



# PUTTING THE FREEZE ON HFCs:

GLOBAL DIGEST OF AVAILABLE CLIMATE-FRIENDLY  
REFRIGERATION AND AIR-CONDITIONING TECHNOLOGIES  
2015 SUPPLEMENT



# RESOURCES ONLINE

## GLOBAL DIGEST OF HFC-FREE ALTERNATIVES

“Putting the Freeze on HFCs: A Global Digest of Available Climate-Friendly Refrigeration and Air-Conditioning Technologies,” available to download from our website:

[http://eia-global.org/images/uploads/2\\_EIA\\_HFCsReport\\_finalcomb.pdf](http://eia-global.org/images/uploads/2_EIA_HFCsReport_finalcomb.pdf)

## COOL TECHNOLOGIES DATABASE

EIA and Greenpeace have jointly launched a new online tool for examining HFC-free alternatives to HCFCs in the refrigeration, air-conditioning and foam sectors. The database, which can be viewed online at [www.cooltechnologies.org](http://www.cooltechnologies.org), features case studies of alternatives and is searchable by application, technology type, manufacturer and country. The database will be continuously updated as new technologies are developed and proven to be effective and energy efficient. We hope it will prove to be a valuable resource for countries, ozone officers, companies and implementing agencies as they seek to maximise the climate benefit of transitioning out of HCFCs and moving to the next generation of refrigerants and foams.

COVER IMAGE  
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## HFCs: A Global Challenge

Today, hydrofluorocarbons (HFCs) are the most commonly used refrigerants in new refrigeration and air-conditioning systems in Article 2 countries and increasingly in Article 5 countries, but these refrigerants are potent greenhouse gases (GHGs) with global warming potential (GWP) ranging from hundreds to thousands of times higher than carbon dioxide (CO<sub>2</sub>). HFCs have been commercialized to replace ozone depleting chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants, which have been or are currently being phased out under the Montreal Protocol on Substances that Deplete the Ozone Layer. Reducing production and consumption of HFCs is the largest, fastest, and most cost-effective short term climate mitigation option currently available and will have a significant effect by 2050.<sup>i</sup>

Fortunately, environmentally safe alternatives exist for almost all HFC uses. Most of these alternatives are also more energy efficient than traditional HFC-based equipment. EIA has and continues to collect case studies from around the world of energy efficient HFC-free alternatives. This document is the 2015 Supplement to EIA's 2014 report, *Putting the Freeze on HFCs: A Global Digest of Climate-Friendly Refrigeration and Air-conditioning Technologies*.<sup>ii</sup> We have transferred the case studies from that report and many more to the Cool Technologies database, which is updated monthly.

## Putting the Focus on Innovative and Not-in-kind Cooling Technologies

Converting to climate-friendly cooling technologies goes hand-in-hand with addressing some of today's most pressing sustainability challenges in the built environment and cold food supply chain. *Putting the Freeze on HFCs: A Global Digest of Climate-Friendly Refrigeration and Air-conditioning Technologies* introduced a variety of proven alternative cooling technologies from around the world using natural refrigerants with low GWP including CO<sub>2</sub>, air, water, ammonia, and hydrocarbons.

This supplement focuses on a subset of the newly developed and proven technologies that are truly breaking the mold on how we keep things cold. Even as natural low GWP refrigerants become more commonly used in conventional systems, the technologies described in this supplement will also be an essential component to meeting the growing demand for air conditioning and refrigeration without harming the global climate.



The cooling technologies described here are free of climate polluting refrigerants such as hydrofluorocarbons (HFCs), and also deliver unprecedented energy efficiency improvements. These technologies include chillers, heat pumps, and equipment known as 'not-in-kind' systems. These case studies introduce applied examples of these technologies from around the world and illustrate how going HFC-free can deliver sustainable, energy efficient heating, cooling, and refrigeration that are lasting solutions for emerging economies.

## What is a 'Not-in-kind' Technology?

In the context of refrigeration and air conditioning, 'not-in-kind' means any system that breaks with conventional technologies reliant on gaseous refrigerants used in a vapor compression cycle to produce cooling. The wide range of promising technologies that fall into this category include magnetocaloric refrigeration, adsorption cooling, district cooling, and evaporative cooling, among others.<sup>iii</sup> While many 'not-in-kind' technologies are still in the early stages of research and development, our case studies focus predominantly on highly energy-efficient adsorption and evaporative cooling technologies, which are already proven to work and commercially available. These technologies can also be powered by waste heat recovery using an integrated heat pump, or paired with a solar energy source to further minimize the climate impacts from indirect emissions of energy use.

## Integrated Heat Pumps

Heat pumps provide both energy-efficient heating and cooling in one as an alternative to having both a furnace and an air conditioner. During the cooling season, these systems work by transferring heat from the interior of a building to the exterior. Heat pumps deliver excellent energy efficiency and can provide equivalent space conditioning at as little as one quarter of the cost of operating conventional cooling systems.<sup>iv</sup> There are four main types of heat pumps: air-source, ductless mini-split, geothermal, and absorption. Geothermal and absorption units deliver high efficiency: Geothermal heat pumps utilize the constant below-ground temperature of the soil or water to heat or cool a building. Absorption heat pumps work by utilizing a heat source, such as natural gas, solar heated water, or heat recovery from an industrial production or other existing source.<sup>v</sup>

### Mayekawa: EcoCute CO2 Heat Pump at Torre Alba Hotel (Panama)

Mayekawa manufactures heat pumps with both air-to-water and water-to-water systems.<sup>vi</sup> The air-to-water system has a capacity of more than 80 kW, which Mayekawa claims is the largest in the world and can be used for large commercial applications, such as hotels, restaurants, hospitals, and food processing factories. The system's coefficient of performance (COP) is 4.0 and when configured with cooling in addition to heating, the COP can reach as high as 8.0.<sup>vii</sup>

## Absorption/Adsorption Chillers Paired with Heat Recovery or Solar Thermal

Chillers are generally installed on the roof of a building to produce chilled water to service a whole building's refrigeration and/or air conditioning needs. Conventional absorption chillers have historically used synthetic refrigerants such as high-GWP HFCs and ozone depleting substances. However, modern innovations in chiller technology include next generation absorption chillers that still rely on the conventional vapor compression cycle, but use water or another low-GWP alternative



including hydrocarbons and ammonia, as the refrigerant. Adsorption chillers, a not-in-kind technology, incorporate a solid 'sorption' material, like silica gel, in combination with water as a liquid refrigerant.<sup>viii</sup> Chillers rely on a heat source or some other energy source for powering the cooling cycle. The most innovative examples are those paired with heat pumps that help recover waste heat from industrial process to power the chiller or a solar thermal energy source.

### SolarNext AG: Air-Conditioning of Children's Hospital (Afghanistan)

A system produced by SolarNext AG was installed in a hospital in Kabul in 2010, pairing an adsorption chiller using water and lithium bromide powered with energy from thermal solar collectors.<sup>ix</sup> The system provides hot and cold water as well as air conditioning for the hospital. The chiller is a Chillii WFC18 model with an 18kW capacity, though the company also manufactures models up to 175kW capacities for larger commercial and industrial applications including industrial process cooling.<sup>x</sup> SolarNext systems have been installed for dozens of residential and commercial cooling applications as well, from a house in Beijing, China to a large office building in Newcastle, Australia.<sup>xi</sup>

### Kawasaki: Solar Air Conditioning for Shiga Factory and University of Indonesia (Japan and Indonesia)

In these applications, solar thermal energy is used to heat water that powers an absorption chiller, which also uses water as the refrigerant. The system includes a back-up gas combustion system that kicks in automatically at times of lower solar energy and is more energy efficient than traditional electric chillers. These systems have been installed to cool offices at Shiga Factory in Japan and in a new building at the University of Indonesia in 2014.<sup>xii</sup> The University of Indonesia system showed electricity consumption of just 2.25kW compared to 70.25kW for a traditional chiller at the same capacity. This contributed to an estimated 57 percent reduction in CO2 equivalent emissions.<sup>xiv</sup>

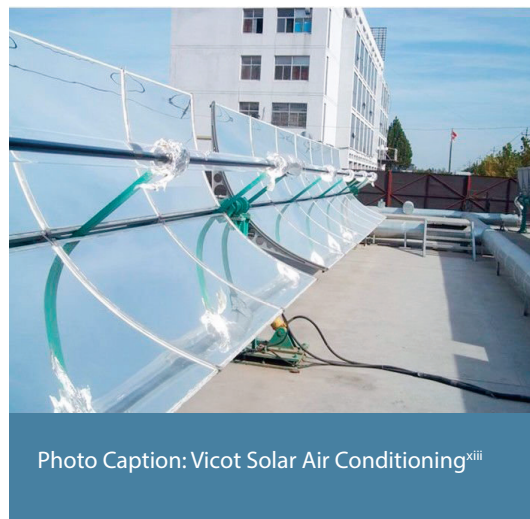


Photo Caption: Vicot Solar Air Conditioning<sup>xiii</sup>

### Shandong Vicot Solar Air Conditioning System (China and Global)

Vicot offers two solar air conditioning systems, the VSA and the VSB. The systems are built with three main parts: a solar collector, an ammonia or lithium-bromide air conditioning unit, and an accumulator. The solar collector harnesses thermal energy and pushes oil through the system to drive the air conditioning unit, while the accumulator acts as a storage space for excess solar energy in order to maintain operation during the night or in conditions of low light. The cooling capacity of the Vicot's VSA system ranges from 72 kW to 504 kW and the system can be used anywhere there is adequate space for solar panel installation, such as hotels, shopping malls, office buildings, exhibition centers, airports, stadiums, and factories. Vicot's other solar model has a larger cooling capacity of 300 kW to 2000 kW and in addition to the air conditioning system, contains an ammonia absorption heat pump. Vicot reports that based on energy and maintenance savings, the system's initial investment payback period is 3.5 years.<sup>xv</sup> Vicot's systems have been installed throughout China and in select markets in Africa, the Middle East, and Eastern Europe.

## Evaporative Cooling

Evaporative cooling is a not-in-kind technology that provides cooling using the same principles as human perspiration. Most units work by using a fan or pump to draw in ambient air from the outside and passing it through a cool water reservoir.<sup>xvi</sup> The heat from the ambient air is absorbed by the water, some of which is evaporated. The result is cooler, more humid air which then enters the building. Since evaporative cooling doesn't require any energy except what is needed to run the fan, it is highly energy efficient, and is most effective in dry climates where the outside air has the greatest evaporative effect. Evaporative cooling for air conditioning has a wide range of applications from residential units resembling typical air conditioners, to larger systems for commercial and industrial applications.<sup>xvii</sup>

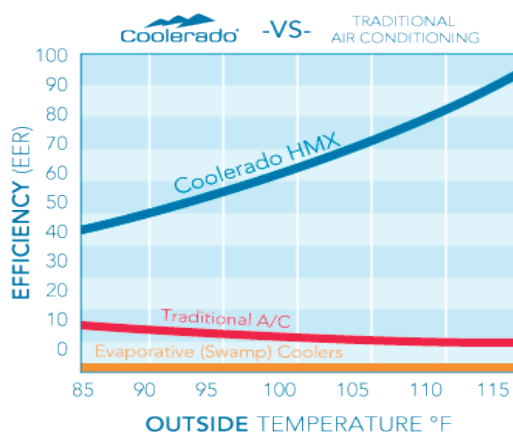


Photo Caption: Energy Efficiency of Coolerado Evaporative Cooling v. Traditional Air Conditioner<sup>xix</sup>

### Coolerado: HMX Air Conditioners in a Food Processing Plant (Mexico)

An installation at a Kellogg's food processing plant in Mexico reduced electricity consumption from 60kW to 7.1kW during peak hours yielding savings of \$62,000 in energy costs annually. Up to 95 percent reductions in energy consumption and costs have been achieved compared to traditional systems.<sup>xviii</sup> Coolerado units have been installed in more than 30 countries for applications including food process cooling, industrial and commercial air conditioning, and for data center cooling. They are available in various sizes from 450-710 watts with Energy Efficiency Ratios<sup>xx</sup> higher than 40.<sup>xxi</sup>

### Seeley International: Breezair for Commercial and Industrial Cooling (Middle East and India)

Evaporative cooling systems like the Breezair units achieve high energy efficiency performance and are ideal for hot, dry climates. They have been installed throughout the Middle East and in Mumbai, India for various commercial cooling applications including factories, restaurants, universities and office buildings.<sup>xxii</sup> Due to their low energy costs, they have been used throughout the Middle East to cool large semi-open commercial spaces in warehouses and factories by up to 15 degrees Celsius below ambient conditions, allowing for higher worker comfort and productivity. In Mumbai, Breezair units were installed for a plastics manufacturing factory reducing temperatures on the production line from 42 to 27 degrees Celsius.<sup>xxiii</sup> They use no synthetic refrigerants and consume on average 20 percent as much energy as conventional air conditioning systems. Models with an inverter drive, which allows a variable speed pump and ventilation controls, further boost efficiency.<sup>xxiv</sup>

### Aztec: Evaporative Cooling Units for Data Centers (Global)

Data centers are a rapidly expanding application for cooling technologies with companies consuming 623 billion kWh of energy globally to cool their servers.<sup>xxv</sup> Aztec evaporative coolers are self-contained, roof-mounted, and easily integrated into existing ventilation systems. One unit can cool up to eighteen 42U server racks, and additional units may be installed for larger capacity servers. The systems require 70 percent less energy than a traditional HVAC system used to cool data centers of this size.<sup>xxvi</sup>

THE NEXT GENERATION OF REFRIGERATION AND AIR CONDITIONING TECHNOLOGY, ELIMINATING THE USE OF HIGH-GWP HFCS AND DRAMATICALLY IMPROVING ENERGY EFFICIENCY, IS HERE.





## Endnotes

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