USAID
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APPLICATION OF THE MONTREAL PROTOCOL AND ITS AMENDMENTS IN USAID PURCHASING DECISIONS

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ACRONYMS

AC	Air Conditioning
AIM	American Innovation and Manufacturing
CAA	U.S. Clean Air Act
CFC	Chlorofluorocarbon
EPA	U.S. Environmental Protection Agency
FTOC	Rigid and Flexible Foams Technical Options Committee
GHG	Greenhouse Gas
GWP	Global Warming Potential
HC	Hydrocarbon
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
ODP	Ozone Depletion Potential
ODS	Ozone-Depleting Substances
PFC	Perfluorocarbon
RTOC	Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee
SNAP	Significant New Alternatives Policy
TEAP	Technology & Economic Assessment Panel
UNEP	United Nations Environment Programme

INTRODUCTION

This document provides guidance on how to ensure that USAID projects and purchasing decisions comply with requirements under the *Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol) and its amendments. In addition, the guidance document sets out a practical approach for selection of alternatives to ozone depleting substances (ODS) and hydrofluorocarbons (HFCs) in sectors that could be encountered in USAID projects. This guidance document is a supplement to the *Application of the Montreal Protocol and its Amendments in USAID Purchasing Decisions* fact sheet.[1]

Universal ratification of the Montreal Protocol and growing ratification of the Kigali Amendment (147 Parties as of February 3, 2023) means that there are existing commitments on ODS and HFC use at the country level. By integrating the Montreal Protocol and its amendments into purchasing decisions for equipment and building materials

> The implementation of the Montreal Protocol and the Kigali Amendment fosters technology transfer and economic growth. This directly contributes to UN Sustainable Development Goal (SDG) 13 on climate action and the achievement of several others, including SDGs to ensure access to affordable, reliable, sustainable and modern energy for all (SDG 7), build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (SDG 9), and ensure sustainable consumption and production patterns (SDG 12) (UNDP n.d.). Implementation of the Montreal Protocol and Kigali Amendment also supports the objectives of the Paris Agreement.

[1] The accompanying fact sheet is available online, at: https://www.usaid.gov/sites/default/files/2022-05/E3-002_Factsheet_Application_of_Montreal_Protocol_to_USAID_Projects.pdf.

(e.g., foams), USAID will ensure that its projects comply with current and future requirements on ODS and HFC use at the local, regional, and international level.

ODS and HFCs are mainly used in six industrial sectors that could be encountered in USAID projects: fire suppression; refrigeration and air conditioning; foam blowing; aerosols; solvents; and agricultural fumigants (EPA 2019). Of those six sectors, the most likely to be encountered in USAID projects are also those with the greatest ODS and HFC consumption of the six: refrigeration and air conditioning, and foam blowing. ODS consumption, specifically of HCFCs, is highest in the refrigeration and air conditioning sector (88% of global HCFC consumption), including in applications like household refrigerators, commercial comfort cooling (chillers), domestic and medical refrigerators, and room AC. Similarly, HCFC consumption is also high in foam blowing agents, which are used to propel liquid plastic resin in foams and are essential in establishing foam density and insulation. Foam blowing agents are used in applications like rigid and flexible polyurethane, extruded polystyrene and polyolefin foams used in insulation applications (10% of global HCFC consumption) (European Commission 2008). Other sectors that use ODS and HFCs include fire suppression, aerosols, solvents, and agricultural fumigants.

To comply with phaseout of ODS and phasedown of HFC requirements, a suite of alternatives have been proposed and marketed in all sectors that use them including the foam blowing agents sector and the refrigeration and air conditioning sector. Alternatives for HFCs include HFOs, HFC-HFO blends, and natural refrigerants (e.g., hydrocarbons or CO_2) (European Commission n.d.).

CONSIDERATIONS FOR PURCHASING NEW EQUIPMENT OR BUILDING MATERIALS FOR USAID PROJECTS:

At all stages, consider safety and efficiency of the equipment or material.

1. Identify if the country has ratified the Kigali Amendment (listed here).
2. Determine if equipment or material contains ODS or HFCs.
3. Identify the appropriate phase-out or phase-down schedules, considering the expected lifetime of the equipment or material.
4. Identify non-ODS or non-HFC alternatives to be used, if possible.

Additional detail on the Montreal Protocol, the Kigali Amendment, and related U.S. regulations can be found below in the Relevant International Treaties and U.S. Regulations section. The tables throughout this document provide detail on common ODS and their substitutes and the regulatory status of these chemicals. Application-specific alternatives can be found in the End Uses section and in Annex A.

FOR MORE INFORMATION:

Visit https://www.usaid.gov/environmental-procedures for resources and templates to implement environmental safeguarding procedures.

Contact your environmental compliance officers for guidance and additional resources: https://www.usaid.gov/environmental-procedures/environmental-compliance-officers.

RELEVANT INTERNATIONAL TREATIES AND U.S. REGULATIONS

MONTREAL PROTOCOL

The Montreal Protocol (1987) is an international treaty that aims to protect the ozone layer by phasing out the production and use of approximately 100 synthetic chemicals (OzonAction n.d.). Specifically, it calls for phasing out certain ODS, including CFCs, halons, methyl bromide, HCFCs, and most recently, HFCs, which are not ODS. The Montreal Protocol uses a stepwise approach to establish different ODS phaseout schedules for developed (non-Article 5) and developing (Article 5) countries (on a ten-year delay).

Similarly, the Kigali Amendment to the Montreal Protocol establishes the global phase-down of hydrofluorocarbons (HFCs) by 2047. Countries that have ratified the Kigali Amendment (available here) must develop their own approach to achieve the HFC phase-down targets and may choose to target specific HFCs and/or specific sectors. In addition, the phase-down schedule for developing countries is further separated into Group I (Article 5 countries not part of Group 2) and Group 2 (Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the United Arab Emirates). Figure I illustrates the Montreal Protocol phase-down schedule for HFCs.

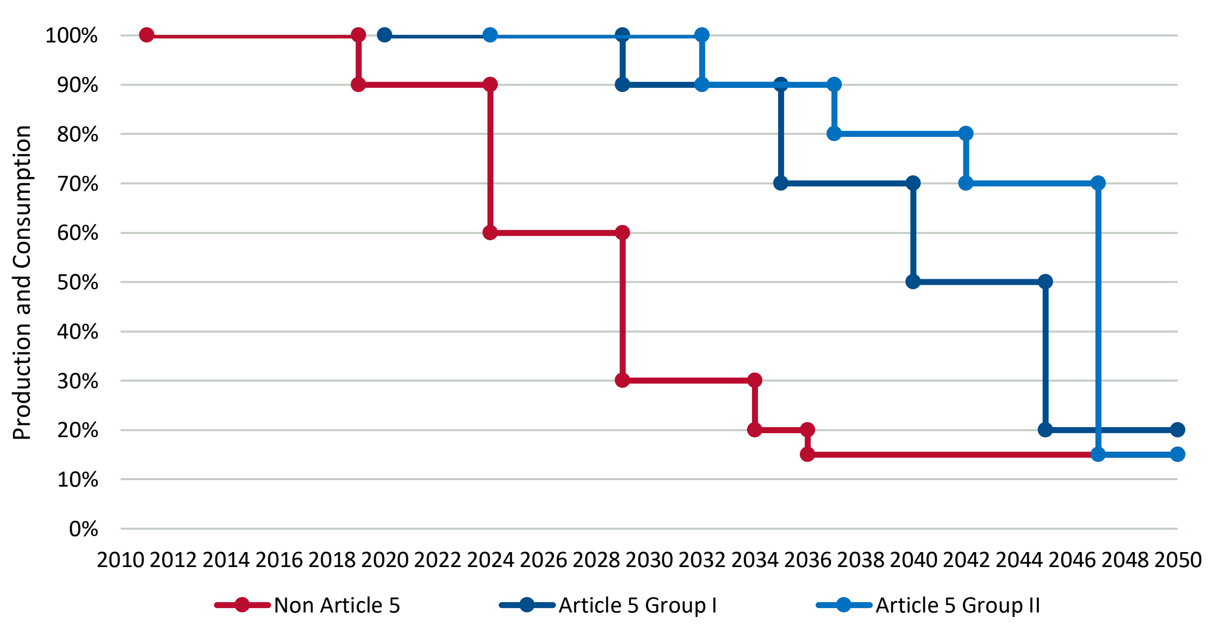

Figure 1. Montreal Protocol Phasedown Schedule for HFCs

UNITED STATES REGULATION

Under Title VI of the Clean Air Act (CAA), the United States has set provisions for protecting the ozone layer, which ensures its commitment to implementing the Montreal Protocol. Specifically, the United States has established the phaseout of ODS in Sections 604 and 605 of the CAA. As in the Montreal Protocol, the phaseout framework established by EPA is based on a "worst-first" approach, which focuses on the phasing out compounds with the highest ozone depletion potential (ODP) first. Under the Montreal Protocol, the United States is a non-Article 5 country and phaseout of ODS is scheduled to be complete by 2030.[2] Additionally, Section 612 of the CAA requires EPA to evaluate substitutes for ODS in order to reduce risk to human health and the environment. EPA's Significant New Alternatives Policy (SNAP) Program implements Section 612 of the CAA and provides lists of acceptable and unacceptable substitutes for ODS for major industrial use sectors (as summarized below in Table 1. SNAP listings are published either in a Notice or in a Final Rule, and the SNAP Regulations webpage (available here) should be referenced and monitored for new listings. Note that some countries follow SNAP regulations follow SNAP requirements within their decision process for acceptance of alternatives.

Congress enacted the American Innovation and Manufacturing (AIM) Act on December 27, 2020, and the United States ratified the Kigali Amendment to the Montreal Protocol on October 26, 2022. The AIM Act directs EPA to address HFCs by phasing down production and consumption by 85 percent over the next 15 years, consistent with the Kigali Amendment phasedown timeline, maximizing reclamation and minimizing releases from equipment, and facilitating the transition to next-generation technologies through sector-based restrictions. For example, EPA allocated 87,695.8 metric tons of exchange value equivalent (MTEVe)[3] for structural composite foam in 2023. These allowances may not exceed established emissions caps, which are not specific to individual HFCs but are instead determined on an exchange value-weighted basis. Further information on the AIM Act and allowance allocations can be found on the EPA website. Figure 2 illustrates the phase-down schedule for HFCs in the United States.

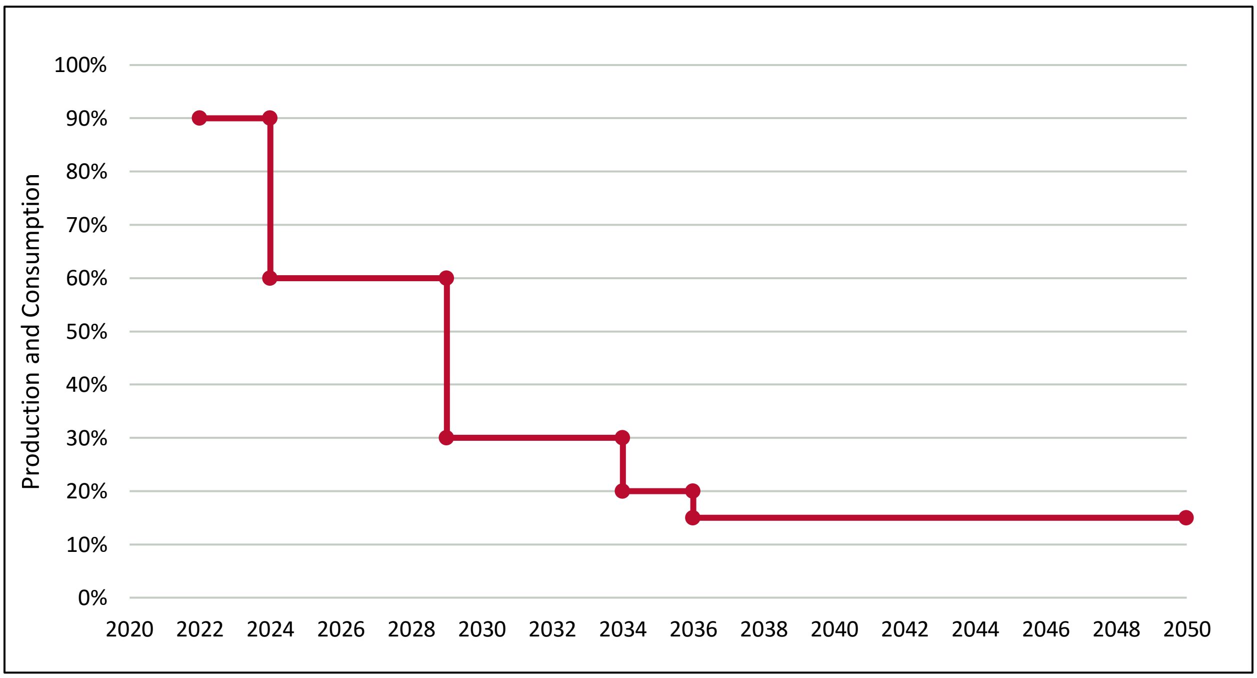

Figure 2. AIM Act Phasedown Schedule for HFCs

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[2] Under the Montreal Protocol, there are exemptions to the phaseout of controlled substances (e.g., process agents use and feedstock use). The CAA Amendments of 1990 codify similar provisions for the United States.
[3] The AIM Act directs EPA to phase down HFCs on an "exchange value"-weighted basis. EPA determined that the exchange values included in the AIM Act are identical to the 100-year global warming potential (GWP) of HFCs as listed in the Intergovernmental Panel on Climate Change's Fourth Assessment Report (Forster, et al. 2007).

REGULATORY STATUS, ODP, AND GWP OF COMMON ODS, HFCs, AND ALTERNATIVES

Table 1. Regulatory Status and GWP of Common ODS, HFCs, and Alternatives lists common ODS, HFCs, and alternatives[4] that are likely encountered as refrigerants and/or foam blowing agents in USAID projects. The table includes the current regulatory status in the United States and under the MP, ODP, and Global Warming Potential (GWP). Some of the substances listed in Table 1 are listed by SNAP as acceptable, subject to use conditions, or acceptable, subject to narrowed use limits, so the SNAP Regulations webpage (found here) should be referenced before a final procurement decision is made.

TABLE 1. REGULATORY STATUS AND GWP OF COMMON ODS, HFCs, AND ALTERNATIVES

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
CFCs				
CFC-11	**Phased out** for production and import: December 31, 1995	**Phased out:** Non-Article 5: January 1, 1996 Article 5: January 1, 2010	1	5,160[f]
CFC-114	**Phased out** for production and import: December 31, 1995	**Phased out:** Non-Article 5: January 1, 1996 Article 5: January 1, 2010	0.5	8,580[f]
CFC-12	**Phased out** for production and import: December 31, 1995	**Phased out:** Non-Article 5: January 1, 1996 Article 5: January 1, 2010	0.73-0.81	10,300[f]
HCFCs				
HCFC-123	**Phased out** for production: January 1, 2020 **Phasing out** for import: January 1, 2030[g] **SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ Industrial Process Refrigeration (IPR) ○ Rigid Polyurethane (PU): Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	**Phased out:** Non-Article 5: January 1, 2020[f] **Phasing out:** Article 5: January 1, 2030	0.02	80[f]

[4] Alternatives vary by end use and can include substances that are not HFCs (e.g., HFO-1234ze(E) and HCFO-1233zd(E)) as well as HFCs (e.g., HFC-152a) and blends that may contain HFCs (e.g., R-448A) with GWPs lower than the typical HFC(s) used in the end use.

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
HCFC-124	**Phasing out** for production and import: January 1, 2030[g] **SNAP Status:** • Acceptable for: ○ Centrifugal Chillers	**Phased out:** Non-Article 5: January 1, 2020[f] **Phasing out:** Article 5: January 1, 2030	0.022	609

HCFC-22	**Phased out** for production and import: January 1, 2020
	
	SNAP Status:
	• Acceptable for:
	  ○ Commercial Ice Machines
	  ○ Retail Food Refrigeration (Stand-alone Units)
	  ○ Centrifugal Chillers
	  ○ Positive Displacement Chillers
	  ○ IPR
	  ○ Cold Storage Warehouses
	• Unacceptable for:
	  ○ Rigid PU: Spray
	  ○ Rigid PU: Sandwich Panels
	  ○ Rigid PU: Slabstock and Other
	  ○ Rigid PU and Polyisocyanurate: Laminated Boardstock
	  ○ Polystyrene: Extruded Boardstock and Billet
	  ○ Phenolic Insulation Board and Bunstock
	  ○ Rigid PU: Appliance
	  ○ Rigid PU: Commercial Refrigeration
		Phased out:
		Non-Article 5: January 1, 2020
		Phasing out:
		Article 5: January 1, 2030
			0.055	1,780[f]

HCFC-142b	**Phased out** for production and import: January 1, 2020
	
	SNAP Status:
	• Unacceptable for:
	  ○ Rigid PU: Spray
	  ○ Rigid PU: Sandwich Panels
	  ○ Rigid PU: Slabstock and Other
	  ○ Rigid PU and Polyisocyanurate: Laminated Boardstock
	  ○ Polystyrene: Extruded Boardstock and Billet
	  ○ Phenolic Insulation Board and Bunstock
	  ○ Rigid PU: Appliance
	  ○ Rigid PU: Commercial Refrigeration
		Phased out:
		Non-Article 5: January 1, 2020
		Phasing out:
		Article 5: January 1, 2030
			0.065	2,070[f]

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
HCFC-141b	**Phased out** for production and import: January 1, 2003 **SNAP Status:** • Unacceptable for: ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	**Phased out:** Non-Article 5: January 1, 2020 **Phasing out:** Article 5: January 1, 2030	0.11	725[f]
BLENDS WITH CFCs AND HCFCs				
R-401A (HCFC-22, HFC-152a, HCFC-124)	Status for HCFC components: **Phased out** for production and import: January 1, 2020 Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Positive Displacement Chillers ○ IPR ○ Cold Storage Warehouses	Status for HCFC components: **Phased out:** Non-Article 5: January 1, 2020 **Phasing out:** Article 5: January 1, 2030 Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0.04	16.1
R-502 (CFC-12, HCFC-22)	Status for CFC components: **Phased out** for production and import: December 31, 1995 Status for HCFC components: **Phased out** for production and import: January 1, 2020	Status for CFC components: **Phased out:** Non-Article 5: January 1, 1996 Article 5: January 1, 2010 Status for HCFC components: **Phased out:** Non-Article 5: January 1, 2020 **Phasing out:** Article 5: January 1, 2030	0.33	4,657

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-500 (CFC-12, HFC-152a)	Status for CFC components: **Phased out** for production and import: December 31, 1995 Status for HCFC components: **Phased out** for production and import: January 1, 2020	Status for CFC components: **Phased out:** Non-Article 5: January 1, 1996 Article 5: January 1, 2010 Status for HCFC components: **Phased out:** Non-Article 5: January 1, 2020 **Phasing out:** Article 5: January 1, 2030	0.66	8.077
R-503 (CFC-13, HFC-23)	Status for CFC components: **Phased out** for production and import: December 31, 1995 Status for HCFC components: **Phased out** for production and import: January 1, 2020	Status for CFC components: **Phased out:** Non-Article 5: January 1, 1996 Article 5: January 1, 2010 Status for HCFC components: **Phased out:** Non-Article 5: January 1, 2020 **Phasing out:** Article 5: January 1, 2030	0.06	14,650
HFCs				
HFC-152a	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	124
HFC-32	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable with Use Conditions for: ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	675

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
HFC-245fa	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Very Low Temperature (VLT) Refrigeration ○ Centrifugal Chillers ○ IPR ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,030
HFC-134a	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,430

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
HFC-227ea	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable with use conditions for: ○ Centrifugal Chillers (will become unacceptable, except as otherwise allowed under a narrowed use limit on January 1, 2024). ○ Positive Displacement Chillers (will become unacceptable, except as otherwise allowed under a narrowed use limit on January 1, 2024). ○ IPR	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	5,310
HFC-236fa	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ IPR	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	9,810
HFC-23	**Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ VLT Refrigeration ○ IPR	**Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	14,800
HFC BLENDS				
Blends with maximum of 51 percent HFC-134a, 17 to 41 percent HFC-152a, up to 20 percent CO_2 and one to 13 percent water[i]	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable with Narrowed Use Limits for: ○ Polystyrene: Extruded Boardstock and Billet	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	≤750
Commercial blends of HFC-365mfc and HFC-227ea containing 7 percent to 13 percent HFC-227ea and the remainder HFC-365mfc	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Rigid PU: Spray	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	≤1,110

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-407H (HFC-32, HFC-125, HFC-134a)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** SNAP has not yet reviewed for the end-uses likely encountered by USAID projects.	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,495
R-407C (HFC-32, HFC-125, HFC-134a)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ VLT Refrigeration ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,774
R-407F (HFC-32, HFC-125, HFC-134a)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,825

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-410A (HFC-32, HFC-125)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ VLT Refrigeration ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	2,088
R-407A (HFC-32, HFC-125, HFC-134a)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	2,107

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]

R-417A
(HFC-125, HFC-134a, HFC-227ea)
	Status for HFC components:
	Phasing down 85 percent from baseline levels for production and import of HFCs:
	January 1, 2036
	
	SNAP Status:
	• Acceptable for:
	  ○ Commercial Ice Machines
	  ○ IPR
	  ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]
	• Unacceptable for:
	  ○ Household Refrigerators and Freezers
	  ○ Retail Food Refrigeration (Stand-alone Units)
	  ○ Centrifugal Chillers
	  ○ Positive Displacement Chillers
	  ○ Cold Storage Warehouses
	  ○ Polystyrene: Extruded Boardstock and Billet
		Status for HFC components:
		Phasing down:
		First Reduction: January 1, 2019
		Final Reduction: January 1, 2047
			0	2,346

R-404A
(HFC-125, HFC-134a, HFC-143a)
	Status for HFC components:
	Phasing down 85 percent from baseline levels for production and import of HFCs:
	January 1, 2036
	
	SNAP Status:
	• Acceptable for:
	  ○ Household Refrigerators and Freezers
	  ○ VLT Refrigeration
	  ○ Commercial Ice Machines
	  ○ Retail Food Refrigeration (Stand-alone Units)
	  ○ Centrifugal Chillers
	  ○ Positive Displacement Chillers
	  ○ IPR
	  ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]
	  ○ Cold Storage Warehouses
		Status for HFC components:
		Phasing down:
		First Reduction: January 1, 2019
		Final Reduction: January 1, 2047
			0	3,922

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-507 (HFC-125, HFC-143a)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import of HFCs: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ VLT Refrigeration ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	3,985
HFOs AND HCFOs				
HCFO-1224yd(Z)	**SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR	Not in scope	0	1
HFO-1234yf	**SNAP Status:** • Acceptable with Use Conditions for: ○ Passenger Cars ○ Light-Duty Trucks ○ Medium-Duty Passenger Vehicles ○ Heavy-Duty Pickup Trucks ○ Complete Heavy-Duty Vans ○ Off-Road Vehicles	Not in scope	0	4
HFO-1234ze(E)	**SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	Not in scope	0	6

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
HCFO-1233zd(E)	**SNAP Status:** • Acceptable for: ○ Cold Storage Warehouses ○ Centrifugal Chillers ○ IPR ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	Not in scope	<0.0004	7
HFO-1336mzz(Z)	**SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	Not in scope	0	8.9
HFO BLENDS				
Blends of zero to 100 percent HFO-1234ze(E), zero to 70 percent methyl formate, zero to 60 percent HFC-152a, zero to 60 percent CO_2, and zero to 60 percent water	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: Polystyrene: Extruded Boardstock and Billet	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	<80
Blends of 10 to 99 percent by weight HFO-1336mzz(Z) and the remainder HFC-152a	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Polystyrene: Extruded Boardstock and Billet	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	3-110

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
Blends of 10 to 90 percent HFO-1234ze(E) by weight and the remainder HFC-152a	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Polystyrene: Extruded Boardstock and Billet	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	13-112
R-454C (HFC-32, HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable with Use Conditions for: ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	148
R-454A (HFC-32, HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable with Use Conditions for: ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	239
R-515B (HFC-227ea, HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ Industrial Process Equipment (New Equipment)	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	287
R-454B (HFC-32, HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable with Use Conditions for: ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	466

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]

R-450A
(HFC-134a, HFO-1234ze(E))
	Status for HFC components:
	Phasing down 85 percent from baseline levels for production and import:
	January 1, 2036
	
	SNAP Status:
	• Acceptable for:
	  ○ Household Refrigerators and Freezers
	  ○ Commercial Ice Machines
	  ○ Retail Food Refrigeration (Stand-alone Units)
	  ○ Centrifugal Chillers
	  ○ Positive Displacement Chillers
	  ○ IPR
	  ○ Cold Storage Warehouses
		Status for HFC components:
		Phasing down:
		First Reduction: January 1, 2019
		Final Reduction: January 1, 2047
			0	604

R-513A
(HFO-1234yf, HFC-134a)
	Status for HFC components:
	Phasing down 85 percent from baseline levels for production and import:
	January 1, 2036
	
	SNAP Status:
	• Acceptable for:
	  ○ Household Refrigerators and Freezers
	  ○ Commercial Ice Machines
	  ○ Centrifugal Chillers
	  ○ Positive Displacement Chillers
	  ○ IPR
	  ○ Cold Storage Warehouses
	• Acceptable with Use Conditions for:
	  ○ Retail Food Refrigeration (Stand-alone Units)
		Status for HFC components:
		Phasing down:
		First Reduction: January 1, 2019
		Final Reduction: January 1, 2047
			0	631

R-452B (HFC-32, HFC-125, HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable with Use Conditions for: ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	676
Blends of 40 to 52 percent HFC-134a by weight and the remainder HFO-1234ze(E)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable with Narrowed Use Limits for: ○ Polystyrene: Extruded Boardstock and Billet	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	≤750

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
Blends of 40 to 52 percent HFC-134a with 40 to 60 percent HFO-1234ze(E) and 10 to 20 percent each water and CO_2 by weight	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable with Narrowed Use Limits for: ○ Polystyrene: Extruded Boardstock and Billet	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	≤750
R-448A (HFC-32, HFC-125, HFC-134a, HFO-1234ze(E), HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Commercial Ice Machines ○ IPR ○ Cold Storage Warehouses • Acceptable with Use Conditions for: ○ Retail Food Refrigeration (Stand-alone Units)	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,387
R-449A (HFC-32, HFC-125, HFO-1234yf, HFC-134a)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Commercial Ice Machines ○ IPR ○ Cold Storage Warehouses • Acceptable with Use Conditions for: ○ Retail Food Refrigeration (Stand-alone Units)	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,397
R-449B (HFC-32, HFC-125, HFC-134a, HFO-1234yf)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** • Acceptable for: ○ Commercial Ice Machines ○ IPR ○ Cold Storage Warehouses • Acceptable with Use Conditions for: ○ Retail Food Refrigeration (Stand-alone Units)	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	1,412

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-452A (HFO-1234yf, HFC-32, HFC-125)	Status for HFC components: **Phasing down** 85 percent from baseline levels for production and import: January 1, 2036 **SNAP Status:** SNAP has not yet reviewed for the end-uses likely encountered by USAID projects.	Status for HFC components: **Phasing down:** First Reduction: January 1, 2019 Final Reduction: January 1, 2047	0	2,140
NON-HFC ALTERNATIVES				
Methyl formate	**SNAP Status:** • Acceptable for: ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	Not in scope	0	0
R-717 (ammonia)	**SNAP Status:** • Acceptable for: ○ Household Refrigerators and Freezers ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Not in scope	0	0
Methylal (dimethoxymethane)	**SNAP Status:** • Acceptable for: ○ Rigid PU: Spray	Not in scope	0	<1

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-744 (CO_2)[j]	**SNAP Status:** • Acceptable for: ○ VLT Refrigeration ○ Retail Food Refrigeration (Stand-alone Units) ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ IPR ○ Cold Storage Warehouses ○ Rigid PU: Spray ○ Rigid PU: Sandwich Panels ○ Rigid PU: Slabstock and Other ○ Rigid PU and Polyisocyanurate: Laminated Boardstock ○ Polystyrene: Extruded Boardstock and Billet ○ Phenolic Insulation Board and Bunstock ○ Rigid PU: Appliance ○ Rigid PU: Commercial Refrigeration	Not in scope	0	1
Blends of 10 to 90 percent HFO-1234ze(E) by weight and the remainder HCFO-1233zd(E)	**SNAP Status:** • Acceptable for: ○ Polystyrene: Extruded Boardstock and Billet	Not in scope	<0.0004	1.3-3.4
R-1270 (propylene)	**SNAP Status:** • Acceptable for: ○ IPR • Unacceptable for: ○ Centrifugal Chillers ○ Positive Displacement Chillers ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h] ○ Cold Storage Warehouses	Not in scope	0	1.8
R-600a (isobutane)	**SNAP Status:** • Acceptable with Use Conditions for: ○ Household Refrigerators and Freezers ○ Retail Food Refrigeration (Stand-alone Units)	Not in scope	0	3
R-290 (propane)	**SNAP Status:** • Acceptable for: ○ IPR • Acceptable with Use Conditions for: ○ Household Refrigerators and Freezers ○ VLT Refrigeration ○ Commercial Ice Machines ○ Retail Food Refrigeration (Stand-alone Units) ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	Not in scope	0	3.3

SUBSTANCE	U.S. STATUS[a]	MP STATUS[b]	ODP[c]	GWP[d,e]
R-441A (ethane, propane, butane, and isobutane)	**SNAP Status:** • Acceptable with use conditions for: ○ Household Refrigerators and Freezers ○ Retail Food Refrigeration (Stand-alone Units) ○ Residential and Light Commercial Air Conditioning and Heat Pumps[h]	Not in scope	0	<5
R-170 (ethane)	**SNAP Status:** • Acceptable for: ○ VLT Refrigeration[h]	Not in scope	0	5.5
R-514A (HFO-1336mzz(Z), t-DCE)	**SNAP Status:** • Acceptable for: ○ Centrifugal Chillers ○ Positive Displacement Chillers	Not in scope	0	6.6
HFE-347mcc3	**SNAP Status:** • Acceptable for: ○ VLT Refrigeration ○ IPR	Not in scope	0	575
Perfluorocarbons (PFCs) and PFC blends[i]	**SNAP Status:** • Acceptable for: VLT Refrigeration	Not in scope	>0	N/A

N/A = Not applicable.

[a] The production and import phaseout targets are found in Sections 604 and 605 of the Clean Air Act. End-use specific approval for HCFCs, HFCs, and other substitutes may be found on the SNAP website (EPA 2021a).

[b] UNEP (1987); For HFC phasedown schedule dates are for Article 5 countries. Note that non-Article 5 countries would have different HFC phasedown schedules.

[c] World Meteorological Organization (WMO) 2018 Scientific Assessment Report (WMO 2018)

[d] Unless otherwise specified, GWP values are from the Intergovernmental Panel on Climate Change Fourth Assessment Report (Forster, et al. 2007), as available; GWP values not available in IPCC (2007) are from the World Meteorological Organization Scientific Assessment of Ozone Depletion (WMO 2018).

[e] GWPs for blends were calculated using Forster et al. (2007) and, when applicable, WMO (2018).

[f] WMO (2018).

[g] From January 1, 2020 through December 31, 2029, newly produced or imported HCFC-123 and HCFC-124 may only be used to service equipment manufactured before January 1, 2020.

[h] The Residential and Light Commercial Air Conditioning and Heat Pumps end-use includes applications such as window units, packaged terminal air conditioners and heat pumps, portable air conditioners, ducted central air conditioners, non-ducted systems, packaged rooftop units, and water- and ground-source heat pumps.

[i] Specific PFCs and PFC blends used in VLT refrigeration are approved for the VLT refrigeration end-use under SNAP.

[j] R-744 should not be used to refer to CO_2 when used as a foam blowing agent and is only applicable when CO_2 is used in refrigeration and air conditioning end-uses.

END USES

REFRIGERATION AND AIR CONDITIONING

The refrigeration and air conditioning sector includes equipment types that use a refrigerant (i.e., ODS, HFCs, and/or a substitute) in a vapor compression cycle to cool and/or dehumidify a space or substances, like a refrigerator cabinet, room, office building, or warehouse (EPA 2020). Consumption of ODS from this sector is by far the largest when compared to other sectors (i.e., foam blowing agents, aerosols, solvents, fire suppression, and agricultural fumigants) and as such, refrigerant transitions away from ODS have been observed in most, if not all, end-uses.

Refrigerant selection depends on several factors including, but not limited to, targeted end-use, safety, ease of use, transition cost, and environmental issues (UNEP 2019a). In some instances, transitions from ODS to HFCs or, most recently, to low-GWP refrigerants do not require a system redesign and the cost to transition is low; however, due to safety concerns (e.g., flammability), some transitions may require a redesign of equipment. These factors should be considered especially when opting to replace a refrigerant in existing equipment or when purchasing new equipment.

MOTOR VEHICLE AIR CONDITIONING

Motor vehicle air-conditioning systems (MVACs) in light-duty trucks, light- and heavy-duty vehicles, and off-road vehicles provide comfort cooling for passengers and operators. Light-duty vehicles (e.g., cars) contain between 0.3 and 1.4 kilograms (kg) of refrigerant (UNEP 2019a).

TABLE 2. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN MVACS

HISTORICAL	COMMON/CURRENT[a]
CFC-12	HFO-1234yf
HCFC-22	**HFC-134a**
	R-744

Source: EPA (2018), UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 3. Light-Duty Truck

ROOM AIR CONDITIONERS: PORTABLE SELF-CONTAINED UNITS

Portable self-contained air conditioning units can be rolled from room to room. They exhaust their condenser air through a small flexible conduit, which can be placed in an open window. Some portable air conditioners use a separate outdoor condenser, which connects to the indoor section with flexible refrigerant piping. Portable AC units have capacities of up to 10 kilowatts (kW) and charge sizes of 0.3 to three kg (UNEP 2019a).

TABLE 3. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN PORTABLE SELF-CONTAINED ROOM AIR CONDITIONERS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**HFC-245fa**
CFC-11	**HFC-134a**
CFC-12	**HFC-236fa**
R-500	

Source: UNEP (2019a) .
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP.

Figure 4. Portable Air Conditioning Unit

ROOM AIR CONDITIONERS: WINDOW UNITS

Window air conditioning units are simple refrigerated coolers packaged into a single box that produces cool air on one side and rejects hot air on the other. The units fit into open windows or through walls. Inside of the cabinet is a compressor, condensing coil, evaporator coil, blower, controls, and sometimes ductwork. The ductwork and possibly a damper allow the unit to draw fresh air in or re-circulate 100 percent of room air. Window units typically have a capacity of one to 10 kW and a refrigerant charge size of 0.3 to three kg (UNEP 2019a).

TABLE 4. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN WINDOW UNITS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**R-407C**
	R-410A
	R-290
	R-1270

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 5. Window Unit

ROOM AIR CONDITIONERS: PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

Packaged terminal air-conditioners (PTAC) and heat pumps (PTHP) are often used in small- and medium-sized low-rise buildings such as offices, motels, barracks, and warehouses. The unit is typically installed in the wall and is self-contained. PTHPs differ from PTACs in that they have a built-in heat pump, but the equipment types look similar. PTACs and PTHPs have capacities that range from one to 10 kW and charge sizes that range from 0.3 to three kg (UNEP 2019a).

TABLE 5. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**R-407C**
	R-410A
	R-290
	R-1270

Source: UNEP (2019a) .
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 6. Room Air Conditioner

SPLIT SYSTEMS (NON-DUCTED)

Split (non-ducted) systems have residential and light commercial uses including schools. The condensing unit is located outside the space to be heated and connected to a fan-coil located inside (usually on the wall). They can be single split or multi-split, in the latter one condensing unit can feed several indoor units. In some instances, the split system is connected to a duct system which supplies air to each room of the residence or commercial building. Non-ducted, split systems typically have capacities of two to 15 kW and charge sizes of 0.5 to five kg (UNEP 2019a).

TABLE 6. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN NON-DUCTED SPLIT SYSTEMS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**HFC-134a**
	R-410A
	R-407C
	R-290
	HFC-32
	R-1270
	R-444B
	R-452B

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 7. Non-Ducted Split System Condensing Unit

SPLIT SYSTEMS: RESIDENTIAL AND LIGHT COMMERCIAL (DUCTED)

Residential and light commercial split (ducted) systems include central air conditioning systems used in houses, as well as condensing units for air conditioning applications with cooling capacities less than 19 kW, central forced air electric furnaces with or without cooling coils, and one piece or matched split system air conditioners and air-source heat pumps with cooling capacities less than 19 kW. A compressor/heat exchanger unit outside the conditioned space supplies refrigerant to a heat exchanger. The cooled or heated air is then supplied to each room by a duct system. Capacities for ducted, split residential systems range from 4 kW to 17.5 kW, and ducted, split commercial systems have capacities ranging from 10 to 1,100 kW (UNEP

2019a). Charge sizes for these systems range from one to seven kg and five to 300 kg, respectively (UNEP 2019a).

TABLE 7. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN DUCTED RESIDENTIAL AND LIGHT COMMERCIAL SPLIT SYSTEMS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**R-410A**
	R-407C

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 8. Residential Ducted Split System Condensing Unit

PACKAGED ROOFTOP UNITS

Packaged rooftop units typically provide conditioned air to small-scale businesses (i.e., small shopping centers, restaurants, banks, etc.) and large commercial spaces (i.e., malls, airports, industrial facilities, etc.). Capacities for packaged rooftop units range from seven to 1,100 kW, and charge sizes range from five to 250 kg (UNEP 2019a). These systems connect directly to a system of ducts to distribute air through the space and return it to the rooftop unit.

TABLE 8. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN PACKAGED ROOFTOP UNITS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**R-410A**
	R-407C
	R-744
	R-290
	R-447B
	R-452B

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 9. Packaged Rooftop Unit

WATER-SOURCE AND GROUND-SOURCE AIR CONDITIONING AND HEAT PUMPS

Water- and ground-source air conditioning and heat pumps—commonly applied to office buildings, hotels, health care facilities, banks, schools, condominiums, and apartments—use the earth or ground water, or both, as the sources of heat in the winter, and as the "sink" for heat removed from the building in the summer. Depending on their usage, water- and ground-source heat pumps can have capacities ranging from 1.5 to 400 kW and charge sizes ranging from one to over 100 kg (UNEP 2019a), (UNEP 2015d).

TABLE 9. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN WATER-SOURCE AND GROUND-SOURCE AIR CONDITIONING AND HEAT PUMPS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**R-410A**
	HFC-134a
	R-407C
	R-417A
	HFC-32
	R-744
	HFO-1234yf
	R-290
	R-600a

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 10. Heat Pump

HOUSEHOLD REFRIGERATORS AND FREEZERS

Household refrigerators and freezers are intended primarily for residential food storage, although they may be used outside the home. Small, refrigerated household appliances may also include mini fridges, household beverage centers, ice makers that are part of a household refrigerator-freezer, and stand-alone ice makers for household use. These appliances can typically store between 20 and 850 liters and contain 20 to 250 g of refrigerant (UNEP 2019a).

TABLE 10. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN HOUSEHOLD REFRIGERATORS AND FREEZERS

HISTORICAL	COMMON/CURRENT[a]
CFC-12	**R-600a**
R-401A	HFC-134a
	HFO-1234yf
	HFO-1234ze
	R-450A
	R-513A

Source: UNEP 2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 11. Household Refrigerators

COMMERCIAL ICE MACHINES

Commercial ice machines are used in commercial establishments, including hotels, restaurants, bars, and convenience stores, to produce ice for consumer use. They produce ice in various sizes and shapes (e.g., cubes, pellets, and flakes) and with different retrieval mechanisms, such as dispensers or self-retrieval from bins. Charge sizes for commercial ice machines typically range from 0.5 to two kg (UNEP 2019a).

Figure 12. Ice Machine

TABLE 11. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN COMMERCIAL ICE MACHINES

HISTORICAL	COMMON/CURRENT[a]
CFC-12	**R-404A**
R-502	**R-290**
HCFC-22	**R-744**

Source: UNEP (2019a) .
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

STAND-ALONE EQUIPMENT

Stand-alone equipment includes refrigerators, freezers, and reach-in coolers (either open or with doors) where all refrigeration components are integrated and, for the smallest types, the refrigeration circuit is entirely brazed or welded. These systems are fully charged with refrigerant at the factory (typical charge sizes range from 100 to 500 g) and typically require only electricity supply to begin operation (UNEP 2015a).

TABLE 12. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN STAND ALONE EQUIPMENT

HISTORICAL	COMMON/CURRENT[a]
R-404A	**R-290**
CFC-12	**R-744**
HCFC-22	**HFC-134a**
R-401A	**R-448A**
	R-449A
	R-450A
	R-513A

Source: EPA (2018), UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 13. Reach-in Cooler

VERY LOW TEMPERATURE REFRIGERATION

Very low temperature refrigeration (VLT) systems require maintaining temperatures at approximately -80 °F (-62 °C) or lower. Examples include medical freezers and freeze-dryers, which generally require extremely reliable refrigeration cycles to maintain low temperatures and must meet stringent technical standards that do not normally apply to refrigeration systems. VLT refrigeration systems typically contain between 98 and 120 grams of refrigerant (Eppendorf 2015).

TABLE 13. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN VLT REFRIGERATION

HISTORICAL	COMMON/CURRENT[a]
CFC-13	**HFC-23**
CFC-113	**HFC-245fa**
CFC-114	**HFE-347mcc3**
R-503	**R-170**
	R-290
	PFCs and PFC blends

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 14. VLT Refrigeration

CHILLERS

Chillers cool water, which is then circulated to provide comfort cooling throughout a building or other location. They can be classified by compressor type, including centrifugal and positive displacement. Positive displacement chillers include reciprocating, screw, and scroll chillers (California Air Resources Board n.d.). Positive displacement chillers are commonly used to provide chilling up to 7,000 kW of cooling capacity with refrigerant charge sizes of 40 to 500 kg. Centrifugal chillers are usually used in applications where up to 21,000 kW of cooling capacity are needed and contain between 500 and 13,000 kg of refrigerant (Energy Star 2008, UNEP 2015c, UNEP 2019a).

TABLE 14. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN CHILLERS

HISTORICAL	COMMON/CURRENT[a]
HCFC-22	**HFC-245fa**
CFC-11	**HFC-134a**
CFC-12	**HFC-236fa**
R-500	
R-401A	

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 15. Chiller

INDUSTRIAL PROCESS REFRIGERATION (IPR)

Industrial process refrigeration (IPR) systems cool process streams in industrial applications. IPR is commonly used in the chemical, petrochemical, manufacturing, and electricity generation industries and consists of complex, custom systems (CMA and EPA 1995). The choice of refrigerant depends on ambient and required operating temperatures and pressures. IPR systems can have charge sizes of up to 5,000 kg and capacities of up to 5,000 kW (UNEP 2015b).

TABLE 15. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN IPR

HISTORICAL	COMMON/CURRENT[a]
R-502	**R-717**
HCFC-22	**HFC-134a**
R-401A	**R-744**
	R-404A

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 16. Industrial Process Refrigeration

COLD STORAGE WAREHOUSES

Cold storage warehouses store meat, produce, dairy products, and other perishable goods at temperatures between 54 °F and -76 °F (12 °C and -60 °C), depending on the storage needs (UNEP 2019a). Small and medium cold storage warehouses generally contain between 10 and 100 kg of refrigerant, while large cold storage warehouses can contain up to 5,000 kg (UNEP 2015b). Most cold storage warehouses in the United States use R-717 as the refrigerant in a vapor compression cycle, although some rely on other refrigerants.

TABLE 16. HISTORICAL AND COMMON/CURRENT REFRIGERANTS USED IN COLD STORAGE WAREHOUSES

HISTORICAL	COMMON/CURRENT[a]
CFC-12	**R-717**
R-502	**R-404A**
HCFC-22	**R-507**
R-401A	**R-407F**
	R-744
	HCFO-1233zd(E)

Source: UNEP (2019a).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 17. Cold Storage Warehouse

FOAM BLOWING AGENTS

Foam blowing agents are used in insulation foam for a wide range of applications, including, but not limited to, refrigerators, buildings, automobiles, furniture, and packaging (EPA 2021b). Foam demand is driven by its wide range of uses; specifically, in building and construction, the foam blowing agent use increase is driven by growth in construction in developing countries and adoption of enhanced energy efficiency in both developing and developed countries (UNEP 2019b). In 2017, foam blowing agent consumption worldwide reached over 400,000 MT and is expected to have an annual grow of 4 percent until 2020, reaching more than 520,000 MT (UNEP 2019b).

Even though there have been significant developments on the successful commercialization of foams with low GWP blowing agents, the transition away from ODS has been slow given a number of challenges, including a significantly lower cost of HCFCs and the flammability of some low GWP alternatives (UNEP 2019b).

According to UNEP (2019b) hydrocarbons are expected to comprise half of the blowing agent market share by 2020.

RIGID POLYURETHANE: SPRAY

Rigid polyurethane spray is applied as insulation for roofing and walls.

TABLE 17. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN RIGID PU SPRAY

HISTORICAL	COMMON/CURRENT[a]
CFC-11	**HFC-245fa**
HCFC-141b	**HFC-365mfc/HFC-227ea**
	CO_2/water
	Methyl formate
	HFO-1234ze(E)
	HFO-1336mzz(Z)
	HCFO-1233zd(E)

Source: UNEP (2019b).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 18. Rigid Polyurethane Spray Insulation

RIGID POLYURETHANE: SLABSTOCK AND OTHERS

Rigid polyurethane slabstock includes insulation for panels and pipes.

TABLE 18. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN RIGID POLYURETHANE SLABSTOCK

HISTORICAL	COMMON/CURRENT[a]
CFC-11	Cyclopentane
HCFC-141b	n-Pentane
	HFC-245fa
	HFC-365mfc/HFC-277ea
	CO_2/water
	Isopentane
	Methyl formate/methylal
	Unsaturated HCFCs and HFCs
	HC with HFO/HCFO or HFC blends

Source: UNEP (2019b), UNEP (2018). .
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 19. Rigid Polyurethane Slabstock Pipe Insulation

RIGID POLYURETHANE AND POLYISOCYANURATE: LAMINATED BOARDSTOCK

Laminated boardstock includes insulation for roofing and walls.

TABLE 19. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN RIGID PU AND POLYISOCYANURATE LAMINATED BOARDSTOCK

HISTORICAL	COMMON/CURRENT[a]
CFC-11	**HFC-245fa**
HCFC-141b	HFC-365mfc/HFC-227ea
	HCFO-1233zd(E)
	HFO-1336mzz(Z)
	n-Pentane
	Cyclopentane/isopentane

Source: UNEP (2019a), EPA (2018).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 20. Laminated Boardstock

RIGID POLYURETHANE: SANDWICH PANELS

Rigid polyurethane sandwich panels include steel-faced insulation panels for walls and metal doors.

TABLE 20. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN RIGID PU SANDWICH PANELS

HISTORICAL	COMMON/CURRENT[a]
CFC-11	**HFC-134a**
HCFC-141b	**HFC-245fa**
HCFC-22	HFC-365mfc/HFC-227ea
	n-Pentane/isopentane
	HCFO-1233zd(E)
	HFO-1336mzz(Z)
	CO_2
	Methyl formate
	HFC-245fa/CO_2

Source: UNEP (2019b), EPA (2018).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

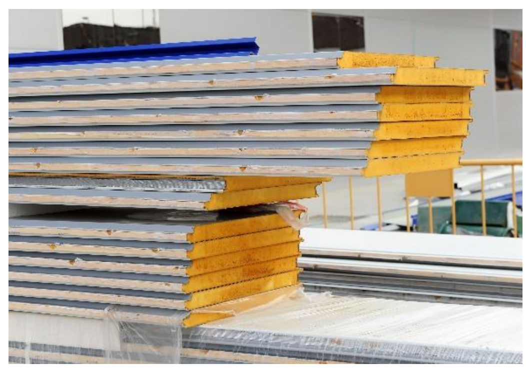

Figure 21. Rigid Polyurethane Steel-Faced Insulation Panels

POLYSTYRENE: EXTRUDED BOARDSTOCK AND BILLET

Extruded polystyrene (XPS) boardstock and billet are typically used in building insulation and are especially resistant to moisture, making them useful for under-floor insulation and cold storage applications (UNEP 2019b).

TABLE 21. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN POLYSTYRENE EXTRUDED BOARDSTOCK AND BILLET

HISTORICAL	COMMON/CURRENT[a]
CFC-12	**HFC-134a**
HCFC-142b	**HFC-152a**
HCFC-22	Cyclopentane
	n-Butane
	Isobutene
	Dimethoxyethane (DME)
	HCFO-1233zd(E)
	HFO-1234ze(E)
	CO_2
	CO_2/ethanol

Source: UNEP 2019b).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.


Figure 22. XPS Billet

PHENOLIC INSULATION BOARD AND BUNSTOCK

Phenolic foam is used primarily for insulation for roofing, walls, and pipes and is popular for its fire and smoke resistant properties. Additionally, phenolic foam is comprised of smaller cells compared to other foam insulation, which improves its thermal performance (UNEP 2019b).

TABLE 22. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN PHENOLIC INSULATION BOARD AND BUNSTOCK

HISTORICAL	COMMON/CURRENT[a]
CFC-11	**HFC-245fa**
HCFC-141b	HFC-365mfc/HFC-227ea
	n-Pentane
	Cyclopentane/isopentane
	HCFO-1233zd(E)
	HFO-1336mzz(Z)

Source: UNEP (2019b).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

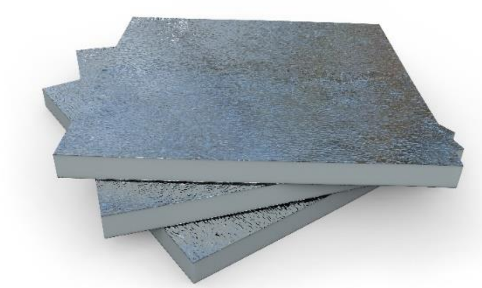
Figure 23. Phenolic Insulation Board

RIGID POLYURETHANE: DOMESTIC APPLIANCES

Rigid polyurethane for domestic appliances includes insulation foam in domestic refrigerators and freezers.

TABLE 23. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN DOMESTIC APPLIANCES

HISTORICAL	COMMON/CURRENT[a]
CFC-11	**HFC-245fa**
HCFC-141b	**HFC-134a**
	Cyclopentane
	Cyclopentane/isopentane
	HCFO-1233zd(E)
	HFO-1336mzz(Z)

Source: UNEP (2019b).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 24. Rigid PU Domestic Appliance Insulation

RIGID POLYURETHANE: COMMERCIAL REFRIGERATION

Rigid polyurethane for commercial refrigeration includes insulation for pipes, walls, and metal doors in commercial refrigeration equipment, vending machines, coolers, buoyancy, and refrigerated transport vehicles.

TABLE 24. HISTORICAL AND COMMON/CURRENT FOAM BLOWING AGENTS IN RIGID PU FOR COMMERCIAL REFRIGERATION

HISTORICAL	COMMON/CURRENT[a]
CFC-11	**HFC-245fa**
HCFC-141b	**HFC-134a**
HCFC-142b	HFC-365mfc/HFC-227ea
HCFC-22	Cyclopentane
	Methyl formate
	Cyclopentane/isopentane
	HCFO-1233zd(E)
	HFO-1336mzz(Z)
	HFO-1234ze(E)
	CO_2/water

Source: UNEP (2019b).
[a] **Bold** font indicates substances that are listed as acceptable for use by SNAP for this end use. Non-bolded font indicates substances that are not listed as acceptable for use by SNAP for this end use.

Figure 25. Rigid PU Commercial Refrigeration

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ANNEX A. REFRIGERANTS AND FOAM BLOWING AGENTS BY END-USE

Table A1 below lists select applications (end-uses) for refrigerants (i.e., ozone-depleting substances (ODS), hydrofluorocarbons (HFCs), and/or alternatives) and the refrigerants historically and currently used in each end-use. The end-uses highlighted below were selected for their potential relevance to USAID activities.**Error! Reference source not found.**

TABLE A1. REFRIGERATION AND AIR CONDITIONING END-USES AND CORRESPONDING HISTORICAL AND CURRENT REFRIGERANTS.

REFRIGERATION AND AIR CONDITIONING	
END-USE/APPLICATION	**HISTORICAL AND CURRENT REFRIGERANTS**
Motor Vehicle Air Conditioning	**Historical:** CFC-12, HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Room Air Conditioners: Portable Self-Contained Units	**Historical:** CFC-11, CFC-12, R-500, HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Room Air Conditioners: Window Units	**Historical:** HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Room Air Conditioners: Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps	**Historical:** HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Split Systems (Non-Ducted)	**Historical:** HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Split Systems: Residential and Light Commercial (Ducted)	**Historical:** HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Packaged Rooftop Units	**Historical:** HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).

REFRIGERATION AND AIR CONDITIONING	
END-USE/APPLICATION	**HISTORICAL AND CURRENT REFRIGERANTS**
Water-Source and Ground-Source Air Conditioning and Heat Pumps	**Historical:** HCFC-22. **Current:** HFC-32; HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-454C; R-454A; R-454B; R-452B; R-717; R-457A; R-290; R-417A; R-441A; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a).
Household Refrigerators and Freezers	**Historical**: CFC-12; R-401A. **Current**: HFC-134a; R-407C; R-407F; R-410A; R-404A; R-507; R-450A; R-513A; R-717; R-600a; R-290 (with use conditions); HFO-1234yf; R-441A. Source: UNEP (2019a).
Commercial Ice Machines	**Historical:** CFC-12; R-502; HCFC-22; R-401A. **Current:** R-404A; HFC-134a; R-744; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-450A; R-513; R-448A; R-449A; R-449B; R-717; R-290; R-417A. Source: UNEP (2019a), EPA (2002).
Stand-alone Equipment	**Historical:** CFC-12; R-404A; HCFC-22; R-401A. **Current:** HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-450A; R-513A; R-448A; R-449A; R-449B; R-717; R-744; R-600a; R-290; R-441A. Source: UNEP (2019a), EPA (2018).
Very Low Temperature Refrigeration	**Historical:** CFC-13; CFC-113; CFC-114; R-503. **Current:** HFC-32; HFC-245fa; HFE-347mcc3; R-170; R-290; R-407C; R-410A; R-404A; R-507; R-744; R-290; perfluorocarbons (PFCs) and PFC blends; HFC-23. Source: EPA (1994), EPA (2001), EPA (2020).
Chillers	**Historical:** CFC-11; CFC-12; HCFC-22; R-401A, R-500. **Current:** HFC-245fa; HFC-134a; HFC-236fa; R-407C; R-410A; R-404A; R-507; HCFO-1224yd(Z); HFO-1234ze(E); HCFO-1233zd(E); HFO-1336mzz(Z); R-514A; R-515B; R-450A; R-513A; R-717; R-744; R-1270; HCFC-123. Source: UNEP (2019a).
Industrial Process Refrigeration (IPR)	**Historical:** R-502**;** HCFC-22; R-401A. **Current:** HFC-245fa; HFC-134a; HFC-236fa; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; HCFO-1224yd(Z); HCFO-1233zd(E); R-450A; R-513A; R-448A; R-449A; R-717; R-744; R-1270; R-290; HFC-23; HFE-347mcc3; HCFC-123. Source: UNEP (2019a).
Cold Storage Warehouses	**Historical:** CFC-12; R-502; HCFC-22; R-401A. **Current:** HFC-134a; R-407C; R-407F; R-410A; R-407A; R-404A; R-507; R-450A; R-513A; R-448A; R-449A; R-449B; R-717; R-744; R-1270 (unacceptable for use in the U.S.). Source: UNEP (2019a), EPA (2018).

Table A2 below lists applications (end-uses) for foam blowing agents (i.e., ODS, HFCs, and/or alternatives) and foam blowing agents historically and currently used in each end-use. The end-uses highlighted below were selected for their potential relevance to USAID activities.

TABLE A2. FOAM BLOWING END-USES AND CORRESPONDING HISTORICAL AND CURRENT FOAM BLOWING AGENTS.

FOAM BLOWING AGENTS	
END-USE/APPLICATION	**HISTORICAL AND CURRENT FOAM BLOWING AGENTS**
Rigid Polyurethane: Spray	**Historical**: CFC-11; HCFC-141b. **Current:** HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze(E); HCFO-1233zd(E); HFO-1336mzz(Z); CO_2; methylal; HFC-365mfc/HFC-227ea; methyl formate; HCFC-123. Source: UNEP (2019b), EPA (2018).
Rigid Polyurethane: Slabstock and Others	**Historical**: CFC-11; HCFC-141b. **Current:** HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze(E); HCFO-1233zd(E); HFO-1336mzz(Z); CO_2; methyl formate; HCFC-123. Source: UNEP (2019b).
Rigid Polyurethane and Polyisocyanurate: Laminated Boardstock	**Historical:** CFC-11; HCFC-141b. **Current:** HCFC-123; HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze; HCFO-1233zd(E); HFO-1336mzz (Z); CO_2; methyl formate. Source: EPA (2018).
Rigid Polyurethane: Sandwich Panels	**Historical:** CFC-11; HCFC-141b; HCFC-22. **Current:** HFC-152a; HFC-245fa; HFC-134a; HCFO-1233zd(E); HFO-1336mzz(Z); CO_2; methyl formate; HCFC-123. Source: UNEP (2019b), EPA (2018).
Polystyrene: Extruded Boardstock and Billet	**Historical:** CFC-12; HCFC-142b; HCFC-22. **Current:** HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze(E); CO_2; methyl formate; blends with maximum of 51 percent HFC-134a, 17 to 41 percent HFC-152a, up to 20 percent CO_2 and one to 13 percent water; blends of 40 to 52 percent HFC-134a by weight and the remainder HFO-1234ze(E); blends of 40 to 52 percent HFC-134a with 40 to 60 percent HFO-1234ze(E) and 10 to 20 percent each water and CO_2 by weight. Source: UNEP (2019b).
Phenolic Insulation Board and Bunstock	**Historical:** CFC-11; HCFC-141b. **Current:** HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze(E); HFO-1336mzz(Z). Source: UNEP (2019b).
Rigid Polyurethane: Domestic Appliances	**Historical:** CFC-11; HCFC-141b. **Current:** HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze(E); HCFO-1233zd(E); HFO-1336mzz(Z); CO_2; methyl formate; HCFC-123. Source: UNEP (2019b).
Rigid Polyurethane: Commercial Refrigeration	**Historical:** CFC-11; HCFC-141b; HCFC-142b; HCFC-22. **Current:** HFC-152a; HFC-245fa; HFC-134a; HFO-1234ze(E); HCFO-1233zd(E); HFO-1336mzz(Z); CO_2; methyl formate; HCFC-123. Source: UNEP (2019b).