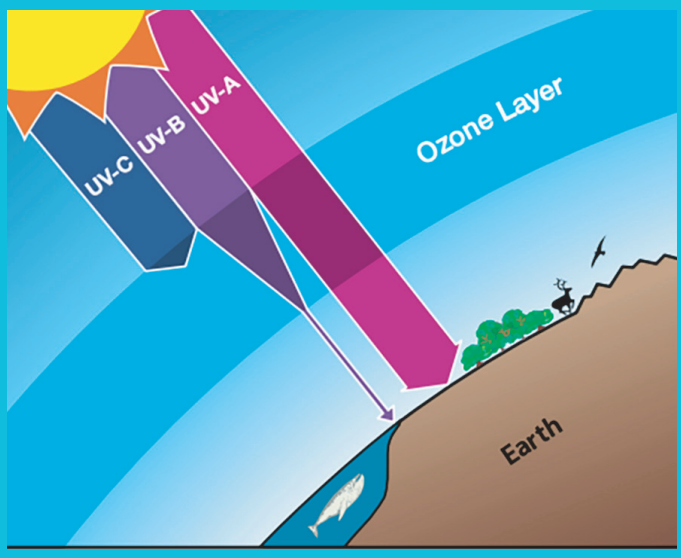
1. Ozone Layer Depletion

Background

Ozone is a pale blue gas composed of three oxygen atoms bonded together. It occurs naturally high up in the Earth's atmosphere, most specifically in the stratosphere from approximately 15 to 35 kilometres and forms the ozone layer. Its thickness varies seasonally and geographically. Under normal circumstances, the ozone layer is thickest over the poles and thinnest around the equator.



Why is Ozone Layer important?

The ozone layer is crucial for life on Earth. It protects the Earth from harmful ultraviolet (UV) rays from the sun. Without this ozone shield more UV rays would reach the Earth and this would lead humans to be more susceptible to skin cancer, cataracts and impaired immune systems. Plants would also not grow in heavy UV rays, while planktons that serve as food for most of the ocean life would not be able to thrive.

The ozone molecules in the ozone layer are not harmful as opposed to the ozone molecules present at ground level which constitute pollutants with adverse effects for life, including human life.

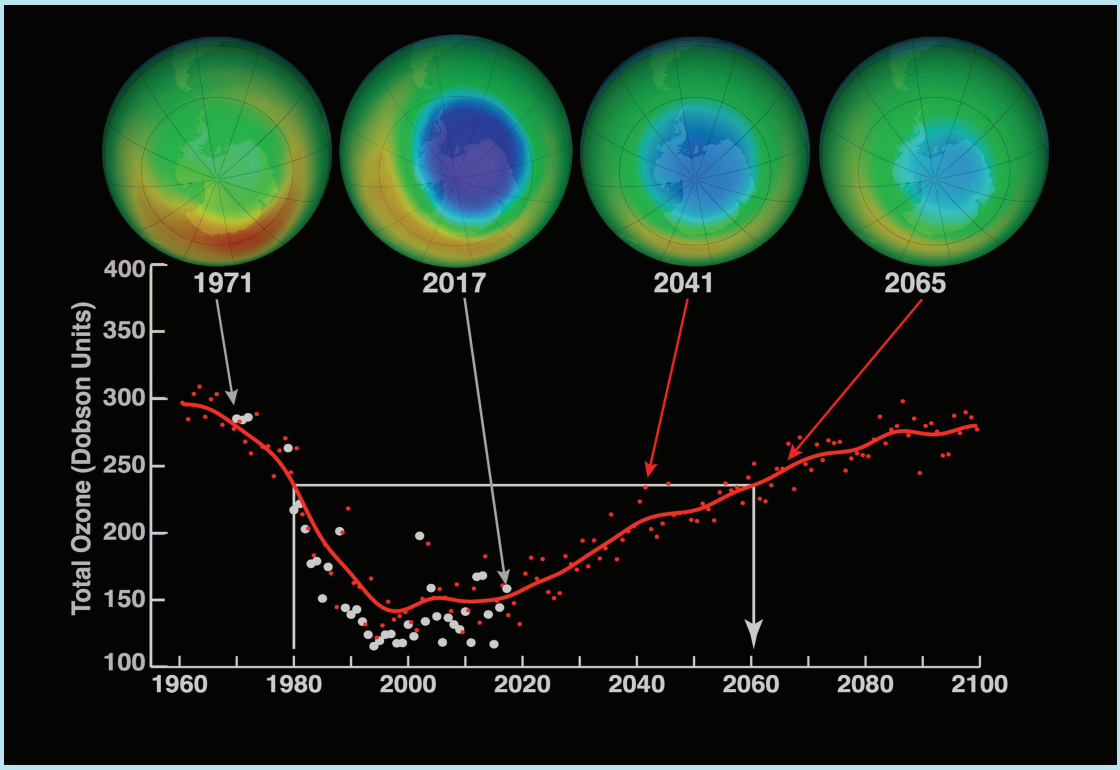
What is 'Ozone Layer Depletion'?

Ozone layer depletion is the thinning of the ozone layer present in the stratosphere. This phenomenon happens when chemical compounds containing bromine or chlorine are released from industrial and human activities into the atmosphere. Such compounds are known as Ozone Depleting Substances (ODS). The chlorine or bromine atoms in the ODS react with ozone molecules of the ozone layer in the presence of UV light and cause the thinning of the ozone layer. One chlorine atom can destroy 100,000 molecules of ozone. Examples of ODS include chlorofluorocarbons (CFCs), carbon tetrachloride (CCl_4), hydrochlorofluorocarbons (HCFCs), methylchloroform (CH_3CCl_3), hydrobromofluorocarbons (HBFCs), bromochloromethane (CH_2BrCl) and methyl bromide (CH_3Br).These compounds are used mainly in the refrigeration and air conditioning equipment.

Depletion of the ozone layer occurs globally but it is more severe over the Antarctic where it is referred to as the 'Ozone Hole'. It occurs mainly in late winter and early spring (August-November) and peak depletion usually occurs in early October, when ozone is often completely destroyed in large areas.

Monitoring of the Ozone Layer

Most of the ODS remain in the stratosphere for decades, meaning that ozone layer recovery is a very slow and long process. Satellite remote sensing of ozone in the stratosphere is used for monitoring ozone depletion.



Healing of the Ozone Layer

The Vienna Convention and the Montreal Protocol have been signed by some 197 countries to take actions to heal the ozone layer through the gradual phasing out of ODS and adoption of ozone and climate friendly alternatives.

2. Impacts of Ozone Layer Depletion

Background

The ozone layer protects life on Earth from harmful solar ultraviolet (UV) radiation. In the late 20th century, emissions of chemical substances called halocarbons adversely affected the amount of ozone molecules in the upper atmosphere resulting in the depletion of the ozone layer. The thinning of the ozone layer is referred to as the ozone hole.

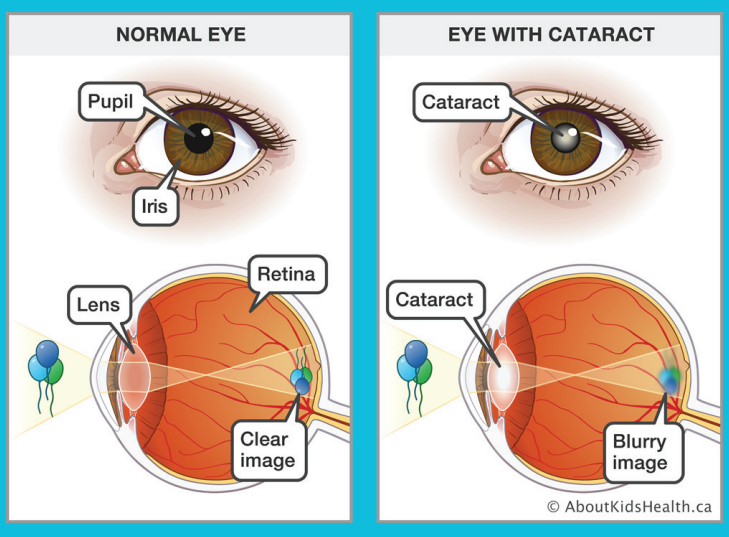
Effects on Human Health

Ozone layer depletion increases the amount of UV rays in particular UVB that reaches the Earth's surface. Prolonged exposure to UVB radiation has been linked to many human health problems, including suppression of the immune system, premature aging of the skin and skin cancer. There are three main types of skin cancer namely, basal cell carcinoma, squamous cell carcinoma, and malignant melanoma. Scientists believe that a sustained 10 % depletion of the ozone layer would lead to a 26 % increase in non-melanoma skin cancer. This could mean an additional 300,000 cases of cancer per year world-wide.

Skin Cancer

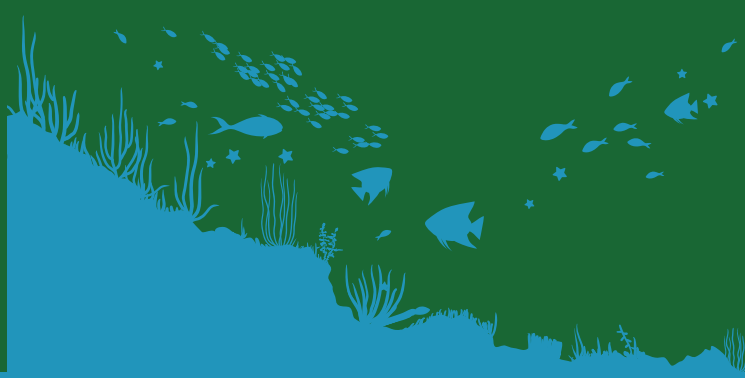
Prolonged UVB radiation can damage several parts of the eye, including the lens, the cornea, and the membrane covering the eye (conjunctiva). UVB has also been linked to the development of cataracts, that is, a clouding of the eye's lens. A sustained 10% thinning of the ozone layer is expected to result in nearly two million new cases of cataracts per year globally.

Eye Cataract



Effects on Plants

UV radiation not only affects human beings but also the growth processes of almost all green plants. There is concern that ozone depletion may lead to a loss of various plant species. A change in the balance of plant species can have serious effects on the ecosystems. Plants form the basis of the food web, prevent soil erosion and water loss, and are the primary producers of oxygen and a primary sink (storage site) for carbon dioxide.



Effects on Marine Ecosystems

Phytoplankton are microscopic organisms that live in aquatic environments, both in salty and in fresh water. They are food for other plankton and small fish, as well as larger animals such as whales and play an important role in carbon cycling. They also generate about half the atmosphere's oxygen.

Exposure to solar UVB radiation has shown to affect the survival rates for these organisms. UVB radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians, and other marine animals. The most severe effects are decreased reproductive capacity and impaired larval development.

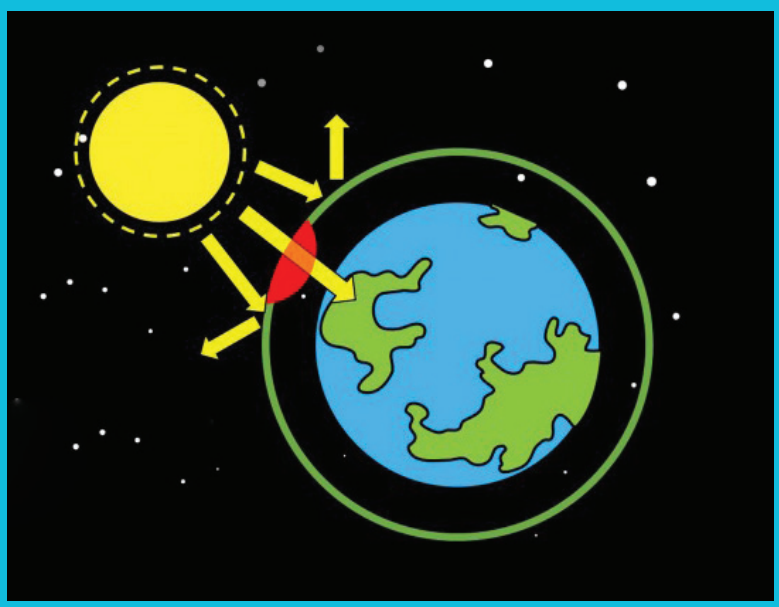
Effects on Materials

Synthetic materials such as plastics, naturally occurring biopolymers, as well as some other materials of commercial interest are adversely affected by UVB radiation. Increases in UVB levels will accelerate their breakdown, limiting the length of time for which they are useful outdoors.

3. What can you do to reduce Ozone Layer Depletion

Background

Ozone layer is affected by chemical substances called Ozone Depleting Substances (ODS) such as Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs). CFCs were formerly used as refrigerants and ,since 2010, they have been replaced by HCFCs which have lower impacts on ozone layer as compared to CFCs. HCFCs are now being replaced by ozone and climate friendly refrigerants such as ammonia and hydrocarbons.



With technological advancement, alternatives to ODS have been introduced on the market. Manufacturers of refrigerators and air conditioners have re-designed their equipment to improve energy efficiency as well as reduce refrigerant leakage rates, which also resulted in reduced operating costs.

What can you do at individual level to protect the ozone layer

By avoiding products and practices that damage the ozone layer we can help to mitigate Ozone Layer Depletion. Some of the simple actions that we can take are as follows:

- When purchasing a new refrigerator and/or air conditioner, opt for equipment using ozone and climate friendly refrigerants.
- Dispose of appliances and equipment with refrigerants responsibly. Old refrigerators should be referred to a qualified expert to recover the refrigerants; else the refrigerant would find its way into the atmosphere and affect the ozone layer.
- When air conditioners and refrigerators need to be serviced, ask for trained and qualified experts to ensure that the equipment are properly repaired.

- Do not place refrigerators next to an oven or any other heat source, otherwise, the refrigerator will consume more electricity to keep the temperature low.
- Set the thermostat of refrigerators and freezers at the right temperature (Fresh food: between 0°C to 4°C; Freezer: close to -18°C; and Chill compartment: close to 0°C). Avoid too low temperatures as same will consume more electricity.
- Switch equipment off when not in use for a long period as even standby mode consumes energy.
- Set air conditioners at 3o to 5oC lower than the ambient temperature to save energy.
- Avoid overloading refrigerators with food items.

4. Achievement under the Montreal protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer is a global agreement to protect Earth's ozone layer by phasing out the consumption and the production of most chemicals that causes its depletion.

The protocol was signed on 16 September 1987 and came into force in 1989. This date marks the World Ozone Day. The Protocol provides a set of practical and actionable tasks to phase out Ozone Depleting Substances (ODS).

The Multilateral Fund for the Implementation of the Montreal Protocol was established in 1991 to provide financial and technical assistance to developing country parties to the Montreal Protocol. The Technology and Economic Assessment Panel (TEAP) is the technology and economics advisory body to the Montreal Protocol Parties. The latter provides technical information related to the alternative technologies that have been investigated and employed to make it possible to virtually eliminate use of ODS.

Since 1987, the Montreal Protocol has been strengthened to reflect the latest scientific information and technological advances. In the beginning, the Protocol addressed the production and consumption of primarily Chlorofluorocarbons (CFCs). Over the past thirty years, the global community has worked together to add amendments to the Protocol that address the use of additional chemicals and adjust the timeframes for phasing out certain chemicals.

Today, the Protocol provides a clear pathway for global reductions in the consumption and production of nearly 100 substances, including Chlorofluorocarbons (CFCs), Hydrochlorofluorocarbons (HCFCs), halons, methyl bromide and other ODS.

The most recent amendment to the Protocol was adopted in October 2016 for the control of Hydrofluorocarbons (HFCs). HFCs do not deplete the ozone layer, they are powerful greenhouse gases (GHGs) that contribute to climate change and have been used extensively to replace CFCs and HCFCs in the refrigeration and air conditioning sectors.

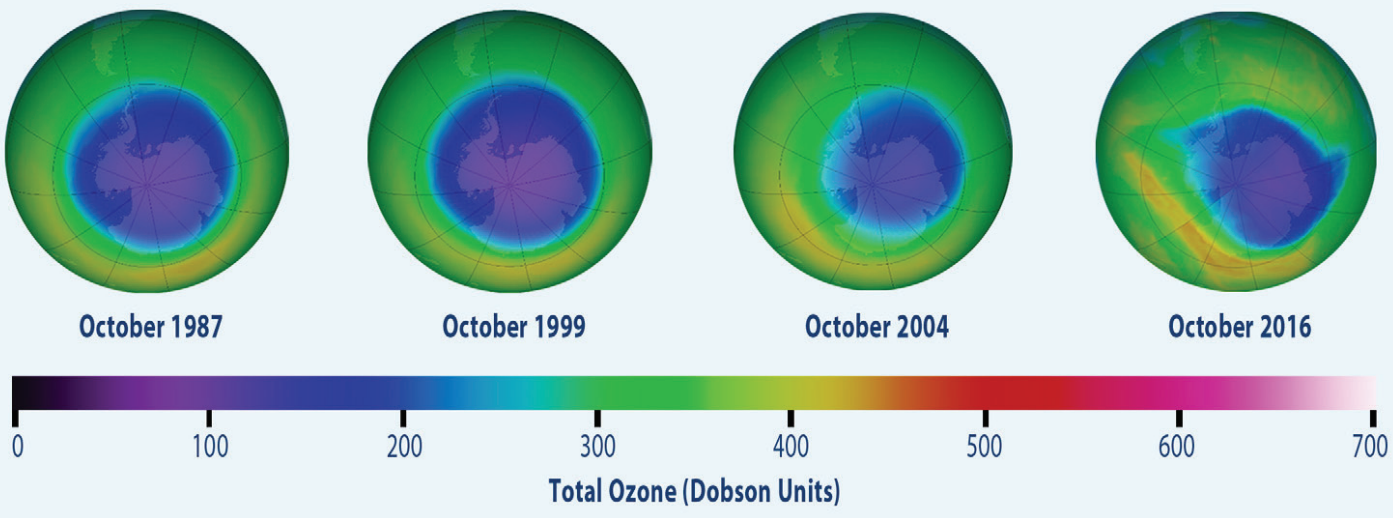
Developing countries, through assistance from the Multilateral Fund, have phased out over 270 000 tonnes of ozone depleting substances by successfully implementing phase out plans such as CFCs phase out management plan till 2010. The CFCs phase out management plan has enabled parties to ensure timely, cost-effective and accelerated CFC phase-out through:

- training of service technicians for good servicing practice;
- training of the Customs Officers for the control of import and export of CFCs;
- adoption of legislative and policy measures; and
- implementation of projects such as Recovery and Recycling, retrofitting and conversion to ozone friendly

HCFC phase out is presently in full swing in the developing countries with the support from the Multilateral Fund. HCFC Phase out Management Plans (HPMPs), investment projects and capacity building activities are being implemented.

The collective efforts of the 197 countries party to the Montreal Protocol have led to the phase-out of 99 per cent of ozone-depleting chemicals in the refrigeration and air-conditioning sector. As a result,

- it is estimated that two million cases of skin cancer and cataracts per year will be avoided by 2030, thus saving significantly in health care costs;
- it is projected that ozone at the southern hemisphere will heal completely in the 2050s and the polar regions by the 2060s;
- parts of the ozone layer have recovered at a rate of 1-3% per decade since 2000, as inferred by the latest Scientific Assessment of Ozone Depletion completed in 2018;
- 35 billion tonnes of carbon dioxide equivalent emissions, from 1990 to 2010 have been averted by using ozone friendly refrigerants with lower global warming potential; and
- it is projected that the Northern Hemisphere and mid-latitude ozone will heal completely by the 2030s;
- it is estimated that implementation of the recent Kigali Amendment can prevent emissions of 80 gigatonnes of carbon dioxide equivalent (GtCO2eq) by 2050, equating to a reduction in global warming of up to 0.5°C by the end of this century.



5. Achievement under the Montreal Protocol in Mauritius

Mauritius is party to the Montreal Protocol (MP) since 1992 and the Ministry of Environment, Solid Waste Management and Climate Change is the National Focal Point. A National Ozone Unit (NOU) was set up and is operational at the Ministry for implementation of provisions of the Montreal Protocol to protect the ozone layer.

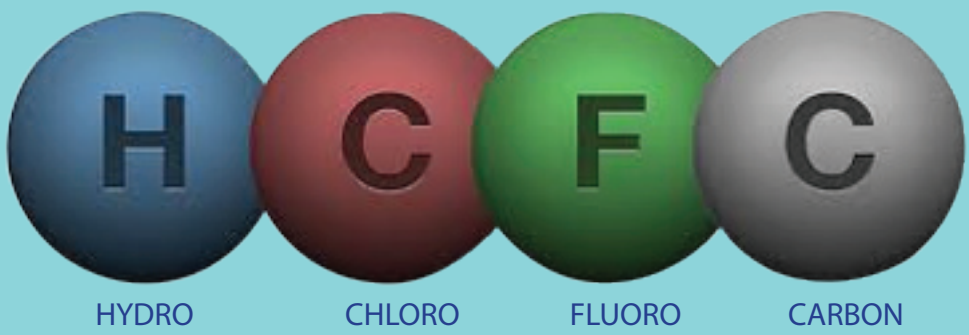
The following measures have been successfully implemented for the elimination of 32 ODP Tons of Chlorofluorocarbons (CFCs) in 2005, five years ahead of the global phase out schedule:

- Banning of importation of all CFC based appliances and aerosols;
- Strict enforcement at entry and exit points by Customs Department;
- Setting up of an import licensing system to control the import of CFCs;
- Implementation of projects, such as Recovery and Recycling of CFCs as well as Conversion projects including Retrofitting;
- Training in good refrigeration practices for Trainers and Refrigeration technicians;
- **Legislative Measures, namely;**
  - The Consumer Protection Act 1999: Control of imports of all equipment/ appliances containing controlled refrigerants;
  - The Dangerous Chemicals Control Act 2004: provides in its different schedules for the control of ozone depleting substances as well as their substitutes; and
  - The Environment Protection Act 2002: the issue of EIA licenses for scheduled undertakings.
- Training of Custom Officers;

Following the phasing out of CFCs, Mauritius embarked on Hydrochlorofluorocarbon (HCFC) phase out management plan (HPMP) in 2012 with the objective of a complete phase out by 2025. Through the HPMP, a series of projects are being implemented comprising:

- The HCFC policy instrument which serves to control the import of HCFCs through a quota system and imposition of a ban on import of all HCFC appliances since January 2013;
- Intensive awareness raising by the NOU and the Information & Education Division of the Ministry of Environment, Solid Waste Management and Climate Change;
- Training in the technical and enforcement fields (e.g.: training of trainers, provision of equipment to training institutions, training of technicians, training of customs, training of Environment Officers);
- Demonstration project on Ammonia chillers under international climate protection initiative project funded by Germany. The equipment has been installed at Université des Mascareignes and is used for training purposes for refrigeration and air conditioning technicians; and
- A survey on HFC appliances was done Under Green Cooling Initiative for Africa (GCIA). The findings were presented in a workshop in June 2017.

These measures have enabled Mauritius to reduce its HCFCs consumption from 8 ODP tonnes in 2013 to 2.14 ODP tonnes in 2020.



6.Timeline on Ozone Layer Protection

The objective of the Vienna Convention, its Montreal Protocol and different Amendments is to protect human health and the environment by closing the hole in the ozone layer.

1991

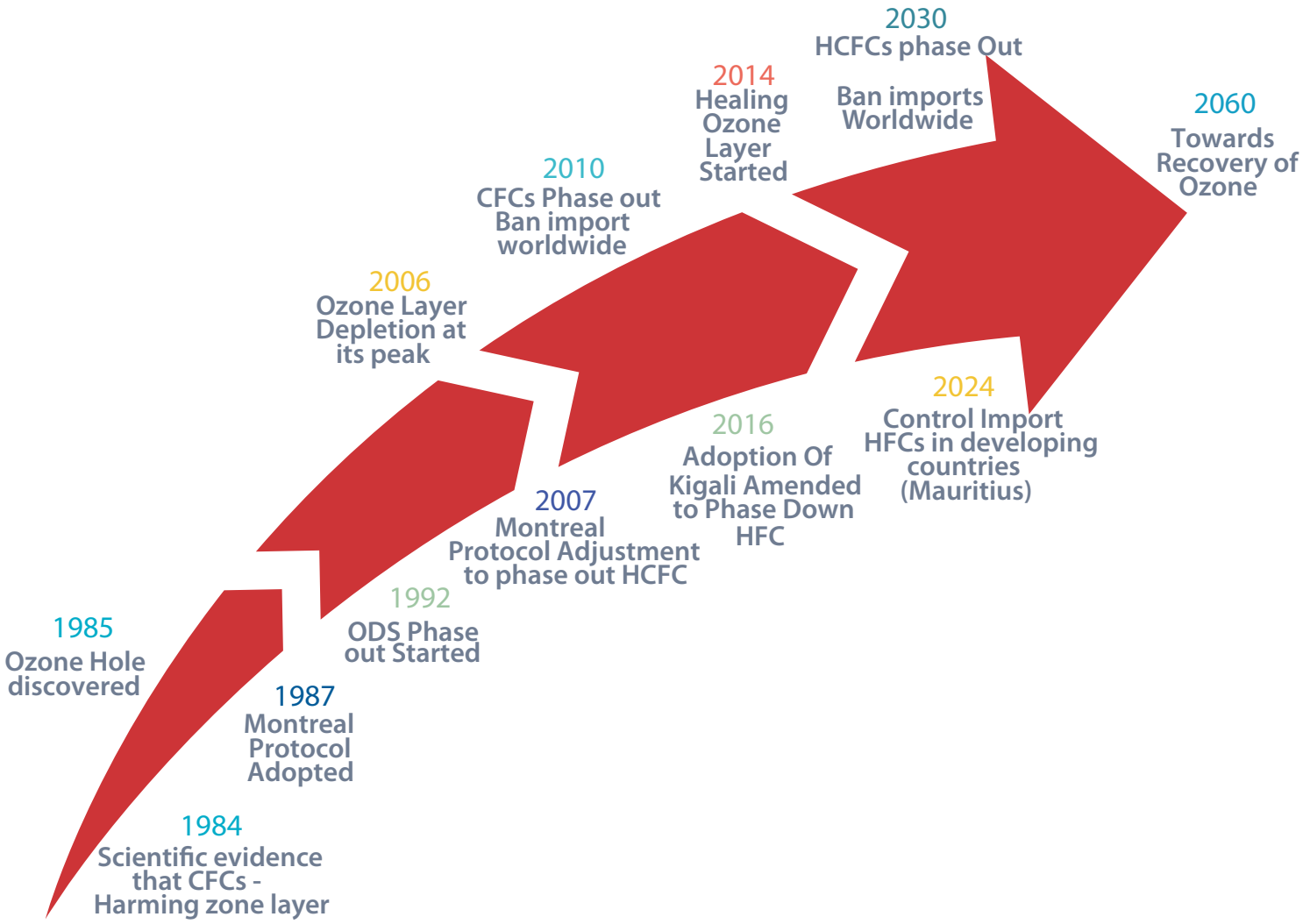
Operationalization of the Multilateral Fund to finance projects in developing countries.

1989

First periodic assessment reports published by Assessment Panels based on scientific, environmental, technical and economic information.

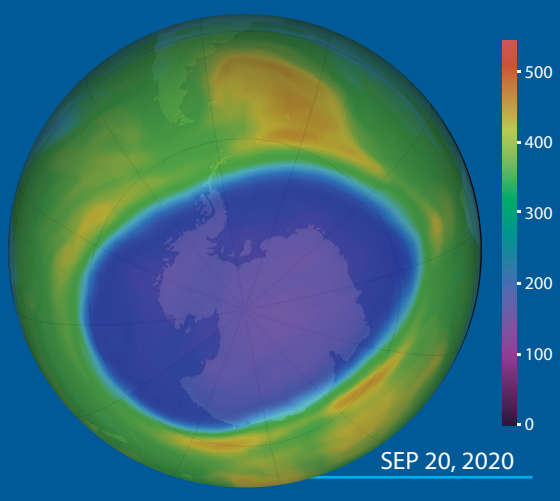
1988

Entry into force of the Vienna Convention for the protection of the Ozone layer under which the Montreal Protocol was adopted in 1987



Status of Ozone hole

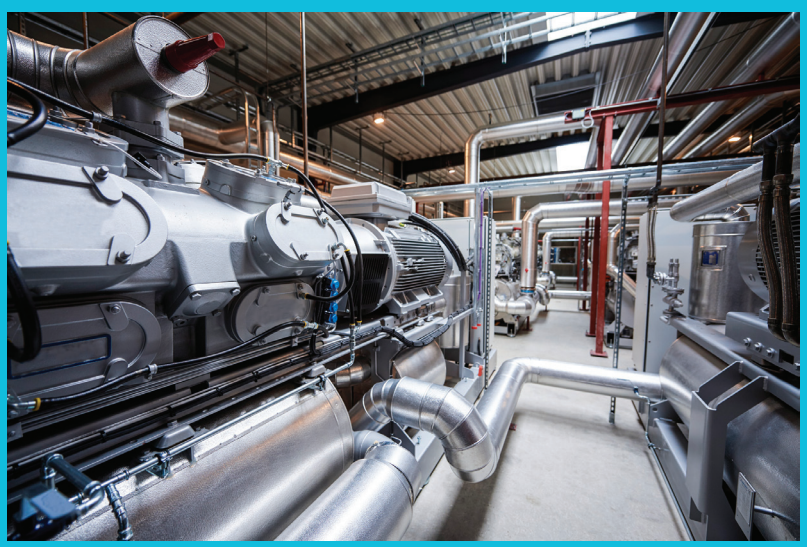
- In 2020, the ozone hole reached its peak at about 9.6 million square miles (or 24.8 million square kilometres), roughly three times the size of the United States. However, the atmospheric abundances of ODS are continually declining.
- This is the 12th-largest hole in 40 years of satellite records, with the 14th-lowest ozone readings in 33 years.



7. Ammonia Refrigerant

Background

R717 is the chemical reference for Ammonia used as refrigerant. Ammonia (chemical symbol NH_3) is produced both naturally and as a byproduct of numerous man-made reactive processes. It is colourless but has a sharp, pungent odour. It contains almost no water (it is 99.98% pure).



Properties of Ammonia refrigerant

- Ammonia has better heat transfer properties than most of chemical refrigerants and therefore allows for the use of equipment with a smaller heat transfer area. As a result, plant construction cost will be lower. However, since these properties benefit the thermodynamic efficiency in the system, they also reduce the operating costs of the system.
- Ammonia has an Ozone Depletion Potential (ODP) rating of 0 and a Global Warming Potential (GWP) rating of 0.
- Ammonia has a lower density in liquid phase.
- Any leakage of ammonia will be detected very quickly due to the odour. Hence, any potential loss of refrigerant will also be lower.

Applications

In food industry such as,

- dairies, ice creams plants;
- frozen food production plants;
- cold storage warehouses; and
- processors of fish, poultry and meat.

Safety

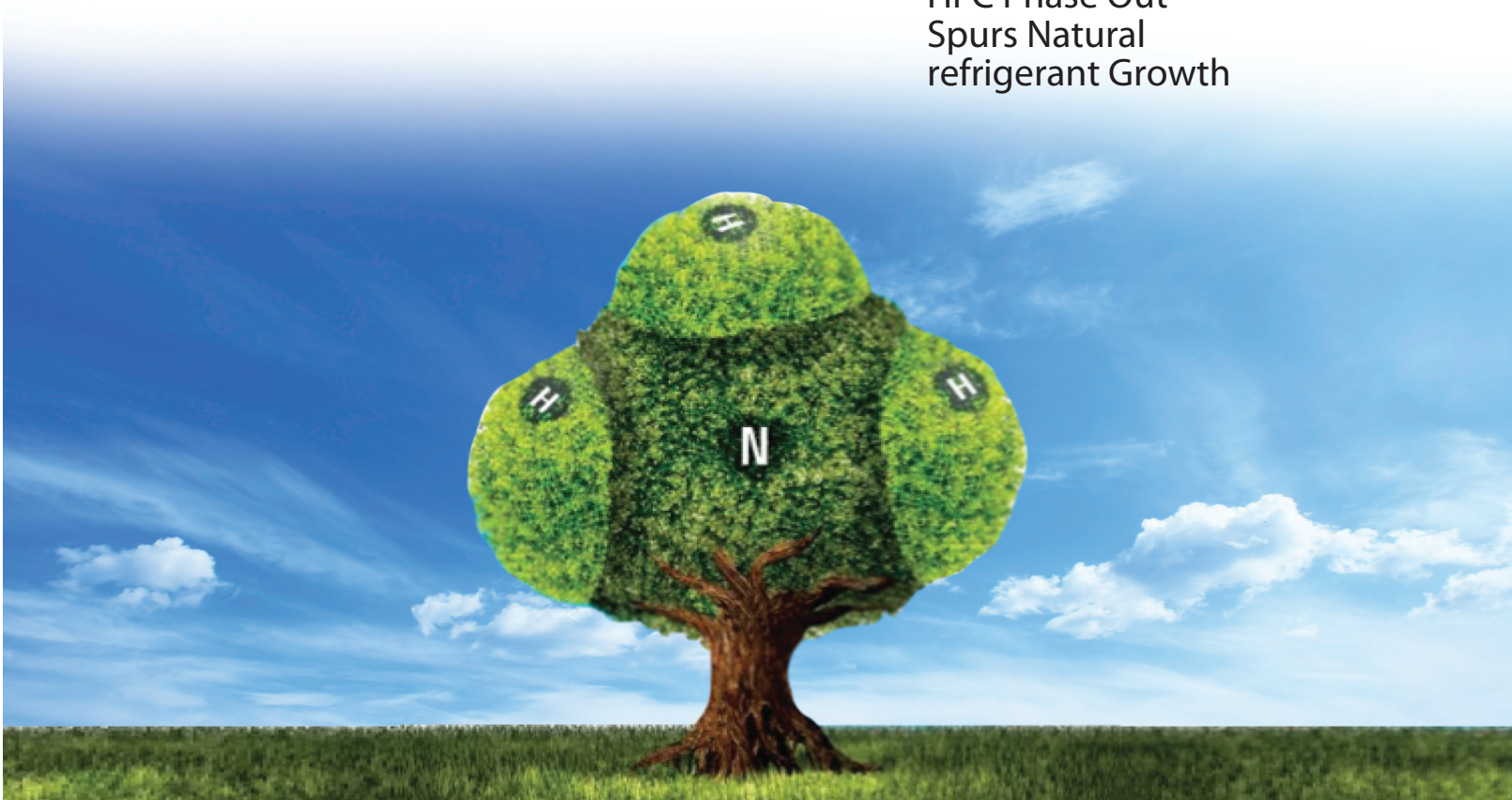
- Since it is not compatible with copper it cannot be used in any system with copper pipes.
- Ammonia is poisonous in high concentrations. Two factors, however, mitigate this risk: ammonia's distinctive smell is detectable at concentrations well below those considered to be dangerous, and ammonia is lighter than air, so in case of leakage, ammonia gas will rise and dissipate in the atmosphere.

Benefits of using Ammonia Refrigerant

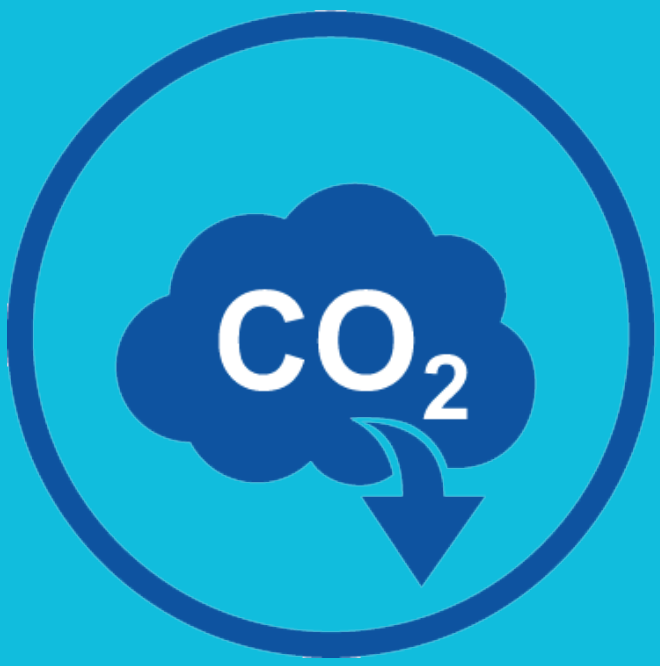
- Reduced emissions of greenhouse gases.
- An ammonia-based refrigeration system costs 10-20% less to build than one which uses HCFCs because narrower-diameter piping can be used.
- Ammonia is safe for the environment: it is both ozone and climate friendly.
- It is energy efficient.

The Green TRANSFORMATION

HFC Phase Out
Spurs Natural
refrigerant Growth



8. Carbon Dioxide Refrigerant



Background

R744 is the chemical reference for carbon dioxide (CO2) used as refrigerant. It is a naturally occurring substance that can be applied as a working fluid in different heating and cooling applications due to its excellent heat transfer properties and its high volumetric cooling capacity.

Properties of Carbon dioxide refrigerant

- Non-toxic.
- Non-flammable.
- Excellent thermodynamic properties.
- Energy efficient.
- Non-ozone-depleting.
- Environmentally friendly, with a Global Warming Potential of 1.

Applications

- Heat pumps and water heaters;
- Mobile air conditioning (MAC);
- Commercial systems;
- Industrial refrigeration, both transcritical and cascade; and
- Secondary coolant applications.

Safety

R744 is considered non-toxic, although at concentrations above 2% (about 5 kg of R744 in a 120-m3 room) it can start to become harmful.

Benefits of using Carbon Dioxide

- Reduced emissions of greenhouse gases;
- Space savings for piping arrangements (self-contained system);
- Reduced costs of piping arrangements and insulation; and
- Energy efficiency.

9. Hydrocarbon Refrigerants

Background

R290 and R600a HC (Hydrocarbon) refrigerants are safe environmentally friendly alternative to HFC (Hydrofluorocarbon) refrigerants R134a in refrigerator applications and R404a in freezer applications, respectively. Hydrocarbons are called natural refrigerants because they occur naturally in the earth.

Properties of Hydrocarbon refrigerants

- Availability and convenience: they are extracted from the soil.
- Global Warming Potential is relatively low. (eg. 5 for R290)
- They are energy efficient. In fact, their latent heat of vaporisation is twice as high as other synthetic refrigerants, which implies a higher cooling/heating effect with the same refrigerant mass flow.
- They are compatible with oils and components found in many existing systems.

Applications

- Household refrigerators and freezers
- Bottle coolers
- Commercial deep-freeze cabinets and freezers
- Commercial cooling cabinets and refrigerators
- Beer coolers
- Drink vending machines
- Dehumidifiers
- Heat pumps
- Refrigeration in grocery stores
- Air-conditioners
- Low-temperature cascades (all stages)
- Water and brine chillers for indirect cooling, especially for outdoor installation

Safety

Hydrocarbon refrigerants have some different chemical properties than fluorocarbon refrigerants, the primary difference being their classification as extremely flammable. Therefore, the handling and use of hydrocarbons require necessary safety measures.
This is especially true if a system is being considered for retrofitting, that is, replacing a non-flammable fluorocarbon with a hydrocarbon.

Benefits of using Hydrocarbon Refrigerants

- Reduce emissions of greenhouse gases.
- Cost-saving option for heating/cooling and also for freezing.
- Lower global warming effect as compared to other synthetic refrigerants.
- Available at a cheaper cost and have a more-affordable running costs.
- Energy efficient.

10. Legislation for the control of Ozone Depleting Substances

Background

There are two main pieces of legislation that control trade and use of Ozone Depleting Substances.

Main legislation

a) Consumer Protection (Control of Imports) Regulations 2017

These Regulations make provision for the banning of import of all appliances containing Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs).
Under the 3rd schedule of the Regulations, the following are listed as prohibited goods:-

- Containers with "aerosols" using CFCs and HCFCs as propellant (except for pharmaceutical products); and
- Items containing CFCs and HCFCs as refrigerant or blowing agent in: refrigerators, freezers, refrigerating cabinets, showcases, counters and other refrigerating or freezing furniture, chilling units, coolers, air conditioners (including motor vehicle air conditioners), automatic beverage vending machines, incorporating refrigerating devices, cold room equipment, refrigerated transport vehicles, refrigerator insulation, freezer insulation, foam packings, dehumidifiers, fishing boat refrigeration equipment and Styrofoam.

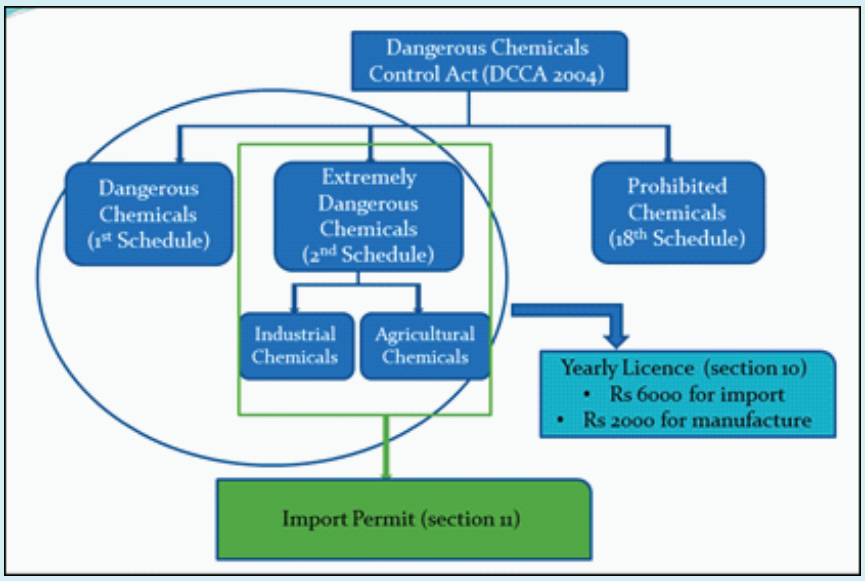
b) Dangerous Chemicals Control Act (DCCA) 2004

The Act controls the trade of Ozone Depleting Substances and their substitutes. Ozone Depleting Substances are classified under this Act as Dangerous Chemicals.
For instance, certain HCFCs (such as Chlorodifluoromethane [R22]) and certain HFCs (such as 1,1,2-Trifluoro Ethane [R143] are listed as "Dangerous Chemicals" under the 1st Schedule of the Act while CFCs are listed as "Extremely Dangerous Chemicals (Restricted)" under the 2nd Schedule.

Other Regulations for controlling/monitoring installation of new refrigeration and air conditioning systems include:

- The Environment Protection Act 2002, which provides for the issue of Environmental Imapct Assessment Licence for certain undertakings where refrigeration is required (e.g. Hotels and Food processing industries).
- The Local Government Act 2011, which provides for the issue of a Building and Land Use Permit by local authorities for cold rooms and refrigeration plants.
- The Occupational Safety and Health Act 2005, which provides for inspections to be carried out by the Ministry of Labour, Human Resource Development and Training, with regard to health and safety issues.

Licencing system



- Under section 10 of the Dangerous Chemicals Control Act 2004, a person shall hold a licence in order to import or export, manufacture, sell, store, distribute or trade in, a dangerous chemical.
- Under section 11 of the Dangerous Chemicals Control Act 2004, a person shall hold a permit in order to import or export a pesticide or an extremely dangerous chemical.
- All applications for Licences and Permits shall be made to the Dangerous Chemicals Control Board (DCCB) of the Ministry of Health and Wellness.

Administrative system

The licensing system is backed up by an administrative process to control import and export of substances controlled under the Montreal Protocol. For this purpose, a quota to import HCFCs and HFCs is allocated to individual companies.

The National Ozone Unit (NOU) of the Ministry of Environment, Solid Waste Management and Climate Change issues a clearance for all applications for imports and exports of refrigerants (HCFCs, HFCs or natural refrigerants), based on which the Dangerous Chemicals Control Board of the Ministry of Health and Wellness issues a Licence or an Import Permit, as applicable.

Mauritian Standard for Refrigerants

The MS-ISO 5149 Standards for the use and safe handling of natural refrigerants has been developed in 2018 and is voluntary. Copies are available at the Mauritius Standards Bureau.

11. Kigali Amendment

Background

- In October 2016, the Kigali Amendment was adopted by all Parties to the Montreal Protocol of the Vienna Convention for the Protection of the Ozone Layer, including Mauritius.
- The Kigali Amendment brings the future production and consumption of hydrofluorocarbons (HFCs) under the control of the Protocol and will make a major contribution towards the fight against climate change.
- The Kigali Amendment was ratified by Mauritius on 1 October 2019.

HFCs are non-ozone depleting chemicals that were first introduced in the 1990s as alternatives to Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs), which are Ozone Depleting Substances (ODS). The use of HFCs has facilitated the rapid phase-out of ODS and has helped protect the Earth's fragile ozone layer. However, the high global warming potential (GWP) of HFCs is a major disadvantage and every effort now needs to be made to use non-ozone depleting alternatives with a low climate impact.

Expected impact of Kigali Amendment

The Amendment will phase-down HFCs under the Montreal Protocol. The use of HFCs is increasing rapidly as substitutes for ozone-depleting substances. HFC phasedown is expected to prevent the emission of up to 105 million tonnes of carbon dioxide equivalent of greenhouse gases, helping to avoid up to 0.5 degree Celsius of global temperature rise by 2100, while continuing to protect the ozone layer

(Source: https://ec.europa.eu/clima/sites/clima/files/faq_kigali_amendment_en.pdf)

Global Warming Potential (GWP) and Ozone Depleting Potential (ODP)of common refrigerants

Fluorocarbon chemicals, including HFCs, include many of the most powerful greenhouse gases. The release of 1 kg of certain fluorocarbons is typically between 1000 and 10000 times worse than the release of 1 kg of CO_2, in terms of impact on global warming.

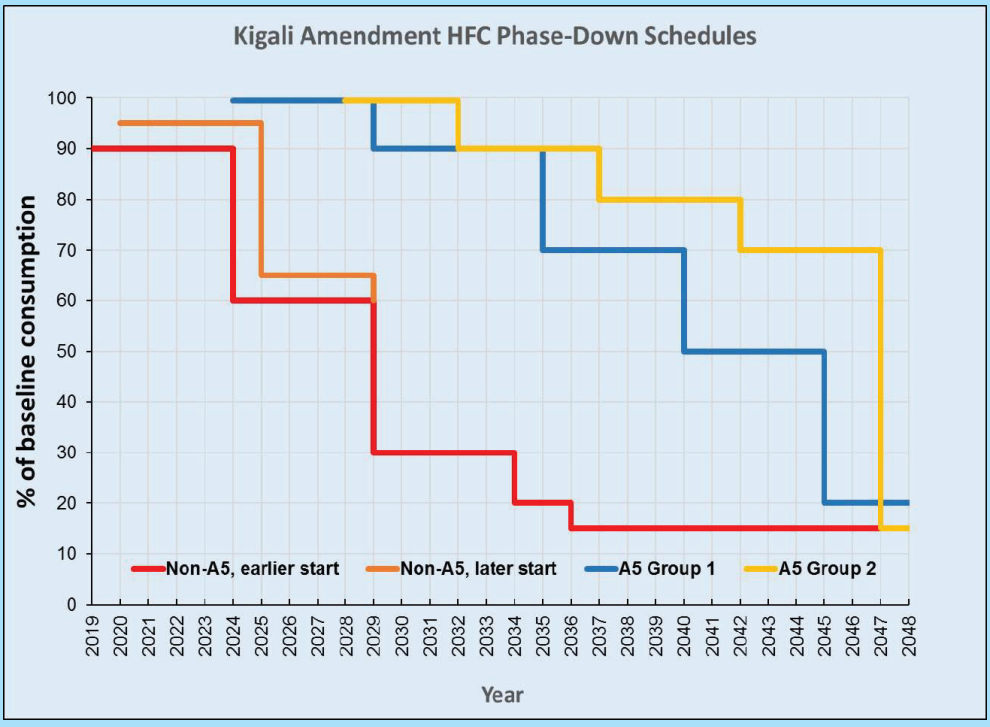
Global Warming Potential (GWP) and Ozone Depleting Potential (ODP) of some refrigerants

Type	Gas	GWP	ODP
Ozone Depleting Substances	CFC-12	10900	1.0
	HCFC-22	1810	0.055
Hydrofluorocarbons	HFC-404A	3922	0
	HFC-410A	2088	0
	HFC-134A	1430	0
	HFC-3	675	0
Natural Refrigerants	Propane (R290)	3	0
	CO_2 (R744)	1	0

HFC phase-down Schedule

Under the Kigali Amendment, the phase-down Schedule varies between four different country groups. Most non-Article 5 (developed) countries began their phase-down as from 2019 and must achieve 85% cut from their baseline by 2036. Most Article-5 (developing) countries will follow with a freeze of HFCs consumption levels in 2024, and in 2028 (for some developing countries) and will follow a slower timetable. The final phase-down steps in Article-5 countries are in 2045 or 2047.

Details of the elements of the agreed HFC phase-down schedule are provided in graph and table below:



(Source: https://wedocs.unep.org/bitstream/handle/20.500.11822/26869/7876FS01Intro_EN.pdf)

Mauritius, which falls under the category of Article 5 (Group 1) countries, will have the following phase-down schedule

Year	Reduction
2024 (freeze year)	Baseline HFC value (Average of 2020 - 2022 consumption)
2029	10% reduction of Baseline HFC value
2035	30% reduction of Baseline HFC value
2040	50% reduction of Baseline HFC value
2045	80% reduction of Baseline HFC value

12. Ozone Layer Protection and Climate Change

CFCs and HCFCs: Chemicals with Ozone depleting and Global Warming effects

Chlorofluorocarbons (CFCs), Hydrochorofluorocarbons (HCFCs) are common refrigerants, used as coolants in the Refrigeration and Air-Conditioning (RAC) sectors. CFCs and HCFCs are classified as ozone depleting substances (ODS) since they deplete the ozone layer and they are controlled under the Montreal Protocol.

In addition to being damaging to the ozone layer, they are potent greenhouse gases and have global warming effects. As such, by controlling them, the Montreal Protocol is also contributing significantly to the protection of the global climate system. From 1990 to 2010, control measures under the Protocol, are estimated to have reduced greenhouse gas emissions by the equivalent of 135 gigatons of carbon dioxide.

Further to an adjustment of the Montreal Protocol in 2007, signatory countries have since 2013, started to control HCFCs and will completely ban these ODS in 2030. As a result, climate benefits will continue to be reaped under the Montreal Protocol. Modeling studies indicate that in the absence of the Montreal Protocol, global mean temperatures would have risen by more than 2°C by 2070 due to the warming effects from ODS alone.

HFCs : Ozone friendly alternatives to ODS but Climate damaging

The phase out of CFCs and HCFCs have led to the use of hydrofluorocarbons (HFCs) as they pose no threat to the ozone layer. However, HFCs are potent greenhouse gases that can be hundreds to thousands of times more potent than carbon dioxide (CO2) in contributing to climate change. Though they represent a small fraction of the current total of all greenhouse gases controlled under the United Nations Framework Convention on Climate Change and the Paris Agreement, their emissions are projected to increase nearly twentyfold in the coming decades, mostly due to increased demand for Refrigeration and Air Conditioning, particularly in developing countries.

In response, in 2016, the Montreal Protocol was amended in Kigali (known as the Kigali Amendment) to control production and consumption of HFCs which have high Global Warming Potentials (GWPs). The Kigali Amendment marks the first time the Montreal Protocol has adopted measures solely for the protection of climate. Some concerned HFCs and the comparison of emissions reduction with and without the Amendment is at Figure 1

[1] carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6), and nitrogen triflouride (NF3)

Projected HFC emissions by 2100, with and without the Kigali Amendment (Source: Ozone UNEP).

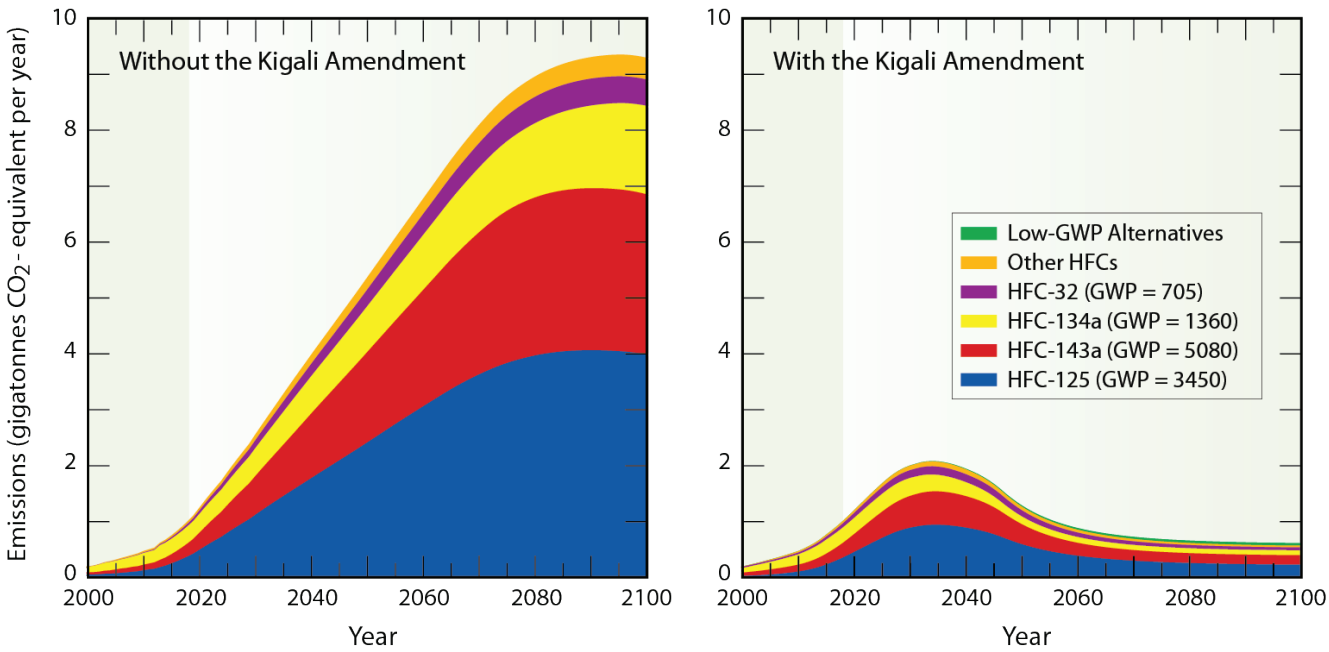


Figure 1: Projected HFC emissions by 2100, with and without the Kigali Amendment (Source: Ozone UNEP)

Reduction of HFCs Emissions to save climate

Studies have estimated that HFCs consumption will rise by 30% by 2030. The Kigali Amendment is effective as from 2019 and is expected to reduce the projected production and consumption of hydrofluorocarbons (HFCs) by more than 80 per cent over the next 30 years (Mauritius acceded the Amendment in October 2019).

The ambitious phase down schedule by both developed nations (as from 2019) and developing countries (as from 2024) will avoid more than 80 billion metric tons of carbon dioxide equivalent emissions by 2050—avoiding up to 0.5° Celsius warming by the end of the century—while continuing to protect the ozone layer. Actions to limit the use of HFCs are expected to prevent the emissions of up to 105 million tonnes of carbon dioxide equivalent of greenhouse gases.

The Kigali Amendment represents the largest single contribution by the world towards keeping the global temperature rise "well below" 2 degrees Celsius, a target agreed under the Paris Agreement in 2015. The Kigali Amendment has further broadened and strengthened the scope of the Montreal Protocol to address ozone depletion and increase future global climate protection.

Implications of ozone hole recovery due to increasing greenhouse gases

Rising abundances of GHG will lead to changes in temperature, chemistry, and the circulation of the stratosphere (10 - 35 Km from ground surface), all of which affect ozone. Chemistry-climate models can be used to project how ozone is expected to respond to changes in ODSs and climate in particular geographical regions during the recovery period. Two scientific bodies – the Intergovernmental Panel on Climate Change (IPCC) under the UNFCCC and the Technology and Economic Assessment Panel (TEAP) of the Montreal Protocol have in 2018, published a Special Report to cover the scientific, technical and policy issues on ozone layer protection and Climate change.