HOW TO LIMIT HFC EMISSIONS?
Eliminate Them

A *Greenpeace* Position Paper

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Core Issues

The core issues facing the Joint IPCC/TEAP Experts Meeting 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.

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 stabilize greenhouse gases concentrations in the atmosphere at levels that are necessary to avoid dangerous climate change we must cut back on total greenhouse gas emissions 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 and sensible course of action.

The need to control HFC emissions is all the more urgent given the most recent scientific findings which confirm that rising levels of CO_2 and other greenhouse gases are likely to significantly amplify the ozone depleting capacity of stratospheric chlorine and bromine loading. These recent scientific developments have not yet been incorporated into the ODS phase-out regime of the Montreal Protocol.

Estimating Future 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 HCFCs where industry is promoting HFC replacements and projected growth in each sector;
- current uses of CFCs where industry is promoting HFC replacements and projected growth in each sector;
- potential for new applications of HFCs.

Chemical corporations that profit from the manufacturing of HFCs downplay, for obvious commercial reason, the potential negative environmental and human health impacts of their products.

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 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". [1]

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. [2]

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"[3].

More recently, a 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%).*" [4]

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%).[5]

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

Such high level of emissions could undermine the intent of the Kyoto Protocol as well as set back the progress that has been made to protect the ozone layer.

Who are we to believe? The industry or the independent sources? The chemical industry does not exactly have a sterling record for disseminating information which may adversely effect its profit base. Either way, we need to adhere to the wisdom of the precautionary principle which requires that *no ingredient should be introduced to the environment prior to it being proven to be environmentally safe*.

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.

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.[6]

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 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.

Unrealistic Industry Strategy for Reducing HFC Emissions

Industry maintains that better recapturing and recycling procedures and more efficient applications will sufficiently reduce HFC consumption. This is simply unrealistic, and is more of a marketing strategy than an effective response to the need to reduce HFC emissions. How realistic can this strategy given the dismal global record of CFC and other ODS recapturing? How realistic is it in the context of developing countries? Not at all.

The fact is that in most applications alternatives to HFCs are as efficient or better than HFCs, so that equipment optimization will yield greater benefits when applied to HFC-free technologies.

Legally Binding Assurances 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 damages resulting from the global use of these substances.

Furthermore, the industry should agree to a global cap on HFC production and emissions. The chemical industry is yet to pay one penny of reparation to help mitigate the damage that CFCs

[6] 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

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.

There Is Life After HFCs

The good news is that there are environmentally sound, technologically reliable, commercially proven alternatives to most applications of HFCs.[7] 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 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 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.

GREENPEACE RECOMMENDATIONS

A. HFCs 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 guideline (similar to Article 2F/Paragraph 7 of the Montreal Protocol regarding HCFCs) stipulating that each Party shall endeavor to ensure that HFCs 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. The Parties to the Montreal Protocol should instruct the Executive Committee of the Multilateral Fund of the Montreal Protocol to show preferential consideration in funding to CFC replacement technologies that do not contribute to global warming.

C. 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 specialized applications, such as metered dose inhalers (MDIs).

[7] See Appendix A for examples of enterprises utilizing HFC-free technologies.

D. Based on best estimate emission scenarios and on ecological limits a global cap should be established on annual HFC emissions. In addition, governments should set national HFC caps.

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

F. The health impacts of HFCs should be thoroughly investigated by an independent, internationally sponsored body.

G. A legally binding contract should be entered into between governments, representing the public's interest, and the chemical industry, which stipulates that the industry will pay full reparations for any and all damages resulting from the global use of these substances.

H. 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 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 industry, with its vast resources, will not attempt to steer the review process towards the wholesale endorsement of HFCs.

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 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.

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

APPENDIX A : 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.

1. 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 35 million Greenfreeze refrigerators in the world today.

Current developments in domestic refrigeration:

• 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.

• 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.[8]

• **Hydrocarbon-Based Home 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.

2. 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.

2.1 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.”*

Recent developments in the use of hydrocarbons in commercial equipment:

- 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.

- 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 commercialization is expected in early 2000.

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

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

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)

2.2 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

2.3 Dessicant Cooling in the United States

2.3.a Supermarkets : dessicant 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)

2.3.b Commercial Enterprises and Public Facilities: dessicant 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)

2.4 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)

2.5 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.

2.5.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)

2.5.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)

2.5.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)

2.5.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)

2.5.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)

2.6 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.

2.7 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

2.8 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.

3. MOBILE AIR-CONDITIONING AND TRANSPORT COOLING

50% of HFC-134s production is for automobile air-conditioning . 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.

• 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.

3.1 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.

- 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

4. FOAMS

4.1 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.

4.2 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.

4.3 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.

4.4 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.

4.5 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.

4.6 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 CO2.

4.7 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 CO2 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

4.8 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

5. 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.

6. 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.

7. 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 CO_2. Many developing countries have switched to, or have always employed propellants such as pentane and butane in industrial uses.

8. FIREFIGHTING
Alternative extinguishing agents, such as CO_2, 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 B : 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;

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