PROCUREMENT RECOMMENDATIONS FOR CLIMATE FRIENDLY REFRIGERANTS

Developed by the Sustainable Purchasing Leadership Council (SPLC) Action Team on Climate Friendly Refrigerants, in partnership with the Institute for Governance & Sustainable Development (IGSD).

This document is the first formal output of the SPLC Climate Friendly Refrigerant Action Team. The Climate Friendly Refrigerant Action Team is dedicated to investigating global regulatory and voluntary programs to avoid and/or reduce emissions from high global warming potential (GWP) HFCs. This document identifies opportunities and specific procurement options to 1) avoid high GWP HFC refrigerants when purchasing new energy efficient refrigeration and air conditioning equipment, and 2) to reduce refrigerant leakage and service emissions. We invite you to read and put their work to use in your own procurement processes, and to offer additional insights and experiences to sharpen and improve the guidance over time.

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1. GETTING STARTED

Are you ready to take action on avoiding obsolete hydrofluorocarbon (HFC) greenhouse gas refrigerants that will be phased down globally under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) and that are prohibited under various state laws?

This procurement toolkit is designed to help select affordable, energy-efficient heating and cooling equipment[1] that uses next-generation refrigerants that are more climate friendly. While this toolkit focuses on avoiding climate change impacts of HFCs, it also takes into consideration refrigerant flammability, toxicity, and atmospheric fate of the replacement refrigerants. This document focuses on small heating, cooling, and refrigeration equipment where climate friendly alternatives are more readily available, cost effective, and compliant with US environmental and safety standards.

What is a refrigerant?
A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. In most cycles it undergoes phase transitions from a liquid to a gas and back again (Wikipedia). Refrigerants are used in air conditioners, refrigerators, freezers, and heat pumps.

Why do refrigerants matter?
As of 2020, the most common refrigerants in use are hydrofluorocarbons. HFCs often have high global warming potentials, thousands of times that of CO_2. Reducing the production and consumption of high global warming potential HFCs can mitigate 70–100 billion tonnes of carbon dioxide equivalent by 2050, and prevent up to 0.5 degrees Celsius increase in the Earth's temperature by 2100. Prioritizing energy-efficient technologies in the refrigeration and air conditioning sector could potentially double these benefits. - Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants

Currently, under the Kigali Amendment to the Montreal Protocol, HFCs are being phased down and replaced with environmentally-superior refrigerants that do less damage to the climate (see Appendix E for more details). In many cases, climate friendly refrigerants can provide higher energy efficiency too.

What is the Climate Friendly Refrigerants Action Team?

The Sustainable Purchasing Leadership Council (SPLC) and the Institute for Governance & Sustainable Development (IGSD) recruited experts from sustainable procurement offices of Maryland, New York, Oregon, and Washington plus the Sustainable Food Trade Association (SFTA) to combine experience and wisdom in assembling this procurement tool kit to implement public and private policy to require climate-friendly refrigerants in high efficiency equipment.

[1] Refrigerators, freezers, air conditioners, heat pumps

The approach of the Climate Friendly Refrigerants Action Team has been to focus on actions that require little new research or administrative effort by taking full advantage of work already accomplished by international, national, state, and professional authorities. This document also provides contract language that can be inserted directly into procurement documents to encourage or require suppliers to offer widely available sustainable technology that is safe for the ozone layer and more friendly to climate.

To help you get a fast start on using procurement to avoid high-global warming potential (GWP) HFCs in heating, cooling, and refrigeration appliances, this toolkit concentrates on product categories where next-generation technology is available that:

- Complies with US environmental and safety standards,
- Is commercialized with high market penetration that achieves economy of scale,
- Is competitive in price and superior in life cycle carbon footprint, and
- Has in-place supply and service infrastructure.

This toolkit supports compliance with HFC phase down laws already passed by several states and under development by many more, and widely supported by citizens and the affected businesses.

WHAT PRODUCTS USE HFCs?

The vast majority of HFC consumption today is in the cooling sector, comprised of refrigeration, air conditioning, and heat pumps (RACHP) in both mobile (vehicle) and stationary applications. These sectors accounted for 86% of global greenhouse gas (GHG) emissions from HFC consumption in 2012[2], as shown in Figure 1. HFCs are also used in the manufacture of thermal insulating foam and in other specialized uses such as fire protection and medicine that are not considered under this procurement document.

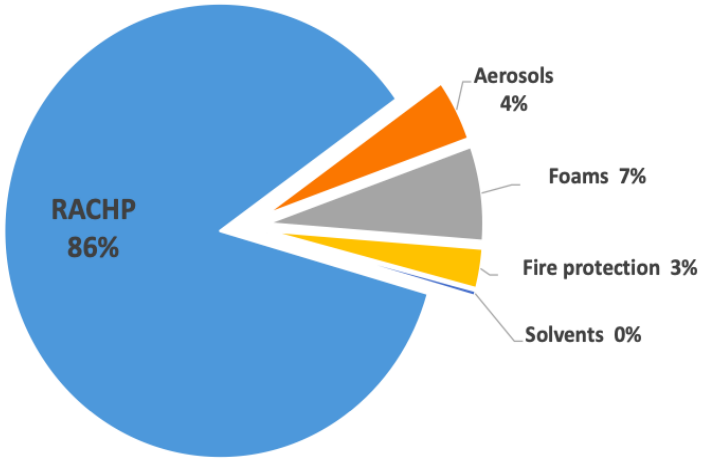


Figure 1: HFC use, 2012. Source: UNEP Ozone Secretariat Workshop on HFC Management: Technical Issues, Fact Sheet 2: Overview of HFC Market Sectors. Bangkok.

[2] United Nations Environment Programme (2015). UNEP Ozone Secretariat Workshop on HFC Management: Technical Issues, Fact Sheet 2: Overview of HFC Market Sectors. Bangkok. *Note:* GWP values used for weighting are based on the IPCC 4th Assessment Report.

Most emissions occur during operations and maintenance and end-of-life of installed refrigeration and air conditioning equipment, so proper servicing and disposal procedures are very important. This is covered in strategy 4: Insist on Proper Equipment Care and Installation Techniques, and strategy 5: Require Proper Refrigerant Disposal and Materials Recycling.[3]

Globally, as the HFC phase down proceeds under the Montreal Protocol, and under national and sub-national laws and voluntary agreements, high-GWP HFC refrigerant scarcity will likely lead to higher HFC prices that will further accelerate the transition to more climate friendly and sustainable refrigerants. Procurement authorities will want to avoid new investment in obsolete HFC technology that will be expensive to operate and service and will also want to reduce refrigerant emissions from existing equipment. It is generally more cost effective to replace older operating equipment that was inefficient at purchase, poorly installed, and badly maintained than to retrofit equipment to a new refrigerant (see Appendix A).

IMPORTANT CONSIDERATIONS

ACT FAST TO HELP AVOID CLIMATE TIPPING POINTS

Although refrigerant technology is expected to evolve rapidly, given the climate crisis, there is no time to waste waiting for a perfect solution. It is important to make the best available choice for new purchases while monitoring market changes. Fast action in procurement can speed the market penetration of low-GWP technology and dramatically reduce GHG emissions.

FIND SYNERGY IN DEMAND REDUCTION, LOW-GWP, AND ENERGY EFFICIENCY

Reduce heating and cooling energy use with options like shading and orientation, natural lighting and ventilation, and smart energy management. Reduce refrigeration energy use with options like thicker thermal insulation, better door seals, and temperature settings that save energy. The implementation of a “Refrigerant Management Program”, which would incorporate leak prevention and repair strategies as well as refrigerant inventory, can minimize the negative impacts of existing refrigeration systems. These strategies, when paired with procuring low-GWP, high efficiency equipment, represent a comprehensive, strategic approach to GHG reduction. IHS has a good White Paper[4] on Refrigerant Management Programs & the Bottom Line.

MOTIVATE AND INVOLVE SUPPLIERS

Low-GWP, high-efficiency equipment is widely available at affordable prices but is sometimes only offered when requested. Purchasers should ask for low-GWP product options, and avoid obsolete technology and equipment that will be progressively more expensive to maintain as the high-GWP refrigerants become less available through the phase down of production and shift to new technology.

[3] *Ibid.* (“Many RACHP systems have relatively high rates of leakage; more than half of total HFC consumption is for topping up refrigerant lost through gradual leakage or more major total loss incidents (e.g. a car air-conditioning system involved in an accident.”).

[4] Refrigerant Management white paper physical link: https://eponline.com/-/media/03A8E03B49414D24A76C9F31B9D4AD2F.pdf

BE MINDFUL OF CHANGES IN HFC LAWS AND REGULATIONS

In the US, many states are enacting and enforcing new regulations to phase out high-GWP HFCs. Use HFCbans.com to keep up with the status of these HFC rules and regulations. Globally, many countries have already enacted strict bans on HFCs in air conditioning and refrigeration equipment, and even more laws and regulations are under development as more countries ratify and implement the Kigali Amendment to the Montreal Protocol. While the U.S. was formerly a strong advocate of this amendment under the Bush and Obama administrations, U.S. leadership on climate ceased under the Trump administration. Despite lack of Presidential leadership, many U.S. states have adopted regulations on HFCs, and as of September 2020, the American Innovation and Manufacturing Act phasing down HFCs has strong support from both Republicans and Democrats in the US Senate and House of Representatives.

RELY ON AUTHORITATIVE SOURCES FOR INFORMATION ON REFRIGERANT ALTERNATIVES AND ACCEPTABLE SUBSTITUTES

The United States Environmental Protection Agency (US EPA) Significant New Alternatives Policy (SNAP) program was established under Section 612 of the Clean Air Act to identify and evaluate substitutes for refrigerants and other ozone-depleting substances that pose lower risk to human health and the environment. The program reviews substitutes within a comparative risk framework. The SNAP program does not provide a static list of alternatives but instead evolves the list as EPA makes decisions that are informed by its overall understanding of the environmental and human health impacts as well as its current knowledge of available substitutes. Learn more about SNAP and substitutes at: https://www.epa.gov/snap.

USE A LIFE CYCLE METRIC FOR UNDERSTANDING GLOBAL WARMING IMPACTS

Life Cycle Climate Performance (LCCP) is a metric for evaluating the combined refrigerant emissions and energy consumption global warming impacts of heating, cooling, and refrigeration systems (equipment and refrigerants) over the life cycle of the system.[5] It is calculated as the sum of the GHG emissions generated over the life cycle of the system.

Fortunately, procurement of many types of refrigeration and heating and cooling equipment can achieve superior LCCP simply by requiring lower GWP refrigerants and equipment with high energy efficiency. Lower-GWP refrigerants are usually more inherently efficient than the high-GWP HFCs they replace. ENERGY STAR's database of energy efficient equipment (the ENERGY STAR Product Finder) is beginning to allow purchasers to filter by the refrigerant used, allowing procurement officials to choose equipment that meets high energy efficiency standards and uses a low-GWP refrigerant.

PROCUREMENT LEADERSHIP CAN IMPROVE ACCESS TO INFORMATION ABOUT LOW-GWP, ENERGY EFFICIENT OPTIONS

Information necessary for a successful procurement is available from the reliable sources referenced in this document. SPLC will be working with organizations to add refrigerant information to key databases for even easier access, such as the Air Conditioning, Heating, and Refrigeration Institute (AHRI) and ENERGY STAR product lists and product finder tools. In the meantime, ClimateFriendlyCooling.com offers information on energy efficient products that use low-GWP refrigerants, including refrigerators, air conditioners, freezers, laboratory equipment, vending machines, heat pumps, water coolers, and more.

[5] https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2723&context=iracc

MARKET TRANSFORMATION

Users of this toolkit will be at the forefront of the market transition to best available technology as: (1) the Montreal Protocol phases down HFCs, and (2) many government authorities, industry associations, and companies who have pledged to climate protection move faster than required by the Montreal Protocol. Competition, economies of scale, lower service costs, and the benefits of climate and the ambition of sustainability will drive a rapid transition.

2. TAKE ACTION

This section will guide you through the process and provide the building blocks necessary for creating a successful plan to purchase energy efficient equipment and appliances that use climate-friendly refrigerants. Note that the strategies in this section are not interdependent, nor are they presented in a required order of operation.

STRATEGY 1: INCORPORATE CONSIDERATION OF HFCs INTO EXISTING SUSTAINABLE PROCUREMENT POLICY AND CREATE AN ORGANIZATIONAL HFC POLICY

Use this guide to understand the products purchased and their uses. Taking these steps will help you earn the support of staff throughout the supply chain. Use the policy template on the following page to create your own policy.

- Take lessons learned from similar companies, agencies, or organizations: what worked, what didn't work, and why? How can you incorporate successful strategies while avoiding pitfalls? Check out the case studies available from the Climate and Clean Air Coalition (CCAC) at: https://www.ccacoalition.org/en/initiatives/hfc.
- Check for the latest laws and regulations banning high global warming potential HFCs at HFCbans.com and research the local rules and regulations in the markets where you operate.
- Start with procurement of cost-effective solutions that can be implemented quickly, such as those included in Table 1: *How to Find Commercially Available Products that Use Low GWP Refrigerants.* This will help prove the value of the policy while also earning buy-in from stakeholders through early successes. There is more information on this in Section 2: Select Energy Efficient Low-GWP Technology.
- See Section 1 of Specifications for policy language to consider.

Get buy-in from leadership. If you have proven your policy to executive leadership, then they can become an advocate that can help you gain buy-in throughout the organization.

Create an inventory, set goals, and track progress. Begin by establishing a baseline and setting goals based on your research, as well as metrics (e.g., key performance indicators) to measure progress toward these goals. Be prepared to adjust or adapt these goals if needed.

Communicate and celebrate progress toward goals. This applies to leadership as well as staff to maintain support and momentum. Policies are successful when employees understand not only what they need to comply with, but also *why* the policies matter.

Be careful to avoid:
- Reinventing the wheel.
- Creating a policy that duplicates or conflicts with another internal policy.
- Creating undue burden on employees.

Organizational HFC Policy Template

[Organization] shall pursue actions to limit the purchase of equipment containing HFCs (hydrofluorocarbons) and HFC blends with high global warming potentials (GWPs). These actions shall enable *[Organization]* to mitigate increased risks attributed with climate change that impact human and environmental health.

Where opportunities exist, *[Organization]* shall pursue complementary energy efficiency measures to maximize the environmental benefits by prioritizing the purchase of equipment certified by ENERGY STAR.

In addition, where *[Organization]* owns or operates existing equipment containing HFCs and HFC blends, *[Organization]* shall pursue actions to reduce emissions through:
1) monitoring refrigerant purchases and use;
2) actively identifying and repairing leaks; and
3) maintaining equipment in proper operating conditions.

As of *[effective date]*, *[Organization]* shall apply this policy to the following end-use categories, as applicable:

- Refrigeration
  - Vending Machines
  - Water Coolers *(e.g. office coolers)*
  - Refrigeration Appliances
    - Residential/break room refrigerators
    - Compact refrigerators or freezers (i.e. in hotels and dormitories)
    - Lab-Grade Refrigerators and Freezers
    - Stand-alone type commercial refrigerators and freezers
  - Retail Food Refrigeration
  - Cold Storage Warehouses
- Air Conditioning Equipment
  - Self-Contained Residential and Commercial AC Units
    - AC Units for Rooms
    - Packaged Terminal AC Units
    - Portable AC Units
    - Unitary AC Systems (e.g., residential split systems)
  - Building Chillers
  - Other types of AC and Heat-Pump equipment where climate-friendly alternatives are available
  - Motor Vehicle Air Conditioning Equipment

STRATEGY 2: SELECT ENERGY EFFICIENT LOW-GWP TECHNOLOGY

Many product categories have a large number of energy-efficient, cost-effective, low-GWP options that comply with US and International safety and environmental standards. Wherever possible, choose equipment certified for high energy efficiency and utilize low-GWP refrigerants (see Appendix B). The EPA Energy Star Product Finder is an excellent source of high-energy efficient products, and for certain product categories, the database also indicates options for refrigerants. ClimateFriendlyCooling.com also has lists of Energy Star qualified product models that contain low-GWP refrigerants.

Table 1 provides information on how to find commercially available energy efficient products that use low-GWP refrigerants for domestic refrigerators and freezers, commercial stand-alone refrigerators and freezers, lab-grade refrigerators and freezers, commercial ice makers, vending machines, water coolers, room air conditioners, and vehicles. Many of these products are also ENERGY STAR certified. (Note: References to specific brands do not indicate nor imply endorsement.) For more discussion of maintenance and end-of-life procedures for these products and equipment, please see the Specifications section.

TABLE 1: HOW TO FIND COMMERCIALLY AVAILABLE ENERGY EFFICIENT PRODUCTS THAT USE CLIMATE FRIENDLY REFRIGERANTS

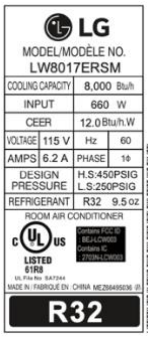
ENERGY STAR qualified **commercial refrigerators** (stand-alone type) 	Commercial refrigerators and freezers that have earned the ENERGY STAR are on average 20 percent more energy efficient than standard models because they are designed with components such as improved evaporator and condenser fan motors, hot gas anti-sweat heaters, and/or high-efficiency compressors, which significantly reduce energy consumption and utility bills. Visit ClimateFriendlyCooling.com or use the ENERGY STAR "Product Finder" at *https://www.energystar.gov/productfinder* Select low-GWP refrigerants such as R-290 or R-600a (both have GWPs<1). Avoid or prohibit purchasing models with refrigerants R-134a (GWP=1,300) or R-404A* (GWP=3,943). *R-404A is a blend made up of 44% HFC-125 (GWP=3170), 52% HFC-143a (GWP=4800), and 4% HFC-134a (GWP=1300).
ENERGY STAR qualified **commercial ice makers**	Automatic commercial ice makers are used in restaurants, bars, hotels, hospitals and a variety of commercial and industrial facilities for both food and patient care applications. According to ENERGY STAR, certified batch-type ice makers save businesses 700 kWh and $75 annually and $660 over the product's lifetime on utility bills, and certified continuous-type

Refrigerant Type ☐ R-134a (37) ☐ R-290 (3) ☐ R-404A (13) ☐ R-410A (8) ☐ R-600a (22) 	ice makers save businesses 1,350 kWh and $145 annually and $1,260 over the product's lifetime on utility bills.[6] Fortunately, ENERGY STAR allows people to see what refrigerants these commercial icemakers use. To find products, visit ClimateFriendlyCooling.com or use the ENERGY STAR "Product Finder" at: *https://www.energystar.gov/productfinder* Climate friendly refrigerant options include R-290 and R-600a. Avoid or prohibit purchasing models that use R-134a, R-404A, or R-410A
ENERGY STAR qualified **domestic refrigerators and freezers** 	Thanks to recent improvements in thermal insulation and inverter technology, today's refrigerators use much less energy than older models. With an ENERGY STAR certified refrigerator, you can maximize your energy and dollar savings without sacrificing the features you want. According to ENERGY STAR, an estimated 190 million refrigerators and refrigerator-freezers are currently in use in the United States. More than 69 million refrigerators are over 10 years old, costing consumers $4.9 billion a year in energy costs. By properly recycling your old refrigerator and replacing it with a new ENERGY STAR certified refrigerator, you can save more than $300 over the next 5 years.[7] To find efficient products that use climate-friendly refrigerants, visit ClimateFriendlyCooling.com or EIA's Buyer Guide for HFC-free refrigerators. Avoid or prohibit purchasing models that use HFC-134a.
ENERGY STAR qualified **lab-grade refrigerators and freezers**	Laboratory grade refrigerators and freezers are used specifically for storing non-volatile reagents and biological specimens in laboratory settings, including hospitals, clinics, university and government research laboratories, and pharmaceutical manufacturing plants. They are designed to contain chemicals or biological specimens at stable, low temperatures. The ENERGY STAR label will appear on laboratory grade refrigerators and freezers across a range of product types and sizes, allowing customers to purchase

[6] https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers
[7] https://www.energystar.gov/products/appliances/refrigerators

 Refrigerant Type: R-290	efficient products right sized and properly controlled for their sample needs. To find products, visit ClimateFriendlyCooling.com or use the ENERGY STAR Product Finder to locate efficient models: *https://www.energystar.gov/productfinder/product/certified-lab-grade-refrigeration*. ENERGY STAR includes "refrigerant type" in the product specifications for laboratory grade refrigerators and freezers so you can conveniently identify low-GWP models. The vast majority of qualified models use low-GWP refrigerants such as R-290, R-600a, or R-744 (GWPs = or less than 1). Avoid or prohibit purchasing models that use R-404A (GWP=3,943).
ENERGY STAR qualified **vending machines** 	ENERGY STAR certified refrigerated beverage vending machines are on average 40% more efficient and save about 1,000 kWh annually.[8] Several ENERGY STAR-qualified product manufacturers offer units with low-GWP refrigerants instead of high-GWP refrigerants like HFC-134a (GWP=1,300). To find products, visit ClimateFriendlyCooling.com. You can also find efficient models with the ENERGY STAR Product Finder tool: *https://www.energystar.gov/productfinder* Require your supplier to offer only equipment with a low-GWP refrigerant. The US EPA SNAP program lists several low-GWP refrigerant options for vending machines, including R-290, R-600a, or R-744 (GWPs = or less than 1). Avoid or prohibit purchasing models that use R-134a.
ENERGY STAR qualified Office Water Coolers 	ENERGY STAR certified water coolers use about 30 percent less energy than conventional models.[9] Some companies have been switching to low-GWP refrigerants such as R-290 (GWP<1). To find products, visit ClimateFriendlyCooling.com or ask your vendor for refrigerant information and specify your preference for low-GWP refrigerants (GWP <150) in procurement. Avoid or prohibit purchasing models that use HFC-134a.

[8] https://www.energystar.gov/products/other/vending_machines
[9] https://www.energystar.gov/products/other/water_coolers

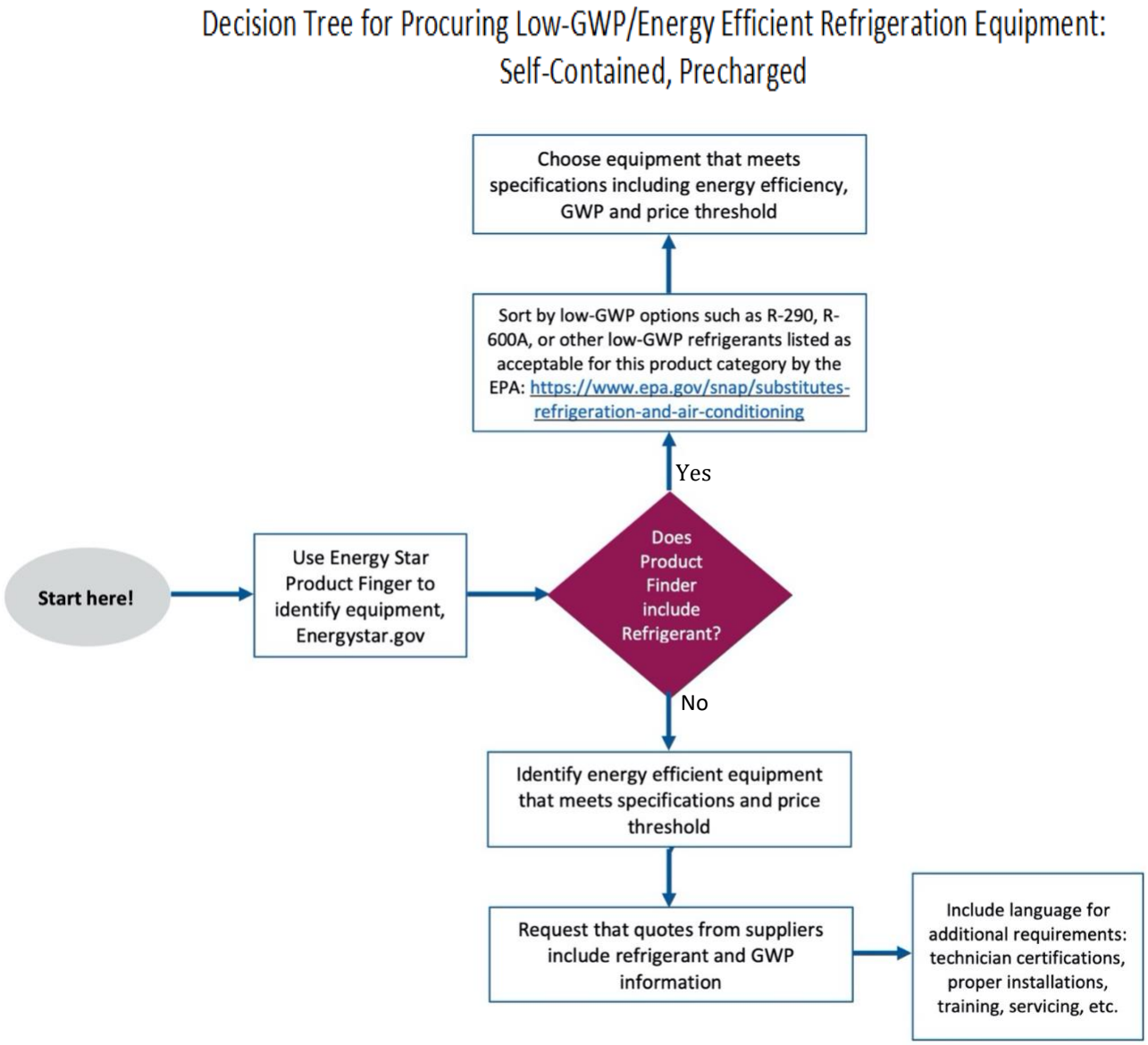
ENERGY STAR qualified **window air conditioners**  	According to the US EPA, if all window air conditioners sold in the United States were ENERGY STAR certified, the cost savings would grow to more than $350 million each year, preventing more than 6 billion pounds of greenhouse gas emissions annually, equivalent to the emissions from over 570,000 vehicles.[10] When purchasing, remember that bigger is not always better! Buying an air conditioner that is too large does not provide better cooling. An oversized air conditioner is actually less effective — and wastes energy at the same time. Make sure your unit is properly sized. Check the product label or specifications (usually available online) to determine what refrigerant the AC unit uses. Choose models with lower-GWP refrigerants like R-32 (GWP=677). R-290 (GWP<1) is also listed by the US EPA's SNAP program as acceptable for use in window AC units. Avoid or prohibit purchasing models that use R-410A* (GWP=1,924). To find products, visit ClimateFriendlyCooling.com or select from the Energy Star Most Efficient product list, as these AC units are more likely to use lower-GWP refrigerants like R32. *https://www.energystar.gov/products/most_efficient* *R-410A is a blend of 50% HFC-125 (GWP=3170) and HFC-32 (GWP=677)
Highly efficient **mini-split air conditioners** or air source heat pumps with lower-GWP refrigerant 	Outside of the USA, building space conditioning is largely provided by ductless mini-split air conditioners or air source heat pumps, commonly referred to as "room air conditioners." An organization called "Top 10" tracks the most efficient models available in international markets. To view efficient models for sale in Europe, for example, go to: *https://www.topten.eu/private/products/air_conditioners* Be sure to check the "product details" tab to find out what refrigerant the AC unit (or heat pump) uses. Lower-GWP options include R32 (GWP=677) and in some markets R-290 (GWP<1). Recently, leading manufacturer Daikin, announced their intent to offer a super-efficient model using low-GWP refrigerant HFO-1234ze (GWP<1), so purchasing officials may have additional options in the future as well.

[10] https://www.energystar.gov/products/heating_cooling/air_conditioning_room/cool_choice_room_ac

Energy efficient **vehicles** with low-GWP refrigerant	Vehicle air conditioning systems account for between one-quarter and one-third of GWP-weighted HFC emissions. Fortunately, all new light duty vehicles sold in Europe and most new light duty vehicles sold in the USA use low-GWP HFO-1234yf (GWP<1) air conditioners with same or better AC performance and no difference in vehicle price. The news of procurement preference for lower carbon footprint will have a motivating influence on automakers to complete the market transformation. Find updated listings of energy efficient vehicles at: *https://www.fueleconomy.gov/feg/best-worst.shtml* Note that when considering electric vehicles, the life-cycle climate performance depends on the carbon intensity of your local electricity power supply (typically expressed in grams or pounds of carbon dioxide (CO_2) per kilowatt-hour). The Union of Concerned Scientists offers a handy tool that allows you to compare electric and gas vehicles based on your zip code: https://evtool.ucsusa.org Ask your supplier what type of refrigerant the car AC uses. If in doubt, the Mobile Air Conditioning Society tracks which models use low-GWP HFO-1234yf versus higher GWP HFC-134a (GWP=1,300): https://macsworldwide.wordpress.com/2019/05/20/finding-yf-2019-refrigerant-update/ Specify GWP<150 in procurement documents. Avoid or prohibit purchasing models that use HFC-134a.

Figure 2 is a decision making tool for optimizing energy efficient equipment with low-GWP refrigerants for “self-contained, pre-charged” equipment”, such as refrigerators and room-size air conditioners. This category of equipment includes complete units that have been filled (i.e., charged) with refrigerant by the manufacturer. Refrigerant losses (emissions) during usage are usually minimal, and therefore recharging not necessary. Changing refrigerant (to a low-GWP one, for example) after the equipment is installed is rarely cost effective and could actually be environmentally detrimental due to losses during changeover.

FIGURE 2: DECISION TRESS



See Section 2 of Specifications for contract language.

Large refrigeration systems, such as those used in a supermarket, are complex, require more comprehensive reviews of system requirements, and would involve additional internal resources such as facility engineers for decision-making.

For more examples of products with high-energy efficiency and low-GWP refrigerant, and for decision-making guidance for large refrigeration systems, see Appendix C.

For more discussion of maintenance and end-of-life procedures for these products and equipment, please see the Specifications section.

STRATEGY 3: DRIVE THE MARKET

Communicate your new demand for energy efficient products using low-GWP refrigerants to your suppliers. In some cases, government or other institutional purchasers may help suppliers offer more low-GWP choices by coordinating with state and local authorities to remove barriers. For instance, adopting the latest building codes and standards may help remove outdated requirements and ensure safety when installing newer low-GWP equipment. Adopting ASHRAE 15-2019 into building codes and recognizing UL 60335-2-40 3rd edition, as Washington State has done, can enable the use of lower GWP refrigerants sooner. Collaborate with your suppliers to find creative solutions to any barriers that arise – this can speed the transition away from high-GWP HFCs.

By adopting similar organizational policies and aggregating demand that drives equipment costs down, governments and other institutional purchasers send a market signal that may drive market transformation. For example, the government of India recently procured low-GWP room ACs with energy efficiency higher than previously offered at price about 30% lower.[11] Bulk purchases by large purchasers (e.g. government agencies or other organizations) can often result in discounts that help justify the purchase price of new equipment. Purchasers can work with suppliers to negotiate bulk purchase discounts.

STRATEGY 4: INSIST ON PROPER EQUIPMENT CARE AND USE PROPER INSTALLATION TECHNIQUES

Improper equipment installation will waste energy, shorten product lifespan, and may pose safety hazards. Insist on proper installation and system commissioning by qualified professionals. Support proper installation, commissioning maintenance, and servicing of air conditioning and refrigeration systems to reduce refrigerant leaks and maintain energy efficiency consistent with Air Conditioning Contractors of America Quality Installation (ACCA QI) standards and original equipment manufacturer instructions. *https://www.acca.org/standards/quality*.

Support optimizing existing refrigeration systems by:

- Ensuring refrigerant purchasing records are maintained (see section 6 in Specifications for contract language).
- Ensuring installers utilize best practices (see section 3 in Specifications for contract language).
- Ensuring internal resources/contractors are compliant with Clean Air Act requirements and EPA regulations.
    - **Stationary refrigeration and air conditioning equipment.** EPA regulations (*40 CFR Part 82, Subpart F*) under Section 608 of the *Clean Air Act* require proper refrigerant management practices by those who buy or sell refrigerant, technicians, and owners and operators of AC and refrigeration systems. *Technicians* who maintain, service, repair, or dispose of equipment that could release refrigerants into the atmosphere must be certified. See the EPA Section 608 Technical Certification Page at https://www.epa.gov/section608/section-608-technician-certification. (These requirements apply for all refrigerants that contain ozone-depleting substances, e.g., hydrochlorofluorocarbons (HCFCs), and non-exempt

[11] http://www.igsd.org/igsd-teri-and-nrdc-congratulate-energy-efficiency-services-ltd-eesl-and-voltas-for-affordable-acs-protecting-climate-and-the-ozone-layer/

substitute refrigerants, e.g., hydrofluorocarbons (HFCs), hydrofluoroolefins (HFOs) and blends thereof).

- **Motor vehicle air conditioning equipment.** According to the US EPA,[12] "Any person who repairs or services a motor vehicle air conditioning (MVAC) system for consideration (payment or bartering) must be properly trained and certified under section 609 of the Clean Air Act by an EPA-approved program. All technicians servicing MVAC-like appliances must be certified. EPA-approved technician training and certification programs provide education on the proper use of MVAC servicing equipment, the applicable regulatory requirements, the importance of refrigerant recovery, as well as the effects of improper handling of refrigerants on the ozone layer and climate. To be certified, technicians must be trained by an EPA-approved program and pass a test demonstrating their knowledge in these areas."
- See the Specifications section for sample contract language.

- Considering the adoption of previously rescinded Rule 608 as best practice for all refrigerants, https://www.epa.gov/section608/revised-section-608-refrigerant-management-regulation. Not only will this reduce the impacts of refrigerants, material and operational costs will also be reduced due to less refrigerant purchases and improved chiller efficiency.

STRATEGY 5: REQUIRE PROPER REFRIGERANT DISPOSAL AND MATERIALS RECYCLING

Ask to see your service professional's Section 608 (or in the case of vehicles , 609) Certification and refrigerant recovery or recycling equipment, and ask how they dispose of used or contaminated refrigerant. If they hesitate or cannot prove their certification, select a different service professional. Refer to US EPA's list of Certified Refrigerant Reclaimers for more information. If you have old ozone-depleting refrigerants, you may even be able to get paid for sending them to a company for destruction for carbon credits. Companies like Tradewater offer these services (IGSD and SPLC do not endorse any specific company offering payment for refrigerant destruction; example provided for illustration only.) Unfortunately, in some cases technicians might vent refrigerant to the atmosphere instead of investing in and/or using proper refrigerant recovery or recycling equipment. Refrigerants of various types and from different systems should be separated to ensure they can be properly recycled as recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRE) and the United Nations Environmental Programme (UNEP) course on Sound Refrigerant Management.

If purchasing new appliances, inquire about disposal practices for old appliances to be sure they are not re-sold in markets with poor environmental controls. Consider working with a partner in the US EPA's Responsible Appliance Disposal (RAD) program. RAD is a voluntary partnership program that works with utilities, retailers, manufacturers, state and local government agencies, affiliates, and others to dispose of old refrigerated appliances using the best environmental practices available—going beyond federal requirements to protect Earth's climate and ozone layer: https://www.epa.gov/rad. See section 5 of Specifications for contract language.

[12] Source: https://www.epa.gov/mvac/section-609-technician-training-and-certification-programs

Special opportunities

New or expanding facilities
New facilities or those that are expanding with new construction or remodeling have more technical choices and can capture volume discounts. Specifications for low-GWP refrigerant products can be incorporated into the initial design, reducing potential burden when replacing equipment in existing facilities with technical constraints.

Student housing
Universities can reduce cost, inconvenience, and energy use with bulk procurement of next generation efficient technology in applications such as dorm room mini-refrigerators and/or air conditioners. Efficient low-GWP models with low carbon footprint can help save money, demonstrate concern for the environment, and help satisfy the increasing student demand for climate protection and sustainability.

GOOD TO KNOW: STATES ADOPT POLICIES TO PHASE DOWN HFCS

The US EPA and industry underwent a rulemaking process, resulting in finalization of EPA regulations in 2015-2016 (SNAP rules 20 & 21) that would have prohibited high global warming potential HFCs in certain end-uses including in new equipment in the refrigeration and air-conditioning sector. HFC manufacturer Mexichem (joined by Arkema), sued, claiming EPA had exceeded its authority. A split US court of appeals decision partially vacated that rule in 2017.

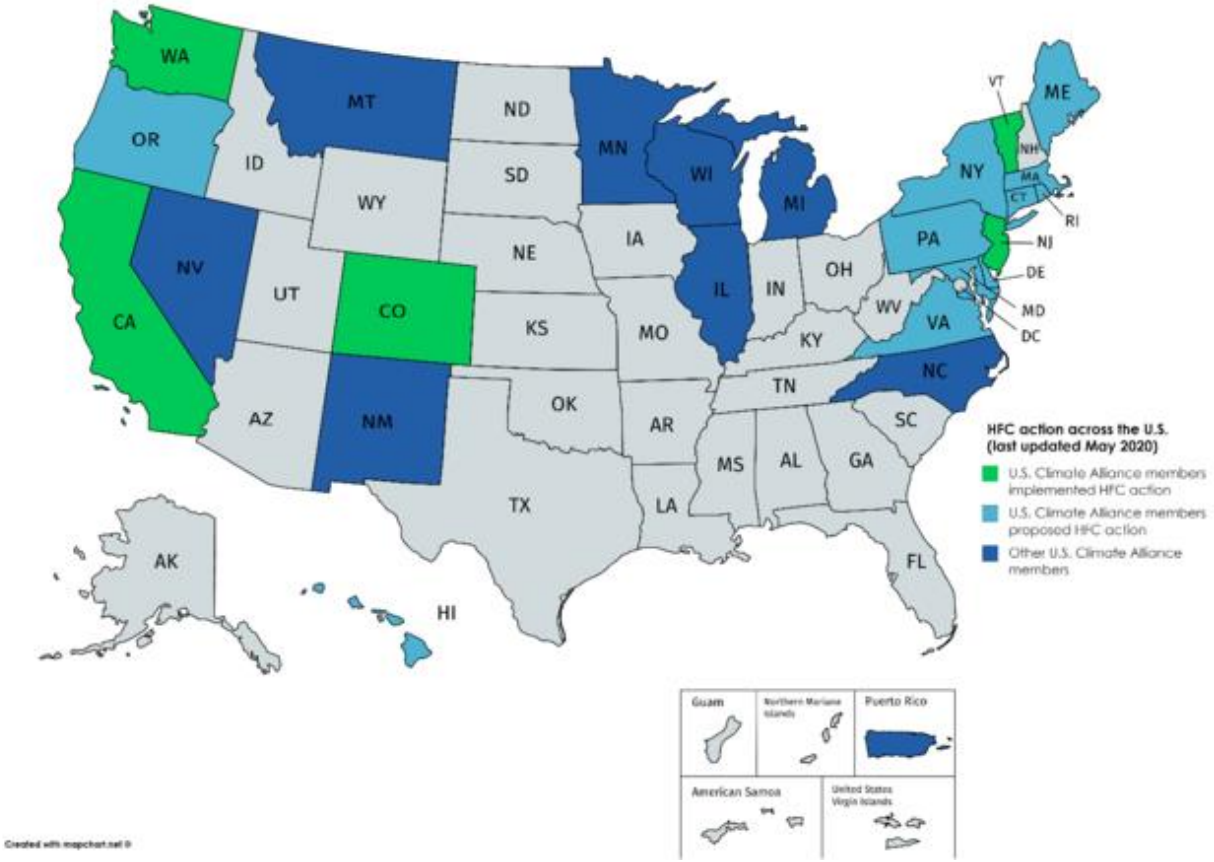
With time running out for the earth's climate and billions of dollars on the line, states were asked to take the lead. On September 14, 2018, the Air-Conditioning, Heating and Refrigeration Institute (AHRI – 315 member companies), was joined by the United States' major heating and cooling equipment manufacturers Carrier corporation, Daikin, Goodman, Lennox, Nortek, and Trane; chemical manufacturers Honeywell and Chemours; and the Natural Resources Defense Council (NRDC) in an unusual alliance to support state action to limit the use of HFCs in air conditioning technologies. *Click here to see letter*.[13] Specifically, this industry-environmental alliance committed to supporting other U.S. states and municipalities wishing to adopt prohibitions on HFCs in all end uses in EPA SNAP Rules 20 and 21. Find out more here: https://www.nrdc.org/experts/david-doniger/super-week-curbing-hfc-super-pollutants-global-summit

As of June 2020, 16 states have taken action to adopt the HFC restrictions originally laid out in EPA SNAP rules 20 and 21, and in some cases have added HFC bans for additional product categories. See Figure 4 or visit HFCbans.com for the latest updates. Large institutional purchasers should understand current laws within their jurisdictions and ensure that purchasing policies comply with the relevant laws. Suggested procurement language is included in section 3 of Specifications.

[13] *http://www.ahrinet.org/Portals/_Appleseed/documents/news/AHRI_NRDC_CARB_Letter_regarding_SLCP_HFC_measures.pdf*

Meanwhile, a bipartisan coalition has proposed legislation pending in both the House of Representatives and the Senate to try to pass the American Innovation and Manufacturing Act. This Act would authorize a phasedown of HFCs over a 15- year period and give EPA the authority to regulate a transition away from HFCs. As of September 2020, the bill is still active but not yet passed.

FIGURE 4: STATES THAT HAVE IMPLEMENTED (GREEN) OR PROPOSED (LIGHT BLUE) HFC RESTRICTIONS BASED ON SNAP RULES 20 AND 21. STATES IN THE US CLIMATE ALLIANCE ARE HIGHLIGHTED IN DARK BLUE. MAP CREDIT: NRDC.



3. SPECIFICATIONS

Use the following specifications in contracts for equipment that uses refrigerants.

1. **Purchase of New Equipment and Products**
   Vendor shall provide equipment containing low global warming potential (GWP) substitutes approved under United States Environmental Protection Agency's Significant New Alternative Policy (SNAP) program and permissible under state regulations.

   Vendors shall provide products with a lower global warming potential to the maximum extent practicable where such products are cost-effective (using life cycle-climate performance (LCCP)) and meet form, function, and utility requirements.
   - ➢ Qualifying products for most categories (e.g. refrigerators, freezers, stand-alone retail food refrigeration equipment, room/window AC units, water coolers, lab-grade refrigerators, and freezers) may be found through the ENERGY STAR Product Finder or at ClimateFriendlyCooling.com. For more information, please refer to Section 2: Take Action
   - ➢ SNAP's acceptable refrigerants by end-use can be found at https://www.epa.gov/snap/snap-substitutes-sector
   - ➢ Substitutions can be filtered by Retrofit or New, and sorted by GWP: https://www.epa.gov/snap/snap-substitutes-sector
   - ➢ HFC prohibitions by state and product category can be found here: www.HFCbans.com
   - ➢ For information specific to alternatives used for retrofitting systems, please contact your equipment manufacturer.

2. **New Equipment Installations**
   Vendor shall ensure technicians who install air conditioning equipment follow original equipment manufacturer instructions, industry-wide best practices, and when applicable, the Quality Installation standards issued by the Air Conditioning Contractors of America (https://www.acca.org/standards/quality). Best practices include optimizing charge size and choosing appropriate capacity for the intended operation.

   Vendors installing new refrigerators, freezers, or other appliances and removing old appliances shall certify that old products are property recycled or disposed of. Recyclers and programs participating in the EPA Responsible Appliance Disposal partnership can help assure that high-GWP chemicals or ozone depleting substances are properly recovered and recycled. See the program website for guidance: https://www.epa.gov/rad

3. **Preventative Maintenance, Service, and Repair for New and Existing Equipment**

   AC systems & equipment - Technician Certification & Refrigerant Recovery Requirements
   Contractors shall demonstrate that they have the proper certifications and refrigerant recovery and recycling equipment prior to performing work. Pursuant to EPA regulations found in 40 CFR Part 82, Subpart F, technicians who maintain, service, or repair of

equipment that may release refrigerants must possess the Section 608 Technician Certification. Vendors are encouraged to use certified reclaimed refrigerant for routine servicing, maintenance or repair**.**

Commercial Refrigeration Systems (if applicable) To ensure energy efficient operations are optimized and refrigerant emissions are reduced, vendor shall ensure technicians follow best practices for all preventative maintenance checks, servicing, and repairs. Technicians shall perform regular leak prevention checks at a schedule appropriate for the equipment end-use and determined by the [Organization] or as required by law.*

- US EPA's GreenChill provides best practices for Refrigerant Leak Prevention through Regular Maintenance and Commercial Refrigeration Leak Prevention & Repair.

Vendor shall ensure HFC and HFC blend refrigerants are captured and reclaimed from existing equipment to reduce the production of new HFCs.

** Reporting requirements may vary on a state-by-state basis. Please review your state's guidelines. Also note that high-GWP refrigerants may have stricter reporting requirements than low-GWP refrigerants.*

4. **End-of-Life Management**

Pursuant to Section 608 of the Clean Air Act, ozone-depleting substance (ODS) and HFC refrigerants may not be vented from appliances.*

Under EPA regulations at 40 CFR Part 82, Subpart F, technicians who dispose of equipment that may release refrigerants must possess the 608 Technician Certification. Technicians disposing of a motor vehicle air conditioning (MVAC) system must possess the Section 609 Technician Certification.

Before disposing of any appliance containing more than 5 pounds of refrigerants, a Section 608 Certified technician must recover the refrigerant to ensure it is not released into the environment. Refrigerants of different types should be separated.

In accordance with Section 608 of the Clean Air Act, refrigerant recovery and recycling equipment must meet the requirements set forth in Appendix B2, B3, and B4 to 40 CFR 82, Subpart F.

For small appliances (e.g., refrigerators, window AC units) refrigerants can be recovered by a technician, appliance recycling facility, or through the vendor supplying the replacement appliance. Small appliances may be disposed of through the Responsible Appliance Disposal (RAD) program referenced below.

Vendor shall ensure that evidence of equipment's proper disposal can be provided.

- Vendor is encouraged to recycle old appliances using a Partner in the US EPA's Responsible Appliance Disposal (RAD) program. Partners in the RAD program go beyond federal requirements by responsibly recycling equipment using the best environmental practices available. Recycling facilities servicing RAD partners can be found here.

- The RAD Program also provides Example Language for Procuring Refrigerated Appliance Recycling Services Using Best Environmental Practices.
- Vendor is encouraged to consider becoming a Partner - or an Affiliate (as appropriate) in the EPA's RAD program.

**Please note that* R-600 (*isobutane) R-441A (a blend of ethane, propane, n-butane and isobutane) in household refrigerators, freezers, and combination refrigerators and freezers, and R-290 (propane) in retail food refrigerators and freezers (stand-alone units only are exempt from the venting prohibition because EPA has determined that their emissions do not pose a threat to the environment. [https://www.regulations.gov/document?D=EPA-HQ-OAR-2012-0580-0036]*

5. **Tracking and Reporting**
   Vendor shall require contractors or technicians to track and report on the amounts of refrigerants, including HFCs and HFC blends, added or removed during routine installation, maintenance, service, repair, and disposal of all equipment, appliances, and supplies.

APPENDIX A: WHAT ARE HFCS AND WHY ARE THEY BEING PHASED DOWN?

HFCs were developed to rapidly replace a portion of the ozone depleting substances (ODSs) such as CFCs and HCFCs that were phased out under the *Montreal Protocol*. ODSs catalytically destroy the stratospheric ozone layer which protects Earth against the harmful effects of ultraviolet radiation including skin cancer, cataracts, suppression of the human immune system, and damage to agricultural and natural ecosystems. HFCs are safe for the ozone layer and are typically less damaging to climate than CFCs and HCFCs, but are nevertheless too damaging to be sustainable with GWP up to almost 10,000 times greater than CO_2.[14]

Fortunately, high-efficiency, lower-GWP replacement technology is available or under development for most sectors. See ClimateFriendlyCooling.com for examples.

COST IMPACTS

Many energy efficient products using low-GWP refrigerants are available at equal or lower costs than comparable products using high-GWP refrigerants. See **Table 1:** How to find Commercially Available Energy Efficient Products that use Low GWP Refrigerants. There is no discernible difference in consumer prices for these products compared to products that use high-GWP refrigerants.

In the future, it is likely that additional product categories, such as larger residential and commercial heat pumps and air conditioning systems, will transition to lower GWP refrigerants. California has proposed restricting the sale of these products starting 1 January 2023 if they contain refrigerants with a GWP higher than 750. On November 9, 2018, JMS Consulting and Inforum published a study on "*The Consumer Cost Impacts of US Ratification of the Kigali Amendment,"* sponsored by the Air Conditioning, heating and Refrigeration Institute (AHRI) and the Alliance for Responsible Atmospheric Policy (Alliance). This report analyzed the ownership cost impacts of switching to low-GWP air conditioning refrigerants residential and commercial air conditioning. See Figures 5 and 6 below. The report found that energy consumption is understandably the dominant contribution to consumer costs, at 66% of lifetime cost for residential air conditioning and 90% for commercial equipment. Refrigerant costs over the lifetime are only 0.7% of lifetime costs for residential and 0.4% for commercial equipment.[15] Improvements in energy efficiency more than offset the small added cost of superior refrigerant.

[14] GWP is referenced to CO_2, which has a GWP of 1

[15] https://www.documentcloud.org/documents/5205002-Consumer-Costs-Final-InforumJMS-20181109.html

FIGURE 5: CONSUMER LIFE CYCLE OWNERSHIP COSTS FOR A REPRESENTATIVE 15 TON COMMERCIAL AC UNIT.

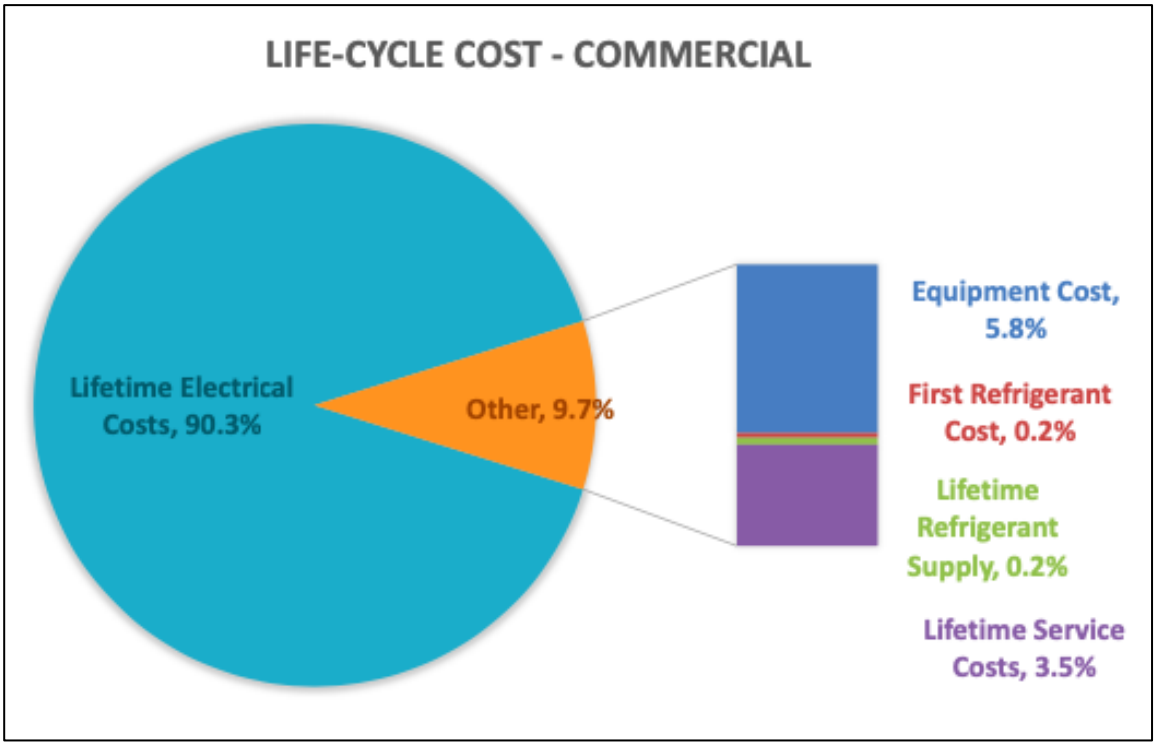
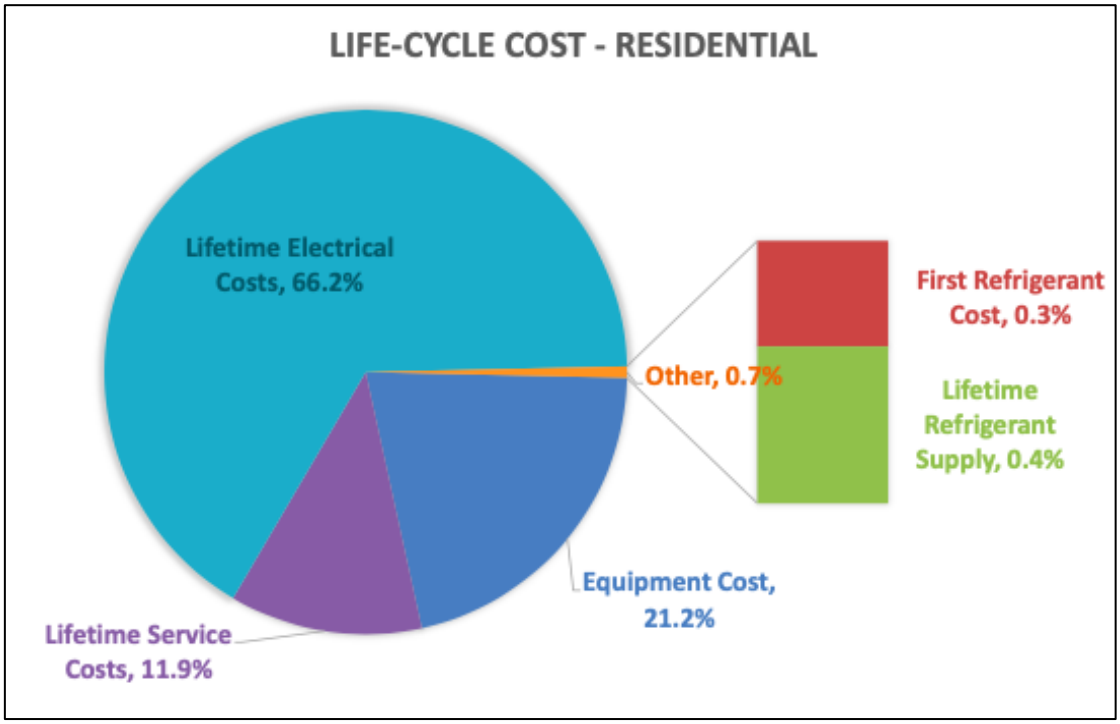
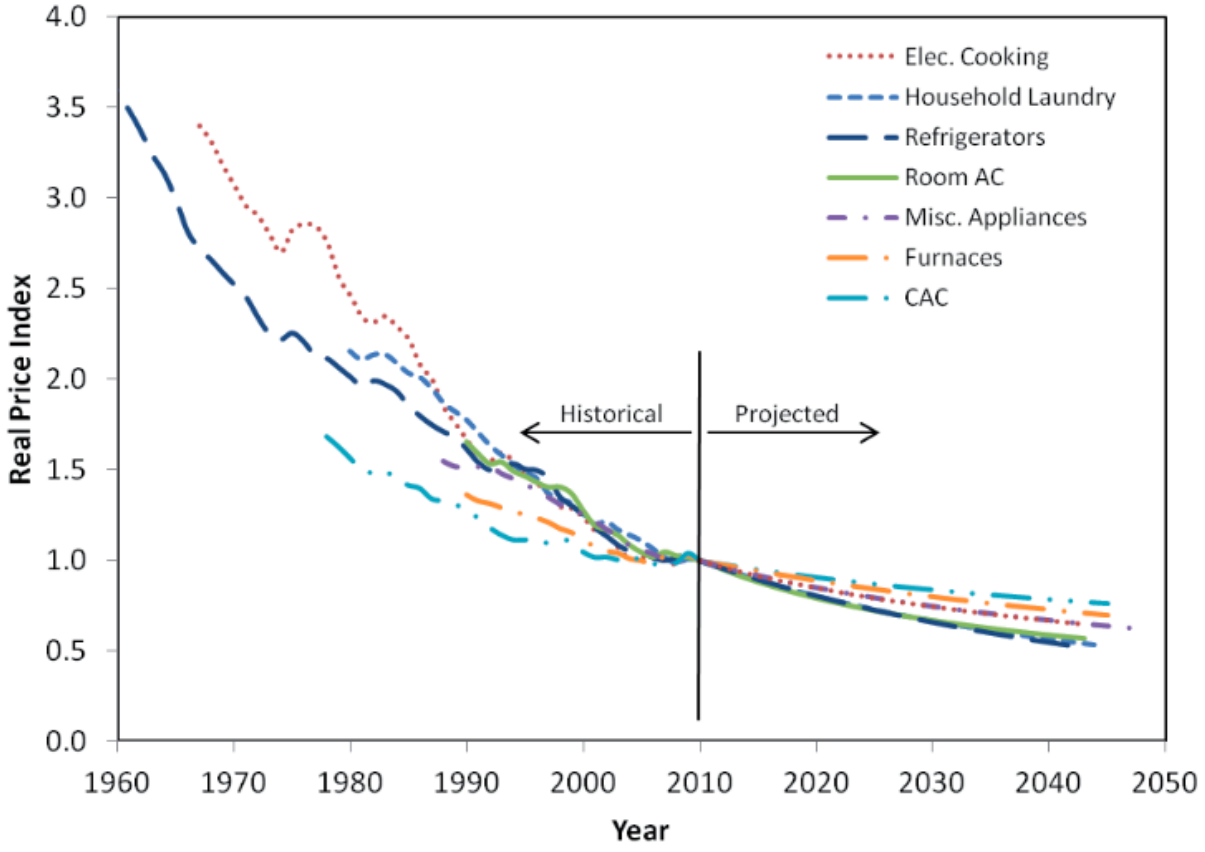


FIGURE 6: CONSUMER OWNERSHIP COSTS FOR A REPRESENTATIVE 2.5 TON RESIDENTIAL OR SMALL COMMERCIAL AC UNIT.



The report authors concluded that "With reasonable expectations about the development of the market, in scenarios assuming U.S. ratification of Kigali compared to assuming no adoption in the U.S., total lifetime ownership costs are very similar, with consumer savings in the 'with Kigali' case. Although there is no reason to expect that refrigerant prices will behave differently during the Kigali transition than during the two previous transitions away from ozone-depleting substances, even assuming a five-times higher price for replacement refrigerants would not significantly change the impact on consumers." They also went on to state that "The consumer savings identified in this report cover only two of the largest industry segments. There are over 60 use segments that could be analyzed using more detailed models, such as EPA's Vintaging Model, as a basis. There are likely benefits elsewhere in HVACR as well as in other industries. A qualitative review of several smaller manufacturing segments supports the expectation of at least small consumer savings in several applications. For several segments there is also an underlying trend of reduced real consumer prices over time through previous transitions." Figure 7 below shows real price indices for refrigerators, room AC, and residential central AC (CAC) along with other appliance categories, and industry's expectations of future costs. Note that costs are expected to continue to decrease.

FIGURE 7: HISTORICAL & PROJECTED REAL PRICE INDICES FOR U.S. MAJOR APPLIANCE CATEGORIES



APPENDIX B: CHARACTERISTICS OF COMMON REFRIGERANTS

Table B1 provides the GWP of chemicals commonly used as refrigerants, or as components in refrigerant blends. The World Meteorological Organization's 2018 numbers reflect the latest science on warming impacts. Many government sources continue to cite the Intergovernmental Panel on Climate Change's 4th Assessment Report (AR4) 100-year GWP values. Some organizations and state governments prefer to cite the IPCC's more recent 5th Assessment Report, and/or use the 20-year global warming potentials for HFCs given their short atmospheric lifetimes. A complete list of chemicals and their associated GWPs can be found in Chapter 8, Appendix 8.A of Climate Change 2013: The Physical Science Basis: Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [16]

TABLE B1: GLOBAL WARMING POTENTIAL OF REFRIGERANTS

Substance / Industrial designation or chemical name	**Total Lifetime (years) (WMO 2018)**	**GWP-100 (WMO 2018)**	**GWP-100 (IPCC AR5*)**	**GWP-20 (IPCC AR5*)**
Hydrocarbons (not ozone depleting, negligible GWPs)				
HC-290 (propane)	**0.4 days**	**<1**	<1*	<1*
HC-600a (isobutane)	**0.2 days**	**<<1**	<1*	<1*
HC-1270 (propylene)		**<<1**	<1*	<1*
Hydrochlorofluorocarbons (ozone depleting, globally eliminated in new equipment, but still present in existing equipment)				
HCFC-22	**11.9**	**1780**	1760	5280
HCFC-123	**1.3**	**80**	79	292
Hydrofluorocarbons (not ozone depleting, some have significant climate impacts)				
HFC-23 (HFC-23 is a byproduct of HCFC-22 production. HCFC-22 used as a feedstock to make Teflon)	**228**	**12690**	12400	
HFC-32	**5.4**	**704**	677	2430
HFC-125	**30**	**3450**	3170	6090
HFC-134a	**14**	**1360**	1300	3710
HFC-143a	**51**	**5080**	4800	6940
HFC-152a	**1.6**	**148**	138	506

[16] https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

Unsaturated Hydrofluorocarbons (not ozone depleting, negligible GWPs)				
HFO-1234yf	**12 days**	**<1**	<1*	<1*
HFO-1234ze(E)	**19 days**	**<1**	<1*	<1*
HFO-1336mzz(Z)	**122 days**	**2**	16*	60*
HCFO-1233zd(E)**	**26 days**	**1**	NA	N/A
Other refrigerants (not ozone depleting, negligible GWPs)				
R-744 (carbon dioxide)	**Thousands of years**	**1**	1	1
R-717 (ammonia)	**Days**	**<1**	<1*	NA

*GWPs for HFO-1234yf, HFO-1234ze(E), and HFO-1336mzz(Z) and ammonia from WMO 2018: *http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Background-Documents/SAP-2018-Assessment-report.pdf*.
**GWP and atmospheric life for R-1233zd(E) are from: http://conf.montreal-protocol.org/meeting/oewg/oewg-39/presession/Japan_submissions/JRAIA-Symposium2016_0804_centrifugal_chiller_E.pdf

In addition to considering refrigerant GWPs and impact on the stratospheric ozone layer, the US Environmental Protection Agency's Significant New Alternatives Policy program, safety professionals, and industry organizations such as ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers) and SAE (Society of Automotive Engineers) evaluate refrigerants' toxicity, flammability, and other characteristics, and set appropriate standards and use restrictions to assure that risks are properly mitigated. Some of these characteristics are included in Table B2.

TABLE B2: CHARACTERISTICS OF REFRIGERANTS

Substance / Industrial designation or chemical name	ASHRAE toxicity*	ASHRAE flammability**	TFA?***
Hydrocarbons			
HC-290 (propane)	**A**	3	No
HC-600a (isobutane)	**A**	3	No
HC-1270 (propylene)	**A**	3	No
Hydrochlorofluorocarbons			
HCFC-22	**A**	1	
HCFC-123	**A**	1	
Hydrofluorocarbons			
HFC-32	**A**	2	No
HFC-125	**A**	1	
HFC-134a	**A**	1	Yes
HFC-143a	**A**	2L	Yes
HFC-152a	**A**	2	No
Unsaturated Hydrofluorocarbons			
HFO-1234yf	**A**	2L	Yes
HFO-1234ze(E)	**A**	2L	Some (<10%)
HCFO-1224yd(Z)	**A**	1	Yes
HFO-1336mzz(Z)	**A**	1	Some (<20%)
HCFO-1233zd(E)	**A**	1	No
Other refrigerants			
R-744 (carbon dioxide)	**A**	1	No
R-717 (ammonia)	**B**	2L	No
R-718 (water)	**A**	1	No

*ASHRAE categorizes refrigerants into 2 toxicity classes: A (lower toxicity) and B (higher toxicity).
**ASHRAE categorizes refrigerants into 4 flammability classes: 1 (generally nonflammable), 2L (very low flammability), 2 (lower flammability), and 3 (higher flammability). See the United Nations-ASHRAE 2019 fact sheet,

"Update on New Refrigerant Designations and Safety Classifications." https://www.ashrae.org/File%20Library/Professional%20Development/Factsheet_ASHRAE_English_20190118.pdf. ***Trifluoroacetic acid (TFA) is an atmospheric break-down product of certain fluorinated refrigerants, such as HFO-1234yf. TFA is an emerging concern to some in the scientific community. Learn more from the United Nations Environment Programme at: https://ozone.unep.org/sites/default/files/2019-08/TFA2016.pdf. (The UNEP link references the following paper: Solomon K, Velders G, Wilson S, Madronich S, Longstreth J, Aucamp P, Bornman J. 2016. *Sources, fates, toxicity, and risks of trifluoroacetic acid and its salts: Relevance to substances regu- lated under the Montreal and Kyoto protocols.* Journal of Toxicology and Environmental Health B. This report is an Accepted Manuscript of an article published by Taylor & Francis in J Toxicol Environ Hlth B on June 27, 2016. The paper is also available online at: http://www.tandfonline.com/10.1080/10937404.2016.1175981.) See also: https://www.epeeglobal.org/wp-content/uploads/2018-11-06-QA-Screen.pdf

APPENDIX C: LARGER EQUIPMENT

Larger systems that require HFCs are complex and require a level of technical expertise that is generally outside of the scope for procurement professionals. Decisions concerning these types of equipment should be made by engineers, facilities managers and others with the appropriate training. Appendix B contains information that may be useful in understanding these systems and making appropriate procurement decisions.

Performance Criteria For Refrigeration Systems

There are three types of performance criteria that apply to selection of refrigeration and air conditioning equipment:

1. Technical Performance, including cooling capacity (measured in TONs, BTUs, etc.), energy efficiency (measured as EER, COP, SEER, etc.), and reliability (lubricant and materials compatibility, duty cycles);

2. Life Cycle Climate Performance—LCCP or life cycle carbon footprint (measured on a product life cycle basis including—on a carbon-equivalent basis—direct GHG refrigerant emissions, indirect fossil fuel or biomass emissions for electricity consumption and embodied emissions from manufacture, transport, and recycle at end of product life).

3. Life Cycle Financial Ownership Cost including the cost of purchase, transport, installation, maintenance, operation, and retirement (recycle of material, recovery and reuse or destruction of ozone-depleting or GHG refrigerants.

Procurement officials can customize their purchase performance criteria requirements based on their individual needs.

LARGE SUPERMARKET REFRIGERATION SYSTEMS

According to the US EPA, most of the 35,000+ supermarkets in the United States use centralized direct expansion (DX) systems to chill their products.[17] Typically, these refrigeration systems are charged with 3000 – 4000 pounds of refrigerant and can leak in excess of twenty percent of their charge each year. Commonly used refrigerants include ozone-depleting HCFC refrigerants, often HCFC-22 (GWP=1,760), and blends consisting entirely or primarily of HFCs, both of which are potent greenhouse gases. Fortunately, in recent years there have been several advancements in refrigeration technology that can help food retailers reduce both refrigerant charges and refrigerant emissions. Refrigerants such as CO_2, ammonia, hydrocarbons, and HFOs have potential to be used in commercial refrigeration systems in the U.S. market. Currently CO_2 is being used as a primary refrigerant in commercial refrigeration system applications in the United States. Refrigeration systems that use CO_2 as a primary refrigerant are commonly referred to as transcritical CO_2 systems. Transcritical CO_2 refrigeration is a type of refrigeration cycle in which CO_2 is the sole refrigerant, evaporating in the subcritical

[17] See: https://www.epa.gov/greenchill/advanced-refrigeration

region and rejecting heat at temperatures above the critical point in a gas cooler instead of a condenser. Recent demonstration projects for utilizing low-GWP alternatives to HFCs presented by the CCAC calculated energy savings of 15% to 30% and carbon footprint reductions of 60% to 85% for refrigeration in commercial food stores.[18] For more information on acceptable low-GWP refrigerants, see *Acceptable Substitutes in Retail Food Refrigeration* at www.epa.gov/snap. Note that smaller stand-alone commercial refrigeration equipment often uses climate-friendly R-290 refrigerant. A list of hundreds of Energy Star qualified commercial stand-alone refrigerators and freezers that use lower-GWP refrigerants is available at ClimateFriendlyCooling.com

One of the best ways for supermarkets to learn about how to reduce refrigerant emissions and decrease their impact on the environment is through the EPA's GreenChill partnership program. GreenChill works to help food retailers transition to environmentally friendlier refrigerants; lower refrigerant charge sizes and eliminate leaks; and adopt green refrigeration technologies and best environmental practices. GreenChill's Store Certification Program for Food Retailers recognizes individual stores for using environmentally friendlier commercial refrigeration systems. While GreenChill does not require low-GWP refrigerants to earn the certification, using low-GWP refrigerants is one pathway to earn the Platinum- level certification. Learn more at: https://www.epa.gov/greenchill.

LARGE INDUSTRIAL REFRIGERATION SYSTEMS

While most procurement officials are unlikely to be purchasing large industrial refrigeration systems, SPLC members may wish to note that large industrial refrigeration systems using low-GWP options have been the industry norm for over a century. According to the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC) of the Montreal Protocol's Technology and Economic Assessment Panel,

> *"Industrial refrigeration systems are used in a wide range of applications globally, applying a variety of refrigerants and technologies for a wide range of temperature levels. In larger industrial refrigeration plants, R-717 (ammonia, GWP=0) has been extensively used for more than 150 years. Current technological advances enable the use of low charge R-717 systems, as well as cascade systems using R-717 together with R-744 (carbon dioxide, GWP=1) opening up new opportunities…The industry has learned to work safely with R-717 by proper education and training. Accidents are less likely to happen when safety procedures are followed."*

Additionally, the Montreal Protocol RTOC notes that "Large size heat pumps are gaining market acceptance due to increased knowledge of the relevant technology benefits. There are several industrial processes where cooling and heating are needed at the same time, for example the dairy industry. These cases demonstrate how to fully use the potential of cooling and heating capabilities of heat pumps simultaneously."[19]

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[18] UNEP/Climate and Clean Air Coalition (CCAC) (2014). Low-GWP Alternatives in Commercial Refrigeration: Propane, CO_2 and HFO Case Studies.

[19] See the RTOC report at: https://ozone.unep.org/sites/default/files/2019-04/RTOC-assessment-report-2018_0.pdf

MEDIUM-TO-LARGER RESIDENTIAL AND COMMERCIAL AIR CONDITIONERS AND HEAT PUMPS

This category includes equipment that cools enclosed spaces in households and commercial industries, such as central air conditioners (i.e., ducted); packaged rooftop units; water-source and ground-source heat pumps; and other products. It excludes small systems (room air conditioning such as window units, ductless mini split air source heat pumps, or packaged terminal air conditioners commonly found in motel rooms) and very large systems (chillers). Residential and light commercial air conditioning and heat pumps are often distinguished from chillers by the fact that they condition the air directly, rather than cool (or heat) water that is then used to condition air.

In the future, it is likely that additional product categories, such as larger residential and commercial heat pumps and air conditioning systems, will transition to lower GWP refrigerants. California has proposed restricting the sale of these products starting 1 January 2023 if they contain refrigerants with a GWP higher than 750.

In June 2020, the US Environmental Protection Agency proposed listing lower-GWP refrigerant R-32 (HFC-32, which has a 100-year GWP of about 700) as acceptable in residential heat pumps and central AC systems. See the proposed listing at: https://www.govinfo.gov/content/pkg/FR-2020-06-12/pdf/2020-11990.pdf. If finalized, this will allow customers in the USA to use air source heat pumps and AC systems with lower-GWP refrigerants. All of the air source ACs and heat pumps listed by TopTen EU use lower-GWP R-32: https://www.topten.eu/private/products/air_conditioners

LARGE COMMERCIAL OR INDUSTRIAL AIR CONDITIONING SYSTEMS (CHILLERS)

Chillers typically cool water, which is then circulated to provide comfort cooling throughout a building or other location. Chillers can be classified by compressor type, including centrifugal and positive displacement. Replacing or specifying a chiller for new construction is a major project, generally involving many stakeholders in addition to the procurement official. The US EPA has listed several low-GWP refrigerants as acceptable for use in chillers, including water/lithium bromide absorption, R-744 (CO_2), and several newer refrigerants with GWPs <10, including HFO-1234ze, brand name Solstice® 1234ze and HFO-1336mzz(Z) ((Z)-1,1,1,4,4,4-hexafluorobut-2-ene), brand name Opteon® MZ. Medium-GWP refrigerants listed as acceptable include R-513A (GWP=572), which is a blend of 56% HFO-1234yf and 44% HFC-134a. Learn more at: *https://www.epa.gov/snap/substitutes-centrifugal-chillers*.

In 2020, major manufacturers have announced the availability of super-efficient chillers that utilize low-GWP refrigerants. For example, in early 2020, Daikin announced brand new chiller technology centered on centrifugal products that use new HFO refrigerants. According to Air Conditioning Heating and Refrigeration News, “The new products, the Aptitude™ oil bearing centrifugal chiller and Magnitude® magnetic bearing centrifugal chiller, both utilize R-1233zd. They are both ultra-high efficiency (as low as 0.49 kW/ton at full load operation and part-load values as low as 0.29 kW/ton) and will be available this year.”[20]

[20] *https://www.achrnews.com/articles/142723-daikin-applied-introduces-new-rooftop-and-chillers*

APPENDIX D: TOOLS, RESOURCES, CERTIFICATIONS & PRODUCT LISTS

For purchasers seeking energy efficient, low-GWP products, below are some additional resources.

Certifications and Standards

Demand products and services with third-party, multi-attribute, environmental and quality certifications. The certifications below do not currently mandate the use of low-GWP refrigerants. You will need to seek out low-GWP options that also meet these certifications or guidelines. For guidance on how to locate low-GWP options, see Table 1, How to find Commercially Available Energy Efficient Products that use Low GWP Refrigerants.

ENERGY STAR OR THE ENERGY STAR MOST EFFICIENT STANDARD

This certification verifies energy efficiency of appliances and equipment. It is a multi-attribute, third party verified certification.

ENERGY STAR also lists “ENERGY STAR Most Efficient” products, which indicate energy efficiencies greater than comparable products with a conventional ENERGY STAR label. ENERGY STAR Most Efficient is a distinction recognizing products that deliver cutting edge energy efficiency along with the latest in technological innovation. Learn more at EnergyStar.gov

GREENCHILL CERTIFICATION

GreenChill is an EPA partnership with food retailers to reduce refrigerant emissions and decrease their impact on the ozone layer and climate change. GreenChill’s Store Certification Program for Food Retailers recognizes individual stores for using environmentally friendlier commercial refrigeration systems. A food retail store can achieve Platinum–, Gold–, or Silver–level certification. Any food retail store in the United States, whether in the design phase, remodel phase, newly constructed, or fully operational, can apply for GreenChill’s Store Certification Award. The process is free. While GreenChill does not require low-GWP refrigerants to earn the certification, using low-GWP refrigerants is one pathway to earn the Platinum-level certification. Learn more at: https://www.epa.gov/greenchill.

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA) QUALITY STANDARDS

Quality Standards describe the procedures that contractors should follow when designing, installing, maintaining, repairing, and verifying indoor environment systems. ACCA’s ANSI-approved quality standards have been adopted by utilities, government agencies, manufacturers

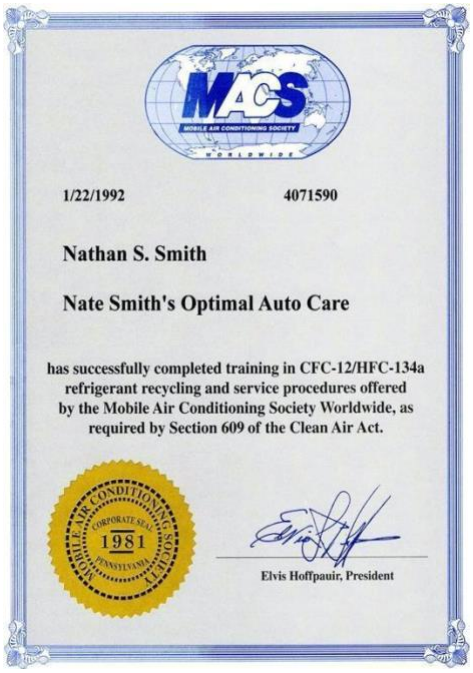
and others nationwide. and are freely available. Learn more at: https://www.acca.org/standards/quality.

AHRI CERTIFIED PRODUCTS

(Air Conditioning, Heating and Refrigeration Institute) certifies product performance and their database also lists ENERGY STAR certified products. The directory is available at: https://www.ahridirectory.org/.

SECTION 608 CERTIFICATION FOR STATIONARY AIR CONDITIONING AND REFRIGERATION TECHNICIANS

EPA regulations (*40 CFR Part 82, Subpart F*) under Section 608 of the *Clean Air Act* require that *technicians* who maintain, service, repair, or dispose of equipment that could release ozone depleting refrigerants into the atmosphere must be certified. Starting on January 1, 2018, this requirement has applied to appliances containing most substitute refrigerants, including HFCs.



SECTION 609 CERTIFICATION FOR MOTOR VEHICLE AIR CONDITIONING TECHNICIANS

According to the US EPA, "Any person who repairs or services a motor vehicle air conditioning (MVAC) system for consideration (payment or bartering) must be properly trained and certified under section 609 of the Clean Air Act by an EPA-approved program. All technicians servicing MVAC-like appliances must be certified.
EPA-approved technician training and certification programs provide education on the proper use of MVAC servicing equipment, the applicable regulatory requirements, the importance of refrigerant recovery, as well as the effects of improper handling of refrigerants on the ozone layer and climate. To be certified, technicians must be trained by an EPA-approved program and pass a test demonstrating their knowledge in these areas."[21] On the left is an example of the certificate provided by the Mobile Air Conditioning Society Worldwide. Learn more at: https://www.epa.gov/mvac/section-609-technician-training-and-certification-programs

Product Lists

ClimateFriendlyCooling.com has lists of energy efficient products available for purchase in North America that use low-GWP refrigerants. Products covered include:

- Refrigerators
- Freezers
- Vending machines

[21] https://www.epa.gov/mvac/section-609-technician-training-and-certification-programs

- Commercial refrigerators
- Commercial ice makers
- Lab-grade refrigerators and freezers
- Air conditioners
- Dehumidifiers
- Vehicle air conditioners

The most complete US product lists to date of energy-efficient refrigeration and air conditioning equipment can be found at the ENERGY STAR, AHRI, and EIA websites:

Energy Star Product Finder: *https://www.energystar.gov/productfinder/*

EIA Buyers Guide for HFC-free Refrigerators: https://eia-global.org/reports/20200625-hfc-free-refrigerator-list

AHRI directory: *https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f*
(Note: Energy Star and the Consortium for Energy Efficiency, a utility program partnership, pull from the AHRI directory listings for their energy efficiency product lists: *http://www.ceedirectory.org*)

AHRI is considering updating its directory to include refrigerant, and has noted that if a sufficient number of customers or states request this update, they will gladly add it. ENERGY STAR currently lists refrigerant for some, but not all, product categories.

Outside of the USA, TopTen is an excellent resource for lists of energy efficient products that use low-GWP refrigerants. To view efficient models for sale in Europe, for example, go to: *https://www.topten.eu/private/products/air_conditioners*. Be sure to check the “product details” tab to find out what refrigerant the AC unit (or heat pump) uses.

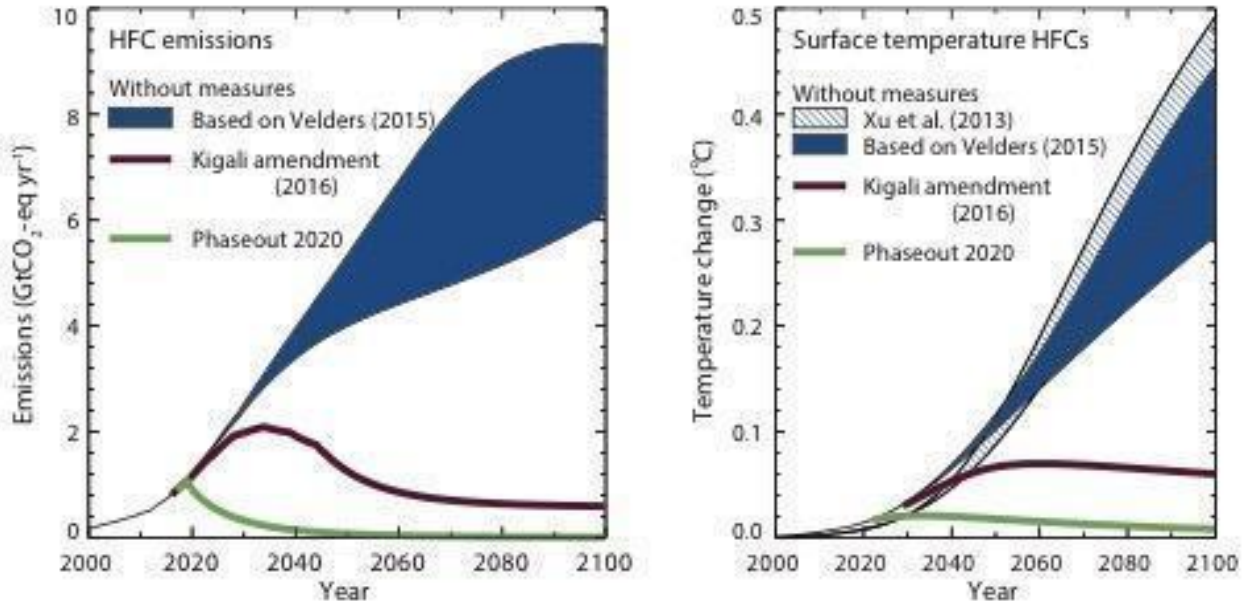
APPENDIX E: DETAILS OF THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER AND THE 2016 KIGALI AMENDMENT

The climate protection legacy of the Montreal Protocol continues: The legally-binding 2016 Kigali Amendment to the Protocol phasing down HFCs, could prevent up to an additional 0.5 degrees Celsius of global warming by the end of this century (see Figures 1 and 2). As of July 2020, more than 100 countries (but not yet the USA) have ratified the Kigali Amendment. For status of countries that have ratified the Kigali Amendment, please visit https://ozone.unep.org/all-ratifications.

However, achieving those ambitious climate protection targets depends on sustainable procurement policies that encourage manufacturers and end-users to make choices that improve products' life-cycle climate performance, taking into account not only direct emissions (refrigerant global warming potential, or GWP), but also indirect emissions (energy related emissions). Energy use can account for 80 percent or more of the climate impact of an air conditioner depending on electricity GHG intensity.

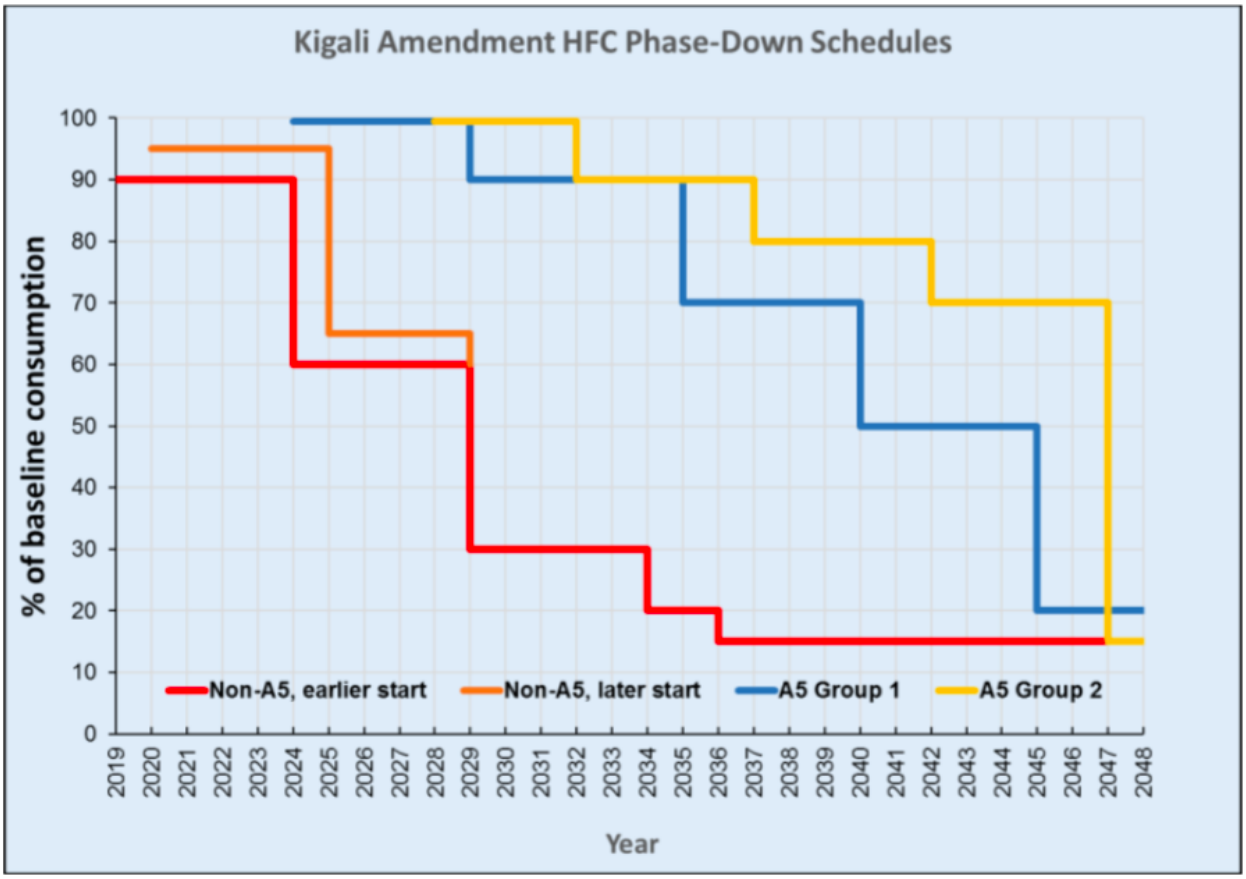
This has led some policymakers to use the 20-year GWP when evaluating HFCs, instead of the 100-year GWPs. A table with both the 100-year and 20-year GWPs associated with common HFCs is included in Appendix C, under "characteristics of common refrigerants."

FIGURE 1: HFC EMISSIONS AND THE CONTRIBUTION OF HFCS TO THE GLOBAL AVERAGE SURFACE WARMING OF EARTH WITH AND WITHOUT THE KIGALI AMENDMENT



Source: Velders, Guus J.M., David W. Fahey, John S. Daniel, Stephen O Andersen, and Mack McFarland. (2015). Future atmospheric abundances and climate forcings from scenarios of global and regional hydrofluorocarbon (HFCs) emissions. *Atmospheric Environment* 123, 200–209. *http://www.sciencedirect.com/science/article/pii/S135223101530488X*. doi: *https://doi.org/10.1016/j.atmosenv.2015.10.071*.

FIGURE 2: HFCS ARE NOW BEING PHASED DOWN UNDER THE KIGALI AMENDMENT TO THE MONTREAL PROTOCOL



"Article 5" or A5 countries are typically developing countries. "Non-Article 5" countries are developed countries. It is the tradition of the Montreal Protocol to accelerate the control schedule as technology is made available, which is absolutely required to avoid Polar tipping points

STRATOSPHERIC OZONE AND CLIMATE SCIENCE

- Salawitch, Ross J. (Lead Author), David W. Fahey, Michaela I. Hegglin, Laura A. McBride, Walter R. Tribett, Sarah J. Doherty, Twenty Questions and Answers About the Ozone Layer: 2018 Update, Scientific Assessment of Ozone Depletion: 2018, 84 pp., World Meteorological Organization, Geneva, Switzerland, 2019.

- World Meteorological Organization (WMO), National Oceanic and Atmospheric Administration (NOAA), United Nations Environment Programme (UNEP), National Aeronautics and Space Administration (NASA) and the European Commission (EC). 2018. Scientific Assessment of Ozone Depletion. 2018. WMO Global Ozone Research and Monitoring Project – Report No. 58, 67 pp., Geneva, Switzerland. https://ozone.unep.org/sites/default/files/2019-05/SAP-2018-Assessment-report.pdf.

HFC SCIENCE AND POLICY

- Zaelke, Durwood, Nathan Borgford-Parnell, and Stephen O. Andersen (Lead Authors), Kristin Campbell, Xiaopu Sun, Dennis Clare, Claire Phillips, Stela Herschmann, Yuzhe Peng Ling, Alex Milgroom, and Nancy J. Sherman (Contributing Authors. 2018. Primer on

HFCs: Fast action under the Montreal Protocol can limit growth of hydrofluorocarbons (HFCs), prevent 100 to 200 billion tonnes of CO_2-eq by 2050, and avoid up to 0.5°C of warming by 2100. http://www.igsd.org/wp-content/uploads/2018/01/HFC-Primer-v11Jan18.pdf.

KIGALI AMENDMENT

- UNEP. 2016. Frequently asked questions relating to the Kigali Amendment to the Montreal Protocol. https://ec.europa.eu/clima/sites/clima/files/faq_kigali_amendment_en.pdf.

US EPA GUIDANCE ON ALTERNATIVES TO HFCS

- https://www.epa.gov/ozone-layer-protection/transitioning-low-gwp-alternatives-commercial-refrigeration
- https://www.epa.gov/snap/transitioning-low-gwp-alternatives-residential-and-light-commercial-air-conditioning
- https://www.epa.gov/snap/transitioning-low-gwp-alternatives-domestic-refrigeration
- https://www.epa.gov/ozone-layer-protection/transitioning-low-gwp-alternatives-building-and-construction-foams
- https://www.epa.gov/ozone-layer-protection/transitioning-low-gwp-alternatives-unitary-air-conditioning
- https://www.epa.gov/ozone-layer-protection/transitioning-low-gwp-alternatives-transport-refrigeration
- https://www.epa.gov/snap/transition-low-gwp-alternatives-passenger-vehicle-air-conditioners

CONSUMER GOODS FORUM RETAIL HFC PHASEOUT RESOLUTION AND CASE STUDIES

- Refrigeration: Taking action to mobilize resources to phase out high GWP refrigerants, https://www.theconsumergoodsforum.com/initiatives/environmental-sustainability/key-projects/refrigeration/

CALIFORNIA AIR RESOURCES BOARD (CARB) HFC PHASEDOWN ADVICE

- CARB. Choosing a New System? Alternatives are increasingly available to replace high-GWP refrigerant technologies. https://ww2.arb.ca.gov/resources/documents/choosing-new-system

ACRONYMS

AC	air conditioning (air conditioners)
ACCA	Air Conditioning Contractors of America
ACCA QI	Air Conditioning Contractors of America Quality Installation
AR4	Assessment Report 4 (of the Intergovernmental Panel on Climate Change
AR5	Assessment Report 5 (of the Intergovernmental Panel on Climate Change
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AHRI	Air Conditioning, Heating & Refrigeration Institute
CARB	California Air Resources Board
CCAC	Climate and Clean Air Coalition
CFC	Chlorofluorocarbon
CO_2	carbon dioxide
EPA	Environmental Protection Agency (US)
GHG	greenhouse gas
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HFO	hydrofluoroolefin
IGSD	Institute for Governance & Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
LCCP	Life Cycle Climate Performance
MACS	Mobile Air Conditioning Society Worldwide
MVAC	motor vehicle air conditioning
NOAA	National Oceanographic and Space Administration
NRDC	Natural Resources Defense Council
ODP	ozone-depletion potential
ODS	ozone-depleting substance
RACHP	refrigeration, air conditioning, and heat pump
RAD	Responsible Appliance Disposal (partnership)
RTOC	Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee
SAE	Society of Automotive Engineers
SAP	Scientific Assessment Panel (of the UNEP Montreal Protocol)
SFTA	Sustainable Food Trade Association
SNAP	Significant New Alternative Policy Program (US EPA)
SPLC	Sustainable Purchasing Leadership Council
TEAP	Technology and Economic Assessment Panel (of the UNEP Montreal Protocol)
TT&C	technician training & certification
UNEP	United Nations Environment Programme
US	United States
WMO	World Meteorological Organization