Danish Ministry of the Environment
Environmental Protection Agency

Going Natural

The Danish road to natural refrigerants

Going natural!

“Two of the global environmental problems that concern me the most are the greenhouse effect and the threat to the ozone layer. But we cannot solve one problem at the expense of another. Concentrating exclusively on reducing CO_2 emissions to prevent a rise in the greenhouse effect is not enough.

We must also limit the emission of other greenhouse gases. It is therefore my sincere hope that in ten years, not a single fridge, freezer or cooling plant will be built in Denmark that requires HFCs or other greenhouse gases.”

Svend Auken, 1996, conference on natural refrigeration in 1996 in Aarhus.

When the former Danish Minister for the Environment, Svend Auken, expressed his hope for a future with less emissions from greenhouse gases, he shocked some parts of the refrigeration industry. Sceptics claimed that without F-gases it would be impossible to have efficient refrigeration and cooling and Denmark would become the land of warm beers and melted butter. It was believed to be impossible to produce freezers without using a lot of HFCs or other greenhouse gases.

But we have proved differently!

The Danish refrigeration industry made a great effort to develop new technology and new refrigeration and freezing methods, and soon new products using natural refrigerants emerged and became available on the market.

The refrigeration community (including national associations and the trade organisation for installers) played an important part in organising conferences and exhibitions and maintaining a constant dialogue with the Danish Environmental Protection Agency about hurdles and opportunities for using hydrocarbons, CO2 or ammonia in the refrigeration systems. All subsequent governments continued Svend Auken’s work to reduce the use of F-gases and to encourage the development of alternative technologies.

The fruitful co-operation between industry, science and government resulted in a remarkable reduction in the use of F-gases and a quick implementation of cooling equipment with natural refrigerants. The change took place with low costs and high reliability. In most cases the alternative technology has resulted in better energy efficiency. As a consequence, the total amount of greenhouse gases emitted to the atmosphere has decreased significantly.

I believe that this report tells a story of how the development of green technologies very quickly turns from being an additional cost to being the basis for a sound business that both the industry and the environment can benefit from. Now, 15 years later, the consumption of HFCs in Denmark has been reduced dramatically and we have a very innovative refrigeration industry based on environmentally friendly technologies.

We all know that while there is a growing demand for refrigeration, the climate and other natural resources are under threat. It is my hope that when the new EU regulation is developed, we will have taken note of the experience presented in this report. I would like to see the EU take the first step towards climate friendly refrigeration without harmful HFCs – not only for our sake, but also as an inspiration for actions globally for the benefit of coming generations.

Ida Auken
Danish Minister for the Environment

Ida Auken
Danish Minister for the Environment

(Foto: Claus Bjørn Larsen)

Denmark: The use of F-gases has de-creased significantly!

The Danish F-gas regulation has led to a decline in use. The import of bulk HFC substances has decreased significantly from around 1000 tonnes/year in 2000 to around 350 tonnes in 2010.

In 2001 and 2002, Denmark introduced national regulation on F-gases. The aim was to reduce the consumption and emission of F-gases and the Danish Parliament (Folketinget) agreed on a number of instruments. They comprised a ban on the use of F-gases for certain purposes, F-gas taxation and support for research and development of alternative technology.

In Denmark, taxation was implemented in 2001 and a ban on certain applications was introduced in 2002.

A short description of the tax/refund scheme

The main principle was the imposition of tax amounting to DKK 100 (app. 13 Euro) per tonne of CO_2 equivalent on the importation of HFC/PFC/SF6. That figure was increased by 50 % from January 2011 to DKK 150 (app. 20 Euro) per tonne of CO_2 equivalent. That means that a tax amounting to DKK 195 (app. 26 Euro) per kilogram is now imposed on the most frequently used F-gas refrigerant (HFC-134a).

In practice, the system is implemented by taxation on all gas in bulk and on imported products. The tax is administrated by the Danish Customs and Tax Administration, which is an organisation under the Danish Ministry of Taxation.

Information from the market indicates that the tax/refund scheme has led to more awareness from owners as well as operators of the equipment. The tax has also increased the interest in alternative substances (HCs, CO_2, ammonia or other substances or techniques) and has resulted in improved housekeeping of reused gas.

Teething troubles have been solved through good co-operation between the industry and ministries and subsequently the administration of the system has worked satisfactorily.

A short description of the ban

In the Danish Statutory Order, no. 552, on regulation of certain industrial greenhouse gases from 2002 there is a general ban on new products containing or using F-gases from 1 January 2006.

There are some exemptions from this general ban. For instance, the use of HFCs in refrigeration systems is still allowed for cooling equipment with HFC charges of between 0.15 kg to 10 kg and the use of HFC for service purposes is exempt from the Statutory Order.

The export of HFC containing products is also exempt from the ban.

Support for alternatives

When the regulation had been approved it was decided to support R&D projects to ensure rapid development of alternative technology. The Danish Environmental Protection Agency (EPA) conducted the scheme and a number of projects in the refrigeration area were supported financially with app. DKK 20 million. In addition, the "HFC free Centre" was established by the Danish EPA. The Centre offers consultancy services that are free of charge (up to 5 hours of engineering consultancy) for the refrigeration industry and installers to help them implement alternative technologies.

Simultaneously, the capacity for educating installers was increased, and hundreds of refrigeration technicians have now been educated to handle refrigeration systems with CO_2, hydrocarbons and ammonia.

Implementation of alternative technologies

In this section, some examples are given of the extent of alternative refrigeration technology in Denmark.

Supermarkets:
A number of different centralized refrigeration systems using CO_2 refrigerant were built and tested in supermarkets in Denmark. Soon it appeared that the transcritical systems were well-suited for conditions in Danish supermarkets and today the technology is standard technology and hundreds of systems are installed showing good performance, energy efficiency and economy. There is also considerable export of CO_2 equipment to installers in other countries.

Commercial plug-in cabinets:
Commercial, refrigerated cabinets using hydrocarbon refrigerants were developed and tested in the past decade. New components (including compressors) were developed and marketed and the technology appeared to be more energy efficient compared to similar HFC refrigeration technology. Today, hydrocarbon technology is standard in bottle coolers, food service cabinets, ice cream freezers, etc. Several international food and beverage companies use professional refrigerators with hydrocarbon technology.

Industrial refrigeration systems:
In Denmark, ammonia has been used for industrial refrigeration for more than 100 years. Today, only very small industrial refrigeration systems are built with F-gases (< 10 kg HFC).

Chillers for air-conditioning and the process industry:
Ammonia chillers have been produced in Denmark for at least 30 years. In addition, two manufacturers have developed and marketed hydrocarbon chillers during the past decade. The ammonia chillers are very efficient and competitive for high-cooling capacity, and the hydrocarbon chillers are very efficient and competitive in the medium to small range. Only very small chillers with F-gases are installed in Denmark (<10 kg HFC). Recently, a commercially competitive chiller with water as refrigerant was developed at DTI together with Japanese companies. It is expected to be introduced to the market in about 3 years by Kobelco and Johnson Controls. The chiller is at least as energy efficient as the very best HFC chillers and 10 to 20% better than typical existing installations. Demonstration of the technology will be established in the near future.

Domestic refrigerators and freezers:
The introduction of the regulation soon resulted in an almost 100 % penetration of hydrocarbon technology for domestic refrigerators and freezers, for domestically produced as well as imported appliances.

Decline in consumption and emissions

The Danish F-gas regulation has led to a decline in consumption. The import of bulk HFC substances has decreased significantly from around 1000 tonnes/year in 2000 to around 350 tonnes in 2010.

There is a delay in the impact for emission of F-gases as most of the consumed bulks are filled into refrigeration systems with certain leakage rates. But in 2008-2010, the Danish emission of F-gases declined from 895,000 tonnes CO_2 equivalents in 2008 to 854,000 tonnes CO_2 equivalents in 2010.

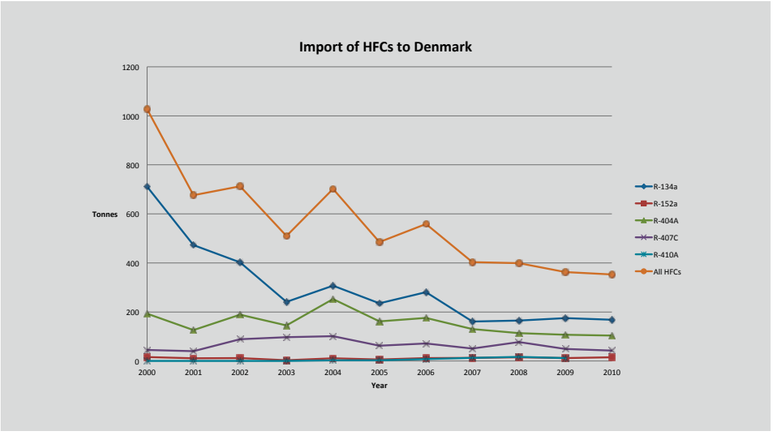

Figure: Import of HFC bulk to Denmark 2000 – 2010. Source: Danish Environmental Protection Agency, 2011.

Gazelle company produces supermarket refrigeration packs

The Danish company Advansor produces remote refrigeration packs for supermarkets and is now the world's biggest manufacturer of transcritical CO_2 refrigeration systems.

Production of supermarket refrigeration systems at Advansor.

The company was founded in 2006 by former employees of Danish Technological Institute and the company now makes 8 supermarket refrigeration systems a week. By the end of 2011, the factory in Aarhus will have built about 300 supermarket systems and almost 80 % of the systems will have been exported to mainly Northern European countries.

Mr. Kim Gardø Christensen, managing director, tells us that 30 employees currently are busy assembling the systems at the 2000 m^2 production facility and another 25 full-time employees are employed at sub-suppliers producing the frames, vessels and the system controls. The insulation work is carried out by sub-suppliers and an independent certification company tests the systems for leakage at the plant in Aarhus.

According to Mr. Christensen the success of the company is based on high-quality products that are competitive with "normal" HFC centralized systems, which formerly were used in supermarkets in Denmark: We have optimized the products so they are competitive and highly efficient. In 2011, the price is about 4 to 5 % higher than for similar HFC systems, but the efficiency is better than in HFC systems especially in Northern Europe (about 10 % less energy consumption) and Central Europe (about 5 % less energy consumption). In Southern Europe the systems have to be tailor-made for each individual case due to higher ambient temperatures in order to be energy efficient.

The additional investment will be paid back in 1 to 2 years in countries with tax on HFC refrigerants (as in Denmark and Norway) and the pay-back time in countries without tax will be 3 to 5 years. "It makes sense to invest in CO_2 supermarket refrigeration systems", says Mr. Christensen.

The customers are often installers who deliver cabinets to supermarket chains and install all the refrigeration and freezing equipment in the supermarket. More than 150 refrigeration technicians have attended courses to learn more about the technology and how to install the systems.

In Denmark, all new supermarkets are installed with CO_2 refrigeration systems. It is expected that about 500 supermarkets will be equipped with CO_2 systems by the end of 2011. For the EU, the figure will be about 2000 supermarkets by the end of 2011.

Kim G. Christensen
Advansor

Installer gains market share on CO_2 refrigeration systems

Mr. Gøttsch says: We were one of the first companies that started using CO_2 in supermarket systems. In 1998, we built the first rather simple system in a small COOP supermarket using a cascade system with propane on the first step and CO_2 on the second step. It did not work very well, but gave us a lot of experience.

It was followed by another supermarket system in 2002. At that time, there was very little experience with CO_2 in supermarkets and there was only limited access to components and knowledge.

The method of "trial and error" was applied. There were no guidelines or available training on how to build a CO_2 system. In co-operation with the engineers at Danish Technological Institute we had to find solutions from the very beginning. We did make mistakes on the way, but we found solutions that were reliable and had an affordable price, says Mr. Gøttsch.
In 2007, we started a co-operation with the new company Advansor, and in the spring of 2008 the first direct expansion, "transcritical" CO_2 system was installed. This first generation system was rather expensive due to a limited amount of components. During 2009, a second generation of the system was built and the energy efficiency was improved due to new and better components optimized for CO_2 systems.

Superkøl has installed more than 100 supermarket systems with CO_2. The company has carried out on-line surveillance of about 2000 supermarket systems, including both HFC and CO_2 systems.

Mr. Gøttsch: I can assure you that the second generation transcritical CO_2 system is more efficient than a similar HFC system. The energy consumption is about 10 % lower. In addition, the systems are reliable and that is for the benefit of our customers who count 3 of the biggest supermarket chains in Denmark.

CO_2 systems are becoming more competitive in relation to price, due to better availability of components. However, the price is still a bit higher compared to HFC systems. Mr. Gøttsch explains: The exercise of reducing CO_2 emissions works very well. Every 700 m^2 supermarket (typically small supermarkets) saves the atmosphere 35 tons of CO_2 equivalents every year. Most of the savings come from less HFC from leakages. A 700 m^2 supermarket with a HFC system will normally have a charge of 85 kg R-404A. The leakage rate is at least 8.5 kg R404A, equivalent to 32 tons of CO_2. In addition, the energy savings will reduce CO_2 emissions from power plants. Bigger supermarkets will reduce more CO_2.

Mr. Tom Gøttsch is managing director at Superkøl, which is the biggest installer of supermarket refrigeration systems in Denmark.

The company has a market share of 35- 40 %, app. 100 employees and works together with 8 other companies that work as sub-suppliers. In that way, it is possible to cover the entire country.

Carlsberg: We prefer natural refrigerants!

Carlsberg Breweries is a global company with headquarters in Copenhagen. Carlsberg produces beer at 75 breweries across 3 continents and sells beer in 140 markets around the world.

Cooling is vital for producing beer and Carlsberg has used huge refrigeration systems with ammonia for more than a century. Ammonia is used for process cooling in all Carlsberg breweries as it is the most efficient refrigerant according to Group Environmental Manager Mr. Eskild Andersen, Carlsberg Breweries. Ammonia is a refrigerant with no impact on the ozone layer and it is not a greenhouse gas. Ammonia is inexpensive and the most energy-efficient refrigerant for the industrial refrigeration systems at our breweries. Safety is an important issue and has to be considered. We have no problems with safety at our installations, says Mr. Andersen.

Bottle coolers

Every year, Carlsberg buys thousands of bottle coolers and installs them in supermarkets, at petrol stations, in kiosks and other locations in many countries. It is important to offer cold drinks to our customers, says Mr. Andersen. We have had great success with the implementation of bottle coolers with hydrocarbon refrigerant. We participated in a field test in supermarkets in Copenhagen and hydrocarbon refrigerators used 28 % less energy compared to similar coolers with HFC refrigerant.

Hydrocarbon bottle coolers are now becoming a standard product and Carlsberg deploys hydrocarbon coolers whenever it is possible and where educated technicians can service the appliances. Hydrocarbon coolers have proved reliable and Carlsberg is installing bottle coolers in the Nordic countries (Denmark, Finland, Norway and Sweden) and has also started to install them in several countries in Europe. We prefer natural refrigerants where it is available, reliable, safe and efficient, and so far our experience has been very good, says Mr. Andersen.

Today, most single-door beer coolers in Denmark use hydrocarbons and in total more than 9000 HC coolers have been installed.

Carlsberg Group

Mr. Eskild Andersen
Carlsberg Breweries, Copenhagen

Professional drink and vaccine cooling

Mr. Lars Gorzelak
Vestfrost Solutions

The Danish Company Vestfrost Solutions produces refrigerators and freezers for professional use for soft drinks, beer, wine, pharmaceuticals, blood and vaccines, and has offered coolers and freezers with hydrocarbon refrigerants since 1994 to the domestic market and since 2000 for commercial use. In total, several million units with hydrocarbon refrigerants have been sold since the introduction.

The SolarChill vaccine cooler built by Vestfrost Solutions.

The company has 330 employees and 90% of the production is exported to the global market.

We were the first company to offer bottle coolers with natural refrigerants, and today these products have become a great success for us. We were also the first company to offer energy optimized open-air impulse sales coolers for soft drinks and energy drinks, says R&D manager Mr. Gorzelak from Vestfrost Solutions. The Company has recently been awarded for that achievement.

The company was also the first company to introduce the SolarChill vaccine cooler on the global market. The vaccine cooler has been approved by WHO and is powered directly by photovoltaic panels, using hydrocarbon refrigerant. It has an ice storage which can keep the vaccine cold for up to 5 days without any power. Several hundreds of SolarChill vaccine coolers are now installed at health centers in areas without grid electricity. The SolarChill technology has been developed in a partnership, and includes the organizations: WHO, UNICEF, UNEP, PATH, GTZ, Greenpeace International and Danish Technological Institute.

Our products are competitive on the global market, and our hydrocarbon coolers use less energy compared to HFC coolers. We conducted a big field test in co-operation with Carlsberg, Danish Technological Institute and the Danish Energy Agency. 18 bottle coolers were installed in supermarkets in Copenhagen, and the result showed 28% less energy consumption for the coolers with natural refrigerants compared to the HFC units, says Mr. Gorzelak.

Vestfrost Solutions offers training of technicians so they can handle hydrocarbon refrigerant and service of the units in new markets. However, that is often not necessary as technicians already are available in many countries and they can repair domestic appliances that use hydrocarbon refrigerants.

The Danish manufacturer Gram Commercial produces about 30.000 refrigerators and freezers for professional use per year, and about 85% is exported to mainly UK, Germany, Austria, the Netherlands, Belgium, Sweden and Norway.

The company has about 200 employees.

Professional kitchens need professional and natural cooling!

Sales director Anders Sjøgaard: We are using the natural refrigerant hydrocarbons (HC), propane (R290) and isobutane (R600a), and our products are placed in top of both the Carbon Trust Energy Technology List for service cabinets and the Danish product list for energy efficient food service cabinets, administered by the Danish Energy Saving Trust.

Mr. Sjøgaard adds: We started developing the new products in 2000 and the products were marketed in Denmark in 2002. They were welcomed by our customers after a field trial showed good results and energy savings. From the beginning, the products were also offered for export, and now most of our customers in Europe (over 90%) prefer natural refrigerants.

Before 2002, the company annually used about 7.8 tons of HFC refrigerant (7.1 tons of R134a and 0.7 tons of R404A), which is equivalent to about 12,000 tons of CO_2, and that has been reduced to almost nothing. Only a few of our customers still prefer HFC cabinets, primarily due to service issues, says Mr. Sjøgaard.

He adds: When we started marketing the HC products, we had to educate our technicians, including the local service personnel in the countries where the products are sold. For instance, several groups of Norwegian service technicians have attended a 2-day practical course in service work with flammable refrigerants at the Technical College of Jutland.

Gram Commercial has good experience in using HC refrigerants. This technology has proved reliable and energy efficient which has been warmly welcomed on the market. Good reliability is the main reason why we can give a 5-year guarantee on our products. It is the longest warranty period in the market. We have experienced growth in our market share in all major markets, says Mr. Sjøgaard.

Chillers with natural refrigerants

At least two companies in Denmark produce chillers with natural refrigerants. A chiller is a factory-made refrigeration system, which can produce cold water (or liquid) to air-condition big buildings or to cool industrial processes.

Hydrocarbon chiller from Bundgaard Køleteknik A/S.

The shopping mall "Fields" in Copenhagen is cooled by ammonia chillers.

Ammonia chillers
Johnson Controls International in Denmark (formerly known as Sabroe) has produced big ammonia chillers for at least 30 years. The chillers are placed all over the world with cooling capacities of between 300 kW to 6.5 MW.

According to Mr. Alexander Pachai, Johnson Controls International, about 200 chillers are produced every year at the site in Denmark. The company has a lot of references and here are some examples:

Ammonia chillers cool terminal buildings at Heathrow Airport in London and at Copenhagen Airport. Ammonia chillers are used to cool hospitals, including Rigshospitalet – Copenhagen University Hospital. Ammonia chillers also cool the new shopping mall "Fields" in Copenhagen.

In addition, ammonia chillers are used by industry e.g. to cool fermentation processes at the Novo Nordisk insulin production site in Denmark.

Ammonia chillers are more expensive than HFC chillers, but the energy efficiency is much better which gives a short payback time of additional costs. That will normally be 2 to 3 years. Ammonia chillers are competitive when looking at the total costs, according to Mr. Pachai.

It is important to use skilled installers when working with refrigerants and that is also the case for ammonia, says Mr. Pachai.

Chillers with hydrocarbons
Two Danish companies (Bundgaard Køleteknik and Johnson Controls International) have started the production of hydrocarbon chillers in the medium to larger range (50 – 400 kW). The two competing companies make about 150 units per year, and most of the units are installed in Denmark, but exports to e.g. Norway, UK and Germany have started.

The energy efficiency is better than that of HFC systems (about 10 %) and the price is about 20 % higher compared to HFC systems. In Denmark and Norway, the price is the same as for HFC systems due to the tax on HFC refrigerant in the chillers. The payback time for countries without tax is typically 1 to 2 years says Mr. Pachai.

A number of hydrocarbon-chillers are used to cool the new University Hospital in Aarhus (Skejby), and in addition, two high-temperature heat pumps produce hot water at 80°C using hydrocarbon as working fluid.

Industrial refrigeration systems
Ammonia has been used in industrial refrigeration systems for more than a century, and ammonia is used in the food industry e.g. in slaughterhouses, dairies, breweries and the fishing industry. Ammonia is also used in other industries such as plastic moulding. Almost 100 % of the industrial refrigeration systems in Denmark use ammonia as refrigerant. Industrial refrigeration systems are built on site, using components suited for ammonia refrigeration systems. As an example we have built the refrigeration system at the biggest slaughterhouse in Scandinavia (Danish Crown in Horsens), says Mr. Pachai.

Some industrial refrigeration systems are built as "cascade systems", consisting of two stages: ammonia in the high temperature stage and CO_2 in the low temperature stage. That is in many cases more efficient and minimizes the amount of ammonia in the system.

Mr. Alexander C. Pachai
Johnson Controls International

Danfoss is ready to supply components to environmental refrigeration systems

Danfoss is the world-leading supplier of components for the food cold chain.

Photo of control valves for CO_2-systems

A cold chain is a temperature-controlled supply chain. It is an uninterrupted series of storage and distribution activities which maintain a given temperature range. It is used to help extend and ensure the shelf life and safety of products. The cold chain covers every aspect from basic farm production to processing in the food industry, cold stores, refrigerated transport at sea and refrigerated land transport and supermarket refrigeration systems.

Ammonia

Danfoss develops and markets components for a wide range of refrigerants, including HFCs, ammonia, CO_2 and hydrocarbons.

"Today, we have a full range of components intended for ammonia and Danfoss is the world leader of components for ammonia refrigeration systems, which often are used in e.g. the food industry. In the future, we will also see smaller ammonia systems for new applications, in the commercial refrigeration sector", says Torben Funder-Kristensen, Head of Public and Industry Affairs.

CO_2

CO_2 was used as refrigerant decades ago but was almost forgotten when CFCs were introduced in the industry.

"CO_2 as refrigerant is a challenge as the refrigerant is very different from other refrigerants. The pressure is much higher and previously it was relatively expensive to build CO_2 refrigeration systems", says Mr. Funder-Kristensen.

That has changed due to new materials and new research: "At this stage, we almost have a full program for components for commercial refrigeration systems in e.g. supermarkets. We have expansion valves, magnet valves, filters, sight glasses and control systems for both subcritical and transcritical CO_2 systems, and I suppose the program will be complete within a short time frame", says Mr. Funder-Kristensen.

Hydrocarbon

Hydrocarbon refrigerants have excellent thermodynamic properties and are very good refrigerants. But hydrocarbons are inflammable, and special precautions must be taken.

"In the 1990s we started to develop compressors for hydrocarbons for domestic refrigerators, and today we market expansion valves and other components for hydrocarbon refrigeration systems, including liquid chillers. Danfoss only delivers components to companies and installers that are professionally skilled to handle hydrocarbon refrigerants. It is very important that the installers are trained", says Mr. Funder-Kristensen.

Energy efficiency

Danfoss pays great attention to energy efficiency.

"New refrigeration technology has to be at least as efficient as the technology of the "old" systems. It is our goal to become world leaders within the production of components for energy efficient refrigeration systems", says Mr. Funder-Kristensen.

Environmental impact

"Danfoss is aware of the environmental impact from using F-gases and we support the use of refrigerants with low GWP (Global Warming Potential). We also support a "phase-down" scheme for F-gases. In the future, we will see a range of different low GWP refrigerants, including ammonia, hydrocarbons and CO_2," says Mr. Funder-Kristensen.

Torben Funder-Kristensen
Danfoss

Info box

F-gases

F-gases are fluorinated gases (HFCs, PFCs and SF6) which are potent greenhouse gases. They are covered by the Kyoto Protocol.

The HFCs (HydroFluoroCarbons) are the most important and they are frequently used in the refrigeration industry as the working fluid in the refrigeration cycle.

There are many different refrigerants based on HFCs. The most important are HFC-134a (R134a) and HFC mixtures: R404A, R410A and R407A. The most common refrigerants that are based on HFCs have Global Warming Potentials from about 1500 to 4000. The baseline is CO_2, which has a value of 1.

Natural refrigerants

Natural refrigerants are substances that can be found in nature's own cycle, e.g. ammonia, hydrocarbons, CO_2, water and air.

None of the refrigerants in the group of natural refrigerants are perfect and they all have technical limitations. Ammonia is toxic in high concentrations, hydrocarbons are flammable when mixed with air, CO_2 operates at high pressure and has a low critical point, water cannot be used below 0°C and air is only an interesting option at very low temperatures below -60°C.

Therefore, natural refrigerants have to be chosen with care and one fluid cannot cover all applications.

Danish industry has successfully implemented natural refrigerants for a wide range of applications and they appear from the examples in this brochure.

EDITOR

Per Henrik Pedersen, M.Sc., Senior Consultant at Danish Technological Institute, conducted the interviews and wrote the text in this brochure in the summer/autumn of 2011.

Danish Ministry of the Environment
Environmental Protection Agency
Strandgade 29
DK-1401 Copenhagen K
Denmark

Phone: +45 72 54 40 00
E-mail: mst@mst.dk

www.mst.dk