GREENPEACE

HOW TO LIMIT HFC/PFC/SF6 EMISSIONS?
Eliminate Them

A *Greenpeace* Position Paper

"Joining Efforts to Limit Emissions of HFC's, PF's & SF6"
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A. Core Issues
The core issues facing policy makers are:
- what are credible estimates of future use and emissions of the three major industrial greenhouse gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) ;
- what will be their proportional contribution to global warming;
- are there environmentally safer, technologically reliable, cost effective means to meet our cooling, insulation and other industrial needs that do not rely on these gases.
- What are the ramifications of technological and policy decisions in industrialized countries on developing countries

B. Logical Ecological Limits
The dual atmospheric crises of ozone layer depletion and global warming induced climate change underscore two inescapable facts: human civilization exists within measurable ecological limits, and nature has a limited capacity to absorb chemical and fossil fuel emissions.

The ecological limits dictate that to stabilise greenhouse gases concentrations in the atmosphere at levels that are necessary to avoid dangerous climate change we must reduce total greenhouse gas emissions below 1990 levels by a minimum of 50% within the next fifty years, and 60-80% in the next century.

Ecological limits have been telling us for decades that we must reduce and eliminate all emissions of ozone depleting substances as soon as it is technologically possible.

Clearly, if credible estimates indicate that the emissions of HFCs/PFCs and SF6 are likely to contribute in any discernable manner to global warming, and if there are safer and technologically reliable alternatives, then the use of these substances must be eliminated as soon as those alternatives are available. That is the only responsible , sensible and pre-cautionary course of action.

Policy makers must be mindful of an avalanche of alarming scientific evidence which underscore the need to act with a great sense of urgency to drastically reduce all greenhouse gas emissions and to immediately eliminate the use of ozone depleting substances. (Please see Appendix A for update items on global warming and ozone depletion.)

> ***"Our climate is now changing rapidly...Our new data and understanding now point to a critical situation we face."***
>
> - James Baker, Undersecretary of the U.S. National Oceanic and Atmospheric Administration, and Peter Ewins, British Meteorological Office Head (December 24, 1999 joint letter in the London Independent)

C. Policy Implications of Discrepancies in Emission Rates
Presently there are large discrepancies in the estimates of historic, present and future HFC emission levels. It is essential for governments to have accurate estimates of consumption and emission levels in order to formulate policies which will protect the climate. Past, present and future emission estimates should dictate policy.

C.1 Discrepancies in HFC-23 Emission estimates: One estimate by March Consultants for 1995 UK HFC-23 fugitive emissions from HCFC-22 production calculates that the UK produced in the range of 29,000 t/yr of HCFC-22, yielding roughly 1200 metric tonnes of HFC-23, which translates into about 14 Mtonnes of CO2 equivalent.[1] This would represent 92% of the UK total global warming HFC emissions. Meanwhile, another estimate prepared for Greenpeace calculates that the1995 HCFC-22 production in the UK was 26,000 t/yr. which yielded 520 metric tonnes of HFC . This provides real emissions in terms of global warming of 6.08 Mtonnes CO_2 equivalent, [2] or less than half that calculated by March.

Obviously, the starting point estimate will have significant ramifications for policy development. Politically, the March estimates would provide industry and policy makers with a very opportune starting point because it is relatively easy and inexpensive to curb HFC-23 emissions from HCFC 22 production. Taking action on HFC-23 emissions would then take pressure off other HFC emission sources (e.g. HFC-134a in commercial cooling and automobile air-conditioning) where real future growth is expected. While it is essential to eliminate fugitive HFC-23 emissions it does not remove the danger from further growth of HFC use emissions in other sectors.

C.2 Discrepancies in total EU HFC emission : A similar discrepancy exists between March Consultant estimates and Greenpeace estimates regarding growth in total EU HFC emissions between 1995 and 2010. March estimates that the total 1995 HFC emissions in the EU was 40.7 Mtonnes CO_2 equivalent, and projects that under a business-as-usual scenario this emission in 2010 will be 66 Mtonnes CO_2 equivalent, or an increase of approximately 55%.[3]

The estimates prepared for Greenpeace present a radically different picture . Greenpeace estimates that the total 1995 HFC emissions in the EU was 31.1 Mtonnes CO_2 equivalent. In a business as usual scenario, this will rise to 80.0 Mtonnes CO_2 equivalent by 2010, or an increase of over 150%. [4]

Again the different estimates will have varying policy implications. While any increase in greenhouse gas emissions is unacceptable, the Greenpeace estimates would more likely catalyze policy makers to control HFCs than would the March estimates.

This discrepancy alone should caution policy makers to proceed with precaution. Governments must have reliable and independent sources of information. Once the infrastructure has been put in place for large scale and continuous HFC emissions, it will be much more difficult and costly to reverse the trend.

D. Estimating Future HFC Use and Emissions

Current HFC use is approximately 101,000 metric tonnes a year. Credible estimates of future use must take into account:

- current applications of HFCs, PFCs and SF6 and projected growth in each sector;
- current uses of CFC and HCFCs where industry is promoting HFC replacements and projected growth in each sector;
- potential for new applications of HFCs.

A major cause for concern is the pending switch from HCFC-141b for PUR foam blowing to HFC-245fa, HFC-365mfc, and if those alternative prove to be inferior, to HFC-134a. The 100 year GWP of HCFC-141b is 700, while GWP of the proposed fluorocarbon alternatives is 1040, 910 and 1600 respectively. [5]

D.1 The chemical industry faces a dilemma: On the one hand, the economies of scale requires full market penetration of HFCs to make them affordable for the end-users and profitable for the manufacturers. On the other hand, if the public and the policy makers become alarmed at the potential impact of HFCs upon the atmosphere then further controls will be legislated which could eventually lead

[1] March 1999 = March Consulting Group, UK Emissions of HFCs, PFCs and SF_6 and Potential Emission Reduction Options, carried out for the UK DETR, January 1999;

[2] Internal Greenpeace study of assumptions and estimates of above mentioned March Study.

[3] March 1998 = March Consulting Group, UK, Opportunities to Minimise Emissions of Hydrofluorocarbons (HFCs) from the European Union, 30 September 1998;

[4] Internal Greenpeace study of assumptions and estimates in above mentioned March study.

[5] Scientific Assessment of Ozone Depletion: 1998 WMO Global ozone Research and Monitoring Project Report No. 44, Geneva, 1999

to a mandatory phase-out schedule, similar to what happened to CFCs. For obvious reasons the industry wants to avoid having HFCs legislated out of existence and thus projects the lowest possible HFC emission scenarios for the next fifty years.

- While independent estimates calculate that HFCs could represent up to 15% of all greenhouse gases by 2040, industry claims that "realistic projections show that emissions will be less than 3% in 2050". [6]

- 1995 estimates of the potential impact of all HFCs upon the atmosphere indicated that by the year 2040, the total global HFC market could be around 1.35 million tonnes a year, which would be the equivalent to 15% of current fossil fuel emissions. [7]

- A 1999 study done for Greenpeace on trends in HFC consumption in the EU15 countries estimates that with 'business as usual' "consumption of HFCs from 1998 to 2012 will increase from 37,500 tonnes to 128,600 tonnes – or 250 percent"[8].

- Another 1999 estimate indicates "With HCFC phase-out and a substitution of HCFC demand by HFCs/PFCs of roughly 50 per cent (which appears to be rather conservative since many potentials for non-fluorocarbon substitution will already have been exploited during transition away from CFCs), *HFC production/emissions might reach roughly 1.6 million metric tonnes in 2050 and roughly 7 million tons in 2100 (under the assumption of average annual growth of 3%)*." [9]

- The same study calculates that based on the revised GWP values of HFCs, as contained in the 1998 Scientific Assessment of Ozone Depletion , by the year 2100 in a Low Emission Scenario HFC/PFC greenhouse gas contribution would be 20-30% of 1990 CO2 emission levels, in a High Emission Scenario 55-85%, and in a Best Estimate Scenario 40% (plus or minus 10%).[10]

- The "Meeting Report of the Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFCs and PFCs" indicates that there is high degree of discrepancy about future HFC emission levels. "HFC emissions in 2010 are projected to amount to less than 1,100 Mton CO2 equivalent (this number compares to 22,000 Mton CO2 emissions from fossil fuel use in 1998). However, the projection results an annual emission range of 1,500-5,000 Mton CO2 equivalent for the period 2030-2100 with three out of four scenarios projecting emissions near the higher end of the range." (p.12) In other words, it is possible that in the 2030-2100 period, HFC emissions could equal 22 to 25% of 1998 fossil fuel contribution to greenhouse gas emissions. Such high level of emissions could undermine the intent of the Kyoto Protocol.

D.2 Unrealistic industry strategy for reducing HFC emissions from refrigeration and air-conditioning : Industry maintains that optimised equipment with lower refrigerant charges, lower leakage rates, better recapturing and recycling procedures and more efficient applications will reduce HFC emissions to almost infinitesimal levels from a global warming perspective.

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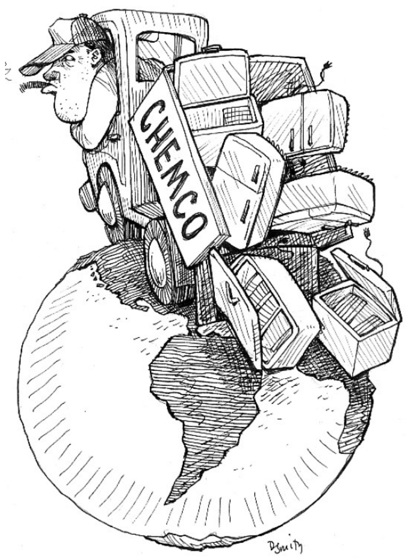
[6] Alliance for Responsible Atmospheric Policy : HFCs an Energy Efficient Solution: 1998
[7] Kroeze. C. (1995) Fluorocarbons and SF6: Global emissions inventory and options for control. Report No. 773001007, RIVM, Bilthoven, The Netherlands.
[8] See Appendix C for summary
[9] Oberthur Sebastian, Future Scenarios of HFC Emissions: *Ecologic – Centre for International and European Environmental Research, Berlin, April, 1999*
[10] Ibid.

This is optimism is simply unwarranted in industrialized countries given the dismal record of industry in arresting CFC and HCFC leakage, and in recapturing ODSs. Even if we were to assume that industrialized countries could bring in optimized technologies that use less HFC charge, with less leakage and a greater recovery and recycling rate, it is naive to think that similar standards could be achieved in developing countries who are slated to be massive consumers of HFCs.

In most applications alternatives to HFCs are as efficient or better than HFCs, so that equipment optimisation will yield greater benefits when applied to HFC-free technologies. Thus the best way to reduce HFC emissions in this sector is by switching to technologically reliable and environmentally safer alternatives.

D.2 Corporate strategy to protect the HFC market: The apparent strategy of the proponents of HFCs is similar to the strategies adopted by the chemical industry to protect the global CFC market when the harmful impacts of CFCs upon the ozone layer first came under public scrutiny.



This can be characterized as the "4 D Strategy" : (1) deny and downplay the problems with HFCs and global warming; (2) delay any further regulatory action on HFCs; (3) dominate the market place and the political and scientific debate; (4) dump the technology in vulnerable developing country markets if and when regulations are developed in industrialized countries.

A major component of this strategy is to marginalize and limit the use of competing technologies to HFCs (e.g. ammonia, hydrocarbons, CO2) to niche market areas which do not represent a threat to the large HFC consuming sectors. Thus for example, the chemical industry and their affiliated equipment manufacturers have conceded that hydrocarbons have a role in domestic refrigeration, or that ammonia can be used in large industrial settings, but they continue to propagate the myth that there are no alternatives to HFCs in commercial refrigeration and cooling and automobile air-conditioning.

D.3 Global warming contribution of HFC manufacturing: HFCs also contribute substantially to global warming indirectly through the manufacturing process. For example, a 1996 study (Banks & Sharratt) of the environmental impacts of the manufacture of HFC-134a calculated that the manufacture of 1 tonne of HFC-134a has a warming impact (on the 100 year time horizon) equivalent to 38.8 tonnes of carbon dioxide.[11] This means that the manufacture of 1000 and 100,000 tonnes of HFC-134a will contribute 38,800 and 3,880,000 carbon dioxide equivalent tonnes, respectively.

E. Headed For Catastrophes - HFCs

The emission of millions of tonnes of HFCs would not only critically exacerbate global warming but could also have serious impact on human health and contribute to the cumulative poisoning of the biosphere.

E.1 Human Health Impacts

There have been earlier studies, as well as anecdotal reports, of negative health impacts from fluorocarbons such as HFC-134a and HCFC-123. A 1999 Swedish study, "The Environmental Health of Cooling Technicians" gives cause for further concern. The study surveyed 704 technicians who are regularly exposed to HFCs while converting equipment from CFC and HCFCs to HFCs. 567 technicians or 82% responded. Skin rashes, breathing problems, heart palpitations, dizziness, stiff joints and headaches were among the symptoms reported.[12]

E.2 Atmospheric Decomposition of HFC-134a

HFC-134a decomposes in the atmosphere into trifluoroacetic acid (TFA). TFA is a persistent toxin, resistant to abiotic degradation processes such as photolysis and hydrolysis and. It is virtually

[11] Banks, RE and Sharratt PN (1996) Environmental Impacts of the Manufacture of HFC-134a: Departments of Chemistry and Chemical Engineering, UMIST, Manchester.

[12] Swedish Department for Building Economy, Lund Technical Highschool, Occupational & Environmental Medicine Academy of Uppfala Hospital, Gutenberg University Sahlgrenstka Hospital : "The Environmental Health of Cooing Technicians" : March 1999

unmetabolizable by most plants and animals. Large scale emissions of HFC-134a and other fluorocarbons, such as HCFC 123, which decompose in similar manner pose a potential toxic time bomb.

H. Think and Act Globally and Locally
Governments and industry in industrialised countries must at all times remain cognisant of the fact that their policies and choice of technologies have significant influence on policy makers, industry and consumers in developing countries. They thus have a global responsibility to ensure that potent greenhouse gases are eliminated. Developing countries are not able to switch from one technology to another in rapid succession of a few years or decades. Since 80 to 90 per cent of technicians in many of these countries are in the informal sector, it is that much more difficult to maintain high standards that require routine recapturing and recycling of gases, and servicing of equipment. Industrialised countries should, by example, encourage developing countries to adopt reliable, cost effective and proven technologies which have the smallest and least negative ecological footprint.

G. Legally Binding Assurances and a Global Cap on HFC Production Needed
A 1998 Alliance for Responsible Atmospheric Policy fact sheet on HFCs calls on governments to "encourage expanded use of HFCs". Given that the chemical companies claim that HFCs will not contribute significantly to global warming and that they are not harmful to humans and the environment , they should be willing to enter into a legally binding contract with governments committing industry to pay full reparations for any and all human health and environmental damages resulting from the global use of these substances.

The chemical industry is yet to pay one penny of reparation to help mitigate the damage that CFCs and other ODSs have caused. It is therefore doubtful that the industry will be willing to commit to taking full responsibility, in perpetuity, for the adverse human health and environmental impacts of large scale emissions of HFCs. It is up to governments to ensure public safety and to secure such legally binding assurances.

Furthermore, the industry should agree to a global cap on HFC production and emissions. This cap should establish a maximum allowable emission in each sector.

H. There Is Life After HFCs
The good news is that there are environmentally sound, technologically reliable, commercially proven alternatives to most applications of HFCs.[13] These present sound business opportunities for companies wishing to work with technologies that have a solid future.

Greenpeace, along with an increasing number of engineers and scientists, maintains that the future of environmentally safer cooling lies with natural substances, such as hydrocarbons, CO2, ammonia, water, air. As long as we continue to rely on industrial chemicals instead of natural working fluids to meet our refrigeration needs, we shall pay an environmental penalty.

***GREENPEACE* CONCLUSIONS**

- HFC/PFC/SF6 emissions present a real danger to the planet.

- Eliminating the use of HFCs/PFCs/SF6 is one of the easiest ways for governments to accomplish their commitments under the Kyoto Protocol and for companies to demonstrate corporate environmental leadership.

- Environmentally safer, cost effective, technically reliable alternatives to HFCs/PFCs exist in virtually all applications. There are companies in many countries that are ready to provide these alternative technologies.

- Developing countries can avoid unnecessarily adding to their greenhouse-gas emissions, and future reduction burden, by immediately converting to CFC replacement technologies which do not contribute significantly to global warming. By so doing, they will not only protect the atmosphere, but in the long run will also save money. After all, these countries can least afford to mitigate the tragic consequences of climate change and ozone depletion.

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[13] See Appendix B for examples of enterprises utilizing HFC-free technologies.

GREENPEACE RECOMMENDATIONS

A. HFCs/PFCs must not be viewed as a long term solution to CFC and HCFC replacement. The Parties to the Kyoto Protocol and the Montreal Protocol should adopt a presumption against HFCs/PFCs guideline (similar to Article 2F/Paragraph 7 of the Montreal Protocol regarding HCFCs) stipulating that each Party shall endeavour to ensure that HFCs/PFCs use is limited to those applications where other environmentally suitable alternative substances or technologies are not available. Such a guideline would send the correct signal to developing countries who have the most to lose by choosing HFCs as replacements for CFCs.

B. A global cap on HFC/PFCs production should be agreed upon to ensure that HFC/PFCs emissions do not reach dangerous projected levels. A cap on production in each sector is necessary to control emissions.

C. SF6 which have extremely high 100 year GWP (22,200) and extremely long atmospheric lifetime should be immediately banned.

D. A legally binding contract should be entered into between governments, representing the public's interest, and the chemical industry, stipulating that the industry will pay full reparations for any and all health and environmental damages resulting from the global use of HFC/PFC and SF6 substances.

E. International funding agencies such as the Multilateral Fund of the Montreal Protocol, and the Global Environmental Facility should be requested to show preferential in funding for non-HFC/PFC/SF6 technologies.

F. An eco-tax on all greenhouse gases, including HFCs/PFCs /SF6 should be instituted based on the relative GWP of each gas.

G.The health and full ecological impacts of HFCs should be thoroughly investigated by independent, internationally sponsored bodies.

H.The use of HFCs should be immediately prohibited in any application where the substance is directly and routinely vented into the atmosphere (e.g. self-chilling cans and klaxons) as part of the normal operation of a device or product. A temporary 'critical use exemption' should be granted for specialised applications, such as metered dose inhalers (MDIs).

I.Resources should be allocated to ensure that developing countries receive comprehensive information regarding the availability of HFC/PFC-free technologies, as well financial and technical support to enable them to make use of these technologies.

J. Full disclosure of corporate affiliation of all technical experts and consultants working for the Montreal and Kyoto Protocols needed: The Parties to the Montreal and Kyoto Protocol should ensure that they are receiving objective opinions in their investigation of alternative technologies to HFCs/PFCs and SF6.

An over-representation in the HFC/PFC/SF6 review process by the fluorocarbon industry will hinder the ability of the Parties to accurately gauge the feasibility of not-in-kind alternatives.

It is unrealistic to expect that the chemical corporations, with their vast resources, will not attempt to steer the review process towards the full endorsement of their products.

The chemical manufacturers and their corporate allies, for example, are over represented in the composition of the Technology and Economic Assessment Panel (TEAP). Not withstanding the "professional oath of objectivity" taken by all TEAP participants, it is doubtful that these chemical industry representatives will recommend any course of action, or technology, which may adversely affect the interests of the companies that pay their salaries, pensions and all of the expenses connected with their participation in TEAP. Nor is it realistic to expect that the chemical companies would pay for the participation of their employees in TEAP if it did not suit their corporate interests.

It is the responsibility of the Parties to safeguard the review process, to ensure that it is not hijacked by vested interests. Experts with extensive experience with not-in-kind alternatives to HFCs should therefore be well represented in the composition of the technical advisory committees. Resources must be committed to ensure that independent experts, from academia and elsewhere, with no commercial ties to the chemical industry , are able to participate for the duration of the process.

Investigation should focus on both available and nearly-available alternative technologies, as some alternatives have not yet entered the market due to commercial obstacles from the chemical industry and their corporate partners, not due to their technological shortcomings.

APPENDIX A : UPDATE OF GLOBAL WARMING AND OZONE DEPLETION NEWS ITEMS

GLOBAL WARMING

• Global thermostat rising:

The World Meteorological Organization reported that 1999 was the fifth warmest since 1860 and that global temperatures were about 0.33°C higher than the average for 1961-90, and about 0.7°C higher than those at the end of the last century. Seven of the top 10 warmest years have been in the 1990s.

January 12, 2000 : A major report released by an independent11-member panel, organized by the US National Academy of Sciences's National Research Council (NRC). estimated that the increase in temperatures over the past century were between 0.7 and 1.4 degrees Fahrenheit--a 30 percent increase from earlier projections that reflects record-shattering high temperatures in the late 1990s. The panel concluded that the warming of the Earth's surface is "undoubtedly real," and that surface temperatures in the past two decades have risen at a rate substantially greater than average for the past 100 years.

• Dangerous sea level rises on the horizon:

The expansion of warmed up ocean waters, combined with the melting of the polar ice, can potentially lead to dangerous sea level rise. Many millions of people live within one metre of sea level. It is estimated that the collapse of the West Antarctic ice sheet could cause global sea levels to rise as much as 20 feet (or nearly 6 metres), which would have disastrous impacts on coastal regions around the world.

• Non-linear climate change could happen again:

Current research of paleoclimate and oceanography scientists indicates that rapid non-linear climate change is a real possible consequence of increasing greenhouse gas levels. In other words, severe climatic changes do not necessarily happen over centuries but rather they can occur within a few decades or less. Once a threshold is crossed, changes are rapid, large and for practical purposes irreversible.

Furthermore, computer modelling indicates that a north-western Europe could suffer a mini-ice age while other parts of the world warm up, if increased fresh water from melting Arctic ice and higher rainfall slows down some of the key mechanisms that drive the Gulf Stream. A 40% reduction in the thickness of the Arctic ice was reported in 1999.

OZONE DEPLETION

• Prolonged ozone layer depletion predicted: In April, 1998 NASA scientists revised the predicted peak period for ozone layer depletion from the years 2000-2005 to around 2020 due to the previously unforeseen impact of global warming on the ozone layer. Predictions are that a “severe Arctic ozone hole” will form, there will be a tripling of the UV radiation hitting northern countries, the duration and severity of the Antarctic ozone hole will increase and the “recovery of the Earth’s ozone layer may take place later than currently expected.” [14]

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[14] Drew Shingled, David Rind & Patrick Lonergan (NASA Goddard Institute for Space Studies and Centre for Climate Systems Research, Columbia University): Increased polar stratospheric ozone losses and delayed eventual recovery owing to increasing greenhouse-gas concentrations: Nature, Volume 392, 9 April, 1998

• Longest lasting ozone hole over the Antarctic in 1999: In October/November 1998 a record breaking ozone hole of over 25 million square kilometers formed over the Antarctic. The 1999 Antarctic ozone hole was 25.04 million square kilometers, the third largest ever measured, and almost 1.8 times as large as the continent. It was the longest lasting ozone hole, remaining until Dec. 26.

• North Western Europe suffers abnormally low ozone levels in 1999: In December 1999 the European Space Agency reported that the "ERS remote sensing satellite detected abnormally low ozone levels over north western Europe. Above the UK, Belgium, Netherlands and Scandinavia ozone levels were nearly as low as those normally found in the Antarctic. Measurements showed ozone levels were some one-third below the norm for this time of year."

• European Ozone Research Coordinating Unit foresees the possibility of record Arctic ozone losses in 2000: The New Scientist (January 22, 2000) reported that scientists at the European Ozone Research Coordinating Unit expect that persistently low temperatures in the Arctic stratosphere, which are as low as ever recorded, have created prime conditions for the formation of an Arctic ozone hole in 2000. Climate change induced by global warming is thought to be amplifying the impact of ozone -destroying chemicals by cooling the stratosphere near the poles.

APPENDIX B : EXAMPLES OF HFC FREE TECHNOLOGIES IN VARIOUS SECTORS

The following sampling of companies and enterprises using HFC-free technologies in various sectors is provided to demonstrate that there is a wide array of technologies available, and that there is no need for the continued reliance on HFCs. It is not meant to be an all inclusive listing nor is the listing an endorsement by Greenpeace of any company or its products.

A. DOMESTIC REFRIGERATION AND AIR CONDITIONING

Domestic Refrigeration

Since 1992, hydrocarbon refrigeration, or Greenfreeze, has increasingly penetrated the domestic markets in Western Europe. Greenfreeze represented 35% of Western European production in 1996. 100% of German industry has now converted to hydrocarbon technology.

- Outside of Europe, hydrocarbons are now used as refrigerants (or soon will be used) in domestic refrigerators in Argentina, Australia, Brasil, China, Cuba, Indonesia, Japan.
- The following manufacturers, among others, are producing or will soon produce Greenfreeze: AEG (Germany), Arcelik (Turkey),Bauknecht (Germany), Bosch/Siemens (Germany), Candy Group (Italy, UK), Email (Australia), Electrolux (Sweden), Foron (Germany), Haier (China), Godrej (India), Inpud (Cuba), Kelon (China), Liebherr (Germany), Matsushita (Japan), Miele (Germany), Quelle (Germany), Thompson (France), Sanyo (Japan), Vestfrost (Denmark), Whirlpool (Italy)

There are over 40 million Greenfreeze refrigerators in the world today.

A.1 Current developments in domestic refrigeration:

• In the fall of 1999 the INPUD company in Santa Clara, Cuba, became the first manufacturer in Latin America to produce Greenfreeze, hydrocarbon refrigerators. The company plans to produce 50,000 the first years and then up to 100,000 units annually.

• In December, 1999 PT. Hartono Istana Electronics of Indonesia became the first manufacturer in South East Asia to produce Greenfreeze hydrocarbon refrigerators . The company plans to produce 120,000 units the first year.

• Whirlpool Argentina has confirmed that the company is now marketing imported Greenfreeze hydrocarbon refrigerators, and plans to start up production in 2000.

• Indian consumers will at long last have the option to purchase environmentally friendly refrigerators. Godrej company recently decided to switch from CFCs to hydrocarbon refrigerants.

In stark contrast, Electrolux is forcing its Indian subsidiaries to switch to HFC-134a, eventhough the company produces Greenfreeze for the European market. Electrolux thus follows the environmentally irresponsible example of Whirlpool India.

• In May, 1999 Candy, the giant Italian refrigerator manufacturer, unveiled its new line of hydrocarbon refrigerator which are produced in the company's newly converted UK plant. Candy Group intends to switch its entire fleet to hydrocarbons.

• In 1999 the French company Thompson announced its intention to produce hydrocarbon refrigerators.

• At the 1999 Domotechnica, Matsushita introduced a big 500 litre hydrocarbon refrigerator under the Panasonic brand. The unit features three doors, no frost freezer, and a super efficient and very quiet variable compressor. The size of this refrigerator puts to rest the often repeated myth of North American refrigerator manufacturers and the chemical industry that hydrocarbons can not be safely used in large fridges with no frost freezers.

• It is estimated that in China Greenfreeze now represents over 50% of production for the total domestic market of 10-12 million units.

• A 1998/99 Environment Canada report by an Expert Panel on Alternatives to Refrigerants found that in domestic refrigeration, air-conditioning and heat pumps hydrocarbons provided the best TEWI results. The study found that compared to HFC units, the hydrocarbon fridge saved between 700 to 800 kilograms of equivalent mass of CO2 over the life time of the refrigerator , and the hydrocarbon air-conditioner saved from 5000 to 7000 kilogram equivalent mass of CO2 over the lifetime of the air-conditioner.[15]

A.2 Hydrocarbon-Based Air Conditioners: The large Italian manufacturer De'Longhi has had on the European market a popular propane cooled portable air conditioners called Pinguino ECO since 1995.

Elstar Company of the UK produces a variety of hydrocarbon based split-air conditioners for both home and office use.

B. HFC-FREE COOLING IN COMMERCIAL ENTERPRISES

There are numerous supermarkets, office buildings, public institutions and commercial enterprises in various countries that have installed HCFC/HFC-free cooling technologies. There is a wide variety of HFC-free technologies available, but there is no single replacement for CFCs. These alternatives include, among others, hydrocarbon or ammonia based secondary cooling systems, dessicant cooling, evaporative cooling, absorption cooling. Consumers of cooling technologies must ensure that they chose the best available solution for their specific needs.

B.1 Hydrocarbon Cooling in Commercial Enterprises

Secondary cooling systems use coolants such as water, brine, glycols, silicon oils, or Flo-ice TM to circulate through refrigeration cabinets. The coolant itself is chilled, through a heat exchanger, by a primary refrigeration circuit using ammonia or hydrocarbons. The primary circuit is usually located in a safely isolated plant room in the back of the store. Non-fluorocarbon refrigerants such as ammonia and hydrocarbons are used as the primary refrigerants. Using secondary cooling significantly reduces the volume of primary refrigerant needed.

In an October, 1998 interview with the trade magazine Refrigeration and Air Conditioning, Mr. Graham Garner, the president of the British Refrigeration Association stated: *"I personally feel that we should look at refrigerants in the same way that we look at other refrigeration products and consider whole life costs. If we did that, our best option would be to use a hydrocarbon primary with a liquid secondary. This reduces maintenance costs, energy costs and is totally environmentally friendly."*

B.2 Recent developments in the use of hydrocarbons in commercial equipment:

[15] Environment Canada: Expert Panel on Alternatives to Refrigerants: Report On Residential Applications: 1998

- The UK based Earthcare Products is marketing a wide range of commercial cooling equipment that use hydrocarbons (e.g. wall mounted and ceiling mounted air conditioners, dehumidifiers, mobile air conditioning, sliding door display coolers, bottle chillers, wine cooler dispensers, glass door merchandiser, mini bars, deli display cabinets, chest chill cabinets, defrost type freezer chillers, multi-deck display cabinets, freezers, ice cream conservators, water coolers).

- Sainsbury's, next to the Millenium Dome in London, currently under construction, is designed to be a state of the art supermarket for energy saving, with all of the air-conditioning and refrigeration provided by HFC-free technologies.

- MacDonalds in the Millenium Dome in London has opted to use all HFC-free cooling equipment.

- The giant food company and ice cream distributor, Unilever, has successfully conducted a pilot project in India for using hydrocarbons in ice cream freezers, and is presently planning to expand the use of hydrocarbon equipment in India, Pakistan, China and Brasil.

- The May 31, 1999 issue of "Ku-cho (Air-conditioning)Times" of Japan reported that General Heat Pump Industry in cooperation with Chubu Electric Power Co.successfully developed a propane chiller for air-conditioning. In drop-in tests the new propane chiller seems to be 5 – 7% more efficient than conventional chillers. Initial price will be 10 to 15% higher. Both companies will continue testing for safety and other details in 1999 and commercialisation is expected in early 2000.

- The Danish manufacturer Vestfrost is now producing a hydrocarbon display cabinet bottle cooler featuring a high efficient Danfoss variable compressor.

B.3 Examples of commercial enterprises using hydrocarbon refrigerants:

- REWE Supermarket (Germany)
- Edeka Supermarkets (Germany)
- Frucor Processors (Hastings, New Zealand)
- Tip Top Bread (Auckland, New Zealand)
- Kiwi Co-operative Diaries Ltd, (Hawera, New Zealand)
- Bodo Airbase (Norway):
- Backhammars Bruk (Sweden)
- AG-Favor (Sweden)
- PUB Department Store (Sweden)
- Sainsbury's Supermarket (UK)
- Tesco's Supermarket (UK)
- Out of This World Stores (UK)
- Iceland Supermarkets (UK)
- National Trust (UK)
- Royal Institute of British Architects (UK)
- National Hospital (UK)
- Chartered Society of Physiotherapy (UK)
- London Transport (UK)
- Esso Gas Station Supermarkets (UK)

B.4 Ammonia Cooling in Commercial Enterprises

CANADA

- Campbell's Soup - Toronto, Ont.- office building

DENMARK

- Hvidovre Hospital
- Copenhagen University Rigshospitalet
- Ilum and Magasin Department Stores
- Scandic Hotel Copenhagen
- SDC Bank (data bank for financial institutions)

- Copenhagen Airport
- Danish National Television
- SAS Building, Aarhus

GERMANY
- Hannover Trade Fair Building: One of the largest commercial ammonia air-conditioning systems in the world , using two and a half tonnes of ammonia to generate 3.5 megawatts of cooling.
- Leipzig Trade Fair Building
- Lindplatz Centrum-Berlin-shopping center
- Casino & Supermarket, Monsdorf

JAPAN
- Ashai Brewery - Nogano

LUXEMBOURG
- Palais Grande Ducal and Parliament
- Cactus Supermarket
- Match Suoermarket
- IBM Luxembourg
- ASTRON Building
- Imprimerie St. Paul
- City Concorde
- Banque Van Lanschot
- Dresdner Bank
- Husky
- Amro Bank

NORWAY
- Oslo Airport
- Kodak Norge Office

SPAIN
- Carlos III University in Leganes

SWEDEN
- Arlanda Airport-Stockholm
- KF Stores

UK
- Middlesex University

UNITED STATES
- Biosphere II Oracle - Tucson, AZ - space a/c
- McCormick Place Convention Center - Chicago, IL-convention center
- Stanford University- Palo Alto, CA - district cooling (multiple buildings)
- Montgomery College-Germantown, MD -district cooling
- USF&G - Baltimore MD- office building
- Rockford Arts & Science Museum-Rockford, IL -ice storage/space cooling
- University of Miami- Miami, FL-marine studies center
- Blue Cross Blue Shield-Chicago, IL-office building
- Xerox Office Complex-Los Angeles, CA-office building
- Montgomery County College, Maryland
- Trinity College, Hartford, CT
- Montgomery County College, Maryland

B.5 Dessicant Cooling in the United States

B.5.a Supermarkets : US

- Super Rite Foods, Inc. Baltimore, MD
- Cub Foods, Atlanta Georgia
- ShopRite, Newton, New Jersey
- First National Supermarket, Windsor Locks, Connecticut (33 stores)
- Shaw's Supermarkets, Seabrooke New Hampshire
- Harris Teeter Stores, Charlotte, North Carolina
- Baker's Supermarkets, Omaha, Nebraska
- Big Bear Supermarkets, Westerville Ohio
- H.E.B. Supermarkets, San Antonio, Texas
- Wal-Mart Stores Benton, AK (Season's 4)
- Wal-Mart Stores, various nationwide (Munters)

B.5.b Commercial Enterprises and Public Facilities: US

- JC Penny Department Store, White Plains, NY (Engelhard/ICC)
- Burger King, Tampa, FL (Advanced Thermal Technologies)
- Denny's Restaurant, Clearwater, FL (Advanced Thermal Technologies)
- Burger King, Aberdeen, MD (Engelhard/ICC)
- Ft. McNair Commissary, Wash. DC, (Engelhard/ICC)
- Ft. Campbell Commissary, Ft. Campbell, KY (Engelhard/ICC)
- Willis-Knighton Medical Center, Shreveport, LA (Munters)
- Northeast Baptist Hospital, San Antonio, TX (Munters)
- Jewish Home for the Elderly, Fairfield, CT (Robur)
- University Hospital, Augusta, GA (SEMCO)
- The Medical College of Georgia, Augusta, GA (SEMCO)
- Walt Disney World swan, Orlando, FL (Munters)
- Park Hyatt Hotel, Wash. DC (Englehard/ICC)
- Liz Claiborne Inc. Montgomery, AL (Englehard/ICC)
- Powers Pharmaceutical Co. Brockton, MA (Munters)
- Nowlin Residence, Minneapolis, MN (Comfort Solution)

B.6 Evaporative Cooling in the United States

Evaporative water coolers are one of several alternatives to current models of refrigerators and air conditioners. In the United States more than 70 companies manufacture evaporative air conditioners for residential, automotive, commercial and industrial markets.

Direct, or single-stage, evaporative coolers are used on tens of thousands of homes in the western US, as well as thousands of commercial establishments-shops, restaurants, dry cleaners, offices, warehouses, factories.

Indirect-Direct, or two-stage, evaporative air conditioning systems are also used in numerous applications- schools, office buildings, commercial buildings and homes.

Examples include:

- America West Airlines Technical Support Facility (Phoenix AZ)
- Golden Hill Office Complex (Denver, CO)
- Intersil/GE Office Building (Cupertino CA)
- Camelback Hospital (Scottsdale, AZ)
- Colorado Springs School District, Colorado Springs, CO (multiple schools
- Cherry Creek School Districts, Aurora, CO (multiple schools)
- Vacaville State Prison, Vacaville, CA
- Anaconda Copper Laboratory (Tucson, AZ)
- Arapahoe Park Race Track Clubouse/Grandstand (Aurora, CO)
- US Postal Service Bulk Mail Facility (Denver, CO)

B.6. Absorption Air-Conditioning in the United States

The examples below are coded by the type of absorption system installed. Where only the manufacturer's name is indicated the building uses a single-effect absorption chiller and where "2x" is indicated a double-effect absorption chiller is used. In either case, the refrigerant is water and the absorber is lithium bromide. Most of the installations noted use natural gas-fired chillers, some use high pressure steam.

B.6.a : Commercial and Retail Buildings: absorption cooling in US

- Reliance Federal Savings, Office Building, Garden City, NY (Carrier-2x)
- Canadian Imperial bank of Commerce, Toronto, Ont. (Carrier-2x n)
- Toyota Motor Sales USA, Torrance, CA (McQuay-2x)
- Oklahoma Natural Gas Co. Oklahoma City, OK (McQuay-2x)
- Ecology and Environment Offices, Buffalo, NY (Trane)
- Owensboro National Bank, Owensboro, KY (Robur
- Yankee Gas Services Co., Stonington, CT (Robur)
- Union Central Life Insurance, Cincinnati, OH (Trane-2x)
- AT&T, St. Louis, Mo (York-2x)
- Merck & Co. Pharmaceuticals Headquarters, Readington NJ (York 2x)
- National Audobon Society, New York, NY (York 2x)
- US Air, Laguardia International Airport Terminal, New York, NY (York-2x)
- Pratt & Whtiney, East Hartford, CT (Carrier)

B.6.b Educational Institutions: absorption cooling in US

- Illinois Mathematical and Science Academy, Aurora, IL (Carrier)
- Brandies University, Waltham, MA (Carrier-2x)
- Texas A&M University, College Station, Texas (Carrier-2x)
- Doane College, Crete, NE (McQuay-2x)
- University of Toronto, Toronto, Ont. (McQuay-2x)
- Dixon University center, Harrisburg, PA (McQuay)
- Oak Hill School for the Blind, Hartford, CT (Robur)
- Estrella Mountain Community College, Phoenix, AZ (Trane)
- Union Community College, Elizabeth, NJ (Trane)
- Viterbo College, LaCrosse, WI (Trane-2x)
- Northbrook Junior H.S., Northbrook, IL (York)
- Winston campus School, Palatine, IL (York-2x)
- The Learning enter, Queens, NY (York-2x)
- Walter and Lois Curtis School, Allen, TX (York-2x)
- Rockwall H.S., Rockwall, TX (York 2x)

B.6.c Government Buildings : absorption cooling in US

- City of Mesquite, Recreation Center, Mesquite, TX (Yazaki)
- Federal Energy Regulatory Commission HQ (FERC) Wash. DC (Trane-2x)
- Cook County Dept. of Corrections, Chicago, IL (Trane)
- US Courthouse and Federal Building, Phoenix, AZ (York 2x)
- Aurora Municipal Justice Center, Aurora, CO (York-2x)
- State of Illinois Building, Chicago, Il (York-2x absorbtion)
- Department of Employment and Training, Boston, MA (York-2x)
- The Ohio Statehouse, Columbus, OH (York-2x)

B.6.d Hospitals and Public Health Buildings: absorption cooling in US

- Resurrection Medical Center, Chicago, IL (Carrier)
- Sherman Hospital, Elgin, IL (Carrier)
- Little Company of Mary Hospital, Evergreen Park, IL (Carrier)
- Loyola Medical Center, Maywood, IL (Carrier)
- Jamaica Hospital Medical Center, Queens, NY (Carrier)
- Claremont Manor, Claremont, CA (McQuay)

- Scripps Clinic, San Diego, CA (York)
- St. Joseph Medical Center, Wichita, KS (McQuay-2x)
- Our Lady of Mercy Medical Center, Bronx, NY (McQuay)
- Rapid City Regional Hospital, Rapid City, SD (McQuay)
- Alexian Brothers Medical Facility, Elk Grove, IL (Trane-2x)
- BroMenn Regional Medical Center, Normal, IL (Trane-2x)
- St. Joseph Medical Center, Joliet, IL (Trane-2x)
- Anne Arundel Medical Center, Annapolis, MD (Trane)
- Dept. Of Veteran's Affairs Hospital (Bronx, NY (Trane)
- Montefiore Medical Center, Bronx, NY (Trane-2x)
- Craven Regional Medical Center, New Bern, NC (Trane-2x)
- St. Luke's Hospital, Maumee, OH (Trane-2x)
- The Toledo Hospital, Toledo, OH (Trane)
- Baptist Medical Center, Little Rock, AK (York-2x)
- Copely Hospital, Aurora, IL (York-2x)
- St. Francis Hospital, Evanston, IL (York-2x)

B.6.e Other Examples of Absorption Cooling in the US

- Guest Quarters Suites, Chicago, IL (York-2x)
- Loctite Corp. Rocky Hill, CT (Trane co-gen absorbtion)
- Nestle Quality Assurance Laboratory, Dublin, OH (York-2x)
- Nestle, New Lehigh Valley, PA (York-2x)
- Apartment Building, Chicago, IL (York-2x)
- Apartment Building, Chicago, IL
- IMAX Theater, Dallas, TX (Yazaki)
- Norfolk International Airport, Norfolk, VA (McQuay-2x)
- Jungle World, Bronx, NY (York)
- Pennsylvania Convention Center, Philadelphia, PA (York)

B.7 Co-Generation Cooling

Air-conditioning technologies based on the use of waste heat from on-site electricity generation have the potential to greatly reduce energy consumption. This eliminates HFC use in many large-scale applications immediately.

- The Banque Generale du Luxembourg has installed a gas fired co-generation system that produces 90% of the Bank's energy needs and 100% cooling and heating. The cooling is provided with three absorption chillers using lithium bromide as the absorbent. The bank estimates that it save 1 million dollars in energy costs, and reduces CO2 emissions by 6500 tons a year. The system is American designed and installed by Trane.

- Ashai Brewery announced in 1999 that the company was installing a co-generation energy system at the Nagoya plant, using ammonia absorption for air-conditioning and hydrocarbons for the beer vending machines. The company expects to save 400 million yen a year from the resultant energy savings.

B.8. District Cooling

In Copenhagen where district heating has been in place for years through the incineration of household and industrial waste, plans are in the works for district cooling, using ammonia as the refrigerant

B.9 Passive Cooling

The architectural redesign of new buildings to make use of natural ventilation, coupled with efficient insulation, can eliminate or reduce the need for mechanical air-conditioning and thus save energy.

C. MOBILE AIR-CONDITIONING AND TRANSPORT COOLING

- Approximately 50% of global HFC-134a production is for automotive air conditioning, 15% for domestic refrigeration, and most of the remaining 35% for commercial and residential air-conditioning and supermarket refrigeration. A 1997 study by Atlantic Consultants of the UK reveals that the HFC-134a leakage from the air-conditioning of autos sold in 1995 in Western Europe alone will generate the C02 equivalent of five new power plants, while the HFC-134a leakage from automobiles sold in Japan in 1995 will contribute the C02 equivalent of ten power plants, or approximately 16 million tonnes of C02.

- A study by the School of Chemical Engineering and Industrial Chemistry, University of New South Wales, indicates that hydrocarbon automobile air-conditioners are almost 35% more efficient than HFC air conditioners and that if countries in Asia used hydrocarbons instead of HFCs in automobile air-conditioners there would be 3.7 billion tonnes less cumulative CO2 emissions by the year 2020.[16]

- "Automobile air conditioners are subject to leakage, with sufficient refrigerant leaking out (15 to 30 percent of the charge) over a 5-year period to require servicing. On its Form EIA-1605, General Motors (GM) reported total HFC-134a emissions of nearly 1,500 metric tons from GM-made vehicles on the road in 1996. GM based this estimate on an assumed annual leakage rate of 10 percent per year. With GM vehicles accounting for about one-third of the U.S. light-duty fleet, the GM emissions estimate implies that total U.S. HFC-134a emissions from mobile air conditioners were equal to about 4,500 metric tons in 1996. Emissions from this source are expected to continue to increase in the near future, as the replacement of vehicles using CFCs proceeds at a rapid pace."[17]

- Car manufacturers realize that they will have to move away from HFCs and already have prototypes for hydrocarbon and carbon dioxide mobile air-conditioners. Denso of Japan, for example, has a prototype for hydrocarbon air-conditioners, while a European consortium of car manufacturers , which includes among others Mercedes Deimler and Volvo, has developed a CO2 system. Either of these options could be commercialized within one or two years. Only the commercial will is lacking to make the switch.

- CO2 systems already have at least 30% lower TEWI than HFC systems, as shown by extensive measurements carried out at the University of Illinois (Yin, 1999). Other studies reporting on trials comparing CO2 prototypes against state-of-the R134a system in real situations indicate that the COP of the CO2 system was typically 25% greater than that of the R134a system. [18]

- Over 300,000 cars have been converted in Australia from CFCs and HFCs to hydrocarbons. Similar conversions are happening in North America without regulatory approval.

- TransAdelaide Bus Company has installed hydrocarbon air conditioning in the drivers' compartment, while the passengers compartment is cooled by dessicant cooling.

- The Denver Regional Transit Department began equipping buses in the early 1980's with roof mounted evaporative air conditioning systems, which saves up to 2000 gallons of diesel fuel per bus per year as a result.

- The German company Konvecta uses carbon dioxide for bus air-conditioning.

- Frigoblock UK will soon be supplying transport refrigeration units operating on hydrocarbon refrigerants to Earthcare Products.

C.1 Evaporative Bus Air-Conditioning

Nearly 500 buses (in Colorado, Utah, California and Texas) and additional buses in Adelaide and Perth, Australia use evaporative or adiabatic air conditioning systems.

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[16] Pham, Tuan and Aisbett, E. : Natural Replacements for Ozone-Depleting Refrigerants in Eastern and Southern Asia: School of Chemical Engineering and Industrial Chemistry, University of New South Wales: to be published by the International Journal of Refrigeration- in press 1998.

[17] US Department of Energy's Energy Information Agency website. http://www.eia.doe.gov/oiaf/1605/gg98rpt/halocarbons.html

[18] Notes from Calor Gas reporting on studies by Walter & Krauss, 1999; Walter 1999; DKK 1998) and confirmed on Mercedes (Daimler-Benz web site (http://www.daimler-benz.com/ind_gfnav_e.html?/research/text/80331_e.htm

- Regional Transportation District, Denver, CO
- Denver International Airport, Denver, CO
- Utah Transit Authority, Salt lake City, UT
- University of California at Berkeley, Berkeley, CA
- Sacramento Regional Transit, Sacramento, CA
- Pacific Gas & Electric Co. CA
- Lewis Bros, Stages, Wendover, NV
- Golden Gate Transit, San Francisco, CA
- Allensworth State Park. Allensworth, CA
- Transperth, Perth, Australia
- State Transit Authority, Adelaide, Australia

D. FOAMS

D.1 Building Insulation

Rigid Polyurethane foam (PUR) is commonly used in construction as an insulating foam. There are a number of different kinds of foam which are all rigid PUR --most noteably, boardstock, sandwich panels and spray foams .

Boardstock is prominently used in roof and wall insulation in commercial buildings. Sandwich panels, where the foam is sandwiched between facing materials such as steel and aluminium, are used for insulating cold stores, cold rooms and doors. Spray foams are made at the point of use and are literally sprayed into place. They are highly suitable for the insulation of uneven or inaccessible surfaces and are used in storage tanks, pipe work and refrigerated trailers.

Particularly in Europe companies are using pentane --a hydrocarbon-- as an alternative blowing agent for both board stock and sandwich panels.

- Thanex in Denmark have used a mechanical process for producing PUR insulating foam.

- Recticel (Belgium), the largest manufacturer of PUR foams in Europe, and Bayer, have been producing hydrocarbon blown foams for construction applications for a number of years.

- The large American company, Atlas Roofing, has begun to convert its 7 plants to producing hydrocarbon blown building foam insulation. This represents the first use of hydrocarbons in foam production in North America and the company received the US EPA Ozone Award for its initiative. The company sites environmental and economic reasons for favouring hydrocarbons over the chemical industry's HFC-356mfc and HFC-245fa.

- The French company Efisole has also switched to using pentane for various polyurethane foam production. German companies have been using hydrocarbons for nearly a decade.

- Alternatively, CO_2 is currently being used as the blowing agent by ICI and Liquid Polymers Group in the UK, ResinaChemie and BASF in Germany and Nassau Doors in Denmark. Carbon dioxide blowing, in combination with process changes, as demonstrated by Windsor Doors in Norway, is a proven technology for spray foams.

- Often the best alternatives to polyurethane boardstock are not foam at all. Magnesium carbonate, as produced by Darchem in the UK, can be made into an insulation product for use in power stations and oil installations. Products such as mineral fiber and fiberboard have always been in competition with polyurethane. Mineral fiber is dominant in insulation products in the UK. Meanwhile, the Swiss company Isofloc produces boardstock panels made out of cellulose. The panels are made out of recycled materials.

  Extruded polystyrene is also used as a rigid boardstock, where its moisture resistance and strength make it suitable for below ground construction insulation , for example, in foundations. Dow Chemicals and BASF use carbon dioxide technology to produce extruded polystyrene. The product is sold in many European countries.

- In most markets, with the exception of North America, cyclopentane has now become the standard choice for the blowing rigid polyurethane foams which continue to be the dominant insulation used in domestic refrigerator-freezers. Alternative foam blowing agents include water, CO_2.

D.2 District heating pipes
More than half of the world production of pre-insulated district heating pipes takes place in Denmark, at four companies: ABB District Heating (I C Moller), Logstor Ror, Tarco Energy and Starpipe (Dansk Rorindustri).

As from January 1993 CFC was no longer allowed for the blowing of insulation foam for district heating pipes in Denmark. HCFC - as a transitional solution - and CO_2 have been used instead. Now all four companies have developed systems based on cyclopentane or other hydrocarbons. Two of the companies also continue producing CO_2-based pipes.
based pipes.

D.3 Portals, industrial doors
Two Danish companies, Nassau Doors and Windsor Door, produce industrial portals and doors with sandwich panels containing polyurethane foam. They are now using CO_2.

D.4 Rigid integral foam
The Danish firm Tinby A/S has a considerable production of rigid integral foam for industry, especially the graphical industry. They stopped using CFC in 1993 and have since used CO_2 in the major part of the production, and HCFC in a minor part. HCFC is now replaced by CO_2.

D.5 Jointing foam
Baxenden Scandinavia produces canister foam sealant (jointing foam) and has, since 1987, produced cans with propane/butane propellant for the Scandinavian market and cans with HCFC for the European market.

D.6 Flexible integral foam
Baxenden Scandinavia has developed systems for producing flexible integral foam with isopentane as blowing agent.

Ecco, a big producer of shoes, has in cooperation with Bayer developed a technology for producing shoe soles of flexible integral foam without using ODS. The blowing agent is CO_2.

D.7 Flexible foam
Three Danish companies (Brdr.Foltmar, KBE and Danfoam) are producing flexible slabstock foam at four localities. They stopped using CFC in 1991 and use CO_2 for the major part of production.

Urepol Oy is a Finnish company manufacturing polyurethane insulated steel-faced and flexible faced panels, and one-component PUR foam insulation. The company is now using hydrocarbons to produce products which were previously manufactured with CFCs and HCFCs

D.8 Vacuum insulation
Vacuum insulation panels, which offer superior insulation for appliances and provide significant energy savings are increasingly being applied. These vacuum panels are filled with e.g. silica , fiberglass, or ceramic spacers.

- NoFrost Co. of the UK is launching a new line of hydrocarbon freezers in 1999 using vacuum panels which were developed in cooperation with ICI for insulation, and hydrocarbons for the refrigerant.

- Vacuum panels in appliances are used by General Electric and Owens-Corning in the USA.

- In Japan, Sharp combines the use of vacuum panels with PUR foam blown with cyclopentane in domestic refrigerators. AEG in Germany has introduced some vacuum panel insulated fridges

- The Swiss Ecofridge Project uses vacuum insulation, where the vacuum is filled with diathomaceous earth. The thermal conductivity is about 0.005 compared with 0.020 in

E. METERED DOSE INHALERS (MDIs)
In 1996 it was reported that there were 70 million asthma sufferers world-wide; 70 per cent of whom relied on CFC propelled MDIs to deliver their therapy; 440 million MDIs were manufactured each year requiring 6,750 tons of CFCs. The total was projected to increase to 800 million MDIs by the year 2000 requiring nearly 11,000 tons of CFCs. Global sales of MDIs in 1996 were more than $4 billion each year.

Asthma sprays filled in Germany in 1996 represented the equivalent of 1,000 tonnes of CFC-11 in terms of their ODP (38 per cent of the country's share).

Pharmaceutical giants like Glaxo and Boehringer-Igelheim have chosen to move away from CFCs by switching to HFC-134a or HFC-227. It is estimated that if all asthma sprays filled in Germany were converted to using HFC-134a as a propellant, their emissions would be equivalent to 2.5 times the greenhouse effect of the annual emissions of all fifty German incineration plants for domestic waste.

The substances which asthma sufferers need to propel into their bronchial tubes can be inhaled just as easily, if not better in many cases, in powdered form. New, easy and safe-to-use powder appliances are said by German pneumologists to be equivalent to CFC-propelled sprays in terms of their medical effect.

- Orion Pharma (Germany have completely switched their whole range of asthma sprays to CFC/HFC free methods.

- In Sweden nearly 80% of asthma patients now use dry powder inhalers.

Greenpeace maintains that the use of HFC-134a in MDIs should be maintained on a “critical use exemption” basis. This should signal the industry that HFC-134a does not represent the long term solution.

F. SOLVENTS
No-clean technology has replaced CFC solvents in much of the electronics industry. Aqueous cleaning, simple soap and water, use of fine ice particles and pressurized gases has also displaced CFC use.

G. AEROSOLS
Alternative application methods, such as solid stick and roll-on dispensers, mechanical pump sprays, brushes and pads are among the wide variety of alternatives in commercial use.

Alternative spray propellants include hydrocarbons, dimethyl ether, and other compressed gases such as air and CO2. Many developing countries have switched to, or have always employed propellants such as pentane and butane in industrial uses.

H. FIREFIGHTING
Alternative extinguishing agents, such as CO2, water, foam and powder are already widely used. Inergen , a mixture of natural gases like nitrogen, carbon dioxide and argon, is another halon alternative. Good fire prevention practices , of course, are a prerequisite.

APPENDIX C : HFCS IN THE EUROPEAN UNION (EU15)

The following represents the summary of a longer 1999 report prepared for Greenpeace on HFC consumption and emissions in the EU15 countries.

I. HFC consumption in 1998

Table 1: HFC consumption and emissions in the EU15 during 1998

		HFCs (metric t)	only 134a (t)
1. Stationary refrigeration/AC			
1.1 New systems		**14000**	**8500**
Domestic refrigeration		2500	2500
Commercial refrigeration		6000	2000
Industrial refrigeration		1500	1000
Residential AC		1000	800
Small hermetics <1 kg		2400	2000
Transport refrigeration		600	200
1.2 Leakage refilling	annual leakage	**4517.5**	**1950**
Domestic refrigeration	1 %	75	75
Commercial refrigeration	20 %	3000	1000
Industrial refrigeration	15 %	562.5	375
Residential AC	10 %	250	200
Small hermetics <1 kg	3 %	180	150
Transport refrigeration	30 %	450	150
2. Mobile AC			
2.1 New systems		**8000**	**8000**
Car AC		7200	7200
AC in other vehicles		800	800
2.2 Leakage refilling	annual leakage	**2700**	**2700**
Car AC	12 %	2400	2400
AC in other vehicles	15 %	300	300
3. One component PU foam		**4900**	**4000**
4. MDI		**1000**	**950**
5. PU rigid foam/Integral skin		**900**	**900**
6. Technical aerosols		**1000**	**900**
7. Fire fighting/solvents/etching		**450**	**0**
GWP 100y of HFC 134a	1300		
Average GWP of all consumed HFCs	1551		
Average GWP of all emitted HFCs	1456		
Consumption in 1998 (metric t)		**37468**	**27900**
Emissions in 1998 (metric t)		**15468**	**11400**
HFC consumption in 1998 was equivalent to CO_2 (million tonnes)		**58.1**	**36.3**
HFC emissions in 1998 were equivalent to CO_2 (million tonnes)		**22.5**	**14.8**

II. A view towards 2012 ("business as usual")

Table 2: HFC consumption and emissions in the EU15 in 2012 "Business as usual" scenario			
	Category*	HFC (metric T)	only 134a (t)
1. Stationary refrigeration/AC			
New systems	C	19000	11000
Refilling annual leakage	E=C	16000	10000
Disposal emissions	E	4000	2400
2. Mobile AC			
New systems	C	10500	10300
Refilling annual leakage	E=C	10500	10300
Disposal emissions	E	2500	2500
3. One component PU foam	C=E	10000	9000
4. MDI	C=E	6600	5000
5. Technical aerosols	C=E	2000	1800
6. Fire fighting/solvents/etching	C (E=450)	500	0
7. PU rigid foam			
New systems	C	41000	1000
Annual life cycle emissions 1%	E	4100	100
Annual manufacturing loss 10%	E	4100	100
8. XPS foam			
New systems	C	12000	10800
Annual life cycle emissions 3%	E	2400	2400
Annual manuf. loss 134a 25%	E	2700	2700
Annual manuf. loss 152a 100%	E	1200	0
9. PE foam			
New systems	C	500	500
Annual life cycle emissions 3%	E	100	100
Annual manuf. loss 134a 25%	E	125	125
Consumption in 2012 (metric t)		**128600**	**69700**
Emissions in 2012 (metric t)		**66775**	**46525**
HFC consumption in 2012 will be equivalent to CO_2 (million tonnes)		**155.8**	**90.6**
HFC emissions in 2012 will be equivalent to CO_2 in 2012 (million tonnes)		**93.9**	**60.5**

*C: Consumption; E: Emission; GWP 100y 134a: 1300; GWP 100y average HFC consumption: 1212; GWP 100y average HFC emissions: 1406.

Conclusion – HFCs in 2012 compared to HFCs in 1998

- As the comparison of Table 2 to Table 1 shows, if "business as usual" continues, consumption of HFCs from 1998 to 2012 will increase from 37,500 tonnes to 128,600 tonnes – or 250 percent.

- Decisive for this trend are new HFC applications that were still HCFC applications in 1998: as blowing agents for PU rigid foam (245fa/365mfc HFCs) and blowing agents for XPS and PE foam (134a and 152a HFCs). More than 53,000 tonnes of HFCs will be used in these new areas in 2012 – more than 40 percent of total HFC consumption. The blowing agent is not emitted immediately; it remains largely in the pores of the foam and escapes in small portions during the foam's life span. In 2012, only some 15,000 tonnes of HFCs will escape from foam (not including canned PU foam).

- Consumption growth in the "old" (already existing in 1998) applications occurs, from 37,500 to 75,100 tonnes. The main reason is that large amounts are needed to refill the constant leakage in stationary refrigeration and air conditioning and mobile air conditioning. Consumption also increases in the production of MDIs and canned PU foam.

- Emissions increase more rapidly in "old" applications than in new ones. Added to the emissions occurring during consumption (leakage refills and aerosol use) are the disposal losses that didn't exist yet in 1998. The direct atmospheric emissions from old applications are 52,000 tonnes (as compared to the 75,000 tonnes consumed during production).

- Emissions of R134a from new applications are 5,500 out of 15,000 tonnes of HFCs altogether; emissions from old applications are 41,000 out of 52,000 tonnes of HFCs altogether.

- Emissions contributing to the greenhouse effect will increase between 1998 and 2012 from 22.5 to 93.9 million CO_2-equivalent tonnes. The portion of 134a increases from 14.8 to 60.5 million CO_2-equivalent tonnes. 134a is by far the most significant HFC for the climate. By 2012 it will represent 65 percent of all greenhouse-relevant HFC emissions.

Sources for Appendix B

Greenpeace research was based on new studies and interviews with experts: "Opportunities to Minimise Emissions of Hydrofluorocarbons (HFCs) from the European Union", March Consulting Group (UK), 30 September 1998;

"Projection à 15 ans des émissions de HFC, Rapport d`etude", AFCE (Association Française du Froid), May 1998;

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