Background

Climate change and its significance for refrigeration technology

Climate change, greenhouse effect and global warming – scarcely any other issue is so omnipresent and so controversially discussed in the 21st century. Those who are convinced in doubting that climate change is man-made refer to various eras in the history of our planet where the earth has heated up or cooled down drastically even without any contribution on our part. In future too, they see climate change as the result of natural causes, including among others a changed ellipsoid orbit of the earth around the sun. Climate researchers counter this by saying that the situation today is exacerbated by a not inconsiderable human contribution to greenhouse gases in the atmosphere, contributing to the fact that the earth will have warmed up by several degrees Celsius by the end of this century. The main cause of this is seen to be industrial and technological development over the last 150 years. However, at the start of this period, climate change and carbon emissions were unknown factors. They have only gradually come into focus of public awareness, with an increasing effect since the 1960s.

Direct and indirect emissions in refrigeration

"Refrigeration and air-conditioning applications fight on two fronts with their contribution to global warming", explains Monika Witt, Chairwoman of eurammon, the European initiative for natural refrigerants. "On the one hand, direct emissions from refrigerants containing fluorine such as FCs and HFCs make a major contribution to the greenhouse effect. Such emissions are caused for example by leaks in refrigeration systems so that the refrigerant escapes into the atmosphere. On the other hand, the operation of refrigeration systems consumes a large amount of energy consumption and as such makes an additional indirect contribution to carbon emissions. Furthermore, demand for refrigeration applications is increasing. On a global scale, installed refrigeration capacity has nearly tripled since 2001."

Political approach: Kyoto Protocol and the F-Gas Regulation

Environmental agreements such as the international Kyoto Protocol in general or the European F-Gas Regulation in particular are dedicated to the issue of greenhouse-relevant substances and look for solutions on a political level. But it is proving extremely difficult to bring about an understanding on shared climate protection and reduction levels as well as elaborating generally binding regulations, in view of the numerous individual interests of the many states involved. This is the case particularly with the Kyoto Protocol which expires next year. Already at the Cancún climate summit in 2010, the participating countries were not able to reach agreement on a binding structure for a follow-on protocol or on a shared approach to a new way of calculating emission values.

While the international Kyoto Protocol stipulates binding reduction targets for gases such as carbon dioxide, methane, nitrous oxide, sulphur hexafluoride and fluorinated hydrocarbons, the European F-Gas Regulation refers particularly to the latter group and their use in various installations. "The Regulation is of special significance for the refrigeration and air-conditioning sector because F-gases are used as refrigerants in refrigeration and air-conditioning systems", explains Monika Witt. To reduce emissions, it regulates for example the placing on the market of F-gases, the monitoring and maintenance of installations in order to avoid leaks, and the initial and advanced training of professionally qualified staff.

The European Commission just recently published a Review Report on the effects and adequacy of the F-Gas Regulation over the last four years[1]. It came to the conclusion that the Regulation has had a quite significant effect on F-gas emissions in Europe. By the end of 2010, such emissions were verifiably reduced by 3 million tonnes CO_2 equivalent. But this is not enough in order to reach the EU's long-term targets of reducing emissions by 80-95% in 2050 compared to 1990. Only about half of all emissions forecast by 2050 could be avoided altogether, and only if all 27 EU Member States were to consistently apply the current specifications from the F-Gas Regulation and the corresponding provisions for mobile air-conditioning units (MAC Directive). This would mean that the emissions would only remain stable on the current level of 110 million tonnes CO_2 equivalent. Crux of the matter: Predictions indicate that there is only very little scope for reducing emissions in the framework of applications covered by the F-Gas Regulation – in the magnitude of around 3 million tonnes by 2010 and around 4 million tonnes by 2050. "It is therefore not possible to reach the target simply by continuing as before", says Monika Witt. "Regulations are only expedient when they are adhered. As long as F-Gas consumption is not closely monitored and more important, so non-compliance is fined, it is very unlikely the consumption can be reduced as planned. Stricter controls and harsher penalties for failure to comply with the requirements are therefore necessary."

[1] German version available at: http://ec.europa.eu/clima/policies/f-gas/docs/report_de.pdf,
English version available at: http://ec.europa.eu/clima/policies/f-gas/docs/report_en.pdf.

Natural refrigerants as an environment-friendly alternative

The objective of the F-Gas Regulation should also be to push the development of new technological innovations and alternative technologies. One alternative to F-gases in refrigeration and air-conditioning systems consists of natural refrigerants such as ammonia (NH_3), carbon dioxide (CO_2) and hydrocarbons. "In contrast to the F-gases, these refrigerants offer the advantage of having either no or only a negligible global warming potential", adds Monika Witt. "As a result, their contribution to the greenhouse effect is only marginal, even in the event of leaks or when disposing of the refrigerant." In the framework of its involvement in the expert group reviewing the F-Gas Regulation, eurammon drew attention among others to the high potential for reducing F-gases by using ammonia as a refrigerant for example in stationary air-conditioning systems. The Initiative also emphasised the good thermodynamic properties of NH_3 and hydrocarbons, also for applications in the critical temperature range. There is still widespread opinion that installations operating with natural refrigerants are always less efficient than those using synthetic refrigerants. "This statement must be revised to the effect that solutions with natural refrigerants are at least just as efficient thanks to skilful planning and systematic installation optimisation", states Witt. "NH_3 for example is deemed to be the refrigerant with the best thermodynamic properties, making it one of the most cost- and energy-efficient refrigerants of all."

The eurammon Chairwoman could also envisage explicit incentives when using systems with natural refrigerants as alternative technology, either in form of subsidies or tax deduction. Another proven possibility could be the penalty for refrigerants with high GWP. In September, the Australian government introduced a bill in Parliament for a CO_2 tax that includes taxation on F-gas imports. In Europe, individual countries have already implemented additional measures to intensify the transition to already existing, more environment-friendly technologies. The Scandinavian countries for example levy an additional F-gas tax. One kilogram of R134a costs €17.50 in tax in Denmark, €35.00 in Sweden and even €39.00 in Norway. “It is important to come to harmonized European standards in order to support the safe use of natural refrigerants. Right now, there exist too many obstacles in certain countries”, states Witt.

In addition: putting resources to better use in future

Natural refrigerants are low in costs, available in unlimited quantities and already cover practically all refrigeration applications today. "This must be the basis for optimising and advancing refrigeration technology", advises Witt. "The energy efficiency of installations and components can still be optimised even further by research and development. In the future, it should be possible for installations to produce the energy that they need to operate." But there is still room for improvements to further reduce the energy consumption. “The waste heat produced by installations for example can be used for preparing hot water or for heating. And if an installation does not have to operate at full capacity most of the time, the corresponding output and energy consumption could be regulated with speed-controlled compressors. Moreover, renewable energy sources such as solar energy could be used for power generation and refrigeration to reduce the carbon emissions generated with fossil energy.”

Annex

Ammonia (NH_3)
Ammonia has been successfully used as a refrigerant in industrial refrigeration plants for over 100 years. It is a colourless gas, liquefies under pressure, and has a pungent odour. In coolant technology, ammonia is known as R 717 (R = Refrigerant) and is synthetically produced for use in refrigeration. Ammonia has no ozone depletion potential (ODP = 0) and no direct global warming potential (GWP = 0). Thanks to its high energy efficiency, its contribution to the indirect global warming potential is also low. Ammonia is flammable. However, its ignition energy is 50 times higher than that of natural gas and ammonia will not burn without a supporting flame. Due to the high affinity of ammonia for atmospheric humidity it is rated as “hardly flammable”. Ammonia is toxic, but has a characteristic, sharp smell which gives a warning below concentrations of 3 mg/m³ ammonia in air possible. This means that ammonia is evident at levels far below those which endanger health (>1,750 mg/m³). Furthermore ammonia is lighter than air and therefore rises quickly.

Carbon dioxide (CO_2)
Carbon dioxide is known in refrigeration technology as R 744 and has a long history extending back to the mid 19th century. It is a colourless gas that liquefies under pressure, with a slightly acidic odour and taste. Carbon dioxide has no ozone depletion potential (ODP = 0) and negligible direct global warming potential (GWP = 1) when used as a refrigerant in closed cycles. It is non-flammable, chemically inert and heavier than air. Carbon dioxide has a narcotic and asphyxiating effect only in high concentrations. Carbon dioxide occurs naturally in abundance.

Hydrocarbons
Refrigeration plants using hydrocarbons such as propane (R 290, C_3H_8), propene (R 1270, C_3H_6) or isobutane (R 600a, C_4H_{10}) have been in operation all over the world for many years. Hydrocarbons are colourless and nearly odourless gases that liquefy under pressure, and have neither ozone depletion potential (ODP = 0) nor significant direct global warming potential (GWP = 3). Thanks to their outstanding thermodynamic characteristics, hydrocarbons make particularly energy efficient refrigerants. Hydrocarbons are flammable, however, with currently available safety devices, refrigerant losses are near zero. Hydrocarbons are available at low cost all over the world; thanks to their ideal refrigerant characteristics they are commonly used in small plants with low refrigerant charges.

Ozone Depletion and Global Warming Potential of Refrigerants

	Ozone Depletion Potential (ODP)	Global Warming Potential (GWP)
Ammonia (NH_3)	0	0
Carbon dioxide (CO_2)	0	1
Hydrocarbons (propane C_3H_8, propene C_3H_6, isobutane C_4H_{10})	0	<3
Water (H_2O)	0	0
Chlorofluoro-hydrocarbons (CFCs)	1	4680–10720
Partially halogenated chlorofluoro-hydrocarbons (HCFCs)	0.02–0.06	76–12100

Per-fluorocarbons (PFCs)	0	5820–12010
Partially halogenated fluorinated hydrocarbons (HFCs)	0	122–14310

Ozone Depletion Potential (ODP)
The ozone layer is damaged by the catalytic action of chlorine, fluorine and bromine in compounds, which reduce ozone to oxygen and thus destroy the ozone layer. The Ozone Depletion Potential (ODP) of a compound is shown as chlorine equivalent (ODP of a chlorine molecule = 1).

Global Warming Potential (GWP)
The greenhouse effect arises from the capacity of materials in the atmosphere to reflect the heat emitted by the Earth back onto the Earth. The direct Global Warming Potential (GWP) of a compound is shown as a CO_2 equivalent (GWP of a CO_2 molecule = 1).

About eurammon

eurammon is a joint European initiative of companies, institutions and individuals who advocate an increased use of natural refrigerants. As a knowledge pool for the use of natural refrigerants in refrigeration engineering, the initiative sees as its mandate the creation of a platform for information sharing and the promotion of public awareness and acceptance of natural refrigerants. The objective is to promote the use of natural refrigerants in the interest of a healthy environment, and thereby encourage a sustainable approach in refrigeration engineering. eurammon provides comprehensive information about all aspects of natural refrigerants to experts, politicians and the public at large. It serves as a qualified contact for anyone interested in the subject. Users and designers of refrigeration projects can turn to eurammon for specific project experience and extensive information, as well as for advice on all matters of planning, licensing and operating refrigeration plants. The initiative was set up in 1996 and is open to European companies and institutions with a vested interest in natural refrigerants, as well as to individuals e.g. scientists and researchers.
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