R-1. Use Alternative Refrigerants Instead of High-GWP Refrigerants

GHG Mitigation Potential

100%

Up to a 100% reduction in GHG emissions during operation

Co-Benefits (icon key on pg. 34)

Climate Resilience

Climate resilience benefits vary by alternative refrigerant; for example, use of NH_3 can reduce energy consumption, thereby reducing the strain on the overall grid, particularly the risk of power outages during peak loads. Reduced energy consumption would also reduce energy costs, particularly if extreme heat would otherwise increase these costs.

Health and Equity Considerations

Evaluate the entire lifecycle impact of alternative refrigerants and avoid those that will degrade into persistent chemicals harmful to the environment. Equipment should be installed in locations with adequate space and/or ventilation in accordance with U.S. EPA and CARB recommendations.

Measure Description

This measure replaces high-GWP refrigerants with lower-GWP refrigerants (e.g., natural refrigerants such as CO_2, ammonia [NH_3], and hydrocarbons, or next generation low-GWP synthetic refrigerants like hydrofluoroolefin-1234yf) in refrigeration and A/C equipment. When emitted into the atmosphere, high-GWP refrigerants (e.g., HFCs) absorb significantly more heat than CO_2 on a mass basis, resulting in larger global warming effects. Shifting to lower-GWP refrigerants reduces the potency of refrigerant leaks, decreasing GHG emissions on a CO_2e basis.

Scale of Application

Project/Site

Implementation Requirements

See measure description.

Cost Considerations

Implementation may require retrofitting existing equipment or purchasing new equipment, which may result in high initial capital costs. Alternative refrigerants, if synthetic and patented, may cost more than conventional refrigerants. Natural, non-patented refrigerants may cost less. Costs differences are expected to decrease over time with increased availability and commercialization of alternative refrigerants. Savings may also be achieved through increased energy efficiency of a refrigerant system using an alternative refrigerant.

Expanded Mitigation Options

Evaluate the entire lifecycle impact of alternative refrigerants and avoid those that will degrade into persistent chemicals harmful to the environment so as to improve local air quality, public health, and ecosystem health. Ensure that Clean Air Act and other regulations are followed during refrigerant disposal.

GHG Reduction Formula

$$A = \frac{(B \times C \times G) - (D \times E \times F)}{(D \times E \times F)}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from refrigerant emissions	0–100	%	calculated
User Inputs				
B	Total alternative refrigerant charge size	[ ]	kg	user input
C	Annual leak rate of equipment with alternative refrigerant	[ ]	%	user input
Constants, Assumptions, and Available Defaults				
D	HFC refrigerant charge size	Tables R-1.2 through R-1.5	kg	U.S. EPA 2016
E	Annual leak rate of equipment with HFC refrigerant	Tables R-1.2 through R-1.5	%	U.S. EPA 2016
F	GWP of HFC refrigerant	Table R-1.1	unitless	IPCC 2007
G	GWP of alternative refrigerant	Table R-1.1	unitless	IPCC 2007 and WMO 2018

Further explanation of key variables:

- (B, D) – The equipment charge size is the total quantity of refrigerant installed in the refrigeration or A/C equipment. The charge size may be the same for equipment using HFC and alternative refrigerants, or it may differ. Default charge sizes for equipment with HFC refrigerants are provided in Tables R.1-2 through R-1.5 in Appendix C. If the user can provide a project-specific value, they should replace the default quantity of refrigerant installed in the GHG reduction formula. Charge size for alternative refrigerants would vary by equipment type. In the case where the alternative charge size is not known, the corresponding HFC refrigerant charge size may be used as a substitute.
- (C, E) – Based on industry data, the average annual leak rates for the given equipment type, including operational and servicing leak rates for the equipment throughout the year. The leak rate may be the same for equipment using HFC and alternative refrigerants, or it may differ. Default leak rates for equipment with HFC refrigerants are provided in Tables R.1-2 through R-1.5 in Appendix C. These are average values and may vary with specific systems. Leak rates for alternative refrigerants would vary by equipment type. In the case where the alternative leak rate is not known, the corresponding HFC refrigerant leak rate may be used as a substitute.
- (F, G) – The GWP measures the contribution to global warming from the release of one unit of the given refrigerant relative to CO_2 on a 100-year time horizon. The GWPs of common refrigerants and alternatives are provided in Table R-1.1 in Appendix C.

GHG Calculation Caps or Maximums

This measure has a maximum GHG emissions reduction of 100 percent.

Example GHG Reduction Quantification

The user reduces high-GWP emissions by replacing a high-GWP refrigerant with a lower-GWP refrigerant alternative. In this example, a 60,000-sf supermarket has a conventional direct expansion system with 1,360 kg (D) of R-404A and a total leak rate of 33 percent (E). The supermarket also has A/C equipment with 13 kg (D) of R-410A and a total leak rate of 8 percent (E). The GWPs of R-404A and R-410A are 3,922 and 2,088 (F), respectively. The user replaces R-404A with R-448, a refrigerant with a GWP of 1,387 (G), and R-410A with R-407C, a refrigerant with a GWP of 1,774 (G). The charge sizes and leak rates for the alternative equipment would be the same as the high-GWP counterpart. Note that the A/C refrigerant transition from R-410A to R-407C is included for illustrative purposes and that this transition in supermarkets is not currently happening in practice. This would reduce GHG emissions from the refrigeration and A/C systems at the supermarket by 65 percent.

$$A = \frac{((1{,}360\ \text{kg} \times 33\% \times 1{,}387)+(13\ \text{kg} \times 8\% \times 1{,}774)) - ((1{,}360\ \text{kg} \times 33\% \times 3{,}922)+(13\text{kg} \times 8\% \times 2{,}088))}{((1{,}360\ \text{kg} \times 33\% \times 3{,}922)+(13\ \text{kg} \times 8\% \times 2{,}088))} = -65\%$$

Quantified Co-Benefits

Energy and Fuel Savings

Depending on system type and refrigerant selected, successful implementation of this measure could result in energy savings or energy penalties (U.S. EPA 2019). This co-benefit cannot be quantified for the purposes of this general methodology.

Sources

- Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. Available: https://www.ipcc.ch/report/ar4/wg1/. Accessed: January 2021.
- U.S. Environmental Protection Agency (U.S. EPA). 2016. Accounting Tool to Support Federal Reporting of Hydrofluorocarbon Emissions: Supporting Documentation. October 2016. Available: https://www.epa.gov/sites/production/files/2015-09/documents/hfc_emissions_accounting_tool_supporting_documentation.pdf. Accessed: May 2021.
- World Meteorological Organization (WMO). 2018. *Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project*. Report No. 58, 5886 pp., Geneva, Switzerland.