freon sticker. The scheme’s budget is ¥200 million (US\$ 1.7 million) per year, which equates to roughly 30 units.

Commercial refrigeration outside Japan



CANADA : 139

Canada leads the charge in North America, benefiting from CO₂ transcritical's excellent efficiency in low-ambient temperatures. Sobey's is the most proactive supermarket in installing CO₂ systems. Sobey's transition was accelerated in Quebec - where 63 of their installations are located - by subsidies provided by Quebec's OPTER programme.



UNITED STATES : 52

The United States has improved its usage of CO₂ supermarkets with an increase from 2 installations in 2013 to 52 in 2015. While the United States may be behind in the total number of transcritical stores, they are at the forefront of technological advancements with innovative CO₂ installations in warm-ambient climates.



EUROPE : 5,500+

Europe is the world leader in terms of CO₂ adoption in commercial refrigeration, with over 5,500 supermarkets using CO₂ transcritical systems, having risen from 2,885 in 2013 and 1,330 in 2011, and continual growth is expected. Starting in 2016, more than 6,000 CO₂ transcritical systems will be added to the European market each year.



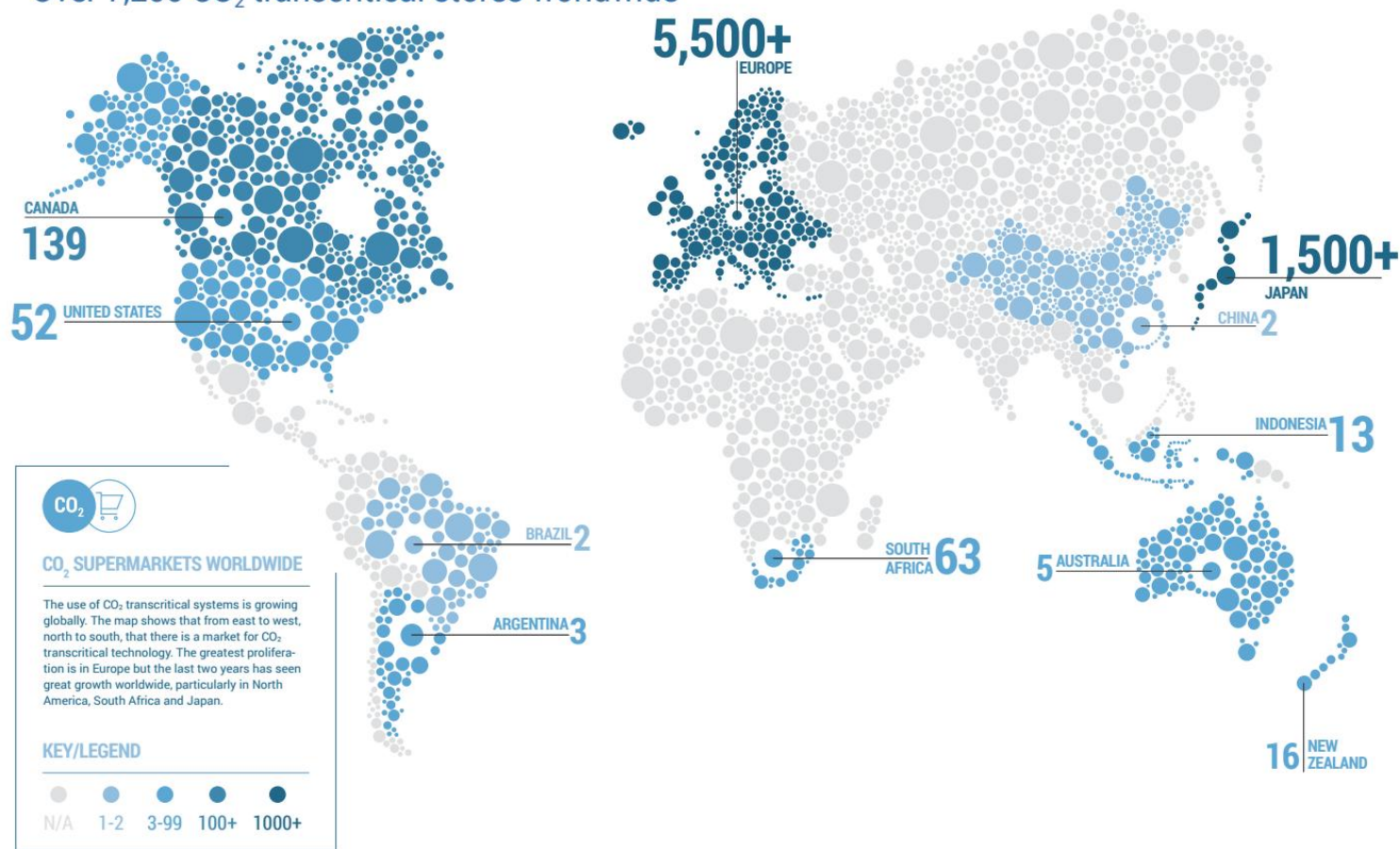
SOUTH AFRICA : 63

South Africa has a growing usage of CO₂ transcritical systems with retailers Woolworths and Makro using the systems in their supermarkets. As the market for CO₂ technology grows globally, system suppliers in South Africa are confident that this market will continue to prosper.



CHINA : 2

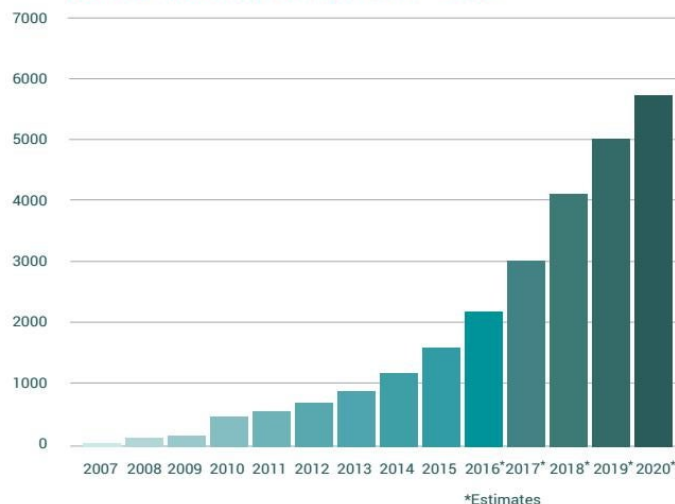
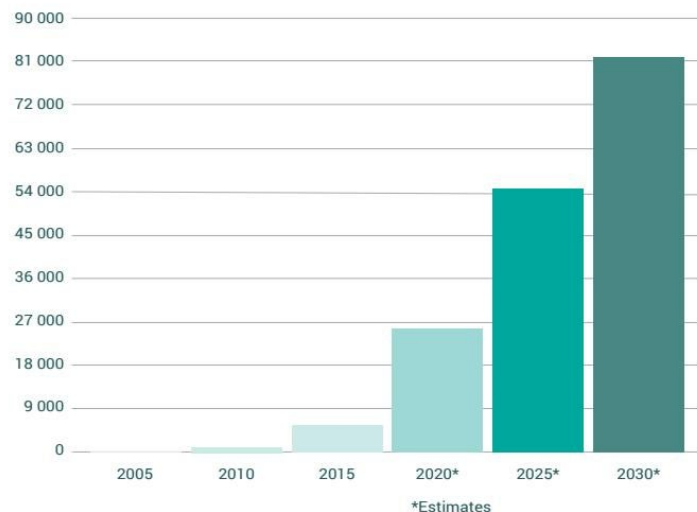
China's commercial refrigeration sector is still in its infancy, with eight stores using CO₂, with one a CO₂ transcritical store. There is, however, an expectation that this will accelerate soon with international supermarkets such as Carrefour looking to increase penetration of CO₂ technology in China.

Over 7,200 CO₂ transcritical stores worldwide

SUSTAINED GROWTH EXPECTED FOR CO₂ TRANSCRITICAL IN EUROPE'S STORES

As the world's largest adopter of CO₂ transcritical systems, Europe's market will continue to grow. shecco Market Development estimates that sustained growth will remain the status quo all the way to 2020. These figures are projected based on increasingly stringent regulations, technological advancements in warmer climates, and a growing acknowledgement and acceptance of the technology and its energy-efficient properties. By 2020, shecco Market Development expects this growth to amount to the installation of 6,000 new systems annually.

This annual growth will contribute to a healthy number of CO₂ stores by 2020, with shecco Market Development estimating that the amount will total 27,000. With acceleration anticipated after 2020, this number will grow to 54,000 by 2025 and 81,000 by 2030.

New CO₂ stores in EUROPE 2007 - 2020Cumulative number of CO₂ stores in EUROPE 2005 - 2030

Policy drivers for natural refrigerants in commercial refrigeration outside Japan

SNAP DELISTING RULE LOOKS TO GET RID OF R404A IN SUPERMARKET REFRIGERATION BY 2019

In 2014, the U.S. Environmental Protection Agency's Significant New Alternatives Policy (SNAP) programme proposed a potential delisting of the ubiquitous R404A among various other high-GWP HFCs as a refrigerant in new commercial refrigeration equipment and retrofits from January 2016. However, in its final rule, the agency moved those dates backwards by at least one year.

For example, for food retail refrigeration applications, the use of R404A, R507A and other HFCs in new supermarket systems will be deemed unacceptable as of 1 January 2017.

R404A, R507A and other HFCs will be delisted from use in new remote condensing units in supermarkets as of 1 January 2018.

In retrofit systems, the same refrigerants will become unacceptable one year after the date of publication of the final rule in the Federal Register (20 July 2016). Although it had been clear for some time that R404A's days were numbered, with manufacturers already moving away from it, this ruling will serve as a further signal to those who have not yet cemented their future plans.

QUEBEC: INCENTIVES HELP DRIVE INTRODUCTION OF CO₂ TRANSCRITICAL SUPERMARKETS

As announced in its Climate Change Action Plan (2013-2020), Quebec continues to incentivise reductions of HFC emissions in the refrigeration systems of supermarkets, warehouses and ice arenas.

The refrigeration optimisation programme (OPTER), administered by Quebec's Ministry of Natural Resources and Wildlife, was an investment grant scheme that encouraged refrigeration system owners to transition to more environmentally friendly systems, including in commercial refrigeration. The scheme offered owners of refrigeration systems up to

CAD\$125,000 to make the shift to more climate-friendly refrigerants, reducing the refrigerant charge by installing secondary loops and integrating refrigeration, heating and ventilation systems.

As of 2013, the scheme continues under a broader 'EcoPerformance' framework, which exclusively supports CO₂ as a refrigerant in projects involving refrigeration systems. The programme runs until March 2017.

EUROPEAN F-GAS LEGISLATION ABOUT TO CRUNCH

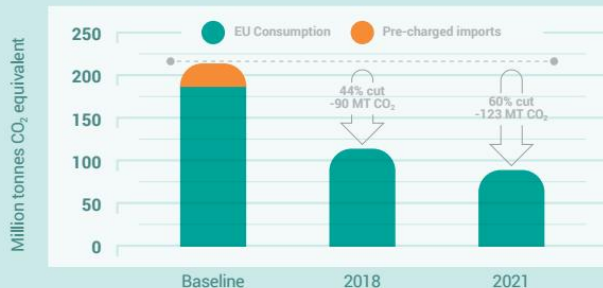
With the F-Gas Regulation looking to reduce 79% of HFC consumption by 2030 (measured in CO₂eq) from current levels, it is now more pressing than ever to create fair conditions for f-gas alternatives and enable their wider uptake across different sectors.

While the effects of the HFC phase-down might not be notable for end users and manufacturers at this point in time, this will change within the next three years. The first significant cut of 37% in HFC quotas in 2018 is expected to have a major impact on the cost of HFCs, which will become less widely available.

Considering the fact that as of 2017 the phase-down needs to incorporate HFCs pre-charged in equipment, the cut in 2018 becomes equivalent to 44% or 90 MT CO₂. Similarly, a major reduction in HFC quotas of 55% will come into force in 2021, which amounts to 60% when considering pre-charged equipment. There is an urgent need to address regulatory and training barriers related to f-gas alternatives, as early action is essential in order to be able to reach the targets.

ACTION IS REQUIRED URGENTLY

- Changing standards and legislation is a slow process
- But impact of EU HFC phase-down becomes very significant within 3 years
 - major cuts occur in 2018 and 2021



Source: Ricardo-AEA Ltd

Let's make the switch

The natural next step in supermarket cooling



With its low global warming potential (GWP) and capability to recover heat at high temperature, CO₂ is the natural refrigerant for green supermarket cooling systems. What's more, the heat recovered by a transcritical CO₂ refrigeration system can be used for tap water and space heating. Equipment from Alfa Laval makes transcritical and cascading CO₂ systems greener, more efficient, reliable and safe.



Air heat exchangers



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www.alfalaval.com/make-the-switch

SANDEN – 100% CO₂ refrigeration in convenience stores

INTRODUCTION

SANDEN has initiated a strategic orientation on CO₂ refrigerant as a climate-friendly and efficient alternative since 2005, with the production of CO₂ heat pumps and vending machines. Since 2010, SANDEN has produced its own CO₂ compressors, and has already delivered over 1.5 million compressor units to the market.

Using its expertise in CO₂ technology, SANDEN made a decision to offer safe and climate friendly refrigeration to convenience (CVS) retail sector (representing some 56,000 outlets in Japan). SANDEN developed a complete CO₂ solution in collaboration with a leading Japanese CVS retailer, providing CO₂ refrigeration units, showcases and installation service.

Since 2012, SANDEN has installed CO₂ refrigeration systems in about 150 convenience stores in Japan.

ENERGY EFFICIENCY AND SAFETY ON TOP OF PRIORITY LIST

Based on available range of SANDEN compressors - reciprocating and scroll types - SANDEN has developed exclusive plug-in display cabinets for low and medium temperature applications.

- » Open top freezing showcase
- » Open top chilling showcase
- » Vertical beverage coolers (including a heated area for hot drinks display)

Field-tests results demonstrated 15% energy savings compared to HFC plug-in cabinets.

Cooling capacity (kW)	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	>>	3.0
Reciprocating	SS	MSC	Sc	Mc	L							
Scroll												Scroll Inverter



Visit for more information

www.sanden.co.jp

Contact information

YUKIO YAMAGUCHI

yamaguchi_yukio@sanden.co.jp

ABOUT THE COMPANY

SANDEN is a world's leading manufacturer of heating and cooling devices, systems and services. Our management policy commits us to creating values through environmental preservation and quality excellence.

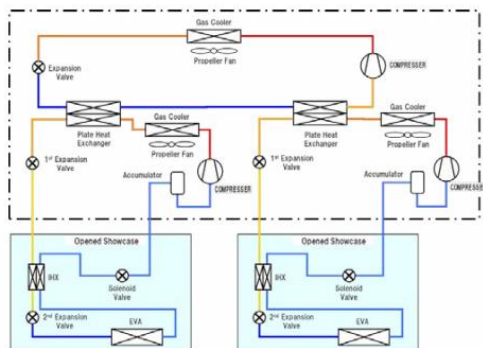
SANDEN operates in four business units: automotive air-conditioning, vending, commercial refrigeration and household comfort.

CO₂ CONDENSING UNITS

SANDEN developed a CO₂-CO₂ cascade system for CVS, the first of its kind in the world. This system places up to 3 compressors and separated refrigeration loops into one system. This exclusive design ensures the highest energy efficiency possible.

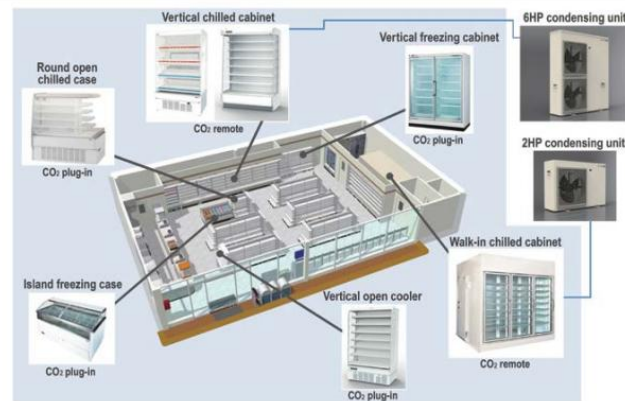
This system has a lot of benefits for operators and retailers:

- No safety risk in case of leakage (CO₂ inhalation) due to reduced refrigerant charge.
- High performance and high efficiency through pressure control
- Lower installation costs thanks to copper piping
- Lower noise and vibration due to quiet SANDEN scroll compressor.
- Efficient operation at high ambient temperatures from the use of high performance micro-channel gas cooler
- Low temperature and medium temperature output



TEST RESULTS IN THE MARKET

SANDEN conducted extensive field tests of the cascade CO₂ system. They showed the energy consumption of the CO₂ system is 70% of a similar R404A system. In 2012, a prominent Japanese convenience retailer, followed by other players, started trial operations of outlets 100% equipped by SANDEN CO₂ refrigeration solutions. There are now around 150 CVS stores successfully running with SANDEN CO₂ technology in Japan.





Energy efficient brine-ice thermal storage system using a new type of CO₂ refrigeration unit

INTRODUCTION

Patented Ultra Eco-Ice System (UEI) is adapted to customers in Japan where it helps reduce daytime electric power demand significantly, improve energy efficiency and reduce running cost. UEI system introduces brine on secondary side and this way significantly reduces HFC refrigerant charge and its leakage.

The brine ice thermal storage-equipped system differs from standard direct expansion CO₂ systems in that it is more compact. The benefit of using the brine (secondary coolant) system to produce and store ice and cool the store's display cases include reducing daytime electric power demand (peak cut), higher energy efficiency, and greater safety due to the thermal storage.

MERITS OF USING THERMAL STORAGE FOR SUPERMARKETS

Accumulation of cooling energy during nighttime at lower temperature for daytime loads has economic advantages over direct expansion system:

- Energy efficiency - refrigerators for thermal storage can operate at high COP
- Reduction of daytime electric power demand
- Reduction in cooling capacity (depends on the design of thermal storage)
- Direct expansion refrigerator
- Thermal storage refrigerator



Vist for more information

http://www.yamato-se.co.jp/technology/ultra_eco.html

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ABOUT THE COMPANY

YAMATO Co. Ltd. is an engineering company specializing in planning, designing, installation and maintenance for freeze and refrigeration facilities and HVAC. For these two areas, YAMATO Co. Ltd. originally developed a thermal heat storage system, accumulating thermal energy during nighttime for daytime loads, to achieve daytime electricity saving.

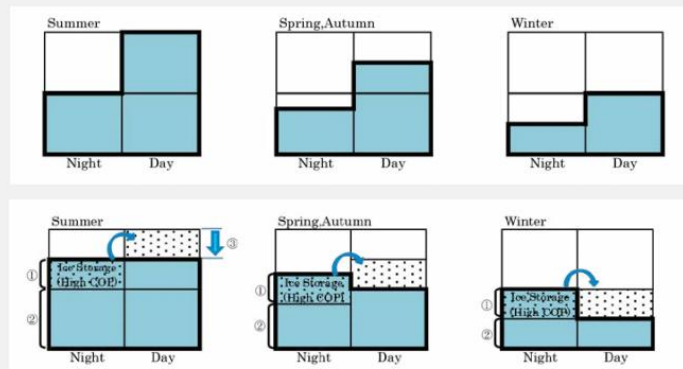


Fig.1 Operation of direct expansion refrigerators and thermal storage refrigerators

CO₂ evaporating temperature for brine-ice thermal storage operation shows gradual decline with increasing of ice production and decreasing of brine temperature in ice storage tank.

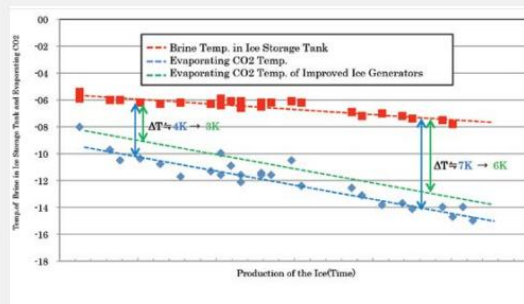


Fig.2 Temperature profiles

CO₂ UEI STORAGE EQUIPPED SYSTEM VERSUS STANDARD DIRECT EXPANSION CO₂ SYSTEM

Advantages of brine-ice storage refrigerator during nighttime over a standard direct expansion refrigerator during daytime lie in three key points:

- **Energy efficiency (kWh):** At least 9% energy efficiency improvements can be measured, increased to 10.2% when using the improved ice generator (indicated in Fig. 2). Real air temperature measured throughout the year is used in this case study.
 - Average COP of DX refrigerator during the year (daytime 10:00am – 10:00pm), with average evaporating temperature of -10°C: 2.55
 - Average COP of brine-ice storage refrigerator during the year (nighttime 10:00pm – 10:00am), with evaporating temperature of CO₂ UEI at -10 – -15°C: 2.78
- **Reduced electric power consumption (kW):** As a result of increased COP, the electricity consumption is decreased by 30% when using the brine-ice storage refrigerator compared to a standard direct expansion refrigerator.
- **Reduced cooling capacity (kW):** The cooling capacity of the a refrigerator is reduced by 35% with CO₂ UEI storage system.

In addition, changing an existing HFC and HCFC-based display case to brine can be done easily and at low cost and without the need to replace the case with a new equipment for secondary coolant system.




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ABOUT THE COMPANY

Tokyo-based Lawson, established in 1975, is a convenience store business that runs on a franchise system, and operates 12,000 stores in almost every region of Japan, from Hokkaido to Okinawa.

The retailer has operations in Japan, China, Indonesia, the US (Hawaii) and Thailand. It aims to achieve 20% energy savings in each store by 2020 (using 2010 as the baseline).

CO₂ refrigeration increases energy efficiency of Lawson's stores by 27%

INTRODUCTION

Lawson works to reduce electricity consumption at the stores to reduce their environmental impact. Setting "Toward a 20% reduction in electricity consumption per store compared with fiscal 2010" as its medium-term energy saving target for fiscal 2020, Lawson is proactively introducing energy-saving CO₂-based refrigeration and air-conditioning equipment as well as LED lighting in its store facilities.

Japanese convenience store operator Lawson is leading a revolution in the commercial refrigeration sector, with plans become the world's number one retail using natural refrigerants. Starting with the rollout of CO₂-based refrigeration in 2010, the retailer now operates around 1,300 natural refrigerant stores in Japan.

ENERGY EFFICIENCY AND SAFETY ON TOP OF PRIORITY LIST

Standard Lawson convenience stores employ two CO₂ systems, a 10 HP and a 2 HP CO₂ transcritical condensing unit made by Panasonic. The CO₂ units contribute to average energy savings of 27% compared to conventional HFC units. It is the energy savings that are most important to the franchise operators. The savings help keep Lawson convenience stores profitable despite difficult sales and soaring electricity costs.

With the aim of demonstrating the performance of CO₂ in warm and humid climates, Lawson installed a trial system in Japan's southernmost island of Okinawa, which showed energy savings of 21% compared to equivalent equipment based on the conventional refrigerant R404A. With the annual power consumption of the CO₂ system measured at 63,801 kWh (compared to 80,605 kWh of the R404A system), the energy savings translate into an annual cut of 235,256 JPY (around €1,708) on the energy bill.

By 2016, Lawson's stores that have adopted CO₂ refrigeration resulted in about 40,000-tCO₂ annual emissions reduction.

ZERO ENERGY STORES

One of Lawson's most advanced CO₂ stores can be found in Toyohashi City, in the Aichi Prefecture. Opened in November 2014, the store also has glass doors on its display cabinets along with ground-source heat pumps, and has a high level of insulation thanks to its double-skin façade. As a result, the store has achieved a 60% reduction in energy use compared to 2010 levels.

Lawson plans to open a flagship Zero Energy stores such as this one every year, with the aim of reducing energy consumption by 70% compared to standard stores in 2010.



GOVERNMENT SUBSIDIES

Although CO₂ refrigeration systems are very energy efficient, the up-front costs are almost double those of traditional refrigeration systems. Looking for support to lower these costs, Lawson turned to the Ministry of Economy, Trade and Industry (METI), which in 2010 granted Lawson a subsidy. It was this subsidy that allowed Lawson to install CO₂ systems in the first 50 stores. Based on the results of these pilot stores, Lawson received funding for further CO₂ installations.

A further round of subsidies, this time from the Ministry of the Environment (MOE) eventually enabled Lawson to make CO₂ refrigeration systems its standard technology across all stores in September 2014. For Lawson, government subsidies have played a key role in the success of CO₂. The subsidies enabled the user to solve teething problems related to system operation and to reinvest in the technology and eventually standardize the systems.

The subsidies also helped the convenience store operator overcome a second hurdle that could have hampered the rollout of CO₂ commercial refrigeration systems: lack of technician training. Working closely with system manufacturer Panasonic, Lawson has so far provided training in the installation and maintenance of CO₂ refrigeration technology to more than 900 refrigeration technicians.

LAWSON



Panasonic

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ABOUT THE COMPANY

Panasonic is globally recognised for manufacturing high quality and reliable products. Panasonic developed the unique CO₂ Direct Expansion Refrigerating System that adopted CO₂ (carbon dioxide), an ultimate natural refrigerant (non-Freon), and has already introduced it to the Japanese market.

Currently, through developments of new types of two-stage compression rotary compressors and a split-cycle with Panasonic's own unique technologies, the company has gained validation - about 60% reduction in annual CO₂ emissions, as well as achieving about 25% of the energy-saving performance at the freezing condition, and about 16% at the refrigerating condition compared to conventional HFC refrigerant (R404A).

Panasonic's CO₂ refrigeration shows 20% energy savings in Indonesia

INTRODUCTION

Indonesian-based retailer MIDI operates over 1,000 'Alfamidi' convenience stores in the country. In a search for climate-friendly refrigeration technology, Alfamidi has partnered up with Panasonic and Japanese-based retailer Lawson.

As part of an initiative to introduce CO₂ refrigeration systems in developing countries, Lawson launched the project "Energy Saving at Convenience Stores in Indonesia" under the Joint Crediting Mechanism (JCM) in 2013, with a plan to fit 15 new stores in and around Jakarta with CO₂ refrigeration units by Panasonic.

By adopting highly energy-efficient CO₂ systems, the company set the goal of reducing annual power consumption for refrigeration by 14% compared to existing standard stores; and by combining these systems with energy-saving equipment for air conditioning and lighting, it also aimed to cut down on overall store energy use by 39,001kWh per year, which is equivalent to energy reductions of 21%.

ABOUT THE NEW SYSTEM

The refrigeration system installed in Indonesia employs "split cycle" refrigeration circuit as same as installed in Japan. It enhances the cooling capacity and the efficiency of CO₂ refrigeration systems. The efficiency is better with commercial refrigeration evaporating temperature range compared to R404A refrigeration systems (16% better in refrigeration and 25% better in freezing, estimated at Japanese climate condition).

The energy saving really depends on the outdoor temperature. High outdoor temperature gives less energy saving. Our estimation still gives approx. 20% energy saving compared to R22 at the climate condition in Jakarta, including the advantage of inverter drive of CO₂ system.

In Indonesia, the refrigeration systems installed in convenience stores are changing. There were only several ice-cream and drink showcases but the display area of refrigerated

items are increasing. So, energy conservation is one of the most important issues for the convenience stores today.

These conventional showcases are self-contained. The heat pumped from inside the showcases is rejected to the sales floor space. According to the increment of refrigerated showcase, the system configuration has to be changed from self-contained to remote type.

Configuration of CO₂ refrigeration system:

- 1 of Outdoor unit for Refrigeration, 10hp output compressor
- 3 of 6 feet width open showcase
- 1 of 6 door walk-in refrigerator
- 1 of Outdoor unit for freezing, 2hp output compressor
- 1 of 2 door reach-in freezer

Operating conditions:

1. Cold room temperature (Refrigeration): 5degC±2K
2. Cold room temperature (Freezing): -20degC±2K
3. Room temperature (A/C setting): 26degC

AT LEAST 13 CO₂ TRANSCRITICAL STORES IN INDONESIA

In collaboration with its local retail partner MIDI, Lawson completed the installation of CO₂ systems at 13 Alfamidi mini-supermarket stores in Jakarta at the end of March 2015. The refrigeration capacity of the new systems increased, and yet results thus far have also proved that they are effective in saving energy.

This project will continue until 2020, and Lawson plans to acquire carbon credits through the JCM scheme funded by the Japanese government. It also hopes to expand this initiative into other countries in South East Asia, where electricity prices are high, to help contribute to their economic development with advanced Japanese technology.

In 2016, Alfamidi plans to open a further 12 natural refrigerant-based stores with Lawson in 2016, featuring reach-in freezers, walk-in chillers and open case cabinets.

20% ENERGY SAVINGS

A case study of two stores in Jakarta found that an average of 20% energy savings leads to a 15% increase in average sales. However, high investment costs for CO₂ technology are a challenge and have yet to be properly addressed in Indonesia. The initial cost of CO₂ refrigeration system including installation is approx. 1.5 times as much as conventional system. Remote monitoring costs such as system charge and communication fee are additional operational cost.



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Panasonic's CO₂ system achieves 23% energy savings at AEON's large-format store

INTRODUCTION

AEON Co. Ltd., the holding company for AEON Group, is the largest retailer in Japan as well as Asia as a whole, and one of the biggest global retailers. It is also one of the most ambitious proponents of natural refrigerants in the world.

AEON, based in Chiba, Japan, staked out that position in 2011 when the group issued its 'AEON Declaration on Natural Refrigerants,' committing to introduce natural refrigerants, specifically CO₂, at all new stores opening in and after the fiscal year 2015 (which ended on 31 March 2016), while also gradually converting existing stores to natural refrigeration. The company was the first retailer in Japan to use CO₂ refrigeration in its stores.

PIONEER IN CO₂ ADOPTION IN JAPAN

Between 2009-2011 AEON opened the first three CO₂ stores. The confirmed energy savings was 10% and CO₂ reduction 50%, sufficient for AEON to further invest in CO₂, as the technology was seen as a viable. The next CO₂ supermarket had even better energy savings of about 20%, while the MiniStop CO₂ CVS saves up to 30%.

The high efficiency of the systems convinced the retailer it had made the right decision. Once it had confirmed the safety of the system and was able to achieve 20% energy savings – larger than expected – compared to conventional HFC equipment, "we reached the conclusion that natural refrigerants are what we are to pursue in the future," said Haruko Kanamaru, General Manager of the Corporate Citizenship Department at AEON.

The air-cooled condensing units, from Panasonic, typically use 15 or 20 HP and are located either on the roof or next to the building. A supermarket between 20,000 and 45,000 square feet would employ 10-20 of these condensing units.

FLAGSHIP STORE ACHIEVES 23% ENERGY SAVINGS

In December 2013 AEON opened its largest format (GMS) flagship store, the AEON Mall Makuhari New City. This GMS store covers an area of 128,000m² and 20 CO₂ systems provide cooling to 144 CO₂ showcases. Performance data accumulated from February to October indicate 23% energy savings in comparison with an R404A system.

Combined direct and indirect emissions were reduced by around 72% compared to an R404A system.

CHALLENGES TO BE TACKLED

While AEON is set on pursuing CO₂ installations in new and existing stores, it has encountered a number of challenges and concerns along the way. The classification of CO₂ as an “active gas” under the High Pressure Gas Safety Act limits the availability of large capacity systems and increases the cost of the solutions for supermarkets.

AEON sees the importance of Japanese Environment Ministry subsidies to supplement initial investment and running costs of CO₂ technology.



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Panasonic's CO₂ systems help CO-OP Mirai achieve its emissions reduction targets

INTRODUCTION

Established by joining Chiba CO-OP, Saitama CO-OP and CO-OP Tokyo in 2013, CO-OP Mirai operates 61 supermarkets, 71 mini-supermarkets, 75 delivery centres and 30 nursing case service offices.

A Japanese consumer Co-operative (CO-OP) is an organisation supported by consumers who become members through payment of their subscription. The fees are used to engage in the business operations necessary for improving the daily lives of its members. CO-OP Mirai is the biggest Co-operative organisation in terms of number of members and turnover, with operations in Chiba, Saitama and Tokyo.

The Japanese-based retailer has set a target of reducing the group's CO₂ emissions by 15% by 2020 compared to 2015 levels. In addition, 20% of group's energy consumptions should be generated from renewable energy sources, including solar energy, wind power, biomass and small-scale water power.

CO₂ SYSTEMS DELIVER 32% ENERGY SAVINGS

As part of plans to slash its overall CO₂ emissions by 15% by 2020, CO-OP Mirai has installed CO₂ refrigeration systems at two of its delivery centers - CO-OP Deli Shin-Omiya center and CO-OP Deli Shin-Misato center, each with a total floor area of around 2,080m². Both facilities are equipped with one 20 HP and two 15 HP R744 units. Compared with traditional HFC-based technology, energy savings of 32% are expected thanks to the CO₂ technology. It is foreseen that the installations will contribute to reduction of 50t of CO₂ emissions annually.

"The reason for introducing CO₂ is that global warming is something we need to address, as well as improving energy efficiency," said COOP Mirai's Tsutomu Saito.

FIRST CO₂ STORE OPENED IN MARCH 2016

In March 2016, CO-OP Mirai completed the refurbishment in its first store with CO₂ showcases. The Shintakakura store in Takakura, originally opened in 1994, is also equipped with LED lights and is expected to deliver energy savings of 27%. With the energy efficient CO₂ refrigeration system it is expected that CO₂ emissions will be reduced by 67t annually compared to previous installation using HFCs.

The total floor area of the store is 3,503 m², with 63 refrigeration / freezing cabinets and 9 cold rooms. A total of 11 CO₂ condensing units have been installed to deliver the cooling needs for the refrigeration equipment - 8 units with 20HP and 3 units with 15HP.



Panasonic®

Industrial refrigeration

Introduction

Up until the mid-1970s, the use of ammonia direct systems was a standard in Japan's industrial refrigeration sector, but a succession of incidents at NH₃ industrial refrigeration sites triggered concerns about refrigerant safety. As a result, the High Pressure Gas Safety Act was strengthened in 1978 to prevent any more incidents at NH₃ sites. This had the obvious impact of diluting the market share of ammonia, which was shunned in favour of HCFCs.

However, with recent innovations leading to increased confidence in the use of NH₃, the market tide is changing. Confidence has been boosted by the increasing deployment of NH₃/CO₂ secondary systems throughout Japan. And while in the past the government had steered the industry away from ammonia, Japan's industrial refrigeration sector is currently being subsidised by the Ministry of Environment to use natural refrigerants, with 113 installations having benefitted from such support in 2014-2015.

While this is a clear step in the right direction, obstacles preventing the wider use of natural refrigerants in industrial refrigeration remain. Regulatory constraints (High Pressure Gas Safety Act) are still in place for the use of CO₂ transcritical technology, the popularity of which is growing in North America and Europe.

STRONG RELIANCE ON R22 CREATES FURTHER OPPORTUNITIES FOR NATURAL REFRIGERANTS

Currently, there are more than 10,000 facilities using ozone-depleting substances in Japan and with an HCFC phase-out quickly approaching in 2020, the cold storage sector represents a huge opportunity for natural refrigerants in Japan.

While the 1970s saw a shift away from ammonia, the Japanese government gradually lessened restrictions for NH₃ equipment in 1999 (Ministerial Ordinance of Refrigeration Safety) and prefectural governments began to accept NH₃ equipment with low refrigerant charges of 100kg or less. Additionally, Japanese manufacturers have developed NH₃/CO₂ industrial refrigeration systems in order to further reduce the ammonia charge and provide end users with systems that are safer and easier to maintain.

AMMONIA, CO₂ AND AIR TECHNOLOGY CONTINUES TO IMPROVE

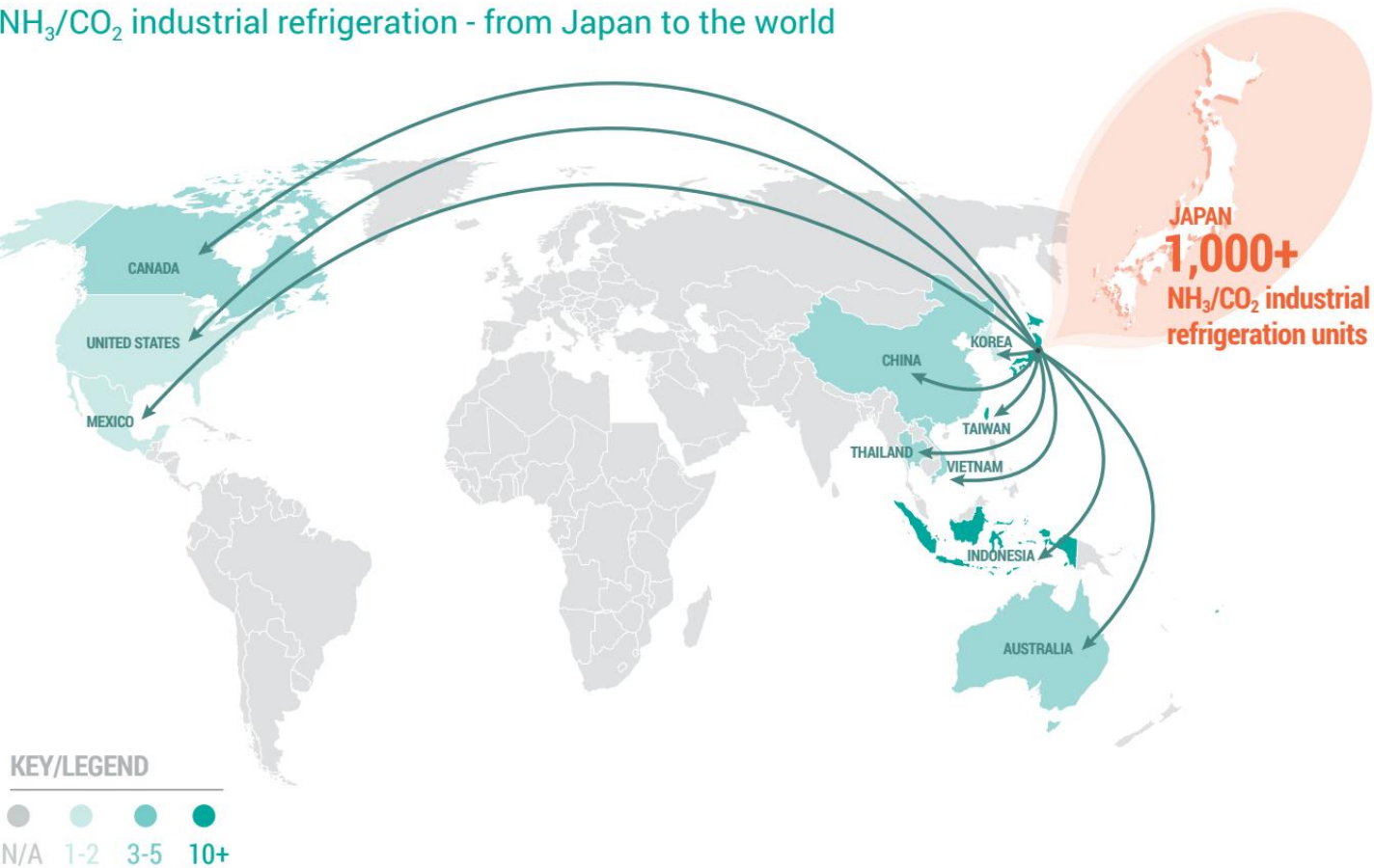
While ammonia still remains the natural refrigerant of choice in new medium- and large-scale industrial refrigeration plants, CO₂ is starting to make significant inroads as a secondary refrigerant in Japan, both in cold storage and food processing facilities. The use of air as a refrigerant is also gaining popularity in ultra-low temperature industrial refrigeration facilities.

NH₃/CO₂ technology is being used in a number of different applications in Japan, including food and chemical manufacturing. In addition, NH₃/CO₂ systems are increasingly being deployed in ice rinks, where the technology offers not just energy savings but also better quality ice. At least eight ice rinks in Japan are currently using NH₃/CO₂ secondary systems. Compared to the previous R22-refrigerated ice rinks, annual power savings of up to 30% have been recorded. Compared to R22/glycol ice rinks, the saving is 46%.

Deployment of technologically advanced systems has been aided by the Ministry of Environment's move to subsidise the installation cost of cold storage and food manufacturing plants using natural refrigerants. Government subsidies have already contributed to the entry of over 1,000 units into the Japanese market, equating to just over 300 separate installations, 113 of which were subsidised by the government. Appreciation of these systems is also growing worldwide, with 42 sets exported to Asia and Australasia and seven sets exported to North America. Exportation to South America began in 2016.

Mayekawa has developed a refrigeration system using air as the natural refrigerant, in cooperation with the New Energy and Industrial Technology Development Organisation (NEDO). Thus far, 54 units have been installed in a number of applications, including ultra-low temperature warehouses, rapid food freezing systems, and in the chemical process cooling industry. In terms of COP, the air refrigeration system has an advantage over conventional systems, and because its application is limited to ultra-low temperatures (below -50°C) – a blank area for natural refrigerants until now – it sets itself apart from conventional systems.

NH₃/CO₂ industrial refrigeration - from Japan to the world



Policy drivers for natural refrigerants in industrial refrigeration in Japan

HCFC PHASE-OUT SEEN AS KEY DRIVER FOR CHANGE

The HCFC phase-out is expected to be the main driver of the introduction of natural refrigerants in the cold storage sector in Japan. Many facilities are yet to consider transitioning to other refrigerants ahead of the entry into force in 2020 of a complete ban

on using R22. After this deadline, it will not be possible to service existing equipment with reclaimed R22, making the equipment obsolete.

GOVERNMENT SUBSIDIES FUEL APPETITE FOR NATURAL REFRIGERANT SOLUTIONS

Given that the government has historically provided industry with incentives to move away from ammonia – having considered chemical refrigerants (HCFCs) to be more stable – some cold storage operators are hesitant to shift back to ammonia without government support. Government support appeared, therefore, in the shape of the Ministry of Environment (MOE) providing five billion JPY in subsidies in 2014 to support the use of natural refrigerants in refrigerated warehouses, commercial refrigeration, and other refrigeration and air conditioning equipment. The scheme supported 36 natural refrigerant

cold store projects in 2014, covering up to 50% of the investment cost. The 34 end users of the 36 cold stores included brands such as Meiji, Baskin Robbins, Kewpie and Maruha Nichiro. An increased budget of 6.3 billion JPY for the 2015 financial year aided 72 installations, including the food production sector after it had also been declared eligible for funding. For the 2016 financial year, the MOE again increased the available budget, this time to 7.3 billion JPY, and added ice rinks and chemical manufacturing processing plants to the list of sectors eligible to receive subsidies of up to one third of the investment cost.

HIGH PRESSURE GAS SAFETY ACT(S) SEEN AS BARRIER TO CO₂ TRANSCRITICAL SYSTEMS

The use of industrial-scale CO₂ transcritical systems is not currently common in Japan, although there are signs that such installations could soon emerge as a trend. A first CO₂ booster system with cooling capacity of 51 kW has been installed in 2016 for a tunnel freezer. Compared to new HFC systems, the CO₂ technology delivers 10-15% efficiency improvement.

The main obstacle to the present lack of deployment of CO₂-only systems in larger applications is the High Pressure Gas Safety Act. The Act regulates the production, storage, sale, transportation and other matters related to handling high-pressure gases, effectively

banning equipment using CO₂ above 40~50 horsepower. Anything with more horsepower requires an official green light.

Although the classification of CO₂ as an “active gas” puts it in the same category as non-flammable fluorocarbons under the High Pressure Gas Safety Act, exemptions are allowed for certain refrigeration capacity ranges of equipment using fluorocarbons and ammonia. However, CO₂ is excluded from the exemption list – just like hydrocarbons. Many key players consider the list to be outdated and are asking for it to be revised.

Industrial refrigeration outside Japan

LOW-CHARGE NH_3 LEADING WAY IN CANADA; PRESENCE GROWING IN US

While every region of the United States and Canada boasts low-charge ammonia systems to some extent, Canada is a clear leader in their adoption with 187 currently installed; Québec and Ontario alone have 102 installations between them. While the use of low-charge ammonia is less prevalent in the United States, with 22 installations, the range of locations demonstrates the varied temperature range within which it can operate, making it a potential solution for the whole of North America. Altogether, these low-charge systems make up nearly 80% of next-generation industrial refrigeration installations.

Reducing the ammonia charge has various benefits, not least safety, greatly reducing the potential area of contamination in the event of a leak. The cost of both system and refrigerant are also more palatable than other options. In addition, as standardised systems, low-charge ammonia units are easy to maintain, take up little space and reduce on-site assembly costs.

BRIGHT FUTURE FOR NH_3/CO_2 CASCADE AND SECONDARY SYSTEMS IN CHINA

NH_3/CO_2 secondary and cascade refrigeration systems have been gaining popularity in China since 2013, when the technology was first developed and tested by a Chinese manufacturer. A NH_3/CO_2 cascade system can effectively reduce the ammonia charge by as much as 90% compared to its ammonia-only counterpart. This opens the door to adopting natural refrigerant-only systems even in large-scale cold storage facilities, where direct ammonia systems are not feasible due to charge limitations. Moreover, confining NH_3 to an engine room where access is limited increases safety and lowers the risk of food contamination.

According to market data gathered from leading Chinese industrial refrigeration manufacturers, CO_2 has been applied as a refrigerant in more than 30 projects in China. The installations range from ice-making facilities and cold storage to ski halls and ice cream production facilities, and also include meat, aquatic products and prepared food processing. In the majority of facilities, CO_2 is used as a secondary coolant or as a low-stage refrigerant in cascade systems alongside ammonia.

Policy drivers for natural refrigerants in industrial refrigeration outside Japan

ENERGY INCENTIVES REDUCING COST OF NEXT-GENERATION INSTALLATIONS IN NORTH AMERICA

As more companies look to remodel their industrial refrigeration systems to adhere to environmental standards, state subsidies in the US are helping businesses to reduce their energy costs and consumption. Federal subsidies can also be tapped into for assistance in improving energy efficiency and reducing environmental impact. The US and Canadian Energy Star programme helps consumers to purchase environmentally-friendly products and encourages companies to improve the environmental performance of their production facilities.

Energy utilities, meanwhile, are offering subsidies to those using efficient technology such as low-charge systems, which offer energy-efficiency improvements of 15-25% over HFC-based refrigeration systems and 5-10% over traditional ammonia systems.

Utility companies are looking to these systems to help reduce demand on the grid, especially at peak times. The subsidies work in conjunction with the cost savings incurred by installing efficient low-charge ammonia systems, which also boast lower installation costs, lower operating costs and lower maintenance costs on top of the favourable price of ammonia as a refrigerant.

STANDARDS IN CHINA BOLSTER FUTURE MARKET FOR NEXT-GENERATION INSTALLATIONS

The industry's efforts to improve safety codes may also have a bearing upon the use of advanced ammonia systems. Until recently, the lack of national safety standards was seriously impeding the introduction of ammonia refrigeration systems, with local government and end users reluctant to adopt the technology due to safety concerns. Therefore, the adoption of the Safety Code for Cold Stores (GB28009-2011) at the end of 2012 alleviated a major market and policy barrier for the use of ammonia in cold stores. Similarly, the introduction of a standard applicable for CO₂ compressors used in industrial refrigeration has been in place since 2012. The drafting of a safety standard related to the design of cold stores using CO₂ as a refrigerant is on-going and will bolster the market further upon its expected completion in the second half of 2016.

Further positive policy has been introduced by China's Foreign Economic Cooperation Office (FECO), which published a draft version of 'The First Catalogue of Recommended Substitutes for HCFCs' in June 2015, listing 12 substitutes to HCFCs including: CO₂, ammonia, hydrocarbons and water. The draft version proposes ammonia and CO₂ as a replacement for R22 in industrial refrigeration applications. The catalogue serves as guidance for manufacturers, end users and policymakers and is not a legislative document. However, based on these recommendations, the government is expected to put in place incentives to support the shift to natural refrigerants. The final version of 'The First Catalogue of Recommended Substitutes for HCFCs' is expected to be officially issued by the Ministry of Environment Protection in 2016.



38% power consumption reduced by installing NewTon

INTRODUCTION

Since its foundation in Yokohama in 1948, Yokorei Reito has been dedicating their business to cold storage facility logistics and food product sales. Their contribution to food safety and its consumers has earned an excellent reputation in the industry.

Upon seeking new refrigeration system for Yumeshima Logistics Center, the foremost consideration of all was to have a system with a natural refrigerant. After considering initial capital cost, operating cost (maintenance and utility), and 20-year life cycle cost, Yokorei's clear decision was to use a Mayekawa NewTon system. Three main points that helped convince Mr Yukio Sasaki, Deputy General Manager at Yokohama Reito, to choose NH₃/CO₂ technology included very little gap between the NH₃'s evaporating temperature, CO₂'s condensing temperature as well as its high performance as a refrigerant.

FACTORY-PACKAGED SYSTEM

A NewTon package comes as a skid-mounted unit that requires no on-site assembly. This is an advantage in workmanship and quality over a conventional built-up system.

In addition, piping and equipment for CO₂ is smaller, resulting in lower cost for material and construction. Furthermore, Mr. Sasaki stated that he has seen other secondary benefits of a packaged system. "Factory packaged systems reduce areas for regular maintenance. The usually required oil flushing is one of those that are not required anymore. Also, the longer product life gives us a very long interval between overhauls. On top of these, the ammonia detector is only required in the machine room. All these benefits have resulted a dramatic decline in maintenance cost."



Vist for more information

<http://www.mayekawa.com/>

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ABOUT THE COMPANY

Mayekawa (MYCOM) is one of the most advanced companies in manufacturing industrial refrigeration compressors. The company was founded in 1924 and since then has increased its market share to 70% from the Japanese industrial refrigeration market, and 30% from the world's industrial refrigeration market. Mayekawa is unique in its focus on natural refrigerants, working with all 'Natural Five' (CO₂, NH₃, hydrocarbons, water and air). The company has over 100 small subsidiaries in Japan and 40 extra subsidiaries overseas, all of them small enough to keep close relations with each customer.

CONSIDERATION TO SAFETY

Newton was also praised for its design consideration to safety. The chance of ammonia leak is minimized due to the low ammonia charge and the semi-hermetic screw compressor, compared with the direct ammonia cooling system of the same size. Also, by containing the ammonia equipment within the machine room, you are reassured as a facility manager that damage would be minimal in case of ammonia-related accident.

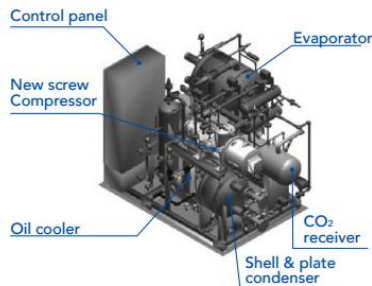
In terms of CO₂ refrigerant management, the over-pressurisation protection during extended shutdown periods is guaranteed by automatically reducing the CO₂ pressure to a set point, when it rises while the compressor is stopped. "NewTon is strong in protective measure to maintain the CO₂ circulation system. Operation to avoid super-cooling and therefore to avoid the refrigerant from turning to dry ice is just one example. These cannot be done in the conventional system," said Mr Sasaki.



RESULTS

Approximately 38% in power usage reduction has been proven at Yumeshima logistics center over a year period, compared with the similar size facilities.

"The direct expansion R-22 system our company have been using does not require fan power for the evaporator and is a very efficient system. It is such a surprise to see NewTon exceed it in efficiency," commented Mr Sasaki. "Upon seeing these results from our first facility with NewTon, we have planned to install NewTon in other facilities as well. To start, Five NewTonR-3000 will be installed at Thai Yokorei Co.,Ltd Bangpakong Distribution Centre Phase II in Thailand."



MAYEKAWA
MYCOM



Mayekawa's NewTon helps deliver fresh and safe halal foods in Indonesia

INTRODUCTION

In Indonesia PT. Adib Global Food Supplies is involved in food processing and logistics services as well as cold storage rental services. They currently have eight distribution centers which provide fresh, high-quality foods mainly to supermarkets in Indonesia.

With a population of nearly 240 million, Indonesia faces a severe shortage of fresh meat, fish, and vegetables. As such, there is an urgent need to establish and expand a cold supply chain for a stable food supply. President Budi Mulyono said, "Our vision of the 'Best Halal Food Service' comes from our desire to provide fresh foods to improve our customers' health so they can work well, making both themselves and the country richer." To achieve this vision, Adib considered freezer and refrigeration equipment required in distribution centers and factories.

ENERGY EFFICIENCY AND SAFETY ON TOP OF PRIORITY LIST

In the beginning the cold store operator considered a liquid ammonia pump cooling system used in many businesses in Indonesia. "Mayekawa Indonesia proposed the NewTon system, whose safety and energy efficiency we found very interesting. With this in mind we visited Mayekawa's Moriya Factory and businesses in Japan that have adopted the NewTon system to see what customers thought of the product. This visit convinced us that the NewTon system has the energy efficiency that Indonesia needs, is compatible with CFC phase-out, and fulfills the most important aspect of continuing business, namely that it is economical." President Mulyono said.

PT. Adib Global Food Supplies has installed two NewTon R-6000 units at the newly-built cool storage facilities in Bekasi, Indonesia, a suburb of Jakarta, and an IQF Freezer and NewTon R-3000 at the Karawang Food Processing Plant.



Vist for more information

<http://www.mayekawa.com/>

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ABOUT THE COMPANY

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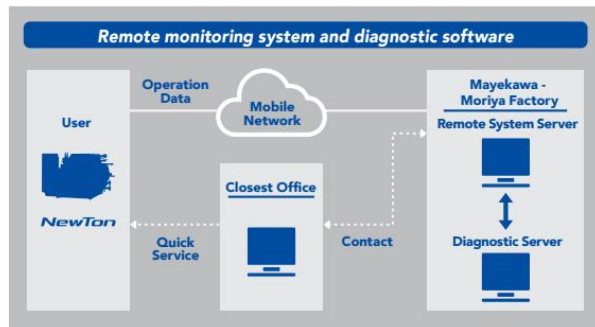
In simulations before adoption of NewTon at the Bekasi cold storage facilities, a comparison with facilities of the same size showed approximate 30% energy efficiency (reduced power consumption). Regarding safety, one of NewTon's features is its low ammonia charge of only 50 kg (NewTon R-6000), and its indirect cooling method which makes it necessary to only circulate ammonia in the machine room. The system has received high praise for its consideration of double and triple safety measures that ensure hazard removal equipment maintains safety even in the event of a leak. Adib was also interested in the stainless steel piping. The possibility of long-term usage was also deemed a significant advantage.

RESULTS

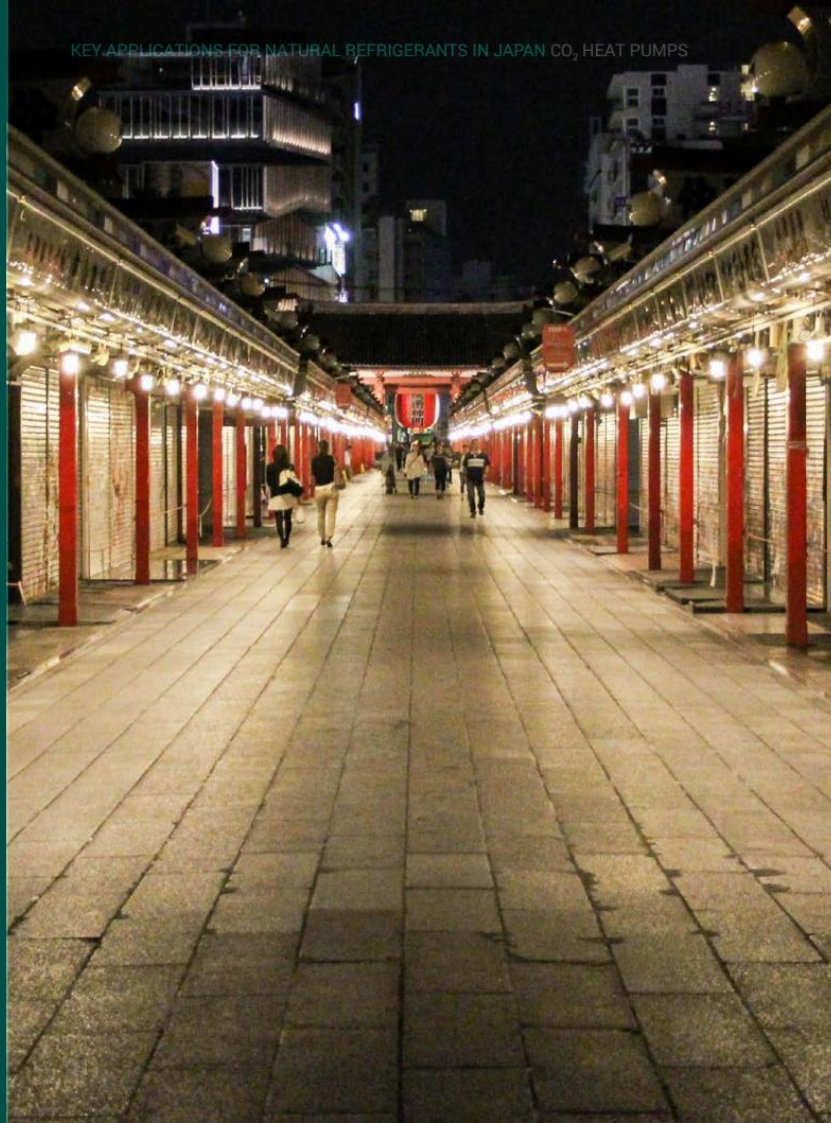
When comparing power consumption of the system in real operation with similarly sized facilities, the energy savings were in range of 25-30%.

Additionally, because the status of the system can be viewed using various data through a remote monitoring system, there is no need to employ specialist technicians, thereby saving on manpower. President Budi mentioned, "Because ammonia is not directly used as a coolant in cool storage where customer goods are kept, heat-exchanged CO₂ is pumped into the warehouse, providing peace of mind and satisfaction for customers who use this service."

Although Adib currently possesses eight distribution centers, they are planning to build 6 more to achieve their vision of the Best Halal Food Service.



MAYEKAWA
MYCOM



CO₂ heat pumps

Introduction

The use of residential CO₂ heat pumps in Japan has rightly been flagged as a standout best-practice case for adopting natural refrigerants globally. While the efficiency of residential CO₂ hot water heat pumps (HWHP) is unrivalled, the penetration of the technology has been somewhat underwhelming outside of Japan.

To a large extent, CO₂ HWHPs in Japan owe their success to progressive government policy that initially subsidised the technology to help reduce the initial price premium typically attached to state-of-the-art systems. As such, CO₂ HWHPs were able to penetrate the market and since then have gone from strength to strength, with sales topping 400,000 annually since 2007.

While the use of CO₂ heat pumps in residential applications in Japan is admirable, there remains significant potential for growth in the use of CO₂ heat pumps for commercial applications. Conversely, in the rest of the world penetration has typically been greater in commercial applications than residential.

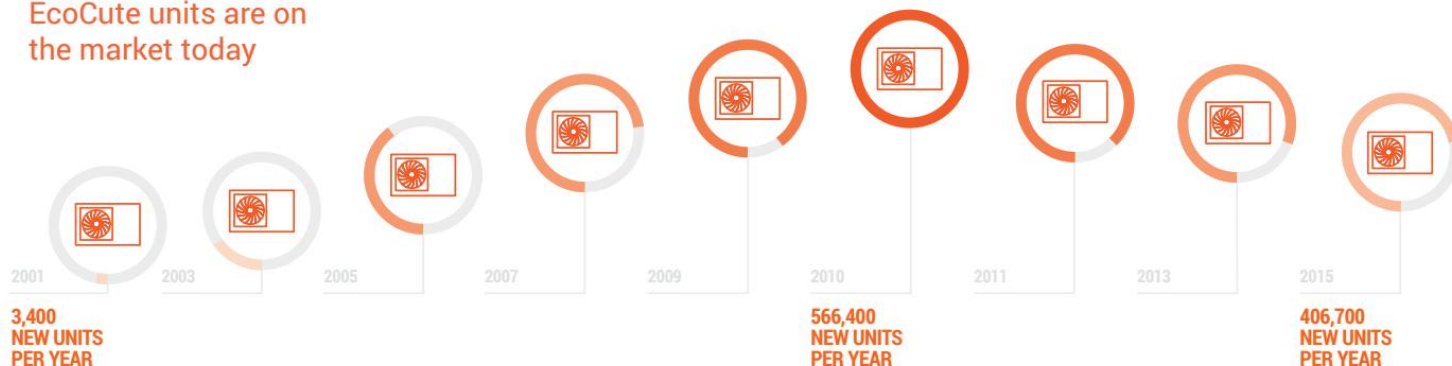
CO₂ HWHP MONOPOLISING JAPANESE RESIDENTIAL MARKET, BUT FACE COMPETITION FROM GAS BOILERS IN OVERALL HEATING MARKET

Since its development in 2001, the 'EcoCute' – which uses CO₂ as the refrigerant – has been a runaway success for residential applications in Japan. It continues to achieve annual sales of between 400,000-500,000 units and as such, the technology has reached a market share of 98% of all new residential heat pump water heaters in Japan. This growth means that at the end of February 2016, approximately 5 million units are in operation.

The Japanese EcoCute market, worth 56.5 billion yen in 2014, is dominated by four major manufacturers that together have a 90% share of the market: Panasonic, Mitsubishi Electric, Daikin and Corona. The remainder is split between seven other companies.

To put the success of the EcoCute into perspective, annual sales of gas water heaters are between 2,000,000 and 2,500,000 units in Japan. CO₂ HWHPs will need to make more headway in this market if they are to achieve a similar monopoly over domestic water heaters as they have over heat pump water heaters. To get there they must reach small households, where market penetration could be accelerated through a reduction of initial costs. Regulatory measures disincentivising gas or electric boilers would help to create market opportunities for EcoCute technology in this segment.

Over 5 million
EcoCute units are on
the market today



TOUGH MARKET CONDITIONS REQUIRE INNOVATION TO PROSPER

Japan has led the global adoption of CO₂-based HWHPs over the last decade and as such, innovation within the EcoCute sector is crucial for its survival.

One example of such market innovation is the development of multifunctional CO₂ HWHPs that can also support space heating, delivering further energy savings. Other innovations include a solar hybrid EcoCute model with a “solar power assist” function allowing the EcoCute to operate on stored energy before solar power can be generated in the morning; and a “summer mode” function, which delivers daytime savings without the risk of running out of hot water.

While the future of CO₂ within the domestic HWHP market appears to be as auspicious as its recent past, there are challenges looming on the horizon, with other companies looking to provide alternative solutions. Two other HWHP types competing with the CO₂ EcoCute are an R290 hybrid HWHP and a recently introduced R32 model.

CO₂ HWHP FOR COMMERCIAL APPLICATIONS CONSIDERABLE, BUT YET TO MAKE MAJOR IMPACT

The use of CO₂ heat pumps is not limited to domestic purposes in Japan; the technology can also be adapted for larger commercial applications. The same positive benefits that the CO₂ EcoCute brings to residential hot water heating can be transferred to commercial properties, reducing running costs by up to 61% and slashing the total amount of CO₂ emissions by 29% compared to conventional gas boilers.

Commercial CO₂ HWHPs can be installed in various buildings, for example hotels, hospitals or schools, as well as in spas or food processing facilities. One advantage of CO₂ technology is that the water can be heated to high temperatures of up to 90°C, which is particularly handy for sterilising water used in buildings where infection must not spread, such as

The introduction of an R290 hybrid water heater system provides significant competition. The R290 system boasts a primary energy efficiency of 125%, while also cutting down on CO₂ emissions by 584kg per unit, representing an annual emission reduction of approximately 43% compared to the company's conventional units and 110kg less than the EcoCute. The manufacturing company is already targeting the next stage of development, which will include further cost reductions and higher energy efficiencies to make the system more competitive with similar products.

Nevertheless, R290 HWHP sales are currently low, with just 2,000 sold in 2014, while the introduction of R32 is still at an early stage. The main competition, therefore, still comes from other forms of heating such as gas boilers.

hospitals and schools. Mayekawa, Itomic, Mitsubishi Heavy Industries and Showa are four prominent suppliers of the CO₂ EcoCute for commercial applications in Japan.

CO₂ HWHPs can be used in all regions, with field testing having taken place in severe winter conditions in Hokkaido, the northernmost of Japan's main islands which reaches temperatures as low as -20°C. The results from the field test in Hokkaido were positive, reducing energy costs by 43-54% compared to conventional boilers.

With between 3,000 and 5,000 commercially-sized hot water heat pumps sold every year since 2008 in Japan, this is a significant opportunity for CO₂ technology to further penetrate the heating market.

Policy drivers for natural refrigerants in heat pumps

GOVERNMENT PLAYING KEY ROLE IN MARKET ACCELERATION

High-level government support has been a major factor in the success of EcoCute CO₂ HWHP in Japan. To draw lessons from Japan's rapid market adoption of natural refrigerant-based heat pump technology, this short overview of the country's effective support scheme from 2002 until today serves as a good example for other countries to follow.

First, the Japanese government's role in raising awareness among market players was instrumental in the early market adoption stage. The "Energy-Saving Grand Prize", an annual government-affiliated award for excellent products and technology developed by Japanese institutions, was awarded to the EcoCute in 2001. When the technology was introduced, the award served as a governmental seal of approval of its effectiveness and reliability.

In 2005, the government announced a target of installing 5.2 million units by 2010 under the "Kyoto Protocol Target Achievement Plan". This national plan noted that local governments were expected to take the initiative in introducing CO₂ heat pump water heaters in line with the "Law on Promoting Green Purchasing". Not only were equipment manufac-

turers eligible to receive grants for technology R&D activities, but a governmental subsidy scheme for buyers – seeking to halve the price difference between an EcoCute and a conventional boiler, was also established in 2002.

Each year, the amount of the subsidy decreased in proportion to the decrease in the price of the EcoCute. After 2006, the subsidy scheme was changed to a fixed amount of support (around 59,000 yen), which decreased gradually. In 2010, subsidies for household and commercial entities buying EcoCute heat pumps became available under the 'Eco-Point Programme', which was introduced back in 2009 as a time-limited measure for energy-efficient appliances. In response to the negative impact of the 2011 earthquake on EcoCute sales, the government included the technology in the Top Runner Program under 2013's Energy Saving Act, setting 2017 as the target year to comply with specific energy consumption features.

CO₂ heat pumps outside Japan

CO₂ COMMERCIAL HEAT PUMPS IN CHINA EXPECTED TO HIT 50,000 INSTALLATIONS BY 2020

Primary market data collected by shecco indicates that there are more than 300 CO₂ HWHP units in commercial and industrial applications in China. CO₂ heat pumps have been adopted to cover the entire cooling and heating requirements of hospitals, train stations, schools and public buildings at a high level of efficiency. CO₂ heat pumps have particularly attracted the Chinese industry's attention due to their reliable performance in all temperatures, which is a plus point in such a climatically disparate country as China. CO₂ HWHPs can work in ambient temperatures as low as -25°C and as high as 43°C.

The success of CO₂ heat pumps in commercial applications is spurring further investment in larger applications such as in the industrial sector. At the same time, the market expand-

ed in terms of both scale and variety when a domestic manufacturer launched the first CO₂ heat pump water heater for residential application in September 2014.

In the next decade, the market share of CO₂ heat pumps has the potential to reach 5% and there could be 50,000 CO₂ heat pumps installed in the country by 2020.

Market development for R744 water and space heating equipment needs to be analysed against the backdrop of growing heat pump sales overall. According to an industry forecast, the heat pump market in China is going to grow at a CARG of 27.86% during 2013-2018 to match the increasing demand driven by an increased concern over environmental protection.

CO₂ HEAT PUMPS BEGIN TO FIND MARKET IN EUROPE

Heat pumps currently cover around 15% of the heating market in Europe. Amid a relative slowdown in new build activity, there is a noticeable switch towards the renovation sector. High temperature heat pumps provide a cost-effective alternative in retrofit environments for existing buildings.

One strong trend in heat pump sales is the increasing interest in sanitary hot water heat pumps, an application that is well suited to CO₂. Heat pump water heaters are the fastest growing segment of heat pumps in Europe – and the only segment recording double-digit growth.

Policy drivers for CO₂ heat pumps outside of Japan

CO₂ HEAT PUMPS AS KEY TECHNOLOGY FOR ENERGY SAVINGS

In China's 12th five-year plan for energy saving and sustainable industry development in 2012, CO₂ heat pumps were listed as a key technology that can deliver energy savings in industry. More recently, in 2015 CO₂ was listed as a key alternative to R22 in residential, commercial and industrial heat pumps in the "First Catalogue of Recommended Substitutes for HCFCs" proposed by China's Foreign Economic Cooperation Office (FECO).

Inspired by the successful implementation of CO₂ technology for heat pump water heaters

in Japan, China introduced a new Top Runner scheme to increase public interest in energy-efficient products for water heating and air conditioning. In addition, in March 2015, the Ministry of Environmental Protection – in cooperation with UNEP, UNIDO, GIZ and CHEAA – introduced a label to promote low-GWP products (GWP < 150) in heat pump water heaters as well as room air conditioning. The label is an important signal to industry to help increase the share of CO₂ as a refrigerant in heat pump water heaters.

BUILDING REGULATIONS UNDERPIN INTRODUCTION OF HEAT PUMPS IN EUROPE

Growing interest in heat pumps is also being driven by new building codes and regulations adopted in EU member states placing a ceiling on the primary energy consumption of buildings and requiring integration of renewable energy. As the EU moves towards low or zero-energy buildings with minimal space heating requirements, hot water and energy-efficient sanitary technologies are set to grow in importance. Heat pumps for water heating using CO₂ reduce both direct and indirect emissions and thereby ensure that the benefits accrued from the deployment of heat pumps are not counterbalanced by potentially higher direct emissions from refrigerants.

The revised EU F-Gas Regulation that came into effect in January 2015 provides a regulatory incentive to shift towards natural refrigerants. While HFC bans foreseen under the Regulation in certain sectors provide the most immediate incentive to move to natural refrigerants, such measures have not been adopted for the heat pump sector. Nevertheless, the requirement to phase-down HFCs by 79% by 2030 compared to 2009-2012 average levels will trigger increased interest in low-GWP solutions in heat pump applications.

Meet the authors



Marc Chasserot

Publisher / Managing
Director

Marc Chasserot is the CEO of shecco, with over 10 years' experience in the HVAC&R sector. In 2006, he founded the industry leading website for CO₂ cooling and heating experts worldwide: www.R744.com. This was followed by three platforms for hydrocarbons, water and ammonia. He has chaired and organised numerous international workshops for policy and industry experts to discuss how to bring natural refrigerants faster to market, known as 'ATMO-sphere'.



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Lead Author / Chief Market
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Nina holds two Master's degrees in business Management and in Environmental Management. For the last 10 years, she has been working in the field of environmental technologies, where she has developed special expertise on natural refrigerants. Today, she is active in market development and consultancy services, as well as special projects and publications. She has been drafting and supervising global studies on behalf of United Nations agencies, as well as serving as an expert for EU and UN projects.

Jan holds a Doctor of Engineering degree in System Design from Hosei University in Tokyo and a Master's degree from the Czech Technical University in Prague. During his studies, and research undertaken in the USA, Europe and Japan, Jan has centered his academic focus on environmental technologies and marketing strategies. Jan is currently based in Tokyo, responsible for business development activities and monitoring Asian markets on behalf of shecco Japan.



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Robert Davidson is the holder of a Master's degree in Development Economics from the School of Oriental and African Studies, London. An interest in the future of energy led him to shecco where he works as a Junior Analyst in shecco's business development department. As a junior analyst he works in identifying trends in natural refrigerants and helping clients optimise their strategy in the HVAC&R market.



Robert Davidson

Analyst,
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Get in touch with shecco's Market Development team to learn more about the market for natural refrigerants in Japan or find out how we can help you in gathering market intelligence and proactively building your business with our tailored market development services, to get your technology faster to market.

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