COOL TECHNOLOGIES: WORKING WITHOUT HFCs: PART ONE

Joint Position Paper by Greenpeace and the Environmental Investigation Agency (EIA) for the European Commission Technical Meeting on HCFC Phase-Out
April 5-6, 2008
Montreal, Canada

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Part 1: Submitted jointly by Greenpeace and EIA
Part 2: Submitted by Greenpeace

Introduction

The Montreal Protocol is a key climate treaty in that it bridges the dual atmospheric crises of ozone layer depletion and global warming. As such it needs to take responsibility, not only for all ozone depleting substances, but also for the high-Global Warming Potential (GWP) substitutes, namely HFCs, that the Protocol has promoted globally. Greenpeace and the Environmental Investigation Agency are concerned that the stage is being set to ensure that the Multilateral Fund of the Montreal Protocol will primarily fund HFC technologies as replacements for HCFCs in developing countries.

This paper presents compelling reasons why high-GWP HFCs should be discounted as viable, sustainable alternatives to HCFCs. Part one presents relevant environmental considerations, along with policy recommendations. Part two offers a partial survey of the many HFC-free cooling technologies available in the world today.

Greenpeace and EIA Policy Recommendations to the Parties

Recognizing the intent of the Parties to the Montreal Protocol to most effectively protect the climate and the environment through the accelerated phasing out of HCFCs, Greenpeace and the Environmental Investigation Agency offer the following policy recommendations:

1. Parties should adopt a “presumption against HFCs” policy, which states that “HFCs must not be used in any new or retrofit applications where there are technologically proven, safe, efficient and lower GWP not-in-kind alternative technologies available. The term “not-in-kind alternatives” (NIKA) refers to all cooling and insulation technologies that operate without fluorinated gases.

2. The Montreal Protocol, in cooperation with the Kyoto Protocol, should urgently work towards the establishment of a GWP weighted global cap on HFC production, consumption and emmissions. Once established this should be followed by an HFC phase-out.

3. Parties should establish and fund, as part of TEAP, a committee of experts that have direct experience in researching and/or working with the installation and retrofit use of natural refrigerants. The committee should conduct a comprehensive analysis of case studies of the use of NIKA technologies in various sectors in both industrialized and developing countries. The analysis should examine (a) the feasibility of the use of natural refrigerants in new equipment as well as the conversion of old CFC and HCFC equipment and (b) the feasibility of altering existing regulations that unnecessarily curtail the use of not-in-kind technologies.

[1] Cool Technologies: Working Without HFCs takes its title from a Greenpeace video produced in 2000. Copies of the video are available from Greenpeace (contact Janos Maté at jmate@telus.net).

4. Following Decision XIX/6 from the Montreal Protocol HCFC adjustment, Parties must ensure that future HCFC phase out funding must not fund HFC projects when environmentally safer and technologically proven alternatives are available. Parties should adequately fund, through the Multilateral Fund and bilateral arrangements, the transfer of NIKA technologies and the training of technicians in the operation and servicing of these technologies. This should involve funding to the Implementing Agencies to promote the use of NIKA technologies in developing countries through information outreach programs.

5. Governments should instate vigorous programs to progressively restrict and ban the use of high-GWP HFCs and the use of HFCs in applications where there are technologically proven, safe, efficient and lower GWP not-in-kind alternative technologies available (Please see Appendix A for HFC legislations already in place). Governments should also ensure that existing regulations do not unnecessarily curtail the use of not-in-kind cooling technologies.

6. To level the playing field, experts representing not-in-kind technologies should be invited to participate in all relevant advisory technical committees within the Montreal and Kyoto Protocols and international regulatory bodies. Typically, companies and independent experts working with NIKA technologies cannot afford to cover the costs of their participation on an on-going volunteer basis, therefore the Parties need to provide some kind of financial assistance.

Accelerated HCFC Phase-out: Good or Bad for the Climate?

In September 2007 the Parties to the 19th Meeting of the Montreal Protocol made an historic decision to accelerate the phase-out of HCFCs by ten years in both industrialized and developing countries. This long overdue agreement has the potential to reduce global emissions by 800,000 to 1.1 million ODP tons of ozone depleting substances (ODS), or approximately 21 to 22.6 billion CO_2-eq. tonnes of greenhouse gases by 2050.[2] According to TEAP the climate benefits provided by an earlier phase-out can only be achieved if (a) the HCFCs are replaced by alternatives that have zero or low GWPs and (b) the energy efficiency of refrigeration and air conditioning equipment is improved.[3]

Presently the ozone benefits of this decision are much more assured than the climate benefits, as we have yet to see what substances and technologies will replace HCFCs. Since the onset of the ozone crisis, when it became apparent that CFCs would have to be phased out, the strategy of the chemical industry has been to hold on to the multi-billion dollar global monopoly it enjoyed with CFCs. In the 1990s, the chemical industry convinced the world that only their products, HCFCs and HFCs, were viable alternatives to CFCs in refrigeration. Today the industry is vigorously promoting the idea that HFCs are the optimal replacements for HCFCs.

However, if governments once again follow the chemical industry's business agenda, and if high-GWP HFCs do become the primary replacement for HCFCs, then the climate loses. For example, it is estimated that, without mitigation, by 2015 the annual global production of the most ubiquitous HCFC, R-22, will be approximately 850,000 tons.[4] The GWP of HCFC-22 is 1810. Table 1 shows the GWPs of the most likely HFC alternatives to HCFC-22. Many of their GWPs are more than double that of HCFC-22. Clearly if any of the very high-GWP were to replace R-22 then the accelerated HCFC phase-out would have a negative, instead of a positive, impact on global warming.

[2] Greenpeace and EIA calculations.
[3] UNEP, TEAP (2007) Report of the Task Force Response to Decision XVIII/12, August 2007; ICF International, 2007. Changes in HCFC consumption and emissions from the US proposed adjustments for accelerating the HCFC phase out. Prepared for the US EPA by ICF International, August 2007
[4] UNEP TEAP (2007) ibid.

Table 1: Global warming potentials (100 year timeline) of some of the most likely alternatives to HCFC-22.[5]

Refrigerant	Global Warming Potential
HCFC-22	1810
HFC-404A	3922
HFC-507	3985
HFC-407C	1774
HFC-410A	2088
HFC-134a	1430
HFC-417A	2346
HFC-422A	3143
HFC-4220	2729
R-290 (propane)	3.3
R-1270 (propylene)	1.8
R717 (ammonia)	0
R744 (carbon dioxide)	1

Among leading alternatives to HCFC-22, only the natural refrigerants such as propane, propylene, ammonia and carbon dioxide have low global warming potentials. Fortunately, there are technologically proven and commercially available technologies using natural refrigerants to replace HCFC-22 in most applications. This applies to both new equipment and to the conversion of existing cooling systems.

As the momentum to phase-out HCFCs builds up, Parties to the Montreal Protocol might be tempted to accept the assertions of the chemical industry that HFCs offer the cheapest, most efficient and the easiest “drop in” solutions for eliminating HCFCs. Industry claims that leakage rates of HFC refrigerants will be greatly reduced through containment due to better designed and built equipment and improved servicing and recovery practices. They also claim, albeit erroneously, that HFC based equipment is more energy efficient than corresponding natural refrigerant based equipment. Therefore, according to industry, the direct greenhouse gas contribution of emissions from high-GWP HFCs, are thus offset by the higher indirect emission contribution of low GWP natural refrigerant based equipment. Parties to the Montreal Protocol have an obligation to thoroughly examine these claims through independent analysis.

The Parties have acted in harmony with the chemical industry’s business agenda before. While the Montreal Protocol clearly stipulated in Article 2F/Paragraph 7, “… that each Party shall endeavor to ensure that the use of [HCFCs] is limited to those applications where other environmentally suitable alternative substances or technologies are not available", for the most part the Parties and the Multilateral Fund elected to ignore this decision. Over the years the vast majority of projects funded by the Multilateral Fund were for HCFC and HFC projects, even when technologically and commercially mature and environmentally much safer not-in-kind alternatives were readily available. Due to the combined pressures of looming Montreal Protocol CFC phase-out target dates, and “penny wise but pound foolish” financial decisions, the Fund and the Implementing Agencies overwhelmingly opted for the short-term, and short sighted solution of replacing CFCs primarily with HCFCs and HFCs.

Should governments in industrialized and developing countries again accept industry’s claims without thorough independent examination of their accuracy and without a full examination of the availability and the merits of not-in-kind technologies to meet global cooling needs, then they will have to accept the responsibility for leading the world into HFC dependency for the foreseeable future, most likely for the next 50 to 100 years. Subsequently, they will also have to accept the

[5] Cohr Pachai, A. “Phase out of R22 and then what?” Johnson Controls.

responsibility for the significant greenhouse gas contributions of large scale HFC emissions into the atmosphere. It is therefore imperative that Parties get it right this time.

Guidelines for Funding the Accelerated HCFC Phase Out

Initially there was only going to be one round of funding by the Multilateral Fund to assist developing countries phase-out their ozone depleting substances. Following the second round of Multilateral Fund money, it is almost certain that there will not be yet another, third round of funding. If developing countries convert their rapidly bourgeoning cooling sectors from HCFCs to HFCs they will become trapped in an HFC cul-de-sac, and the whole world will suffer the growing consequences of increased HFC emissions.

It is therefore imperative that during this second, and final, round of funding, the Parties live up to the full intent of Decision XIX/6 which "Encourages Parties to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate" [and directs] "… the Executive Committee….[to] give priority to cost-effective projects and programmes which focus on… Substitutes and alternatives that minimize other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors."

The Decision further states that "In accelerating the HCFC phase-out.. Parties are to take every practicable step consistent with Multilateral Fund programmes, to ensure that the best available and environmentally-safe substitutes and related technologies are transferred from Article 2 Parties to Article 5 Parties under fair and most favourable conditions.

WHY AND HOW HFCs ENDANGER THE CLIMATE

HFC Containment a Failure

In the 1990's HFCs were sold to the world by the chemical industry and HFC equipment manufacturers with the promise of 'containment'. Containment involves avoiding emissions during production, operation, servicing and end-of-life disposal of equipment. However a 2004 study, by Atlantic Consulting, argues that the containment of HFCs has failed. Analysis of fluorocarbon industry data that found that leak rates of HFC-134a over the period of 1990-2000 were the same as they were for its predecessor, CFC-12, in the mid-1980's.[6] It therefore comes as no surprise that some estimates indicate that over 50% of all HFCs produced to date have already been emitted into the atmosphere.7 Within the German food retail sector it is estimated that around 50% of the annual 7 million tons of CO_2-eq emissions are due to leaking refrigerants.[8] Without significant improvements in equipment design and construction, servicing practices, and end of life disposal programs, it is highly unlikely that there will be much change in leakage rates in the near future.

It has been noted that it would be technically possible to build leak proof, hermetically sealed cooling systems. However they would be significantly more expensive and therefore unappealing to equipment users. It should also be noted that regular system leakages are a steady source of revenue for the chemical and service industries.

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[6] Atlantic Consulting, (2004) "HFC containment has already failed." URL: http://www.climnet.org/pubs/HFC_Containment_Failed.pdf

[7] Greenpeace (2007) "No Time for Complacency: Proposed measures to limit further damage from CFCs, HCFCs and HFCs"

[8] R-744.com, (2008) "EuroShop explores eco-friendly food cooling." www.r744.com/news/news_ida304.php

HFC Recovery Unlikely

The Montreal Protocol operates on the assumption that once a substance is consumed it will be emitted into the atmosphere. Unfortunately this assumption is close to reality in both industrialized and developing countries. In 2002 refrigerant recovery in industrialized countries was estimated at 32,500 metric tonnes, less than 5% of the annual refrigerant market.[9] Existing mechanisms for the recovery of F-gases such as HCFCs and CFCs are few. In developing countries regular preventive maintenance of air-conditioning and refrigeration equipment is rare[10] and there is currently no effective recovery of refrigerants.[11] It is therefore very probable that HFC recovery rates in future will mirror the current rate of recovery of CFCs and HCFCs.

HFC Emissions Data

The world is facing the daunting challenge of rapidly reducing greenhouse gases. While most attention is focused on reducing CO_2 emissions, the large scale emissions of HFCs threaten to undermine the intent of the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC).

In 2004 it was calculated that if the combined present-day emissions of chlorine containing F-gases (that is CFCs and HCFCs) were to be replaced by HFCs, the present global warming contribution of total F-gas emissions would equal 4.1% and 5.2% of total greenhouse gases, rated on a 100 year and 20 year time horizon respectively.[12]

The climate catastrophe that HFCs have the potential to unleash is often misunderstood due to the fact that they currently represent a relatively small proportion of all global warming gases. In 2004 emissions from HFCs, PFCs and SF6 accounted for 1.1% global annual emissions of anthropogenic greenhouse gases[13]. However, this figure is rising at an alarming rate; between 2001 and 2003, HFC atmospheric concentrations rose at a rate of 13-17% per year.[14] A 2005 Intergovernmental Panel on Climate Change (IPCC) report predicted a tripling of annual HFC emissions from 0.4 billion tonnes CO_2-eq. in 2002 to 1.2 billion tonnes CO_2-eq. in 2015, unless mitigation measures are taken.[15]

If the growth of HFCs is allowed to continue unchecked, scientists estimate that emissions of HFCs by 2050 will be 765 million - 1.5 billion CO_2 equivalent metric tonnes which, when expressed as a percentage of 1990 total GHG emissions, is 7.2% - 13.9%.[16] Suddenly HFC emissions do not seem like such a small problem.

HFC-134a Production and Emissions

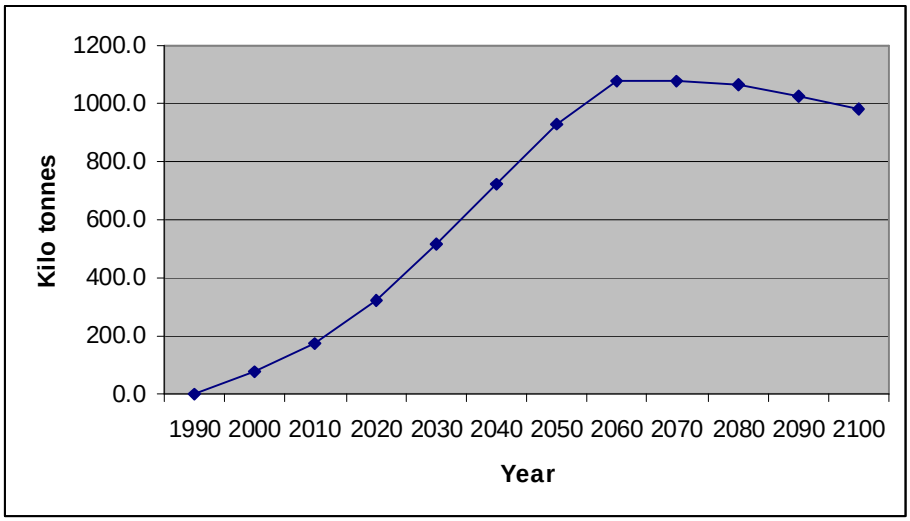
HFC-134a currently dominates the HFC market, accounting for almost two-thirds of all HFCs in use.[17] Introduced in the early 1990s, HFC-134a is now widely used throughout the refrigeration

[9] US EPA and ADEME, (2004) "Determination of comparative HCFC and HFC emission profiles for the Foam and refrigeration sectors until 2015."
[10] IPCC (2005) Special Report on Safeguarding the Ozone Layer and the Global Climate System Issues related to Hydrofluorocarbons and Perfluorocarbons, Chapter 5
[11] US EPA and ADEME, (2004) ibid.
[12] Schwartz, W., (2004) "The high and still growing share of fluorinated greenhouse gases in overall global warming emissions." Oko-Recherche study
[13] IPCC, (2007) Fourth Assessment Report, Summary for Policy Makers
[14] IPCC (2005) ibid.
[15] IPCC (2005) Special Report on Safeguarding the Ozone Layer and the Global Climate System Issues related to Hydrofluorocarbons and Perfluorocarbons - Summary for Policy Makers
[16] Climate Action Network, (2002) "Ozone and climate at the crossroads - the other double phase-out"
[17] Atlantic Consulting, (2004) ibid.

and foam industries. Production capacity of HFC-134a has risen steeply from very low levels in 1990 to 185,000 tonnes in 2002.[18]

Meanwhile, the atmospheric concentrations of HFC-134a have been rising at an average rate of 20% per year since 2000.[19] Arctic atmospheric concentrations of HFC-134a doubled over the four year period 2001-04 according to the Norwegian Institute for Air Research (NILU).[20] And according to the 2006 AFEAS Alternative Fluorocarbons Acceptability Study (2006) more than half of all the HFC-134a refrigerant ever produced has already been emitted in the atmosphere.[21]

Graph 1. Projected HFC-134a emissions under BAU Scenario[22]



Graph 1. depicts HFC-134a emissions under a business as usual scenario. In 2070 emissions peak at 1,078 kilo tonnes. This would be equivalent to 1.5 billion tonnes CO_2, which equals the annual emissions of about 280 million cars, or more than double the greenhouse gas emissions of the UK in 2010.[23]

If we do everything to try to curb annual CO_2 emissions to 11 billion tonnes of CO_2 emissions by 2050 (that is, increased energy efficiency and conservation, mass introduction of renewable energy systems, reduction in reliance on fossil fuels, moving energy production closer to the consumer,) but we continue as business as usual with HFC-134a then 134a will make up 17.1% This figure is incorrect, my calculations make it 14% of all greenhouse gas emissions in 2070.

Energy Efficiency Deficit of HFCs

Contrary to the HFC industry's claims, systems using natural refrigerants are often more energy efficient than those using HFCs. Of course there are many factors to be considered when comparing the efficiency of cooling equipment, but many studies have revealed that systems using natural refrigerants often display greater energy efficiency.

A recent study comparing the coefficients of performance (CoP) for hydrocarbon mixtures and HFC-245ca in a spray evaporator found a 6% increase in CoP when the hydrocarbon mixture

[18] IPCC (2005) ibid. Chapter 11, p 405
[19] IPCC (2005) ibid.
[20] Multisectorial Initiative on Potent Industrial Greenhouse Gases (MPIGGs) newsletter, (2006) www.mipiggs.org
[21] AFEAS Alternative Fluorocarbons Acceptability Study 2006
[22] Data taken IPCC Special Report on Emissions Scenarios (2000): http://sres.ciesin.org/final_data.html
[23] Greenpeace (2007) ibid.

was used.[24] Another study analysed various papers to draw comparisons between hydrocarbons and F-gas refrigerants. They found that in 90% of the cases reviewed hydrocarbons offered higher CoPs than their F-gas counter parts, with an average improvement of 10% of the CoP.[25]

Similarly, HFCs, compared with hydrocarbons, are seen as poor substitutes for HCFC-22 in heat pumps. "For example, the critical temperature of HFC R410A is only 72°C, far less than for the previous generation HCFC R22, which had a critical temperature of 96°C. However, propane, R290, has a critical temperature of 97°C, making it the ideal replacement for heat pump applications that would previously have used R22."[26]

Other natural refrigerants such as carbon dioxide also offer favorable energy efficiency when compared to HFCs. A Life Cycle Climate Performance study on the use of CO_2 (R-744) in mobile air-conditioning found that an R-744 system demonstrated a higher CoP than an enhanced HFC-134a system. Seasonal data was integrated to simulate performance in various cities around the world including Phoenix, Arizona, and Indian cities such as Bombay and New Delhi. The results showed that around 13 % reductions in energy (fuel) consumption could be obtained with R-744 in areas with a moderate to hot climate.[27]

Ammonia systems have demonstrated some of the greatest energy savings over HFCs. Earthcare Ammonia Series chillers have been documented to produce CoPs around 5-7 higher than those exhibited by HFC systems at full and part loads. This has reported potential energy savings of around 50% annually.[28]

An international study into the energy and environmental performance of supermarket refrigeration concluded that the use of natural refrigerants in conjunction with optimised design could achieve reductions in electricity consumption of 20% over conventional direct expansion (DX) systems and reductions in Total Equivalent Warming Impact (TEWI) of 36% over conventional DX systems.[29]

Converting existing R-22 Systems to HFCs or Natural Refrigerants

One of the key arguments of the chemical industry for the replacement of R-22 with HFCs is that as "drop in" substitutes they will cause the least disruption in the installation of new equipment and the conversion of old equipment, making HFCs the most cost-effective option.

To convert existing equipment several considerations must be taken into account including, mass flow, pressures and efficiency. A paper by Johnson Controls comparing the qualities of HFCs and natural refrigerants as R-22 replacements in existing equipment concludes that "comparison from different data show that the natural refrigerants are an obvious alternative to R22. However if you have to comply to current regulations these solutions are mostly for new installations".[30]

Clearly it is time to revise any regulations which act as disincentives for safe and environmentally friendly natural refrigerants.

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[24] Tadros, A., J.W. Clark, I.L. Maclaine-Cross and E. Leonard, (2006) "Replacing fluorocarbons with hydrocarbon mixtures in centrifugal water chillers" Presented to 7th IIR Gustav Lorentzen Conference on Natural Working Fluids, Trondheim, Norway.
[25] D. Colbourne and K. O. Suen, (2000) "Assessment of Performance of Hydrocarbon Refrigerants"
[26] Cox, N., (2006) "Sustainable Cooling: Refrigerants Beyond the Crisis", presented to the EU Commission, Brussels, Belgium
[27] Hafner, A., A. Jakobsen, P. Nekså and J. Pettersen, (2004) "Life Cycle Climate Performance (LCCP) of Mobile Air-Conditioning Systems with HFC-134a and R-744."
[28] Earthcare Proposal, (2005)
[29] Annex 22 - Compression Systems with Natural Working Fluids - Final Report & Guidelines for Design and Operation, IEA Heat Pump Centre, 1995
[30] Cohr Pachai, A., Ibid.

Converting R-22 systems to hydrocarbons in developing countries

Ecozone, a Netherlands based ecologically minded refrigeration company, with many years experience working in developing countries, has conducted numerous conversions of various size and types of chillers from HCFC-22 to hydrocarbons. These conversions were made in hotels, offices, hospitals, factories and supermarkets of several developing countries. Benefits included up to 20% energy savings, extended lifetime of chillers (both technologically and economically) and use of a cheaper and environmentally much safer refrigerant.

The experience of Ecozone demonstrates that such conversions are technologically and financially feasible, and most importantly, safe. Of course, in conversions from HCFC-22 to hydrocarbons, thorough safety measures must be followed including the proper training of installers and service technicians and the revision of service manuals.

The Parties to the Montreal Protocol need to examine in detail the technological, commercial and safety issues involved in converting existing HCFC-22 units to hydrocarbons. An independent panel of experts, with expertise in hydrocarbon refrigeration, working in collaboration with TEAP and national safety boards, such as TUV in Germany or TNO in the Netherlands, should be mandated to research the feasibility of such conversions. Such research needs to be conducted before the Multilateral Fund begins to fund the conversions of HCFC-22 units to HFCs.

Conclusion

HFCs are entrenched in developed country markets, so much so that a plethora of regulations are emerging against their continued use. EIA and Greenpeace are calling on countries to act now to prevent the large scale uptake of high-GWP HFCs in developing countries. The timing is right for a transition away from F-gases. If HFCs are allowed to dominate the markets of developing countries, an important opportunity to positively affect climate change will have been missed. As demand for air conditioning and refrigeration continues to grow so will emissions from cooling sectors.

Please refer back to the policy recommendations at the beginning of this report.

APPENDIX A: HFC Legislations

Europe

The use of HCFC-22 as virgin refrigerant in new equipment or for servicing of existing plants will be disallowed by December 31st 2009. The use of recycled R-22 will be prohibited after December 2014. This will create a demand for HCFC-22 replacements. Companies considering HFCs as the substitute for HCFC-22 need to be cognizant of the possibility of future legislated restrictions on the use of high-GWP HFCs.

In 2007, Europe brought the F-gas regulation into force. The most significant aspect of the regulation is within the MAC sector where the use of refrigerants with a GWP over 150 is banned in new model cars from 2011 and in all cars by 2017. The legislation was introduced in order to spur technological innovation in the development of alternative, environmentally neutral technologies, and it has been successful in instigating the viability of natural refrigerants.

Following the introduction of the regulation, the German car industry announced that it was turning it's back on HFC-134a in favour of low GWP refrigerants such as CO_2.[31]

Nordic nations such as Denmark and Sweden operate tax and refund schemes, whereby imports of HFCs are taxed per tonne of CO_2-eq. The equivalent amount is refunded for (used) gas that is delivered for destruction. Market data indicate that these schemes have led to increased awareness of climate neutral alternatives.[32] In addition to the tax/refund scheme, Denmark has banned the use of new equipment containing or using F-gases, with some exemptions.

In 2003 Austria implemented the Ordinance for Industrial Gases, eliminating the use of HFCs in stages so that by 31 December 2007, the domestic use of HFCs and PFCs as refrigeration and cooling agents and in foams will be banned. The legislation allows some exceptions, for example HFCs with a GWP value of less than 300 may continue to be used in some foams.

Other European countries such as UK, Ireland, Switzerland, Germany, Luxembourg and France have limited the use of HFCs.

U.S.

The California Air Resources Board (CARB) has initiated a process of setting legal requirements for high-Global Warming Potential (GWP) refrigerants used in Mobile Air Conditioning and Commercial Refrigeration. The items discussed by the board include the restricted use and phase-out of HFC-134a in MACs. In commercial refrigeration emissions reductions would be targeted by improving design, energy efficiency, and addressing high leakage rates.

[31] R744.com (2008) "Now official: VDA picks CO_2 air conditioning" http://www.r744.com/news/news_ida190.php
[32] Temanord (2007) Potent Greenhouse Gases:Ways of Reducing Consumption and Emission of HFCs, PFCs and SF6