GUIDE TO NATURAL REFRIGERANTS TRAINING IN EUROPE 2017

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GUIDE to Natural Refrigerants Training in Europe 2017

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WELCOME MESSAGE BY LEAD AUTHOR

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There is currently a significant level of uncertainty regarding the availability of natural refrigerant training in Europe. This is due to a number of factors. Firstly, there is not a single body coordinating the training activities on natural refrigerants, but a wide variety of industry players are involved in such training, including system and component manufacturers, training institutes, vocational schools and universities as well as associations and end users. They all have different roles in the industry and target different groups of HVAC&R industry representatives.

Secondly, EU legislation does not mandate the training providers to report about their activities on natural refrigerant training and numbers of people trained, unlike for training on f-gases. This means that national authorities do not get a good picture about the availability of natural refrigerant training in their countries. This is becoming a concern for some of the member states that are commencing initiatives to cover natural refrigerants in national training and certification schemes.

With a view to bring more clarity to the industry and policymakers about the current and future status of the market for natural refrigerant training, shecco has initiated a project the result of which is this GUIDE to Natural Refrigerant Training in Europe. For the first time, we have created a list of organisations that offer training for CO_2, hydrocarbons and ammonia. We were pleasantly surprised that there are already close to 200 such organisations around Europe. The findings of the report are to a large extent based on an online survey that was conducted among more than 340 industry experts.The large number of participants is an indication that the industry is interested in this topic and is eager to get more clarity about different aspects and future expectations with regard to natural refrigerant training.

This report finds that the uptake of training on natural refrigerants in Europe is progressing rapidly, mainly as a consequence of the F-Gas Regulation that drives the industry away from high-GWP HFCs, nevertheless there are still barriers to overcome. Among them, lack of awareness and investment costs related to both setting up training facilities and taking part in courses appear as the biggest ones. It is now up to all industry players as well as governments to work together to facilitate the wider uptake of natural refrigerant training as a prerequisite for the safe use of natural refrigerants on a broader scale.

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1 About this GUIDE

A SHORT OVERVIEW

Chapter 1: About this GUIDE

This chapter provides an introduction to the GUIDE Training on natural refrigerants and a simple overview of the topics that are in focus on the publication. It starts by presenting the structure and a brief overview of the chapters.

The chapter also provides an overview of the profiles of respondents to the survey, which was conducted among European industry experts to enhance the understanding of the current and future market for natural refrigerant training.

Chapter 2: Natural refrigerants and their application

To better understand the basic characteristics of natural refrigerants this chapter details their key features. In addition, a short overview of the typical applications is mentioned.

The current state of the European market for natural refrigerants is explored in three ‘ecosystems’: City & buildings; Industry, special applications and sports; and Food chain. The purpose of the ‘ecosystems’ is to highlight the variety of natural refrigerant products and technologies currently in use in Europe and the huge scope for their further adoption.

Chapter 3: Training in Europe - an overview

This chapter looks at the key aspects of HVAC&R training in general and the training on natural refrigerants in particular. The first section outlines the key factors that determine the importance of HVAC&R training as well as main carrier option and specialities in this sector.

The following section addresses natural refrigerant training in particular and starts by detailing the training requirements that are specific to natural refrigerants. Furthermore, to better understand drivers and barriers for the uptake of natural refrigerant training, the chapter analyses the results of the survey conducted among industry experts.

Chapter 4: Market for natural refrigerant training today & tomorrow

Through independent market research, surveys and interviews, this chapter offers a comprehensive evaluation of current and future status of natural refrigerant training in Europe. A map of natural refrigerant training providers gives a better perspective on the current situation, while the analysis of the survey findings unveils more details in regard to availability, topics covered, cost.

This chapter also examines the industry viewpoint on the future developments with regard to natural refrigerant training.

Chapter 5: Policy for natural refrigerant training

As one of the most significant drivers for the uptake of natural refrigerants training, legislative measures at international, EU and national level play an important role. This chapter zooms in on the key pieces of EU legislation, while providing examples of best practice in some of the member states, which could be an inspiration for others looking to streamline the training on natural refrigerants.

Directory of natural refrigerant training providers

The final section of the GUIDE lists organisations that offer theoretical or practical training on natural refrigerants in Europe.

SURVEY ABOUT NATURAL REFRIGERANTS TRAINING

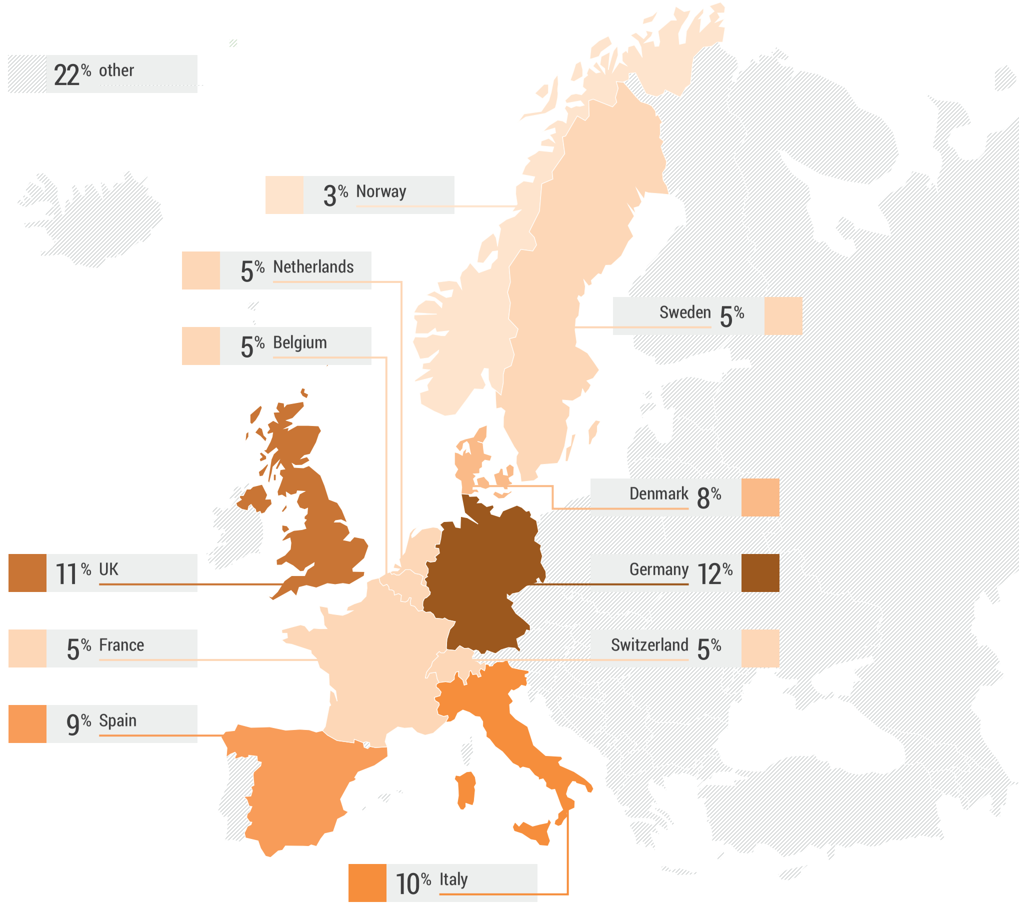
TO PROVIDE AN OVERVIEW OF THE CURRENT MARKET SITUATION OF TRAINING FOR NATURAL REFRIGERANTS IN EUROPE AS WELL AS ITS FUTURE OUTLOOK, SHECCO CONDUCTED AN ONLINE SURVEY AMONG 340 EXPERTS IN THE EUROPEAN HVAC&R SECTOR. THE DATA AND FINDINGS REFLECTED IN GUIDE TRAINING EUROPE 2017 ARE BASED ON THIS SURVEY.

The survey asked the opinions of key stakeholders from Europe on subjects such as the state of the market, the potential drivers and barriers for the uptake of natural refrigerant training and the effectiveness of current relevant policy as well as the perceived effect of potential upcoming policy changes.

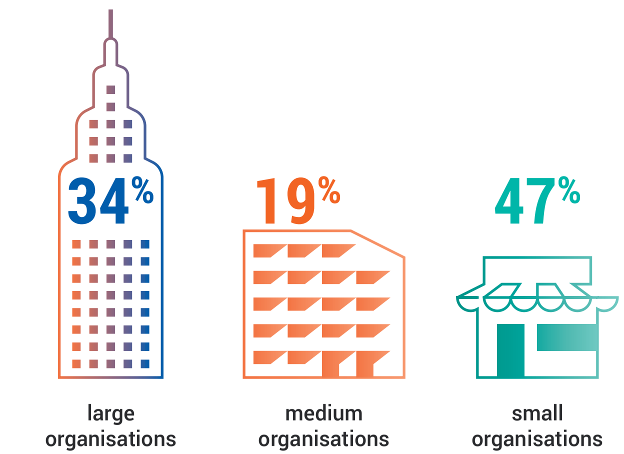
The results show that there is a great degree of diversity in the survey respondents' profiles.

Representation dominated by Western Europe

The location of the organisations that responded to the survey was predominantly in Western Europe, with a fair share of representatives from Southern Europe as well. Most of the respondents were located in Germany (12.6%), the United Kingdom (11.3%), Italy (11%) and Spain (9.2%).

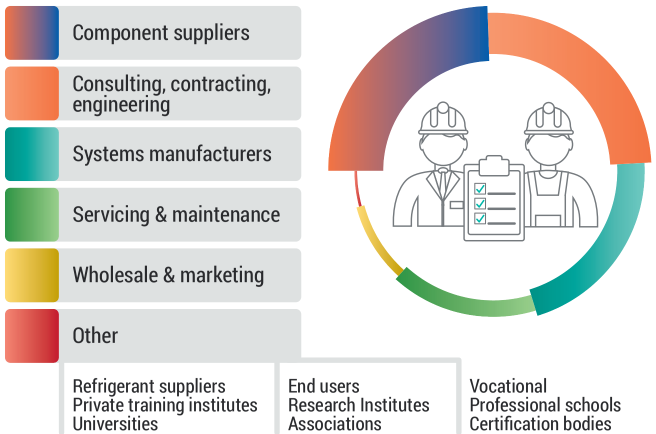


Small companies show highest interest



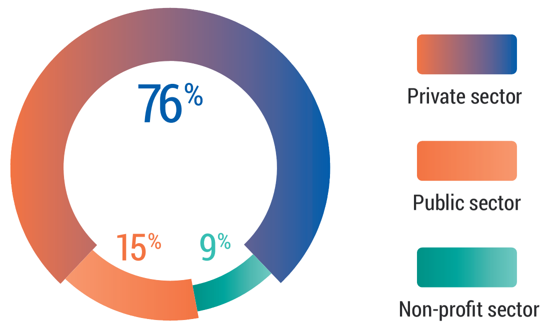
Close to half of the respondents were representatives of small companies (less than 99 employees). A bit more than one-third of those that participated in the survey were representatives of large companies (over 500 employees), with the remaining share representing medium-sized organisations (100-499 employees).

Component suppliers and contractors prevail



Component suppliers and consulting, contracting and engineering firms were the most represented in the survey (30% representation each). System manufacturers were the third most represented group (26%). A relatively high percentage of servicing & maintenance companies as well as wholesale & marketing organisations answered the survey, with 20% and 11% representation, respectively. Other organisation types with representation between 2.5 - 7% included private training institutes, universities, research institutes, end users, associations, refrigerant suppliers and certification bodies.

Strong representation of private sector



Given that most of the organisations were manufacturers of systems and components it is no surprise that the representation of private sector organisations was dominant in the survey with over three-quarters of representatives that identified this option. 15% of organisations were from the public sector, with the rest representing non-profit sector.

2 Natural refrigerants and their application

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 fluorinated gases, which, given their chemical complexity and comparatively short period of usage, have confirmed and/or unknown negative effects on ozone depletion, global warming and ecological safety, and therefore, are subject to continued debate. Moreover, natural refrigerants are naturally ocurring substances, whereas fluorinated gases are not.

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

ODP :
Ozone Depletion Potential

GWP :
Global warming Potential

Carbon dioxide (ODP= 0; GWP= 1)

Carbon dioxide is colorless, odorless 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 safest possible), 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. With a long atmospheric lifetime, CO_2 does not lead to any by-product 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. It is generally regarded as a cheap and easily available refrigerant.

Key applications

In Europe, the use of CO_2 in commercial refrigeration (centralised systems in supermarkets) has become particularly popular, while the refrigerant is also becoming common in industrial refrigeration plants, either as a sole refrigerant or in combination with ammonia. Besides these large equipment applications, CO_2 is a common refrigerant in plug-in commercial refrigeration equipment, such as vending machines, bottle coolers and display cabinets. Moreover, CO_2 heat pumps for residential, commercial and industrial use have been increasingly utilised and are poised to gain more popularity in the years to come. In transport applications, CO_2 has been used for refrigeration of goods in transit, while air-conditioning systems using the refrigerant have been developed for cars, buses and trains.

Ammonia (ODP= 0; GWP= 0)

Ammonia is a colorless 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.

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 odor, making leaks easy to detect.

Key applications

Today, more than 90% of large industrial refrigeration facilities in Europe use ammonia as a refrigerant. Besides food processing, cold storage and distribution, ammonia has found its place in breweries, wineries, ice rinks, chemical plants, cargo ships and fishing vessels as well as district heating and cooling and large-scale air-conditioning for office buildings, universities and airports.

Hydrocarbons (ODP= 0; GWP< 4)

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

Hydrocarbon (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 optimal for developing countries.

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.

Key applications

Typical applications for hydrocarbons include self-contained residential and light commercial equipment, such as domestic refrigerators and freezers, air-conditioners and dehumidifiers, as well as stand-alone light commercial refrigerators, bottle coolers, ice cream freezers, beverage dispensers and beer coolers. In addition, hydrocarbons are used in supermarket refrigeration in combination with secondary cooling or as a high temperature stage in a cascade CO_2 system. Today more than 700 million domestic fridges utilise isobutane as a refrigerant worldwide, with Europe being 100% converted to this refrigerant in new equipment. Over two million HFC-free units are used in light commercial refrigeration in Europe, most of which use hydrocarbons.

Water (ODP= 0; GWP= 0)

Water (R718) is one of the oldest refrigerants used for refrigeration applications. It is an environmentally safe refrigerant with zero ozone depletion potential and zero global warming potential. It is odourless, colourless, nontoxic, nonflammable, non-explosive, easily available, and it is one of the cheapest refrigerants.

Key applications

In refrigeration applications, the use of water as a refrigerant has been mostly limited to absorption and adsorption systems that can be driven by heat sources such as solar thermal, biomass or industrial waste heat, which provides additional environmental and economic benefits as compared to electric driven machines. Water as a refrigerant can provide cooling for buildings, such as universities, offices and data centres.

Air (ODP= 0; GWP= 0)

Air is one of the oldest refrigerants used for refrigeration applications. It is an environmentally safe refrigerant with zero ozone depletion potential and zero global warming potential. It is odourless, colourless, nontoxic, nonflammable, non-explosive, easily available, and it is one of the cheapest refrigerants.

Key applications

Air as a refrigerant was used on refrigerated cargo ships around the turn of the 20th Century. Today, at least 54 units using air as a refrigerant have been installed in Japan and other Asian countries in a number of applications, including chemical process cooling, ultra-low temperature warehouses, and rapid freezing. Systems using air as a refrigerant have not yet been commercialised in Europe.

Refrigerants number	R717	R744	R290	R600a	R1270	R718	R729
Chemical formula	NH_3	CO_2	C_3H_8	C_4H_{10}	C_3H_6	H_2O	-
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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AN ECOSYSTEM APPROACH

THE PURPOSE OF THE "ECOSYSTEMS" IS TO OUTLINE THE SECTORS AND APPLICATIONS WHERE NATURAL REFRIGERANTS ARE DEPLOYED IN EUROPE TODAY. HERE ARE EXAMPLES OF INSTALLATIONS USING A VARIETY OF NATURAL REFRIGERANTS IN DIFFERENT EUROPEAN COUNTRIES.

The ecosystems are categorised into the following sections:

CITY, BUILDINGS & TRANSPORT:

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. In the transport sector, natural refrigerants are used in buses, trucks, trains, electric vehicles & fuel stations.

INDUSTRY, SPECIAL APPLICATIONS & SPORTS

Natural refrigerants are applied in larger scale applications like industry processing in laboratories, pharmaceutical, petrochemical industry, agriculture and power plants. Today, natural refrigerants are also used in ice rinks, snow making, and aquatic centres in many European countries.

FOOD CHAIN:

Natural refrigerants are widely adopted in food and beverage storage, distribution, production and processing, and supermarkets, basically covering the entire food chain.

CITY & BUILDINGS

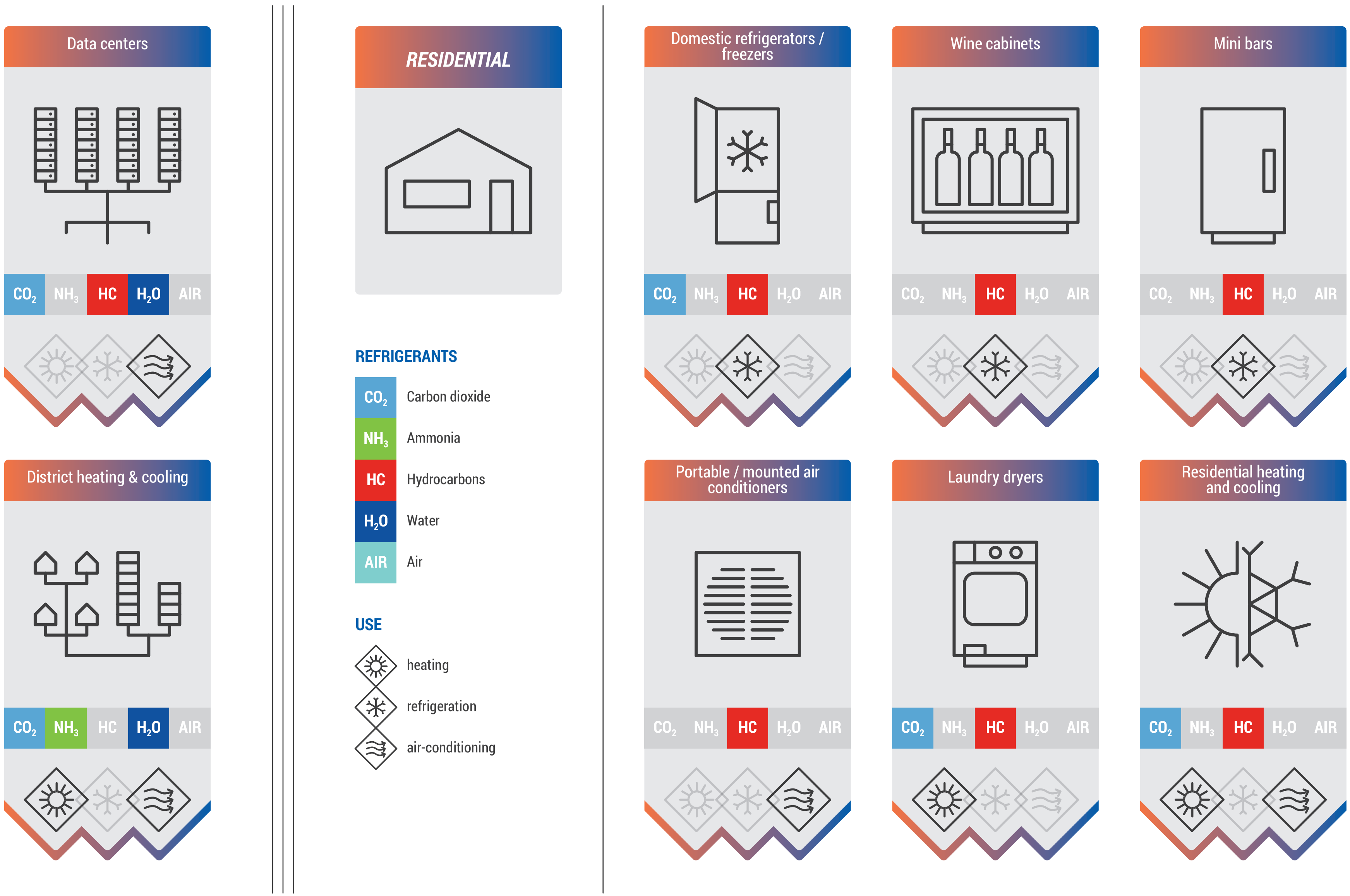
REFRIGERANTS

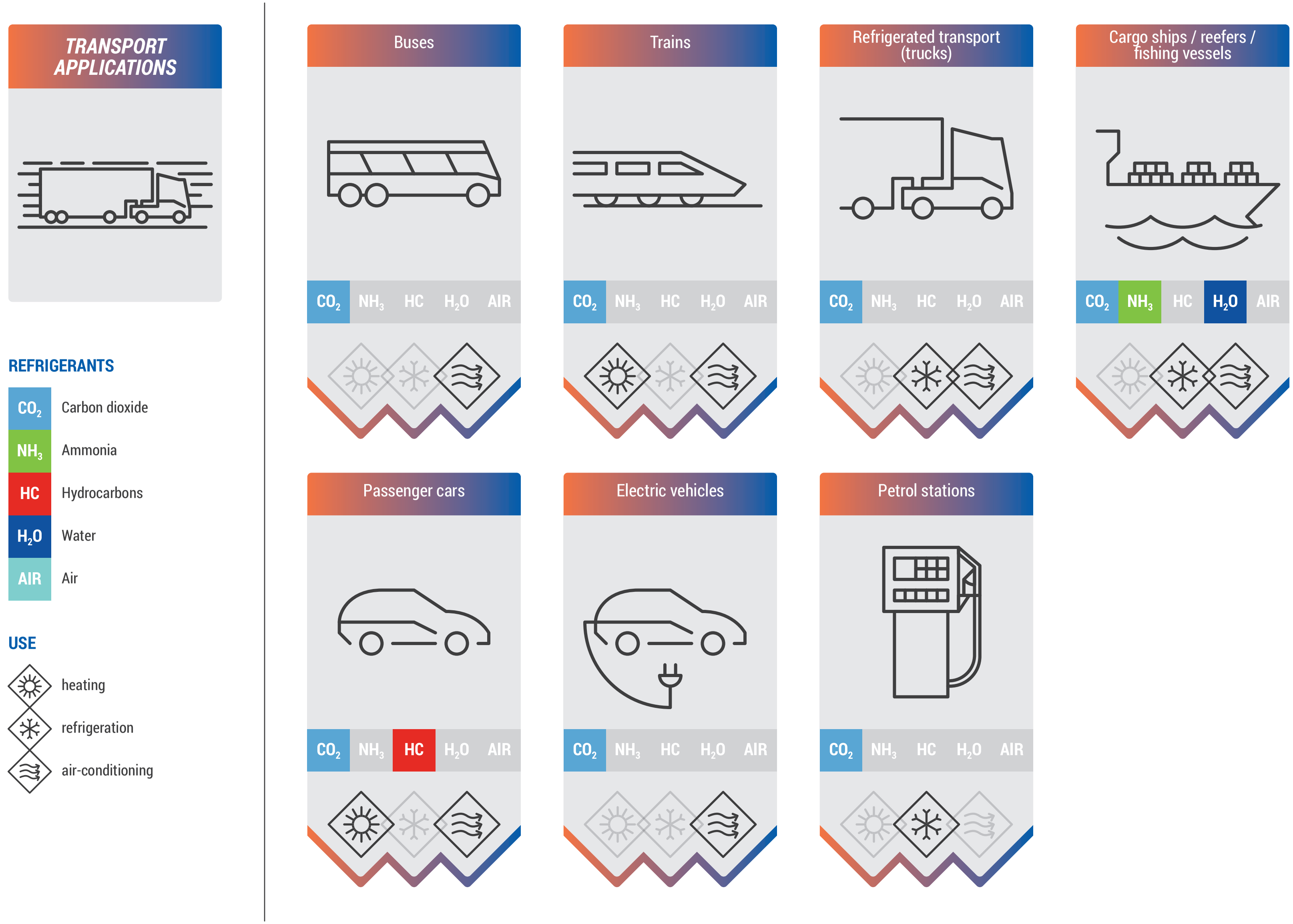
- CO_2 Carbon dioxide
- NH_3 Ammonia
- HC Hydrocarbons
- H_2O Water
- AIR Air

USE

- heating
- refrigeration
- air-conditioning

Application	Refrigerants	Use
Ship terminals	CO_2	refrigeration
Airports	NH_3	heating, air-conditioning
Office buildings	CO_2, NH_3, HC, H_2O	heating, air-conditioning
Universities	CO_2, HC	heating, air-conditioning
Museums	CO_2	air-conditioning
Hospitals / nursing homes	CO_2, NH_3, HC	heating, air-conditioning
Libraries	NH_3, HC, H_2O	heating, air-conditioning
Movie theaters	HC, H_2O	air-conditioning
Shopping malls	CO_2, NH_3, H_2O	heating, air-conditioning


Data centers
CO2 NH3 HC H2O AIR
District heating & cooling
CO2 NH3 HC H2O AIR
RESIDENTIAL
REFRIGERANTS
CO2 Carbon dioxide
NH3 Ammonia
HC Hydrocarbons
H2O Water
AIR Air
USE
heating
refrigeration
air-conditioning
Domestic refrigerators / freezers
CO2 NH3 HC H2O AIR
Wine cabinets
CO2 NH3 HC H2O AIR
Mini bars
CO2 NH3 HC H2O AIR
Portable / mounted air conditioners
CO2 NH3 HC H2O AIR
Laundry dryers
CO2 NH3 HC H2O AIR
Residential heating and cooling
CO2 NH3 HC H2O AIR


TRANSPORT APPLICATIONS
REFRIGERANTS
CO2 Carbon dioxide
NH3 Ammonia
HC Hydrocarbons
H2O Water
AIR Air
USE
heating
refrigeration
air-conditioning
Buses
Trains
Refrigerated transport (trucks)
Cargo ships / reefers / fishing vessels
Passenger cars
Electric vehicles
Petrol stations
CO2 NH3 HC H2O AIR

CITY, BUILDINGS & TRANSPORT

Public and commercial buildings

CO_2

Shipping company Hurtigruten's terminal in Bergen, Norway uses the natural refrigerant CO_2 for cargo storage. The refrigeration system is 100% CO_2, and was chosen as an alternative to the environmentally harmful R22 (chlorodifluoromethane, a type of HCFC). The cooling and freezing area covers an area of 4,100m^2 and is located on the mezzanine above the loading bays on the landsides for cargo from the ships. The excess heat from the cooling and freezing areas is used to heat the terminal and offices.

NH_3

A commercial office building in Slough, United Kingdom was one of the first in the country to install an NH_3 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 6.6MW, or 1,875 tonnes. The units, powered by high-voltage electricity, use twin compressors, which ensures efficient part load performance, while the 11 kilowatts (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 benefit more from the chilled water store.

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. New hydrocarbon chillers been installed to replace out-of-date R22 chillers, and hydrocarbon heat pumps have also been put in place. The larger chiller system uses nine air-cooled propane (R290)- based chillers, each with a cooling capacity of 250kW and a coefficient of performance (COP) of 4.5, and using a total of about 210kg of refrigerant.

Eight 650kW water-cooled water chillers using hydrocarbon refrigerant R290 were installed at the Co-operative Group's new headquarters in Manchester, the largest ever propane chiller project in a commercial building in the UK. The building has achieved the highest BREEAM rating, receiving the 'outstanding' accreditation for a large, commercial building in the UK.

H_2O

The Reichstag building in Berlin, Germany has a total floor area of approximately 240,000m^2 and uses three absorption chillers with capacity of 850kW for cooling purposes during the summer. The surplus heat resulting from operation of the motor-driven cogeneration plants is stored as hot water in an aquifer deep below ground. 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 centers

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.

CO_2

A new STABILO Cube office building in Heroldsberg, Bavaria, includes a 400m² data centre, a combination of geothermal plant, a CO_2 heat pump and free cooling is designed to maximise sustainability. Waste heat from the data centre is also used to fuel the energy cycle.

Scientific research by Y. Solemdal, T.M. Eikevik;
I. Tolstorebrov and O.J. Veiby concluded that CO_2 is more energy efficient than HFCs in data centre cooling. The research team conducted the study on an existing indirect refrigeration plant using R410A in Trondheim, Norway and compared it with a direct CO_2 system as well as with a filled indirect CO_2 system. The tests revealed that the direct CO_2 system only used 52% of the energy consumed in the existing system while the indirect system performed even better by consuming only 29% of the energy.

H_2O

In the iDataCool project, jointly developed by the University of Regensburg and the IBM Research and Development Lab Böblingen, an innovative adsorption chiller driven by waste heat was installed in the computing centre of Regensburg University, Germany.

District heating and cooling

NH_3

Several hundred ammonia heat pumps have been installed in Norway since the early 1990s. Most installations are in larger buildings (200 kW to 2 MW) and in district heating and cooling systems (700 kW to 8 MW). In a large district-wide natural heat pump system in Drammen Fjord near Oslo, Norway, an ammonia heat pump is used to provide over 13MW of heat for a community of 60,000 people. The system supplies hot water through underground pipes to heat several thousand homes and businesses.

At Glasgow University in the UK, ammonia heat pumps are used to meet the University's heating needs. The ammonia heat pump delivers 14 megawatt (MW) of heat at over 90°C and saves 15% in terms of energy consumption. In recent years, high temperature heat pumps for various applications that can extract heat from a wide variety of sources and produce hot water up to 90°C are more and more widely used in Europe.

The London Underground has a large ammonia heat pump installed in autumn 2016 that reclaims hot air from the underground's ventilation shaft which is constantly at around 24 to 30°C. The system is an extension of the Islington Council district-heating network that started in 2013. Heat recovered from the ammonia heat pump in London's underground will be used to supply both cooling capacity for the underground trains as well as hot water for the nearby buildings within the network.

CO_2

A large-scale 100% renewable energy project that provides the Danish city of Marstal with district heating system incorporates a 1.5MW thermally CO_2-driven heat pump. The project, developed with a grant from the EU's Seventh Framework Programme, includes a solar plant, a combined heat and power (CHP) system, an Organic Rankine Cycle (ORC) Unit and a 75,000 m^3 pit for heat storage, with the CO_2 heat pump moving energy to the energy storage pit.

H_2O

In the Mediterranean city of Montpellier, France, a district solar cooling project with an absorption chiller was built for the Arche Jacques Coeur building, which includes 11,000m^2 of office space, 170 residences and 3,000m^2 of commercial space. The solar cooling and absorption chiller installation is estimated to reduce CO_2 emissions by 40 tonnes per year, the equivalent of 25 cars driving 10,000km per year.

Passenger cars, buses

CO_2

Régie des transports de Marseille (RTM) is moving to phase out the refrigerant R134a in its mobile air conditioning, running tests using CO_2 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 CO_2 to increase energy efficiency and reduce its carbon emissions.

CO_2 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

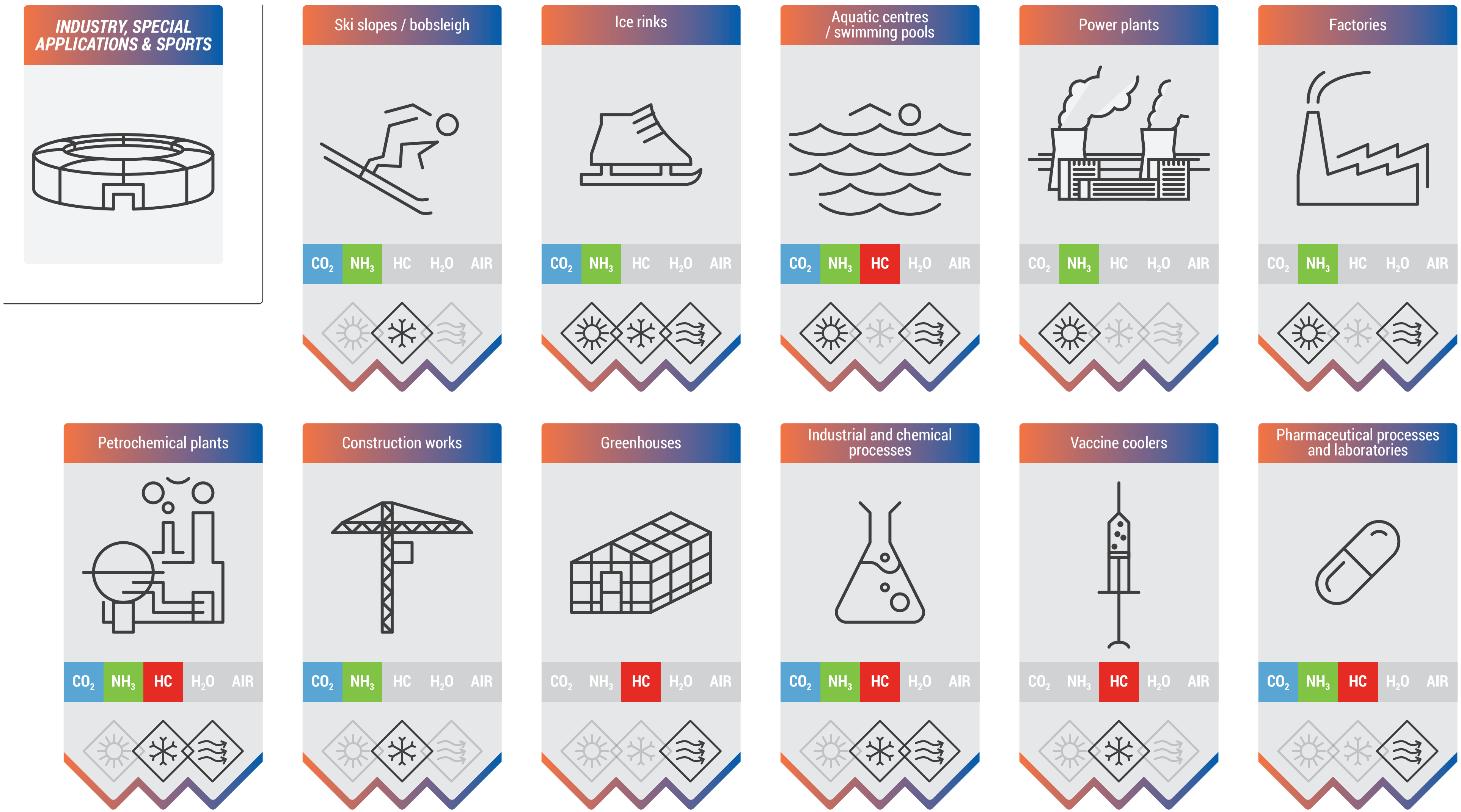
CO_2

Since 2012, a CO_2-based shipping refrigeration container has proven practicality and efficiency for marine transport applications. The system's total CO_2 equivalent emissions (CO_2e) are up to 35% less than previous equipment. As the CO_2 refrigerant is recycled from the atmosphere, the unit eliminates concerns about direct emissions in the event of a refrigerant leak. Over its lifetime, the system's CO_2e (CO2 equivalent) emissions are 10% less than the closest competitive unit.

A CO_2-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 CO_2-equivalent emissions by up to 35% compared to the previous equipment. Sainsbury's hopes they will save over 70,000 tonnes of CO_2 emissions compared to its current refrigerated trailer fleet.

At the International Motor Show in Frankfurt, Germany in September 2016, a new transport cooling system with CO_2 was introduced to the market. The supermarket chain Netto is the first one to use this cooling unit in a pilot phase starting October 2016. The transporter is amongst the first ones worldwide to be solely based on natural refrigerants and is a big step towards environmentally friendly transport cooling.

CO_2 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 CO_2, 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.



REFRIGERANTS

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