Building Owners Save Money, Save the Earth

Replace Your CFC Air Conditioning Chiller







DRAFT - March 2002

The Montreal Protocol and Industry Leadership

By the 1980s, scientists had concluded that chlorofluorocarbons (CFCs) were destroying the fragile ozone layer, and the United Nations Environment Programme had begun diplomatic negotiations. Deciding that international action was needed, negotiators from governments around the world crafted a treaty called *The Montreal Protocol on Substances that Deplete the Ozone Layer.* The Montreal Protocol provided the first global controls on CFCs and halon fire fighting chemicals. In the decade that followed, the Montreal Protocol was made more stringent by amendments and adjustments as scientific expeditions and space observations proved that the Antarctic ozone hole was caused by chemical emissions and that depletion was also occurring over Europe and North America. More than 180 countries have now ratified the Montreal Protocol.

Fortunately, industry leadership and innovation, combined with prudent environmental regulations, facilitated the development of new refrigerants that perform as well or better in new equipment than the ozone-depleting chemicals they replaced.

In the refrigeration and air conditioning sector, industrialized countries have used a combination of voluntary, regulatory, and economic measures to encourage the development and use of new technology, to encourage retrofitting to more environmentally acceptable refrigerants, and to encourage improved containment and recovery practices for all refrigerants. HFC and HCFC chillers are used for new construction and for retrofit or replacement of equipment with CFC-11 and CFC-12 refrigerants. Now is the time to evaluate and schedule a chiller replacement.

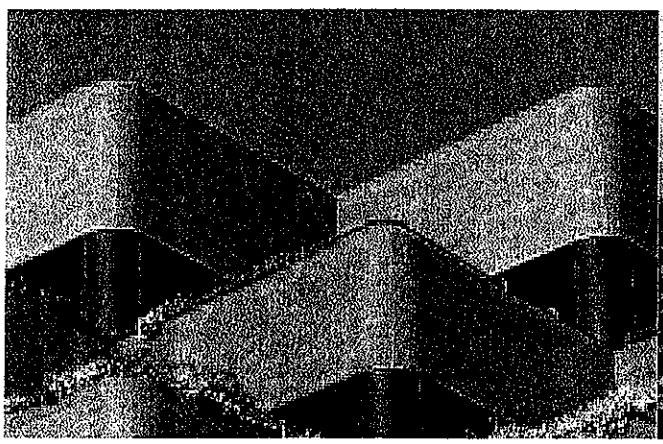
Imagine the satisfaction of earning a high financial return on your investment while increasing building comfort and air quality and protecting the environment...

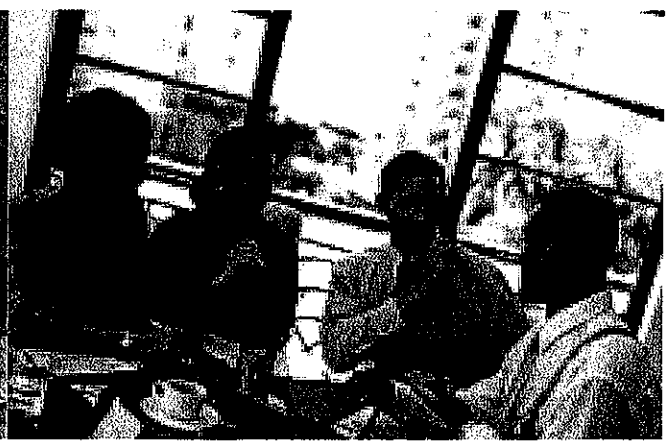
The Building Air Conditioning Climate Protection Partnership—The Key to Total Building Performance

Air conditioning cools air in homes, vehicles, and workplaces—keeping occupants more comfortable and productive while helping communities in hot and humid climates grow and prosper.

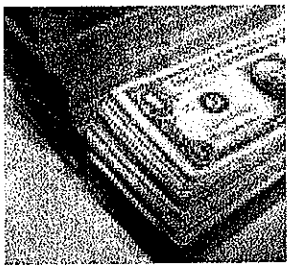
Innovative building technologies are now available. Modern lighting uses less than half the energy than older lighting and presents colors just as vividly as natural sunlight. Windows let in light but not heat and glare, and building control systems integrate comfort, safety, and security. New building air conditioning systems cut cooling costs by half or more and eliminate chlorofluorcarbon (CFC) chemicals that destroy the ozone layer. Yet the potential of these efficient technologies is not always realized in older buildings or even in some new construction!

Now, a new industry-government partnership is promoting replacement of CFC building air conditioning chillers as part of the ENERGY STAR® systems approach. This integrated chiller retrofit approach captures all of these benefits—energy efficient office machines and lighting reduce cooling loads, thus allowing the use of smaller, highly efficient air conditioning systems without the use of CFCs. Integration of components and controls using systems analysis (commissioning), good equipment startup, and continuing verification of efficiency assures that your building makes a quantum leap in performance and value.





Keep Cool, Save Money

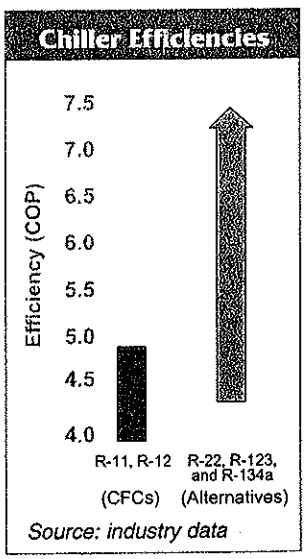


A comfortable work place affects work habits and productivity in positive ways.

Most large commercial, institutional, and industrial buildings are cooled by machines called "chillers" that are typically named after the type of compressor used—centrifugal, screw, scroll, and reciprocating. Building chiller systems are designed to cool and control humidity to create a more comfortable environment for tenants.

A new energy-efficient chiller can easily pay for itself in electricity savings, improved reliability, and lower maintenance costs. In addition, building energy consumption can be significantly reduced at the time of chiller replacement through cooling system improvements (e.g., use of variable speed drives on fans and pumps, improved cooling towers, evaporative coolers, and improved controls) and cooling load reductions (e.g., lighting system retrofits, better insulation, and new windows). Reducing cooling load and improving cooling system efficiency will enable downsizing of the new chiller, thereby cutting capital cost and increasing overall operating efficiency. Comprehensive projects along these lines are known as "integrated chiller retrofits."

Financing for integrated chiller retrofits is readily available from a number of sources, including local or regional energy authorities, electric utilities, equipment suppliers, and commercial lenders. Building owners around the world have saved millions of dollars in electricity bills through careful choice of upgraded air conditioning chiller installations and through complementary investments to reduce building cooling load. Today's chillers use about one-third or less electricity compared to those produced just two decades ago. Building owners can typically pay back the investment cost of replacing an old CFC chiller in 5 years or less in virtually all locations that cool for more than 3 months a year. In fact, replacement chillers can pay for themselves in as little as 2 or 3 years, with a typical return on investment of 20% to 35%. Generally, the added cost of the highest efficiency chillers is paid back through energy savings alone. Today's state-of-the-art building automation systems further reduce operating and maintenance costs by monitoring and controlling everyday building operations and by notifying managers of small problems before they become big problems.



Keep Cool, Save the Earth

New chiller installations save money, improve occupant comfort, and protect the global environment. New energy-efficient chillers are better for the environment because they use far less electricity from the power plants that supply buildings with electricity, reducing emissions that contribute to air pollution and global warming. New energy efficient chillers are better for the stratospheric ozone layer because they do not use potent ozone-depleting CFC refrigerants—made obsolete by global regulations and thus becoming increasingly scarce and expensive. Because CFC refrigerants cannot be legally produced or imported for sale in developed countries, building owners with obsolete equipment compete for dwindling supplies of reclaimed CFCs—paying high prices and risking refrigerant shortage.

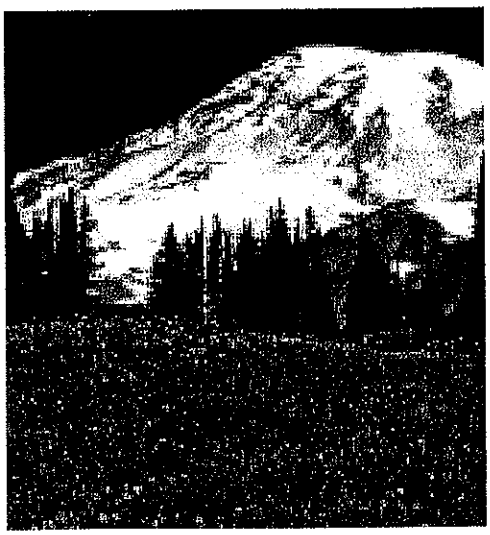
Most centrifugal chillers manufactured before 1995 used CFC-11, CFC-12, or HCFC-22 refrigerants. CFCs damage the protective ozone layer that shields the earth from the harmful effects of overexposure to ultraviolet radiation, including skin cancer and cataracts. Because stratospheric ozone depletion threatens the health and well being of future generations, countries have joined the treaty called *The Montreal Protocol on Substances that Deplete the Ozone Layer* and have agreed to its plan to halt production of CFCs and other ozone-depleting substances. In 1996, developed countries stopped producing and importing CFC refrigerants. HCFCs are less damaging to the ozone layer and are considered important "transitional refrigerants" under the Montreal Protocol. The Protocol authorizes HCFC production for use in developed countries in new equipment until 2020 and for service until 2030 and HCFC production for use in developing countries in either new equipment or servicing until 2040. After production phaseout, reclaimed and recovered HCFC refrigerants will be available.

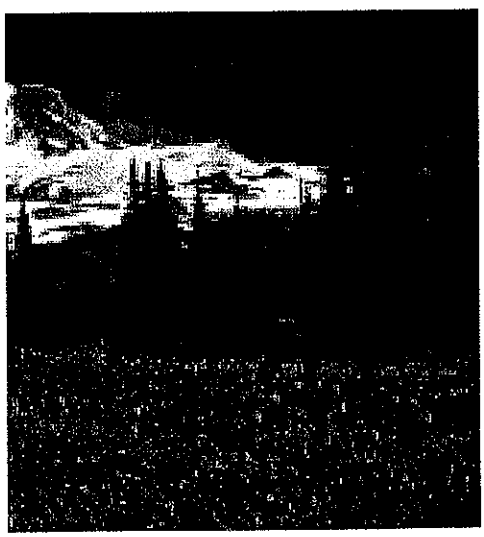
Older refrigerants, including hydrocarbons and ammonia, are making a comeback in some applications where safety can be assured. For example, hydrocarbons are increasingly used in small refrigeration and air conditioning appliances, and ammonia is gaining market share in new industrial refrigeration applications, such as ice-making, cold storage, and district cooling, where higher energy efficiency is sometimes achieved.

The most commonly used new refrigerants for large building air conditioning applications—HFC-134a and HCFC-123—are allowed, approved, or endorsed for use by Environment Australia, Environment Canada, the Japan Ministry of Economy, Trade and Industry, the Japan Ministry of the Environment, the U.S. Environmental Protection Agency, and most other environment ministries worldwide. HFC-134a can achieve high energy-efficiency and is ozone-safe, but refrigerant emissions are potent greenhouse gases. HCFC-123 can achieve high energy-efficiency and is not a potent greenhouse gas, but does have an ozone-depleting potential, albeit low. Energy efficiency is the main environmental consideration in the selection of a chiller as long as the equipment is carefully maintained and refrigerant emissions are kept near zero.

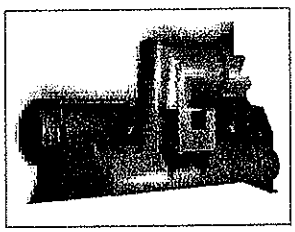
Building owners can make a significant contribution to environmental protection by replacing old chillers. The ozone layer is safe with properly maintained, high-efficiency, HCFC-123 or HFC-134a chillers. Energy-efficient equipment helps protect the environment by reducing the nitrous oxides, sulfur dioxide, particulates, carbon dioxide, and mercury emissions from power plants supplying electricity to the buildings.

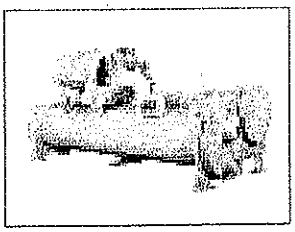
Electric utilities typically use their least efficient power plants for the peak periods of electricity demand, which is when chiller loads are usually highest. Therefore, reduced electricity use has an even larger benefit for local air quality and climate protection.

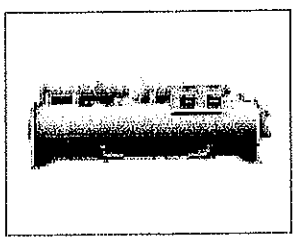


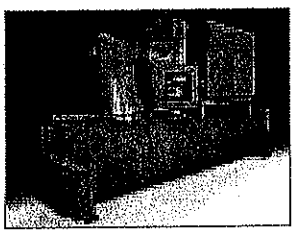


Which Chiller Should I Purchase?









Several old and new refrigerants exist today that are environmentally acceptable. If you want the highest environmental performance, follow the "Responsible Use" criteria: *Focus on the Life-Cycle Climate Performance (LCCP), not the refrigerant. LCCP includes the emissions during the manufacturing of the chemical, the transportation to the site, during charging of the chiller, lifetime leakage, and finally during recovery and disposal. And, very importantly, this calculation must include emissions from the generation of electricity to power the chillers and account for any additional energy that may be necessary to assure safe operation. Select the investment with the best LCCP with emissions minimized.*

Small-Scale Screw Chillers

New screw chiller technologies with high full and part-load energy efficiency are replacing existing CFC centrifugal chillers primarily in the smaller tonnage ranges. These chillers are ideal for buildings with highly variable daily cooling loads. These screw chillers use a wide range of refrigerants including HCFC-22, HFC-134a, HFC-407C, and HFC-410A.

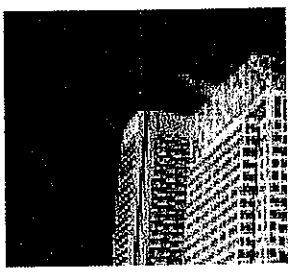
Medium- and Large-Scale Ammonia Chillers

Building owners will want to consider ammonia chillers using screw compressors where they can safely achieve higher energy efficiency. Emissions of ammonia refrigerants are ozone- and climate-safe, but because ammonia is toxic and moderately flammable, safety precautions are necessary. Ammonia is particularly attractive if higher efficiencies can be achieved for new installations involving ice-making, commercial refrigeration, and cold storage warehouses, and in district cooling applications.

Large-Scale HFC-134a and HCFC-123 Centrifugal Chillers

For centrifugal chillers, choose either HFC or HCFC chillers with the highest cost-effective energy efficiency, and focus on maintaining the equipment's peak performance and minimal refrigerant emissions. Any refrigerant is environmentally safe as long as it is never emitted, and all refrigerants require careful handling to avoid worker exposure. Emissions can be substantially reduced or eliminated with new equipment, modern refrigerant monitoring technology, and a proper maintenance program. Computerized controls and building automation systems can cost-effectively sustain and document the performance of the chiller plant.

Will Ammonia, HFC, and HCFC Refrigerants Be Available For the Life of the Air Conditioning Equipment?



National building code safety regulations restrict ammonia use, but international treaties do not control use. Ammonia is among the oldest industrial chemicals, with continuous improvements in design and maintenance, and little likelihood of additional environmental controls.

HCFCs are controlled by the Montreal Protocol. Developed countries are allowed to produce HCFCs for new equipment until 2020 and for service until 2030. Some developed countries plan to stop HCFC-22 production for new air conditioning equipment by 2010 and production for service by 2020. Recycled and stockpiled HCFC refrigerants will ensure adequate quantities for future use during the economic life of equipment. HCFC-22 is a high-pressure gas with an ozone depleting potential (ODP) of 0.034 and a direct global warming potential (GWP) of 1700.

Refrigerant Ozone Depletion Potential (ODP) and Global Warming Potential (GWP)

REFRIGERANT	ODP	100-Year GWP
CFC-11	1.0 (index)	4600
CFC-12	0.82	10600
HCFC-22	0.034	1700
HCFC-123	0.012	120
HFC-134a	0.0	1300
HFC-407C (blend)	0.0	1700
HFC-410A (blend)	0.0	2000

Source: Montreal Protocol *Science Assessment of Ozone Depletion: 1998* and 2002 Intergovernmental Panel on Climate Change *Third Assessment Report*

HCFC-123 is a low-pressure gas with an ODP of 0.012 and a direct GWP of 120.

HFC emissions have less impact on climate change than the CFCs they replace but are included in the basket of greenhouse gases whose emissions need to be reduced. The United States and some other countries will use voluntary measures to encourage energy efficiency and to minimize HFC emissions. Other countries plan to more directly restrict HFC use and emissions. HFC blends, including HFC-407C and HFC-410A, are often selected to optimize the energy performance of specific air conditioning systems and particular sizes. HFC blends have zero ODP and moderate GWP depending on the exact composition.

The most uncertain choice is to continue the use of energy-intensive equipment using CFC refrigerants. One year of refrigerant and power plant emissions from old CFC equipment with high leak rates results in greater harm to the ozone layer and climate than 30 years' operation of most energy-efficient new equipment using HFC-134a or HCFC-123. Leaking CFC equipment frequently operates undercharged, requiring additional energy to achieve the same cooling. Now is the time to retrofit or replace.

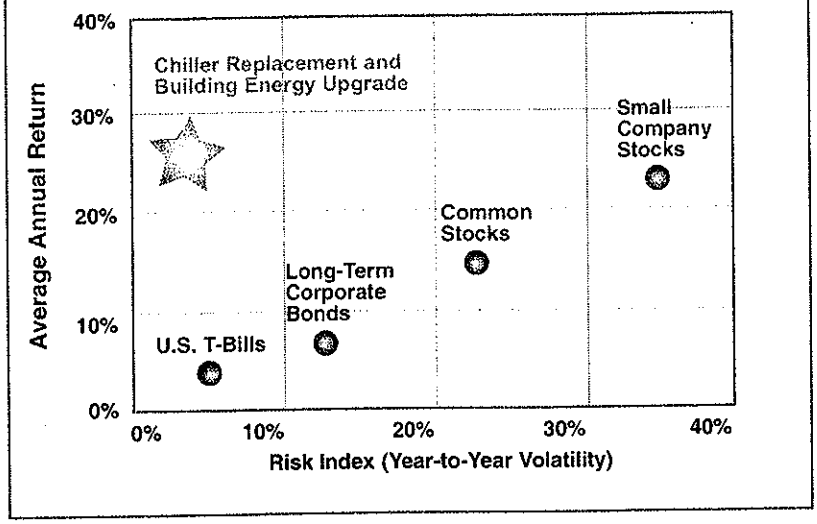
Market Incentives for Chiller Replacement



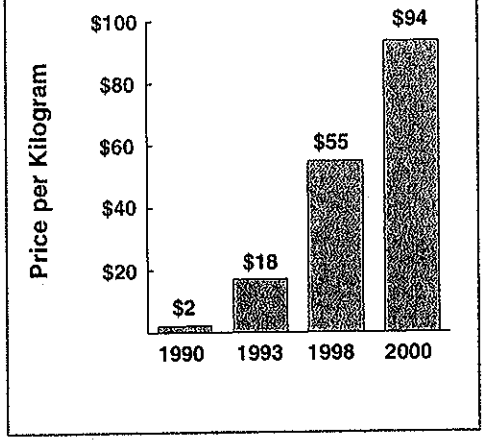
Relying on obsolete CFC chillers might end up costing building owners and tenants more than they bargained for, while replacing an old chiller can be an owner's best investment. Here's why:

- ★ Building owners with obsolete CFC equipment compete for dwindling supplies of reclaimed refrigerants and parts—paying high prices and risking refrigerant shortage.
- ★ Savings from electricity costs alone pay back the investment at high rates of return—even at low energy prices.
- ★ A new, efficient chiller installation with better building controls, high-efficiency auxiliary equipment, efficient lights, and other building and office equipment upgrades protects owners from electricity price fluctuations and shortages, which increases the resale and rental value of the building.
- ★ Companies that use newer and more efficient technologies can become environmental leaders in their communities, enhance company reputation, and earn accolades from public and private authorities.

Rate of Return vs. Risk for New Chillers and Building Energy Upgrades



Price of CFC-12



Tools and Information

Equipment suppliers, governments, utilities, and others are cooperating with building owners and tenants to help save money while protecting the environment. Available resources include:

★ *EPA ENERGY STAR® Buildings*
www.energystar.gov
ENERGY STAR® leads you to a results-oriented energy management approach that produces twice the savings for your bottom line and the environment than the typical strategy. EPA offers tools that rate whole building energy performance. Technical guidance focuses on proper equipment sizing and design and mechanical system integration that match your building's load requirements. ENERGY STAR® offers public recognition for buildings that achieve the best results.

★ *UNEP DTIE's OzonAction Programme*
www.earthprint.com
In partnership with ARI, OzonAction conducted training sessions on refrigerant management in the chiller sector in three major cities in developing countries—Bangkok, Bahrain, and Jakarta—and offers jointly developed manuals to assist building owners.

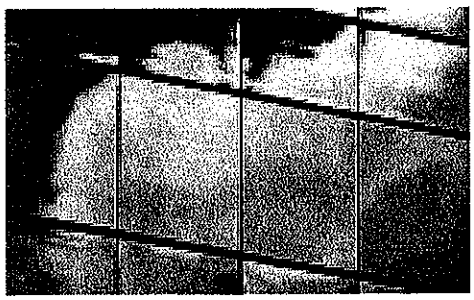
★ *BOMA—The Building Owners and Managers Association International*
www.boma.org
Representing more than 8.5 billion square feet of office space in North America alone, BOMA offers research, performance data, publications, and services.





★ *ARI—Air-Conditioning and Refrigeration Institute*
www.ari.org
Software from equipment suppliers and others helps designers maximize energy and cost savings. Ask your chiller supplier to recommend cost-cutting upgrades. Contact suppliers through ARI or at individual Web sites:

- API Ketena–
  www.apiketena.com
- Carrier–
  www.carrier.com
- Dunham-Bush–
  www.dunham-bush.com
- Edwards Engineering–
  www.edwards-eng.com
- McQuay–
  www.mcquay.com
- RAE Corporation–
  www.rae-corp.com
- Trane–
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- York–
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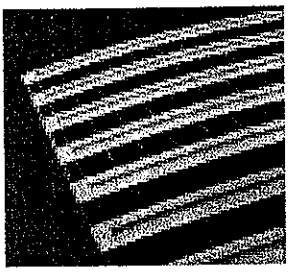


★ *ASHRAE—American Society of Heating, Refrigerating and Air-Conditioning Engineers*
www.ashrae.org
With more than 50,000 members worldwide, ASHRAE advances air conditioning and related sciences through research, standards writing, continuing education, and publications.

More Opportunities to Save Money

When replacing a CFC chiller, building owners and tenants can take additional steps to save money and help protect the environment. Design engineers can identify more ways to save energy by conducting an overall energy performance review. The entire air conditioning system can be improved by using more efficient fans, pumps, cooling towers, and system controls, and by reducing cooling loads with more efficient lighting and better insulation. With these investments, owners might be able to downsize equipment, cutting both capital and operating costs.

Supporting Organizations



★United Nations Environment Programme

★National Governments and Regional Authorities
- Environment Canada
- Industry Canada
- Japan Ministry of the Environment
- Japan Ministry of Economy, Trade and Industry
- U.S. Environmental Protection Agency

★Air Conditioning Equipment Manufacturers
- Carrier
- McQuay
- Trane
- York

★Energy and Supply Companies
- Cryo-Line Supplies
- McKenney's Inc., Mechanical Contractors and Engineers
- Pacific Gas and Electric

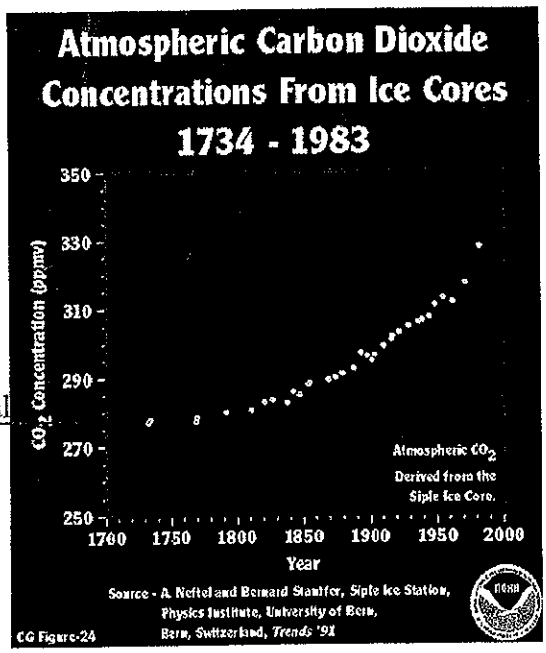
★Industry and Environmental Non-Governmental Organizations (NGOs)
- Alliance for Responsible Atmospheric Policy
- Alliance to Save Energy
- Americans for an Energy Efficient Economy
- Australian Fluorocarbon Council
- Heating, Refrigeration and Air Conditioning Institute of Canada
- International Climate Change Partnership
- Japan Industrial Conference for Ozone Layer Protection
- Japan Refrigeration and Air Conditioning Industry Association
- Natural Resources Defense Council

Global Environmental Threats

Learning From the Past and Planning for the Future

Larry Butz, P.E.
The Trane Company
April 2002

The environment is taking on an increasingly important role in our businesses as well as our personal lives. With the solution to the ozone depletion threat having been outlined by the Montreal Protocol we now turn to global warming which poses a more serious and complex threat to our planet.
There is little doubt that manmade gases being added to our atmosphere are causing an increase in temperature through the greenhouse effect. The difficulty is in trying to understand how our climate will change as result of the higher temperatures.



According to the U.S. National Climatic Data Center 2001 was the second warmest year on record and it was the 23rd consecutive year of above normal temperatures. Perhaps most troubling is the fact that the rate of temperature increase is accelerating. Add to this the data just released from insurer Munich Re stating that deaths from natural disasters were more than double in 2001 versus 2000 and insured losses were up more than 50%.

What have we learned from our first environmental threat that might help us with our response to the global warming threat?
First, we saw that the world can work together successfully to take the necessary action to respond to the threat. Global production of CFCs was reduced by 87% between 1987 and 1997. Secondly, the success of the Montreal Protocol was not due to its initial targets but rather the fact that it initiated action which was subsequently adjusted and fine tuned as a result of further understanding gained by ongoing and rigorous scientific study.

natural levels

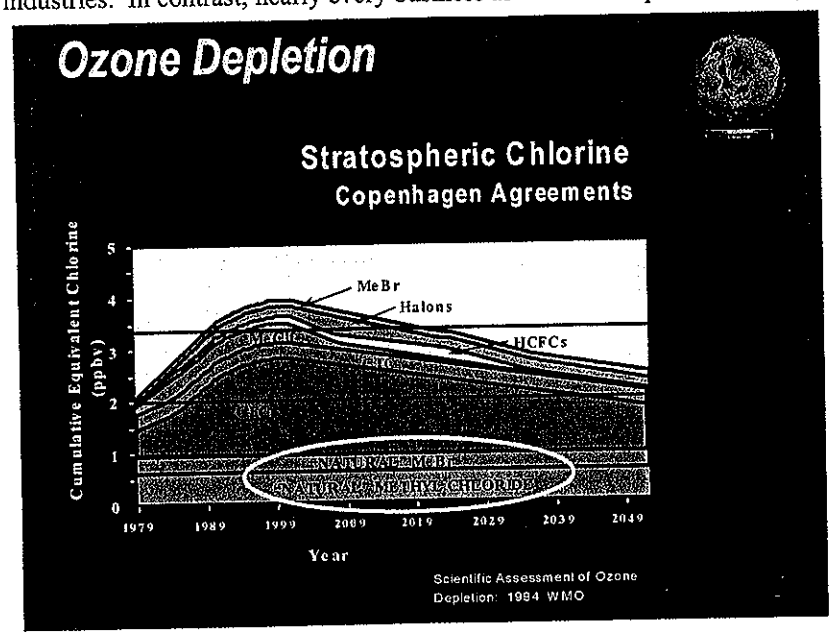
There are similarities between global warming and ozone depletion. What do they tell us?



Both global warming and ozone depletion are the result of manmade chemicals upsetting the balance in nature. The process of ozone creation and ozone destruction is a natural process in which natural quantities of methyl bromide and methyl chloride consume ozone in balance with the ozone creation process. The addition of manmade CFCs has more than doubled the natural rate of ozone destruction causing the ozone hole. Similarly, natural levels of CO_2 which existed before the start of the Industrial Revolution have increased more than 30% due primarily to the use of fossil fuels for energy. To reduce and eliminate the ozone depletion and global warming threats we must reduce concentrations back closer to more natural levels.
We have also learned that what was once considered an attractive characteristic, chemical stability in the atmosphere, is now considered harmful to the environment. The long atmospheric lives of CFCs is a primary reason why they are the primary source of ozone depletion as well as being one of the most powerful global warming gases. We can see the same characteristic among the six gases listed under the Kyoto Protocol.
We can also see a similarity in the role of HCFCs in ozone depletion and HFCs in global warming. As seen in the figure on the next page HCFCs account for 1 to 3% of the contribution to stratospheric chlorine loading. This includes the impacts of the higher ODP HCFCs used in foam and solvent industries. This is comparable to the 1.78% estimated contribution of HFCs to global warming according to the latest AD Little study.
The final similarity is that it is the *emissions* of substances that is the issue rather than the *use* of substances that cause the actual environmental harm. If it does not get into the atmosphere it does no

harm. This simple fact has transformed our industry from a "leaky" industry in the mid 1980's to a nearly hermetic industry of the 21st century.

Although there are similarities, there are clear contrasts. Ozone depletion affected only a few industries. In contrast, nearly every business as well as our personal lifestyles will be affected by global warming simply because we all use energy which is the primary global warming gas.



But perhaps the biggest difference is the relative simplicity of ozone depletion in comparison to global warming. The detailed chemistry and subsequent impacts of ozone depletion are well understood. The complexity and many interactions involved in climate change will likely never be understood to the same degree. The seriousness of this threat however necessitates taking action before a high degree of certainty is obtained.

We are seeing the pain and difficulty of putting in place a plan that can meet the goal of the Kyoto Protocol to reduce emissions of global warming gases to 5% below 1990 levels. Not easy and certainly not painless. What is most troubling is that this does not solve the problem. Our scientists tell us that it will take a 70 to 80% reduction in emissions just to stabilize CO_2 concentrations at 450ppm (which is some 60% above natural levels).

What is important is that the process has started. Methods and goals will be modified as we go forward.

How does one plan in such rapidly changing, complex and uncertain times? First, by recognizing that we cannot afford to concentrate on just ozone depletion or global warming. The issue is the environment. We will likely see new environmental threats that will become clearer in the near term future. We need to recognize these possibilities and minimize these risks. **Minimize the Total Environmental Impact** of air conditioning equipment and systems is the goal of the Trane Company. This is achieved by minimizing wastes and emissions (by becoming a hermetic industry), minimizing energy use; designing and selecting equipment with minimum refrigerant charge; using refrigerants with minimum atmospheric life, ODP and GWP. This is embodied in the term "Responsible Use" and illustrated in what we call a Sustainable chiller.

New S Series Sustainable Chiller

What is it and why is it called sustainable? Quite simply it is an oil free chiller. By use of a low pressure direct drive design we are able to replace steel bearings by a new hybrid ceramic bearing which is refrigerant cooled. What this does is to eliminate oil which is actually a contaminant to the refrigerant, the working fluid in a chiller. Efficiency losses due to oil contamination can exceed 10% in older chillers. Eliminating oil systems makes the chiller simpler and reduces the parts count by more than 40%. This reduction in joints makes the S Series a truly near zero emissions hermetic design. The goal of such a chiller is to have the initial refrigerant charge be the final refrigerant charge.