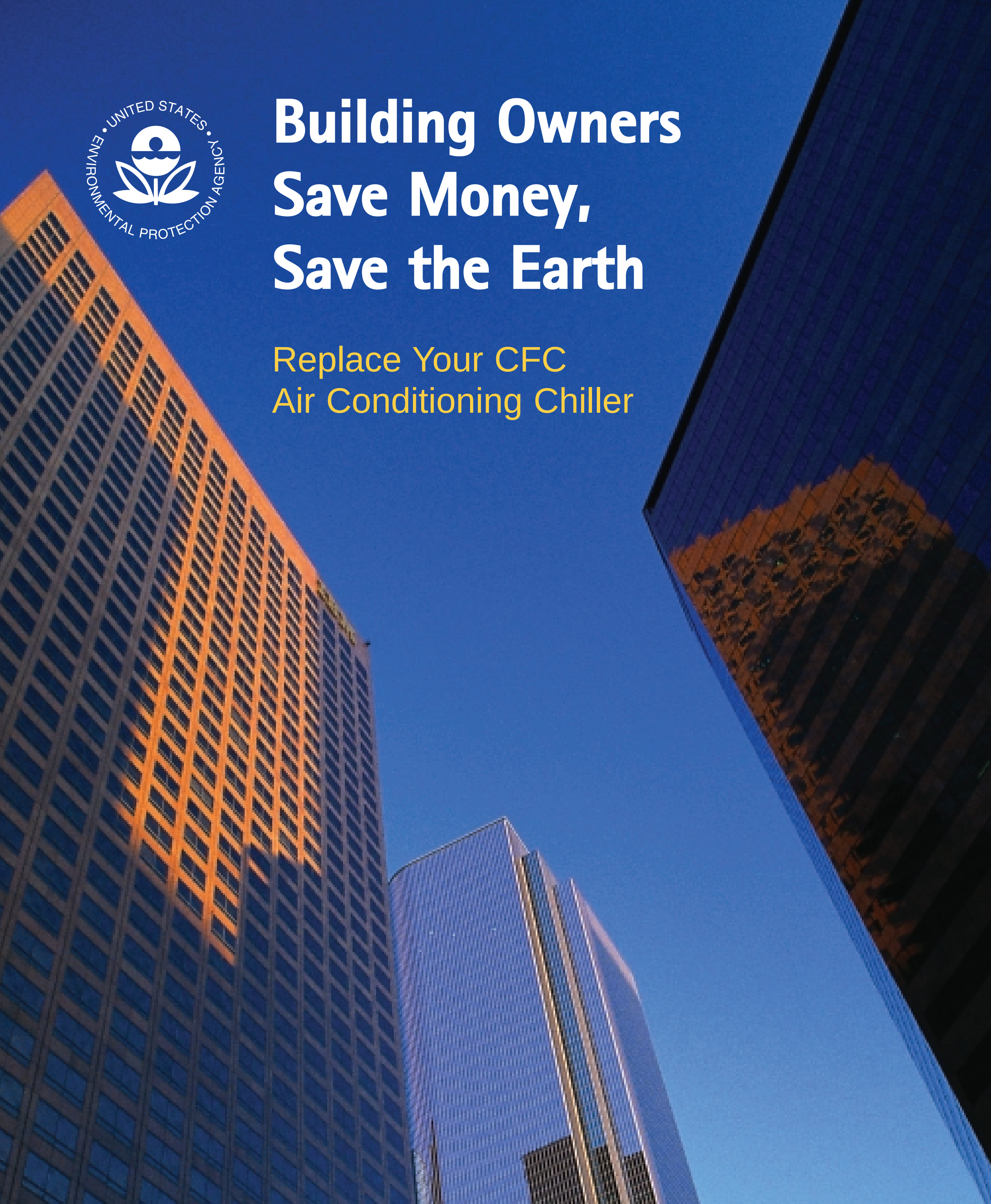
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Building Owners Save Money, Save the Earth

Replace Your CFC Air Conditioning Chiller



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 to protect the ozone layer, which shields the earth from the harmful effects of overexposure to ultraviolet radiation, negotiators from governments around the world crafted a treaty in 1987 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 mounting scientific evidence and space observations proved that stratospheric ozone depletion and the Antarctic ozone hole in particular, were caused by emissions of manufactured chemicals. It was also discovered that ozone depletion was occurring over Europe and North America. Since 1987, more than 180 countries have 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. 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. Hydrochlorofluorocarbon (HCFC) and hydrofluorocarbon (HFC) 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.*

Responsible Use

Governments, industries, consumers, and environmental organizations worldwide are endorsing the concept of "Responsible Use" of refrigerants. The Responsible Use principles for building air conditioning are:

- ★ Select the refrigerant and air conditioning chiller for each building application that provides the highest health and safety, environmental, technical, economic, and other unique societal benefits.
- ★ Minimize emissions to the lowest practical level during manufacture of the refrigerant and equipment, and during use and disposal of the equipment, using cost-effective technology.
- ★ Design and operate chiller plants to maximize Life-Cycle Climate Performance (LCCP), minimizing the combined emissions of refrigerant from the air conditioning chiller and greenhouse gases from the production of power for the chiller.

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 comfortable and more productive, also helping communities in hot and humid climates to grow and prosper.

Innovative building technologies are now available. Modern lighting uses less than half the energy of older lighting. New window designs 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 chlorofluorocarbon (CFC) chemicals, which destroy the ozone layer. Yet the potential of these efficient technologies is not always realized in older buildings or even in some new construction!

To help achieve that energy efficiency, a new industry-government partnership is promoting the replacement of CFC building air conditioning chillers. In the United States, the partnership is part of the ENERGY STAR® systems approach. In other countries, industry and government authorities are spearheading programs promoting building energy efficiency.

The partnership is also promoting integrated chiller retrofits. This approach incorporates other investment into the chiller replacement such as retrofitting lighting systems, window and insulation upgrades, and replacing old office machines. This reduces the cooling load thereby allowing the use of smaller, highly efficient air conditioning systems without the use of CFCs. Integration of components and controls using systems analysis, good equipment startup, and continuous monitoring of energy efficiency will help ensure that your building makes a quantum leap in performance and value.

Keep Cool, Save Money

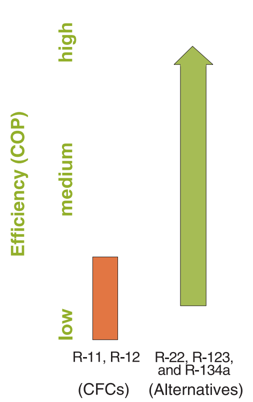
A comfortable work place can affect work habits and productivity in positive ways.

Most large commercial, institutional, and industrial buildings are cooled by machines called "chillers." The chiller is 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 comfortable and more productive environment for tenants.

A new energy-efficient chiller can easily pay for itself in electricity savings, improved reliability, and lower maintenance costs in as little as five years. 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 available from a number of sources, including regional or national energy authorities, electric utilities, equipment suppliers, and commercial lenders (see pages 8-9). Building owners around the world have saved millions of dollars in electricity bills by upgrading air conditioning chiller installations and through concurrent 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 five years or less in virtually all locations that cool for more than three months a year. In fact, replacement chillers integrated with building retrofits can pay for themselves in as little as two or three 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 costly problems.

Chiller Efficiencies



Source: Industry data

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 energy, 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 treaties and thus becoming increasingly scarce and expensive. Because CFC refrigerants can not 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.

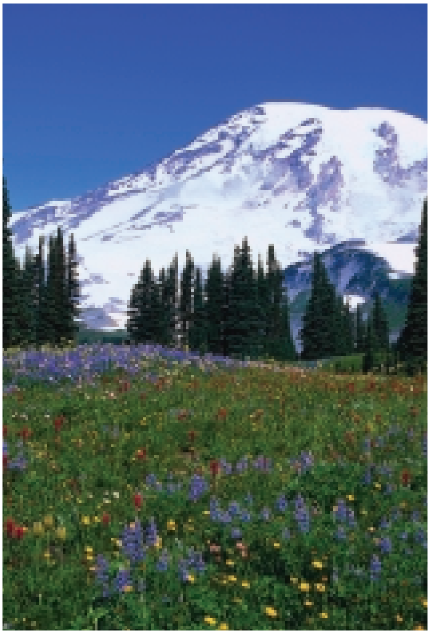
Most centrifugal chillers manufactured before 1995 used CFC-11, CFC-12, or HCFC-22 refrigerants. Emissions of CFCs and HCFCs damage stratospheric ozone. Countries that have ratified the Montreal Protocol will halt production of CFCs and other ozone-depleting substances. In 1996, developed countries stopped producing and importing CFC refrigerants. HCFCs are less damaging to the ozone layer and are considered important "transitional refrigerants" to allow an accelerated CFC phaseout under the Montreal Protocol. The Protocol authorizes HCFC production for use in developed countries in new chillers 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, HCFCs can be supplied from reclaimed and recovered sources.

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.

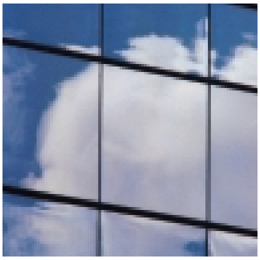
The most commonly used new refrigerants for large building air conditioning applications—HFC-134a and HCFC-123—are allowed, approved, or endorsed for use by Environment Australia; Environment Canada; the Japan Ministry of Economy, Trade and Industry; the Japan Ministry of the Environment; the U.S. Environmental Protection Agency; and most other environment ministries worldwide. HFC-134a can achieve high energy efficiency and is ozone-safe, but refrigerant emissions are relatively 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.

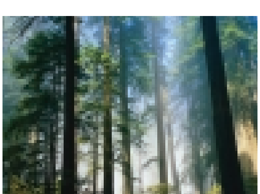
Building owners can make a significant contribution to environmental protection by replacing old chillers. Properly monitored and maintained, high-efficiency HCFC-123 and HFC-134a chillers minimize the effect of air conditioning systems on climate change and do not significantly affect the ozone layer. By using less electricity, energy-efficient equipment helps protect the environment by reducing nitrous oxides, sulfur dioxide, particulate matter, carbon dioxide, and mercury emissions from power plants supplying electricity to the buildings.

Electric utilities sometimes 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 refrigerants are environmentally acceptable. However, if you want the highest environmental performance, follow the "Responsible Use" criteria, focusing on the Life-Cycle Climate Performance (LCCP), not the refrigerant. LCCP takes into account the emissions during the manufacturing of the refrigerant, 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. Insist that financial calculations consider both partial and full-load operation, that the performance of equipment based on alternate refrigerants is compared, and that available energy efficiency options are considered, including variable speed motor drives, heat recovery, and free-cooling. 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, and the HFC blends R-407C and R-410A.

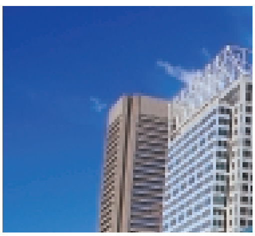
Medium- and Large-Scale Ammonia Chillers

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, cold storage warehouses, and in district cooling applications.

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

For centrifugal chillers, choose either HCFC or HFC 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. By retrofitting or replacing chillers, emissions can be substantially reduced or eliminated. The goal of near-zero refrigerant emissions is possible 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, HCFC, and HFC Refrigerants Be Available For the Life of the Air Conditioning Equipment?



The use of ammonia as a refrigerant is not restricted by international treaties, although it may be subject to national or local codes for building safety. Ammonia is among the oldest industrial chemicals, and with continuous improvements in chiller design and maintenance, there is 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. Adequate quantities of HCFC refrigerants can be supplied for the economic life of equipment by recycling and stockpiling. HCFC-22 is a high-pressure gas with a Montreal Protocol ozone depletion potential (ODP) of 0.055 and a global warming potential (GWP) of 1700. HCFC-123 is a low-pressure gas with a Montreal Protocol ODP of 0.02 and a GWP of 120.

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

REFRIGERANT	Montreal Protocol ODP	WMO Model ODP	100-Year GWP
CFC-11	1.0 (index)	0.82	4600
CFC-12	1.0	0.90	10,600
HCFC-22	0.055	0.034	1700
HCFC-123	0.02	0.012	120
HFC-134a	0.0	<0.000015	1300
R-407C (HFC blend)	0.0	<0.0004	1700
R-410A (HFC blend)	0.0	<0.00003	2000

Source: Montreal Protocol *Science Assessment of Ozone Depletion: 1998*, 2002 Intergovernmental Panel on Climate Change *Third Assessment Report* and the *Handbook for the International Treaties for the Protection of the Ozone Layer*, 2000 edition. Note that the Montreal Protocol ODPs were officially established in 1992 and may be reviewed and revised periodically. The 2002 Scientific Assessment presents the WMO (1999) Model results as above (the ODPs for HFCs are upper limits).

HFC emissions have lower GWPs and less impact on climate change than the CFCs they replace but are included in the basket of greenhouse gases. Some countries, including the United States, 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 R-407C and R-410A, are often selected to optimize the energy performance of specific air conditioning systems and particular sizes. HFC blends have zero ODP and a GWP that depends on the exact composition.

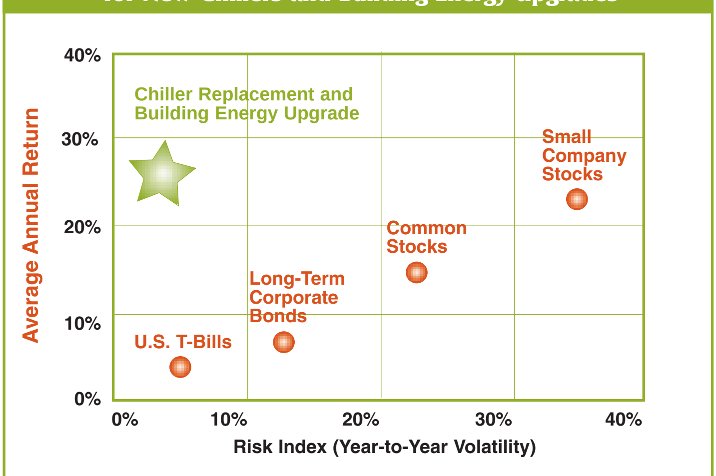
The most uncertain choice is to continue the use of energy-intensive equipment using CFC refrigerants. One year of refrigerant and power plant emissions from old CFC equipment with high leak rates results in greater direct harm to the ozone layer and climate than 30 years' operation of new equipment using HFC-134a or HCFC-123. The most energy-efficient new chillers will reduce electric generation and associated greenhouse gas emissions by up to 50% or more compared to the CFC chillers they replace. 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

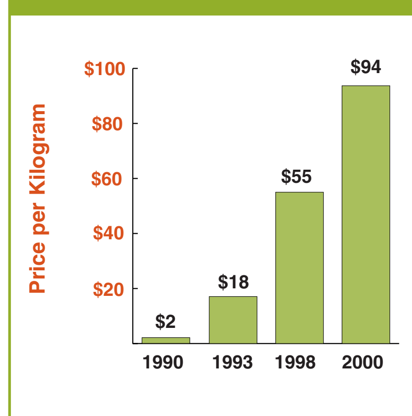
Relying on obsolete CFC chillers might end up costing building owners and tenants more than they bargained for. Replacing an old chiller can be an owner's best investment. Here's why:

- ★ Building owners and managers who use obsolete CFC equipment will have to 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 with 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. Lower cooling costs increase the resale and rental value of the building.
- ★ Companies that use newer and more efficient technologies demonstrate environmental leadership in their communities, enhance company reputation, and have even earned accolades from public and private authorities.

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



Price of CFC-12



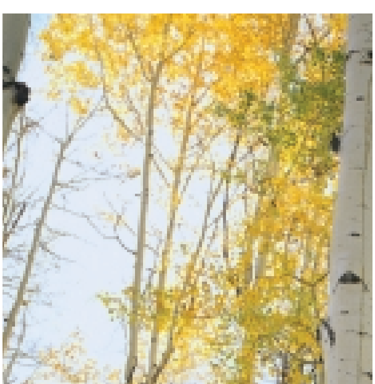
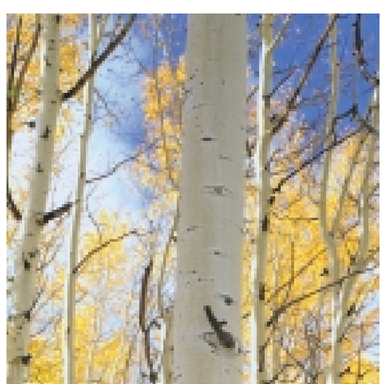
Tools and Information

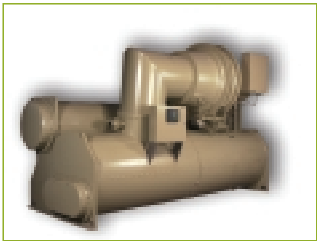
Equipment suppliers, governments, utilities, and others are cooperating with building owners and tenants to help save money while protecting the environment. Available resources include:

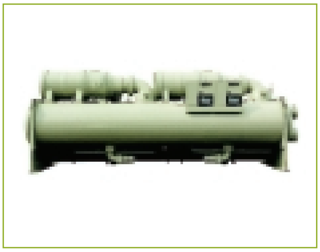
- ★ ***EPA ENERGY STAR® Buildings.***
  www.energystar.gov
  ENERGY STAR® leads you to a results-oriented energy management approach that produces twice the savings for your bottom line and the environment than the typical strategy. EPA offers tools that rate whole building energy performance. Technical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

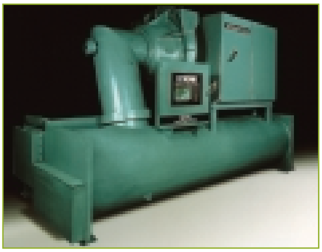
- ★ ***UNEP DTIE's OzonAction Programme.***
  www.uneptie.org and www.earthprint.com
  In partnership with the Air-Conditioning and Refrigeration Institute (ARI), OzonAction conducted training sessions on refrigerant management in the chiller sector in three major cities in developing countries—Bangkok, 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.

★ ***Chiller Suppliers***
Contact suppliers through ARI or at individual websites:

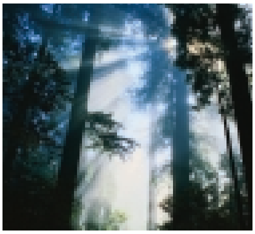
- API Ketena – www.apiketena.com
- Carrier – www.carrier.com
- Daikin – www.daikin.com
- Dunham-Bush – www.dunham-bush.com
- Edwards Engineering – www.edwards-eng.com
- Lennox (Europe) – www.lennoxeurope.com
- McQuay – www.mcquay.com
- Mitsubishi Heavy Industries – www.mhi.co.jp
- RAE Corporation – www.rae-corp.com
- Trane – www.trane.com
- York – www.york.com

★ ***ASHRAE—American Society of Heating, Refrigerating and Air-Conditioning Engineers***
www.ashrae.org
With over 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 integrated new systems, owners can downsize equipment, cutting both capital and operating costs and increasing the return on their investment.

Supporting Organizations



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December 2002

Global Programs Division (6205J) and Climate Protection Partnerships Division (6202J)

www.epa.gov/ozone/

www.energystar.gov/

★ United Nations and World Bank
- United Nations Development Programme
- United Nations Environment Programme
- The World Bank

★ National Governments and Regional Authorities
- Australian Greenhouse Office
- Environment Canada
- Industry Canada
- Japan Ministry of Economy, Trade and Industry
- Japan Ministry of the Environment
- Singapore Ministry of the Environment
- Thailand, Department of Industrial Works, Ministry of Industry
- U.S. Environmental Protection Agency
- Vietnam National Office for Climate Change and Ozone Protection

★ Air Conditioning Equipment Manufacturers
- Carrier
- Daikin
- Lennox (Europe)
- McQuay
- Mitsubishi Heavy Industries
- Toshiba-Carrier
- Trane
- Turbocor
- York

★ Energy and Supply Companies
- Cryo-Line Supplies
- Exelon Services
- McKenney's Mechanical Contractors and Engineers
- Pacific Gas and Electric Company

★ Industry and Environmental Non-Governmental Organizations
- Air-Conditioning and Refrigeration Institute
- Alliance for Responsible Atmospheric Policy
- Alliance to Save Energy
- Americans for an Energy Efficient Economy
- Australian Fluorocarbon Council
- China Building Research Institute
- Ecole des Mines de Paris Center for Energy Studies
- Friends of the Earth
- Heating/Piping/Air Conditioning Engineering Magazine
- Heating, Refrigeration and Air Conditioning Institute of Canada
- Industrial Technology Research Institute
- International Climate Change Partnership
- Japan Industrial Conference for Ozone Layer Protection
- Japan Refrigeration and Air Conditioning Industry Association
- Natural Resources Defense Council