

# Refrigerant transition



Environmental protection, safety and energy efficiency

The power behind **your mission**



# Past and future

The effort to reduce the environmental footprint of HVAC/R systems spans several decades. In 1987, ozone depletion was addressed by the Montreal Protocol, which set the requirements for the complete elimination of refrigerants having a substantial ODP (Ozone Depleting Potential), especially CFCs and HCFCs. These efforts are widely viewed as being successful with recent reports indicating the ozone hole is shrinking.

Global warming is a heating effect caused by greenhouse gases being trapped in the earth's atmosphere. These gases act like a blanket by preventing heat from escaping, thereby warming the planet.

Gases that could have a significant potential impact on climate change include carbon dioxide, methane, nitrous oxide, and fluorinated refrigerant gases such as CFC, HCFC, PFC, SF6, and HFC.

Carbon dioxide (CO<sub>2</sub>) emissions are the greatest contributor to the greenhouse effect. CO<sub>2</sub> is introduced to the atmosphere through the burning of fossil fuels (oil, coal, natural gas) to generate the electricity that powers our vehicles and heats our homes. The primary source of methane comes from agriculture and is linked to our food supply.

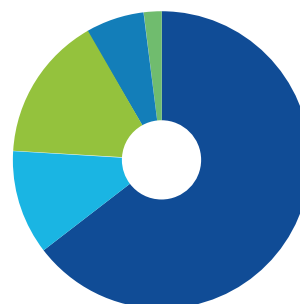
Refrigerants used in the HVAC/R industry represent a small percentage of total greenhouse gas emissions but receive a lot of attention. This is because HFCs are classified as short-lived climate pollutants that can have a greater impact on global warming when compared to carbon dioxide and other greenhouse gases. Therefore, proper refrigerant management and containment has the greatest potential to reduce the environmental impact of HFC use in HVAC/R systems.

# Refrigerant transition for environmental protection and energy efficiency

Today, air conditioning and refrigeration are no longer considered luxuries in most parts of the world. These systems are a necessity and essential to our buildings, agriculture, industrial processes, transportation, healthcare, and residential homes.

Operating these HVAC/R systems is energy intensive. While the use of renewable energy sources from solar, wind, and water are increasing, the vast majority of energy generation still relies heavily on fossil fuels. Reduced annual energy consumption and improved operational efficiency are imperative in minimizing the overall environmental footprint of HVAC/R systems.

As a result, the refrigerant industry is successfully transitioning away from Ozone Depleting Substances (ODS) and is now focusing on Greenhouse Gas (GHG) emissions and total carbon footprint. A current challenge facing the HVAC/R industry is the regulation of refrigerants based solely on their global warming potential (GWP). Some new refrigerant alternatives present their own technical and commercial challenges. As part of our commitment to environmental stewardship, Johnson Controls approaches these challenges holistically by evaluating several principles regarding our products and technologies that utilize refrigerants.



65% CO<sub>2</sub> (fossil fuel and industrial processes) 6% Nitrous Oxide  
11% CO<sub>2</sub> (forestry and other land use) 2% F-gases  
16% Methane

Source: [www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data](http://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data)

# Lifecycle emissions and energy efficiency

Energy consumption is the most dominant contributor to the total cost of ownership of HVAC/R systems, making energy efficiency a key driver when comparing technologies. In addition, climate change concerns, fluctuating energy costs, energy independence, and a lack of power distribution infrastructure in some countries make efficiency even more appealing.

This focus on system efficiency is increasingly reflected in local and global regulations. In many countries, more stringent energy efficiency standards are being implemented in parallel to phase-down requirements of conventional refrigerant fluids.

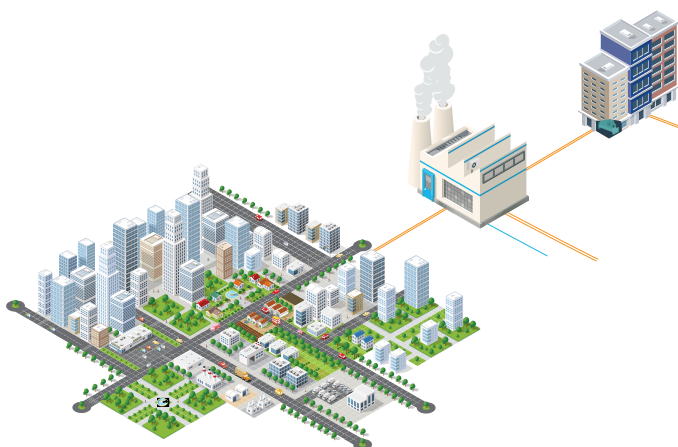
However, low-GWP refrigerant alternatives do not always guarantee a lower carbon footprint because they may result in systems consuming more energy. New alternatives often have different chemical properties than existing refrigerants and do not match system performance. This can result in potentially negative impacts to efficiency and capacity, including the following:

- Lower efficiency results because more energy is needed to provide equal cooling or heating performance.
- Lower capacity results in larger or additional equipment required to provide equal performance.

**Lifetime GHG emissions (in CO<sub>2</sub> equivalence) = Indirect emissions + Direct emissions**

**Indirect emissions** are the result of CO<sub>2</sub> emissions from the energy used to operate HVAC/R systems. According to the European Partnership for Energy and the Environment (EPEE), indirect emissions typically account for 80 percent or more of the total lifetime GHG emissions and they will vary according to equipment efficiency, operating schedule, and the carbon footprint of the electricity used. EPEE figures refer to indirect emissions across different product applications in Europe.

**Direct emissions** are derived from a combination of refrigerant GWP, leakage, and end-of-life recovery. The quantities of refrigerant released to atmosphere are highly dependent on HVAC/R equipment design, maintenance requirements and refrigerant management practices.



Lifecycle evaluations are critical for the HVAC/R industry to understand the potential climate impact of both the refrigerant fluid and the system operating performance.

**Solutions that do not provide the best combination of lowest lifecycle GHG emissions and total cost of ownership will become counterproductive and cannot be truly sustainable.**

**Note:** The indirect emissions percentage is based on multiple product applications across multiple countries. Actual emissions data can be calculated for individual HVAC/R systems in a specific location and power source mix.

# Refrigerant stewardship

The first generations of synthetic refrigerants were developed in the 1930s with the goal of improving the safety and efficiency of refrigeration processes. Following the Montreal Protocol in 1987, a second generation of synthetic refrigerants, essentially the HFCs, was developed to replace the Ozone Depleting Substances (ODS).

The next step is to address the effects of greenhouse gases. The greenhouse gas effect of refrigerants is measured in terms of CO2 equivalence and is represented by the Global Warming Potential (GWP) of a refrigerant. The next generation of refrigerant alternatives are focused on reducing this GWP value.

These alternative refrigerants are the latest generation of synthetic refrigerants, including the HFOs, and "natural" refrigerants. All these have very low or no GWP. The natural refrigerants include water, carbon dioxide and propane. They had been continuously used in some HVAC/R applications for more than a century, and are offered in many technology platforms including absorption chillers, supermarket refrigeration and industrial process systems.

Refrigerant available in Johnson Controls HVAC/R Products						
Refrigerant	Designation	ODP	GWP* (AR4)	GWP* (AR5)	ASHRAE Safety Classification	Pressure
R-22	HCFC	0.055	1810	1760	A1	High
R-134a	HFC	0	1430	1300	A1	Medium
R-404A	HFC	0	3922	3943	A1	Medium
R-407C	HFC	0	1774	1624	A1	High
R-407F	HFC	0	1825	1824	A1	High
R-410A	HFC	0	2088	1924	A1	High
R-507A	HFC	0	3985	3985	A1	High
R-32	HFC	0	675	677	A2L	High
R-448A	HFO Blend	0	1387	1273	A1	High
R-449A	HFO Blend	0	1397	1282	A1	High
R-454B	HFO Blend	0	466	467	A2L	High
R-513A	HFO Blend	0	631	573	A1	Medium
R-1233zd	HFO	-0	-	<1	A1	Low
R-1234ze	HFO	0	-	<1	A2L	Medium
R-290 (Propane)*	Natural	0	3	-	A3	High
R-704 (Helium)	Natural	0	0	0	A1	Cryogenic
R-717 (Ammonia)	Natural	0	0	0	B2L	High
R-718 (Water)	Natural	0	0	0	A1	Very Low
R-744 (Carbon Dioxide)	Natural	0	1	1	A1	Very High
R-1270 (Propylene)*	Natural	0	2	-	A3	High

\*GWP values as per the Fourth Assessment Report (AR4) or Fifth Assessment Report (AR5) of the IPCC  
 \*Additional Hydrocarbon refrigerants are available for specific Industrial Refrigeration applications

## There are several important aspects to consider when evaluating and selecting refrigerants:

### Safety

The application and maintenance of refrigerants must be safe for installers, technicians, distributors, and building occupants. Local guidelines establish procedures for the proper use of refrigerants and local safety regulations must be developed, implemented and adopted by the particular jurisdiction where the equipment will be installed. Comprehensive technician training and personal protection measures specific to the equipment type and application are also essential to the safe and successful use of refrigerants in HVAC/R systems.

### Efficiency

Improved efficiency reduces energy consumption, minimizes overall environmental impact, and helps to lower the total cost of ownership.

### Reliability

Extensive reliability testing is required to ensure refrigerant stability and compatibility with HVAC/R system gaskets, lubricants, and materials of construction. Also, if the composition of refrigerant blends changes over time because of fractionation, the system performance and operation will be impacted. This results in expensive and time-consuming repairs. Johnson Controls requires suppliers to run specific tests, engages third-party independent labs to conduct testing, and internally completes endurance and lifecycle testing on material compatibility, new refrigerants, and associated lubricants.

### Availability and affordability

Long-term availability and affordability are essential to guarantee lifetime system operation. New refrigerants are occasionally introduced to the industry with limited production and distribution. It takes time for production to increase and for supply chains to be established. A lack of availability can create risks for building owners in the case of charge loss or if emergency repairs are needed. Alternative refrigerants may initially cost more than conventional refrigerants. In some regions, this cost is offset by quotas or taxes incurred on conventional refrigerants in order to encourage the use of newer, low-GWP alternatives.

## Flammability and toxicity

Refrigerant safety classification standards like ASHRAE 34 and ISO 817 designate the flammability and toxicity group of each refrigerant. A1 refrigerants have the lowest flammability and toxicity classification while B3 refrigerants have the highest.

With appropriate safety standards, training, monitoring requirements, and maintenance practices established, refrigerants from every classification can be safely and successfully implemented in HVAC/R systems around the world.

Johnson Controls has a mandatory Hydrocarbon Systems Safety Policy. This defines the necessary requirements for customers, installers, and service technicians to follow to safely perform work on systems that utilize Hydrocarbon refrigerants (propane, butane, ethane) in accordance with regulatory and industry standards.

A continued focus on safety measures and technical training for flammable and toxic refrigerant use is essential to the growth and health of the HVAC/R industry.

Johnson Controls supports and works closely with legislative bodies to develop safety standards for refrigerants. We have a long history of safely manufacturing equipment that uses natural refrigerants, including propane and ammonia, and fund research for the safe use of flammable refrigerants. Johnson Controls remains committed to finding safe, sustainable, and long-term solutions for our customers.

		Refrigerants safety groups	
Flammability	Higher	A3	B3
	Lower	A2	B2
	Difficult to ignite and sustain	A2L	B2L
	No flame propagation	A1	B1
		Lower	Higher
		No identified toxicity at concentrations $\leq$ 400 ppm	Evidence of toxicity below 400 ppm
		Toxicity	

Source: ASHRAE Standard 34 Safety Classification

## Technician training and demonstrating competency

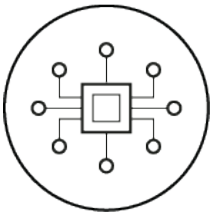
The HVAC/R industry must provide and enforce proficient technical training based on equipment design and application to assure system installation safety, efficiency, reliability, and environmental protection.

Guidelines for technical training vary based on location, refrigerant type, refrigerant volume, equipment type, and system application. HVAC/R systems that require low refrigerant charge often have different technical competency requirements compared to systems with high volumes of refrigerant charge. This is also true for systems with varied operating pressures and refrigerant safety classifications. A small, low-charge air conditioner that uses an A1 refrigerant does not demand the same technical skill level to monitor or maintain operating performance as a large industrial cooling system utilizing a toxic and/or flammable fluid does.

Updated regulations are necessary to safely address transportation, storage, and recovery of flammable refrigerants in specific HVAC/R applications and regions. Individual countries may also require technician certifications or licenses to handle and interact with refrigerant fluids. Johnson Controls provides training programs for all our service technicians globally and continues to comply with local refrigerant safety and training requirements.

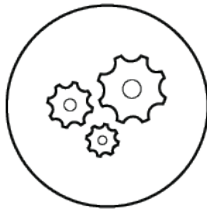
# Refrigerant management

Refrigerant gas will not directly impact the environment unless it is released into the atmosphere. Therefore, comprehensive refrigerant management practices provide one of the greatest opportunities to reduce GHG emissions during HVAC/R system operation, maintenance, and end-of-life recovery.



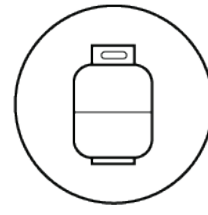
## System operation

Maintaining an optimal refrigerant charge in HVAC/R equipment is essential to the efficient performance of the system. The potential for refrigerant loss during regular operation is generally dependent on equipment design and routine maintenance efforts, but refrigerant loss will almost always have a negative impact on system capacity, efficiency, and total carbon footprint. Proper refrigerant management throughout the equipment's life is necessary to optimize equipment performance.



## Monitoring and maintenance

HVAC/R systems that are continuously monitored for refrigerant loss can provide the benefit of proactively addressing potential refrigerant leaks and specific maintenance needs. Servicing procedures specific to system application must be implemented to minimize refrigerant loss during scheduled and unplanned maintenance requirements. In the medium to long term, this streamlines the overall cost of maintaining your equipment.



## Refrigerant recovery

End-of-life recovery can account for a majority of potential refrigerant emissions directly from the HVAC/R equipment of a building. Accurate removal and storage or disposal are critical to an effective refrigerant management plan. In many regions, they provide guidelines for end-of-life refrigerant management practices, and recycling programs for some refrigerants used in existing equipment.

# Total cost of ownership

Each refrigerant product transition introduces new challenges for HVAC/R owners and facility maintenance staff. Evaluating the economic implications of new refrigerant alternatives is a major focus for current and future technology developments.

Energy consumption of HVAC/R systems has the greatest impact on operational cost - it is typically more expensive than the installation and first cost of system equipment. Purchasing energy-efficient equipment with potentially higher first cost can often be offset by continued operational savings over the lifetime of the system. Payback analysis is available to compare a wide range of system efficiencies and equipment types.

New refrigerants must provide long-term HVAC/R solutions that avoid premature obsolescence of large capital investments. Competitive refrigerant technologies will support continued growth in the HVAC industry and multiple supply chains are ultimately required to support the end-user's aftermarket needs.

## Designing HVAC/R systems for optimized life cycle performance

- ✓ Require high-operating efficiency and a comprehensive operating envelope.
- ✓ Implement advanced control systems to improve efficiency and detect failures and degraded equipment performance.
- ✓ Design equipment for low direct refrigerant emissions by minimizing potential risks for leaks (reduced number of fittings, joints, etc.).

# Support for global refrigerant initiatives from Johnson Controls

To further the cause of sustainability, government, industry, and civil society must collaborate to adopt a consistent approach to managing refrigerant transitions. These transitions must take place in a proactive, environmentally sound, economical and equitable manner. Johnson Controls supports global agreements and has made voluntary commitments to initiatives aimed at driving this consistent approach to managing the refrigerant transition.

Johnson Control supports and works with leading industry associations around the world to encourage governments to ratify the Kigali Amendment to the Montreal Protocol, a global regulation for the phase-down of high-GWP HFC refrigerants. Johnson Controls also supports the Paris Agreement, which aims to strengthen global response to the threat and impact of climate change in industrialized and developing countries.

In addition to support of global agreements, Johnson Controls has committed to initiatives that support an equitable approach to the refrigerant transition. These include the Cool Coalition, which promotes collaborative actions across a wide range of key stakeholders to achieve energy efficient and climate-friendly cooling, and the EP100 Cooling Challenge, an initiative to improve cooling efficiency in the built environment.

Johnson Controls has also signed up to the We Mean Business Short-Lived Climate Pollutants initiative, which is a commitment to reduce short-lived climate pollutant emissions, including hydrofluorocarbons (HFCs).

## Johnson Controls family of products using refrigerants



Compressor Packages · Condensers · Evaporators · Replacement Parts · Packaged Refrigeration Systems · Compressors · Air-Cooled Chillers · Condensing Units · Pressure Vessels · Hygienic Air Handlers · Heat Exchangers · Heat Pump Water Heaters · Absorption Chillers · Rooftop Units · Indoor Packaged Equipment · Split Systems · Variable Refrigerant Flow Systems · Mini-Split Systems · Water-Cooled Chillers

### **About Johnson Controls**

At Johnson Controls, we transform the environments where people live, work, learn and play. From optimizing building performance to improving safety and enhancing comfort, we drive the outcomes that matter most. We deliver our promise in industries such as healthcare, education, data centers and manufacturing. With a global team of 105,000 experts in more than 150 countries and over 130 years of innovation, we are the power behind our customers' mission. Our leading portfolio of building technology and solutions includes some of the most trusted names in the industry, such as Tyco®, York®, Metasys®, Ruskin®, Titus®, Frick®, Penn®, Sabroe®, Simplex®, Ansul® and Grinnell®.

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