

The Kigali Amendment and Opportunities for Energy Efficiency

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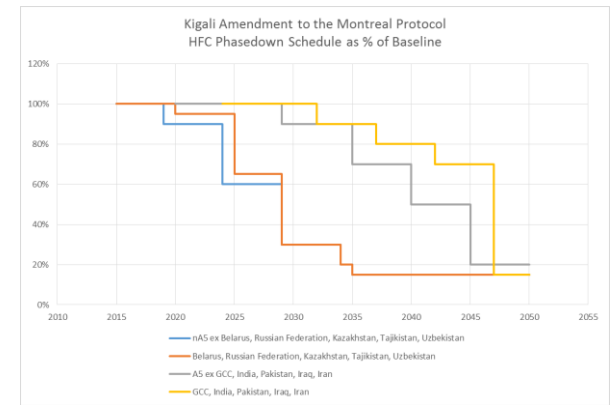
Montreal Protocol on Substances that Deplete the Ozone Layer

(protocol to the Vienna Convention for the Protection of the Ozone Layer)

- In 1973, Mario Molina and Frank Sherwood Rowland (University of California) discovered that CFCs were stable for 50 to 100 years in the stratosphere where they would ultimately be broken down by ultraviolet radiation releasing chlorine atoms. The chlorine atoms were expected to breakdown ozone (O₃) in the stratosphere
- Stratospheric ozone absorbs much of the sun's ultraviolet-B radiation (UV-B) which increases incidents of skin cancer and cataracts and damages crops and marine phytoplankton
- The Montreal Protocol is an international treaty to protect the ozone layer by phasing out controlled ozone depleting substances. The treaty entered into force in January of 1989. It has been ratified by 196 countries and the European Union.
- As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.
- As the first universally ratified treaty in United Nation history, the Montreal Protocol has been described as "perhaps the single most successful international agreement to date..." by former United Nations Secretary General Kofi-Anan
- In 2016. the Kigali HFC phasedown amendment to the Montreal Protocol was agreed upon and will enter into force January 1, 2019.

Montreal Protocol HFC Amendment Phase Down Schedules

- Montreal Protocol Kigali HFC Amendment has been agreed to by the Parties and will be in force 1/1/19
- Implementation required ratification by 20 countries (39 have ratified)
 - https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-2-f&chapter=27&clang=en
- Any country can implement the content of the Amendment without ratification
- Any country that does not ratify by 2033 will be subject to non-Party trade provisions
- Ratification in the US requires 2/3 majority vote in the Senate



	A5 Group 1	A5 Group 2	A2 Group	A2 Exceptions
HFC baseline	2020-2022	2024-2026	2011-2013	2011-2013
Formula	Average HFC consumption during baseline plus HCFC Contribution			
HCFC	65% baseline	65% baseline	15% baseline	25% baseline
Freeze	2024	2028	-	-
1st step	2029 – 10%	2032 – 10%	2019 – 10%	2020 - 5%
2nd step	2035 – 30%	2037 – 20%	2024 – 40%	2025 - 35%
3rd step	2040 – 50%	2042 – 30%	2029 – 70%	2029 - 70%
4th step			2034 – 80%	2034 - 80%
Plateau	2045 – 80%	2047 – 85%	2036 – 85%	2036 - 85%
	A5 countries excluding Group 2 countries	GCC, India, Pakistan, Iraq, Iran	A2 countries excluding A2 Exceptions	Belarus, Uzbekistan, Russian Federation, Kazakhstan, Tajikistan



DECISION XXVIII/3: ENERGY EFFICIENCY

- **Recognizing that a phase-down of hydrofluorocarbons under the Montreal Protocol would present additional opportunities to catalyse and secure improvements in the energy efficiency of appliances and equipment,**
- *Noting* that the air-conditioning and refrigeration sectors represent a substantial and increasing percentage of global electricity demand,
- **Appreciating the fact that improvements in energy efficiency could deliver a variety of co-benefits for sustainable development, including for energy security, public health and climate mitigation,**
- **Highlighting the large returns on investment that have resulted from modest expenditures on energy efficiency, and the substantial savings available for both consumers and Governments,**
- To request the Technology and Economic Assessment Panel to review energy efficiency opportunities in the refrigeration and air-conditioning and heat-pump sectors related to a transition to climate-friendly alternatives, including not-in-kind options;
- To invite parties to submit to the Ozone Secretariat by May 2017, on a voluntary basis, relevant information on energy efficiency innovations in the refrigeration, air-conditioning and heat-pump sectors;
- To request the Technology and Economic Assessment Panel to assess the information submitted by parties on energy efficiency opportunities in the refrigeration and air-conditioning sectors during the transition to low-global-warming-potential and zero-global-warming-potential alternatives and to report thereon to the Twenty-Ninth Meeting of the Parties, in 2017;

<http://ozone.unep.org/en/handbook-montreal-protocol-substances-deplete-ozone-layer/41478>

DECISION XXIX/10: ISSUES RELATED TO ENERGY EFFICIENCY WHILE PHASING DOWN HYDROFLUOROCARBONS

Recalling decision XXVIII/2, in which the Meeting of the Parties, inter alia, requested the Executive Committee **to develop cost guidance associated with maintaining and/or enhancing the energy efficiency of low-global-warming-potential (GWP) or zero-GWP replacement technologies and equipment when phasing down hydrofluorocarbons, while taking note of the role of other institutions addressing energy efficiency, when appropriate,**

Recognizing the importance of maintaining and/or enhancing energy efficiency while transitioning away from high-GWP hydrofluorocarbons to low-GWP alternatives in the refrigeration, air-conditioning and heat pump sectors,

Noting that the use of air conditioning and refrigeration is growing in countries operating under paragraph 1 of Article 5,

Recognizing that maintaining and/or enhancing energy efficiency could have significant climate benefits,

1. To request the Technology and Economic Assessment Panel in relation to **maintaining and/or enhancing energy efficiency in the refrigeration, air-conditioning and heat-pump sectors, including in high-ambient-temperature conditions,** while phasing down hydrofluorocarbons under the Kigali Amendment to the Montreal Protocol in parties operating under paragraph 1 of Article 5, to assess the following items:

(a) Technology options and requirements including:

(i) Challenges to their uptake;

(ii) Their long-term sustainable performance and viability;

(iii) Their environmental benefits in terms of carbon dioxide equivalents;

(b) Capacity-building and servicing sector requirements in the refrigeration and air-conditioning and heat-pump;

(c) Related costs including capital and operating costs;

DECISION XXIX/10: ISSUES RELATED TO ENERGY EFFICIENCY WHILE PHASING DOWN HYDROFLUOROCARBONS

2. Also to request the Technology and Economic Assessment Panel to provide an **overview of the activities and funding provided by other relevant institutions**, as well as **definitions, criteria and methodologies** used in addressing energy efficiency in the refrigeration, air-conditioning and heat-pump sectors in relation to maintaining and/or enhancing energy efficiency in the refrigeration, air-conditioning and heat-pump sectors while phasing down hydrofluorocarbons under the Kigali Amendment to the Montreal Protocol, as well as those related to low-GWP and zero-GWP hydrofluorocarbon alternatives including on different financing modalities;
3. To request the Technology and Economic Assessment Panel to prepare a final report for consideration by the Open-ended Working Group at its fortieth meeting, and thereafter an updated final report to be submitted to the Thirtieth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer taking into consideration the outcome of the workshop described in paragraph 4 below;
4. To request the Secretariat to organize a workshop on energy efficiency opportunities while phasing down hydrofluorocarbons at the fortieth meeting of the Open-ended Working Group;

Montreal Protocol Activities Related to Energy Efficiency

- Bottom Line: The parties to the Montreal Protocol are still determining how energy efficiency will be incorporated into the HFC amendment. At a minimum, “energy efficiency should be maintained or improved”.
 - Ozone officers are not necessarily experts in energy efficiency
 - Energy Efficiency Workshop (July 2018)
 - Technical and Economic Assessment Panel (TEAP) Task Force report on Energy Efficiency
- There are additional organizations funding energy efficiency work
 - Kigali Cooling Efficiency Program (K-CEP)
 - GEF – Global Environment Facility
 - Green Climate Fund

TEAP Report - Opportunities

Energy efficiency is primarily due to equipment selection and design (10% to 70%) improvement vs refrigerant selection (5% to 10%)

Similar to high GWP options, low GWP options can benefit from equipment and system design:

1. Minimize cooling and heating loads
2. Select appropriate refrigerant
3. Include high efficiency components and system design
4. Install equipment properly (including duct work)
5. Optimize controls under multiple operating conditions
6. Design for ease of maintenance
7. Energy efficiency labeling

http://conf.montreal-protocol.org/meeting/oewg/oewg-40/presession/Background-Documents/TEAP_DecisionXXIX-10_Task_Force_EE_May2018.pdf

TEAP Report – Challenges

- Components with higher energy efficiency tend to be more costly
- Oftentimes decision-maker does not occupy building or pay energy bills
- Building owners/occupants may not be aware of options
- Lack of standards, regulations, education, minimum efficiency performance standards (MEPS)
- Testing facilities may not be available in all countries
- Maintenance / Service training and education

High Ambient Temperature Challenges

- Refrigerant stability at high ambient temperatures
- Additional costs: larger condenser sizes with corresponding larger refrigerant charges
- Larger charge sizes may require unique codes/safety standards
- Higher cooling loads and condensing temperatures
- Narrower refrigerant options due to operating temperatures
- Need for precise servicing practices and strong training programs

Greenhouse Gas Impact

- Direct emissions related to leak rates and end-of-life refrigerant management and associated GWP
- Indirect emissions due to energy consumption estimated at 80% of the overall impact
- Power generation impacts GHG
- Leak rates of equipment estimated at 52% of global emissions of HFCs

United Nations Environment Program Fact Sheet

- Most significant global issue is leaky stationary refrigeration and air conditioning equipment
- Impact from refrigerants is expected to increase as there is increased access to refrigeration and air conditioning in Article 5 countries

Figure 6: HFC use for topping up leaks in RACHP

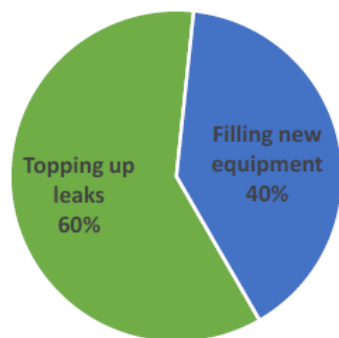


Figure 2 Split of global HFC consumption, tonnes CO₂ 2012

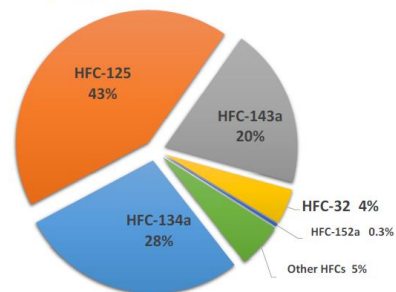
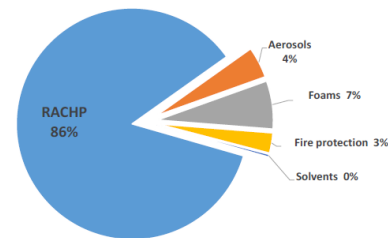


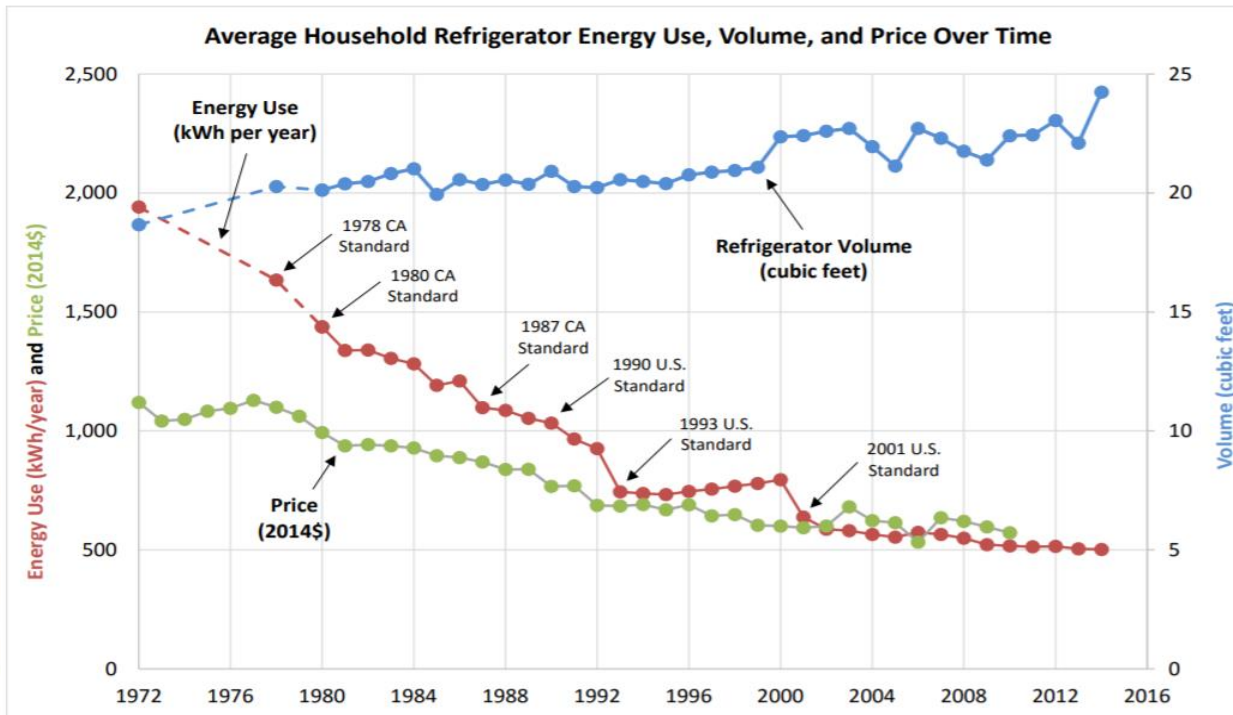
Figure 4 Markets using HFCs, % of tonnes CO₂ 2012



Service Sector: Risk / Opportunity & Enabling Activities partially funded by GEF and K-CEP

- Energy efficiency degrades over time; improved design and servicing slows this trend by up to 50% at minimal cost
 - Refrigerant and oil levels
 - Clean filters
 - Properly set control systems and valves
- Improved training programs and certification requirements
 - Policies requiring regular maintenance
 - Warranties or maintenance contracts
- Consumer awareness

Energy efficiency and costs over time



Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price.

- Notes:
- a. Data includes standard-size and compact refrigerators.
 - b. Energy consumption and volume data reflect the current DOE test procedure.
 - c. Volume is adjusted volume, which is equal to fresh food volume + 1.76 * freezer volume.
 - d. Prices represent the manufacturer selling price (e.g. excluding retailer markups) and reflect products manufactured in the U.S.

<http://aceee.org/blog/2014/09/how-your-refrigerator-has-kept-its-cool>

“How your refrigerator has kept its cool over 40 years of efficiency improvements”

[Marianne DiMascio](#)



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