"32 years and healing"

THE MONTREAL PROTOCOL
INDIA'S SUCCESS STORY

सत्यमेव जयते

OZONE CELL
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE
GOVERNMENT OF INDIA
NEW DELHI, INDIA
2019

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प्रकाश जावड़ेकर
Prakash Javadekar

सत्यमेव जयते

भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्री
GOVERNMENT OF INDIA
MINISTER FOR ENVIRONMENT, FOREST & CLIMATE CHANGE

FOREWORD

Both the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on substances that deplete the Ozone Layer are recognized as the most successful international environmental treaties. As a result of the implementation of the Protocol the abundance of Ozone Depleting Substances (ODSs) in the atmosphere is declining and a recent study has indicated that the ozone hole is recovering. The phase out of ODSs has had a very significant impact in mitigation of climate change. It is estimated that more than 135 billion tonnes of carbon dioxide equivalent emission into the atmosphere has been averted by the phasing out of ODSs under the Montreal Protocol.

India has been successfully implementing the phase-out program for ODSs in the country. Presently, Hydrochlorofluorocarbons (HCFCs) Phase-out Management Plan (HPMP) Stage II is under implementation. HCFCs are mainly used in refrigeration, air-conditioning and foam sectors.

An important compliance step under the Montreal Protocol is approaching on 1.1.2020, wherein, HCFC-141b, a chemical used by foam manufacturing enterprises will be completely phased out. Towards meeting this compliance target, the Ozone Cell of the Ministry is providing technical and financial assistance to foam manufacturing enterprises for conversion to HCFC-141b free alternative technologies with low global warming potential. The Ozone Cell has signed a Memorandum of Agreement with the Central Institute of Plastics Engineering & Technology, Department of Chemicals & Petrochemicals, Govt. of India for providing Competency Enhancement of System Houses and Micro, Small and Medium enterprises (MSMEs) in foam manufacturing sector for ensuring smooth and sustainable phase out of HCFC-141b.

Recently, India became one of first countries in the world with the launch a comprehensive Cooling Action plan which has a long term vision to address the cooling requirement across sectors such as residential and commercial buildings, cold-chain, refrigeration, transport and industries. The cooling demand is expected to grow in the country following the growth trajectory of the economy. The India Cooling Action Plan (ICAP) lists out actions which can help reduce the cooling demand, which will also help in reducing both direct and indirect emissions.

The ICAP recommends synergies with ongoing government programmes and schemes such as Housing for All, the Smart Cities Mission, Doubling Farmers Income and Skill India Mission, in order to maximize socio-economic co-benefits. The following benefits would accrue to the society over and above the environmental benefits by the implementation of ICAP (i) Thermal comfort for all, (ii) Sustainable cooling, (iii) Doubling Farmers Income, (iv) Skilled workforce for better livelihoods and environmental protection, (v) Make in India and (vi) Robust R&D on alternative cooling technologies.

The World Ozone Day 2019 is being celebrated globally with the theme "32 Years and Healing". The theme signifies over three decades of remarkable international cooperation to protect the ozone layer and also the climate system under the Montreal Protocol. It reminds us that we must keep up the momentum for ensuring the continued protection of the stratospheric ozone layer. On the occasion of the 25th World Ozone Day, India reiterates its commitment to protect the Ozone layer.

Date: 13.09.2019

(Prakash Javadekar)

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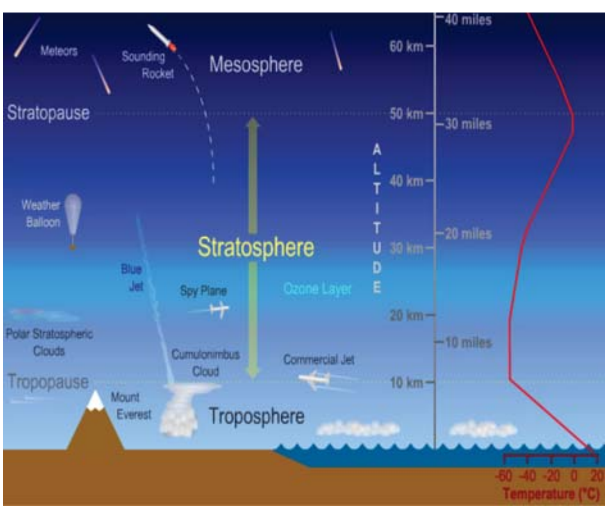
1. OZONE LAYER

The small blue and green planet we call home is a very special and unique place. We live on the only planet in our solar system and possibly in the galaxy, where life is known to exist. All life exists within thin film of air, water, and soil. This spherical shell of life is known as the biosphere. The biosphere can be divided into three layers; the atmosphere (air), the hydrosphere (water), and the lithosphere (rock and soil). It is the unique attribute of the Earth's atmosphere that allows it to be a habitable place for humans, animals, microbes and plants, as we know them.

The atmosphere is a mixture of gases and particles that surround our planet. When seen from space, the atmosphere appears as a thin seam of dark blue light on a curved horizon.

The Earth's atmosphere is divided into several layers. The lowest region, the troposphere, extends from the Earth's surface up to about 10 to 15 kilometres (km) in altitude. The height of the Mount Everest is only about 9 km. Virtually, most of the human activities affects the troposphere. The next layer, the stratosphere, continues from 10 km to about 50 km.

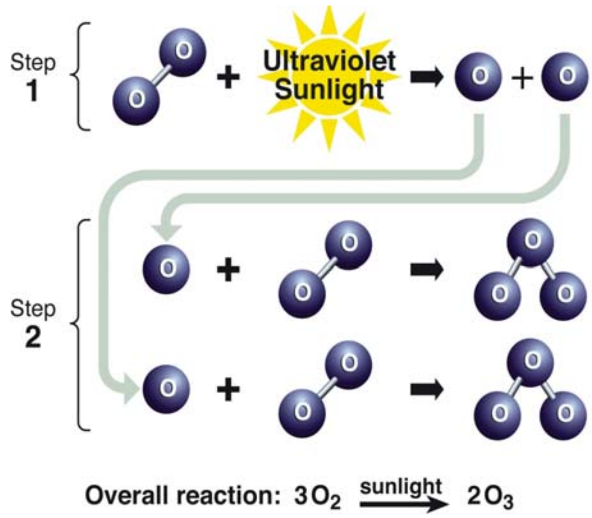
Earth's Atmospheric Layers



Concentration of Ozone in the Atmosphere

Ozone is a tri-atomic molecule of oxygen instead of normal two. It is formed from oxygen naturally in the upper levels of the Earth's atmosphere by high-energy ultraviolet (UV) radiation from the Sun. The radiation breaks down oxygen molecules, releasing free atoms, some of which bond with other oxygen molecules to form ozone.

Stratospheric Ozone Production



About 90 per cent of all ozone formed in this way lies between 10 km and 50 km above the Earth's surface - this part of the atmosphere is called the stratosphere. Hence, this is known as the 'Ozone Layer'. Even in the ozone layer, ozone is present in very small quantities; its maximum concentration, at a height of about 17-25 km, is only ten parts per million. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson.

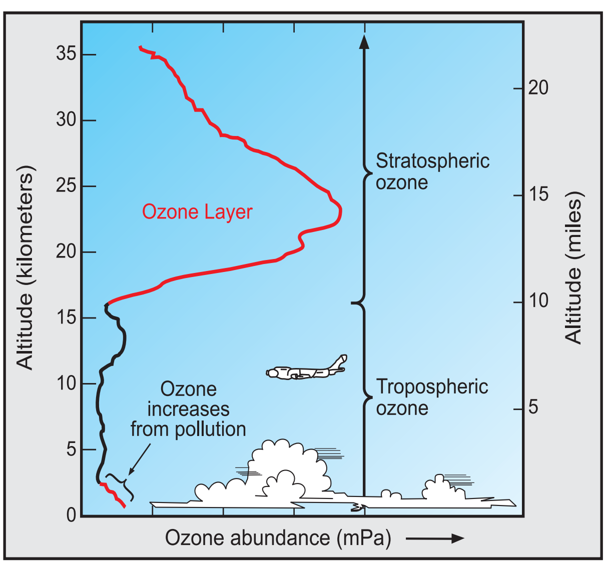
Since solar radiation is the strongest over the tropics, the global ozone is formed in tropics. However, strong solar radiation also causes rise of air to high altitudes and ozone is transported away from the equator towards the poles where it accumulates in the cold sub polar regions. At the equatorial region formation and photochemical depletion of ozone take place simultaneously and ozone cannot accumulate in this region. In the polar region there is accumulation of ozone because photochemical depletion is low and due to transport of ozone from equator. Therefore, in winter the highest ozone values are observed over the Polar regions as long as there is no other disturbing influence.

Total ozone at any point from Earth's surface to Stratosphere is quantified in Dobson Units (DU). One hundred DU equals the quantity of ozone that would form a layer of 1mm thick at sea level if compressed at Standard Temperature and Pressure (STP).

Typical distribution of ozone is about 240 DU near the equator with a maximum of 440 DU during early spring at high latitudes in the Arctic and 360 DU in the Antarctic. When the concentration of ozone, over any area, falls below 220 DU, we call it Ozone Hole.

Ozone is an unstable molecule. High-energy radiation from the Sun not only creates ozone, but also breaks it to oxygen, recreating molecular oxygen and free oxygen atoms. The concentration of ozone in the atmosphere depends on a dynamic balance between creation and destruction of ozone.

Concentration of Ozone in Atmosphere



What is the Ozone Layer?

The ozone layer is a term used to describe the presence of ozone molecule in the stratosphere. The layer stretches around the entire globe of the Earth like a bubble and acts as a filter for the harmful ultraviolet radiation (UV-B). UV-B radiation is a highly energetic light that originates from the sun and which has severe impacts on human health and the environment.

Good and Bad Ozone

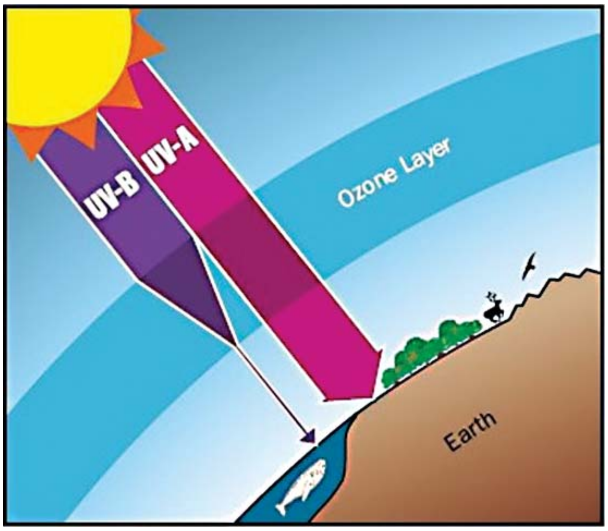
"Good" ozone is produced naturally in the Stratosphere and is good because it blocks harmful UV radiations from reaching the Earth's surface.

Ozone is also present in the lower levels of the atmosphere (i.e. the troposphere), but in very lower concentrations than in the stratosphere. Close to the Earth's surface, most of the Sun's high-energy UV radiation has already been filtered out by the stratospheric ozone layer and therefore the main natural mechanism for ozone formation does not take place in the troposphere.

However, elevated concentrations of ozone at ground level are found in some regions, mainly as a result of pollution. Burning of fossil fuels and biomass releases compounds such as nitrogen oxides and volatile organic compounds, usually found in car exhausts, which react with sunlight to form peroxy intermediates, which catalyses to form ozone. This is "bad" ozone. Bad ozone is an air pollutant and is bad because it is harmful to breathe and can damage crops, trees, other vegetation, plastics, rubbers etc.. Ground level ozone is a main component of urban smog.

There is little connection between ground level ozone and the stratospheric ozone layer. Whereas the stratospheric ozone shields the Earth from the Sun's harmful rays, the ground level ozone is a pollutant. Ozone, formed due to pollution at the Earth's surface, cannot replenish the ozone layer. In addition, though ground level ozone absorbs some UV radiation, the effect is negligible.

UV Protection by the Ozone Layer



Why is the ozone layer so important?

The ozone layer is vital to life on the planet's surface. It acts as a filter and prevents the harmful UV-B from reaching the Earth.

If ozone molecules are depleted faster than they can be replaced by new ozone molecule that nature produces, the result is what could be called an ozone deflict. The depletion of the ozone layer will lead to a reduction of its shielding capacity and thus an increased exposure to UV-B radiation.

Measurement of Ozone in the Atmosphere

Ozone is spread from the surface of Earth upto the top of stratosphere, 50 km as a very thin layer. The question often asked is how is the concentration of ozone in this thin layer is measured and quantified with a reasonable accuracy.

Atmospheric ozone is measured both by remote sensing and by in-situ techniques.

Generally, the following three characteristics of atmospheric ozone are routinely measured by various monitoring systems:

(a) Surface Ozone (b) Total Ozone over an area and (c) The vertical profile of Ozone.

Surface ozone is generally measured by in-situ techniques using optical, chemical or electro chemical methods. The most convenient method is the optical method which depends upon the strong absorption of UV light at 254 nanometer (nm). The absorption is measured in a UV cell at 254 nm against another cell containing air free from ozone. By comparing the two irradiation signals, it is possible to determine the concentration of ozone from 1 to 1000 parts per trillion (ppt) by volume.

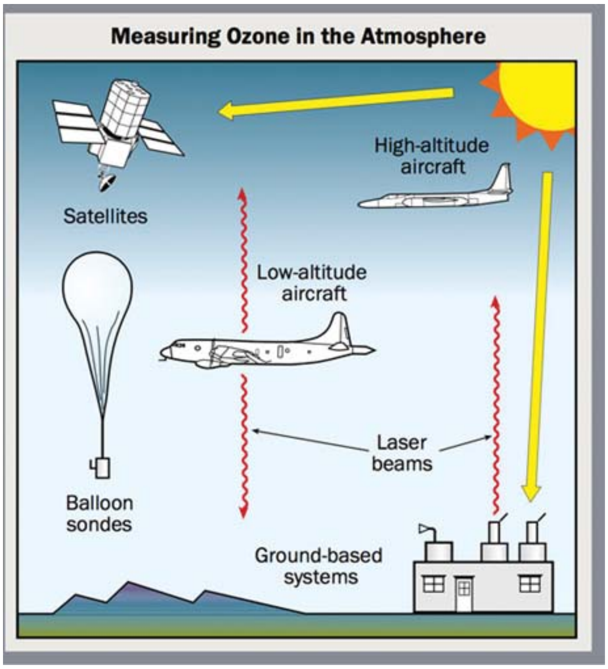
Total ozone is measured by remote sensing methods using ground based instruments, measuring the intensity of absorption spectrum of ozone between 300 and 340 nm using direct sun or direct full moon light and satellite based instruments, measuring the solar UV radiation scattered back to space by the Earth's atmosphere. The most commonly ground based instruments used by World Meteorological Organization (WMO) global ozone network are the Dobson and Brewer Spectrophotometers.

The most accurate and the best defined method for determining total ozone is to measure direct solar radiation from ground at UV wave bands between 305 and 340 nm.

Dobson instrument measures spectral intensities at three wave length pairs and the Brewer spectrophotometer at five operational wavelengths. Moon light as a source of UV radiation can also be used, but the accuracy is reduced due to lower intensity of light. For accuracy and comparison, all spectrometers are calibrated regularly at National Oceanic and Atmospheric Administration (NOAA) subtropical high altitude observatory at Mauna Loa, Hawaii where other interfering air pollutants like Sulfur dioxide (SO_2), Nitrous Oxide (NOx), aerosols etc. are absent.

Vertical profile of ozone is measured with (a) Ozonesondes (b) Ground-based Dobson and Brewer Spectrophotometers using light from zenith sky during twilight using the Umkher inversion method and (c) laser radars (Light Detection and Ranging (LIDAR)).

Ozonesondes measure the concentration of ozone as a function of height by a wet chemical method (ozone liberating iodine when bubbled through potassium iodide solution and measured electro chemically) during its balloon borne ascent to an altitude of about 35 km (mid stratosphere). They operate regularly in all climatic regions and have been the backbone of ozone profiling since 1960.



The latest method of vertical profiling of ozone is the LIDAR system in which a short laser pulse at a wave length in the UV ozone absorption spectrum is sent towards the zenith. Back scattered radiation is measured as a function of time which gives the height and its intensity gives the concentration of ozone. Two wave-lengths are used, one of which is absorbed by ozone, and the other is not which serves as a reference. The concentration of ozone measured at different heights thus gives the vertical profile.

Ozone Measurement over India

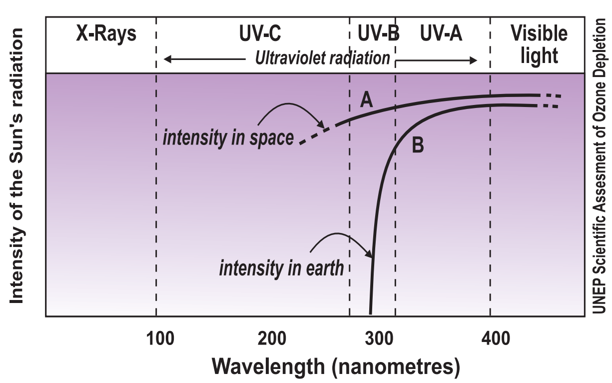
Indian Meteorological Department (IMD) is the nodal agency to measure the ozone levels in India. IMD has established a National Ozone Centre. The centre maintains and control a network of Ozone Monitoring Stations located at New Delhi, Ranichauri, Guwahati, Nagpur, Pune, Kodaikanal, Thiruvananthapuram, Vanarasi, Port Blair and Maitri (Antarctica). The ozone data measured is regularly sent to World Ozone Data Centre, Canada.

What is UV Radiation?

The Sun emits radiations of varying wavelengths in the form of electromagnetic spectrum. The UV radiation is one form of radiant energy coming out from the Sun. The various forms of energy, or radiations, are classified according to wavelength measured in nm. The shorter the wavelength, the radiation are more energetic. In order of decreasing energy, the principal forms of radiation are gamma rays, X-rays, UV rays, visible light, infrared rays, microwaves, and radio waves. The UV radiation, which is invisible, is so named because of its wavelengths are less than those of visible violet radiations.

Of these, UV-B and UV-C being highly energetic, are harmful to life on Earth. UV-A radiation being less energetic is relatively less harmful. Fortunately, UV-C radiation is absorbed strongly by oxygen and also by ozone in the upper atmosphere. UV-B radiation is absorbed only by the stratospheric ozone (ozone layer) and thus only 2-3% of it reaches the Earth's surface. The ozone layer, therefore, is essential for protection of life on the Earth by filtering out the dangerous part of Sun's radiation and allowing only the beneficial part to reach Earth. Any disturbance or depletion of this layer would result in an increase of UV-B and UV-C radiation reaching the Ear th's surface leading to dangerous consequences for the life on Earth. The ozone layer, therefore, acts as Earth's sunscreen.

Range of Wavelengths of UV Radiations

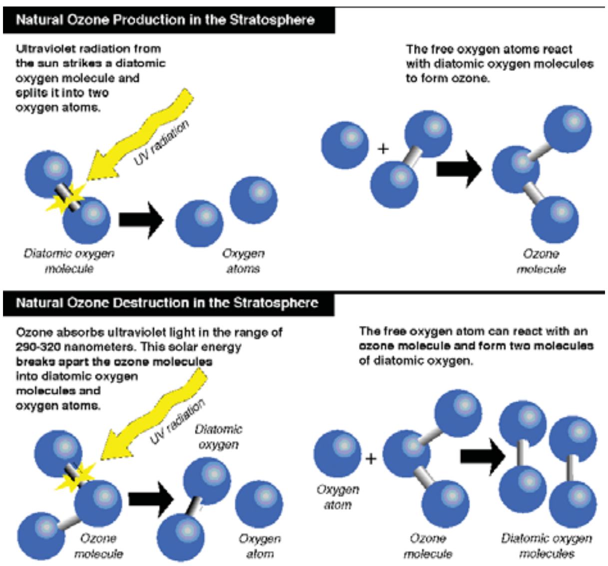


A - Undisturbed Ozone Layer
B - Disturbed Ozone Layer

Ozone Depletion

At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount, however, remains relatively stable. The dynamic equilibrium between creating and breaking down ozone molecules depends on temperature, pressure, energetic conditions and molecule concentrations. The concentration of the ozone layer can be thought of as a stream's depth at a particular location. Although, water is constantly flowing in and out, the depth remains constant.

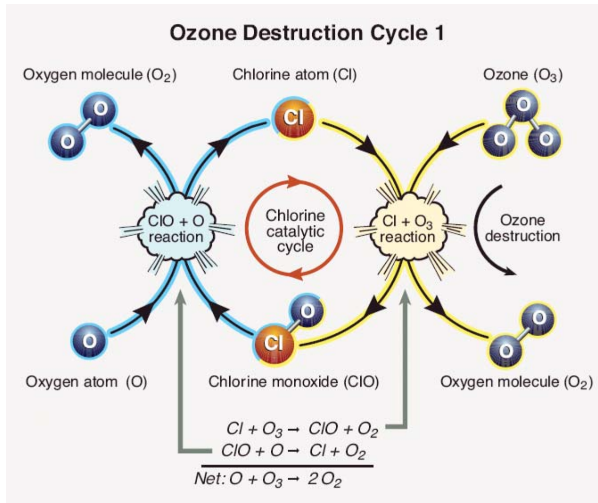
Natural Formation and destruction of Ozone



The concentrations of ozone vary naturally with sunspots, seasons, and latitudes. The processes of variation of ozone are well understood and predictable. Scientists have established records for several decades which show distribution of ozone during the natural cycles. It has been observed that each natural reduction in ozone levels has been followed by a recovery cycle. However, convincing scientific evidences have shown that the ozone layer is being depleted well beyond changes due to natural processes.

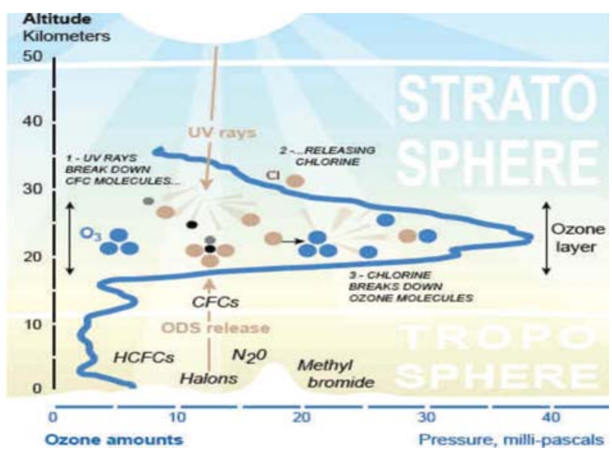
Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is shifted towards destruction. The equilibrium can be disturbed for instance by other molecules which react with the ozone molecules, and thereby destroying them. If this destruction process is fast and the creation of new molecules is too slow to replace the destroyed ozone molecules, the equilibrium will get out of balance. As a result, the concentration of ozone molecules will be reduced. An upset in this balance can have serious consequences for life on Earth, and scientists are finding evidence of the changed balance. As a result, the concentration of ozone within the protective ozone shield is decreasing.

Reaction of Chlorine with Ozone



When very stable man-made chemicals containing chlorine and bromine enter into the atmosphere, and reach the stratosphere, these chemicals are broken down by the high energy solar UV radiation and release extremely reactive chlorine and bromine atoms. These undergo a complex series of catalytic reactions leading to destruction of ozone.

Process of destruction of ozone



Large fires, certain types of marine life and volcanic eruptions also produce chlorine molecules. These are chemically active but most of it gets converted into water soluble inorganic compounds which gets washed down by rain and only traces reach the stratosphere. However, United States Environment Protection Agency (USEPA) exper iments have shown that Chlorofluorocarbons (CFCs) and other widely used chemicals produce roughly 85% of the chlorine in the stratosphere.

It was also believed that large volcanic eruptions can have an indirect effect on ozone levels. Although, Mt. Pinatubo's 1991 volcanic eruption did not increase stratospheric chlorine concentrations, it did produce large amount of tiny particles called aerosols. These aerosols increase chlorine's effectiveness in destroying ozone.

The aerosols only increase depletion because of the presence of CFC- based chlorine. In effect, the aerosols increase the efficiency of the CFC siphon, lowering ozone levels even more than that would have otherwise occurred. Unlike long-term ozone depletion, this effect is however short-lived. The aerosols from Mt. Pinatubo have already disappeared, but satellite, ground based, and balloon data still show ozone depletion occurring closer to the historic trend.

Beginning of Threat to Ozone Layer

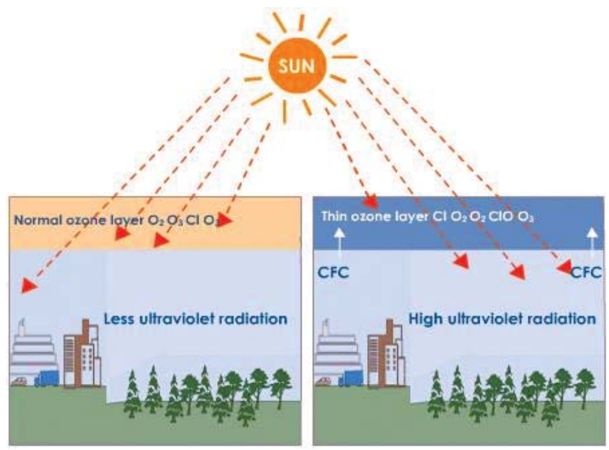
For over fifty years, CFCs were thought of as miracle substances. CFCs were first created in 1928 as non-toxic, non-flammable refrigerants, and were first produced commercially in the 1930's by DuPont. The first Chlorofluorocarbon was CFC-12, a single carbon with two chlorines and two Fluorines attached to it.

These have been used in many ways since they were first synthesized in 1928. They are stable, inert, non-flammable, low in toxicity, and inexpensive to produce. Over the period, CFCs have been used as aerosols, refrigerants, solvents and foam blowing agents in other smaller applications. Other chlorine and bromine-containing compounds include methyl chloroform, a solvent, Carbontetrachloride (CTC), an industrial chemical, halons, extremely effective fire extinguishing agents, Hydrochlorofluorocarbons (HCFCs) mainly used as a refrigerant and foam blowing agent and methyl bromide, an effective fumigant used in agriculture and grain storage.

All of these compounds have very long atmospheric life which allow them to be transported by winds into the stratosphere.

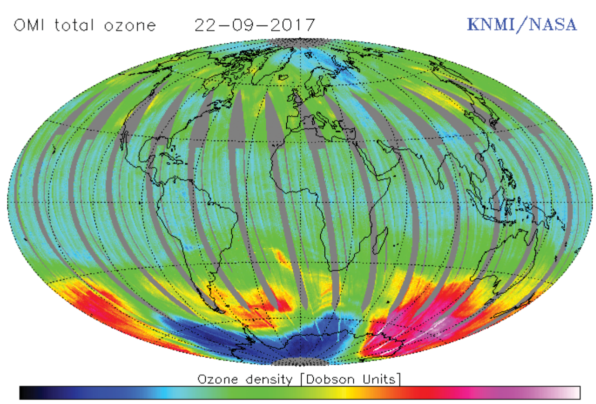
During the past 5 decades, Ozone Depleting Substances (ODSs) including CFCs have been emitted into the atmosphere in large quantity which has resulted in depletion of the ozone layer resulting increased UV-B radiations on the Earth surface.

UV Radiations on Earth Surface



The largest losses of stratospheric ozone occur regularly over the Antarctica every spring, leading to substantial increase in UV levels over

Status of Global Stratospheric Ozone : September, 2017



the region. A similar, though weaker, effect has been observed over the Arctic. There was enough evidence that ozone levels decrease by several percent in the spring and summer in both hemispheres at middle and high latitudes.

There is also fall in ozone levels during the winter at these latitudes in the southern hemisphere. The higher levels of loss of ozone have been noticed since late 1970s.

In the early 1970s, researchers began to investigate the effect of various chemicals on the ozone layer, particularly CFCs, which contain chlorine. They also examined the potential impacts of other chlorine sources like chlorine from chlorination of water, industrial plants, sea salt and volcanoes etc. The chlorine released from such applications and from other sources readily combines with water and other chemicals and form compounds which do not reach the stratosphere. In contrast, CFCs are very stable and do not dissolve in rain. Thus, there are no natural processes that remove the CFCs from the lower atmosphere. Over a period of time, the CFCs diffuse into the stratosphere where these interact with UV rays of short wave length which breaks them.

The CFCs are so stable that only exposure to strong UV radiation breaks them. When that happens, the CFC molecule releases atomic chlorine. It has been estimated that one chlorine atom can destroy over 100,000 ozone molecules. The net effect is the destruction of ozone, faster than its natural creation. To return to the analogy comparing ozone levels to a stream's depth, CFCs act as a siphon, removing water faster than normal and reducing the depth of the stream.

No one could imagine that these miracle chemicals could one day turn out to be harmful substance to life on Earth. It all began when at the first United Nations on the Human Environment Conference at Stockholm in 1972, questions were asked about the effect of jet aircrafts on upper atmosphere. It was known that the high temperature jet exhausts contain an appreciable amount of nitrous oxide and it was also known that this substance can catalytically decompose ozone. The conference author ized United Nations Environment Programme (UNEP) to address this issue and focus on the possible damage to the ozone layer by hundreds of supersonic aircrafts that were expected to be in operation by the late 1980s. They were also entrusted with the task of finding out the effect of release of nitrous oxide from fertilizer manufacturing units on the ozone layer.

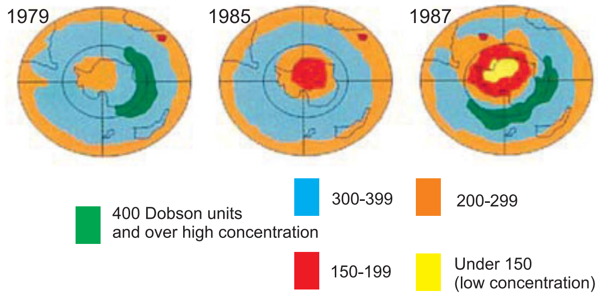
These investigations did not make much headway and were dismissed as false alarms.

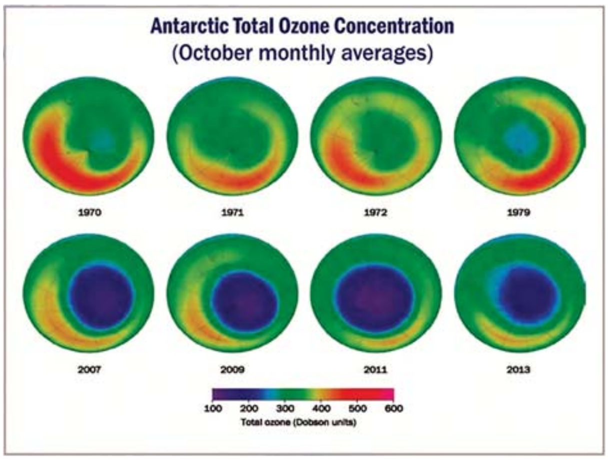
The Antarctic Ozone Hole

The term "ozone hole" refers to a large and rapid decrease in the concentration of ozone molecules in the ozone layer. "When the concentration of ozone over any area falls below 220 DU, it is called ozone hole". The Antarctic "Ozone Hole" occurs during the southern spring between September and November each year. The British Antarctic survey team first reported the hole in May 1985. The team found that for the period between September and mid November, ozone concentration over Halley Bay, Antarctic, had declined by 40% from levels during the 1960s. Severe depletion has been occurring since late 1970s.

The problem is worst in this part of the globe due to extremely cold atmosphere and the presence of polar stratospheric clouds. The land under the ozone depleted atmosphere increased steadily to more than 20 million sq km in the early 1990s and in the Antarctic spring of 1998, the area of the ozone hole exceeded 26 million sq km and also covered some populated areas of the southern hemisphere. The total ozone dropped to about 97 DU on 1 October, 1998.

Evolution of the Antarctic Ozone hole (1979 - 1987 October)



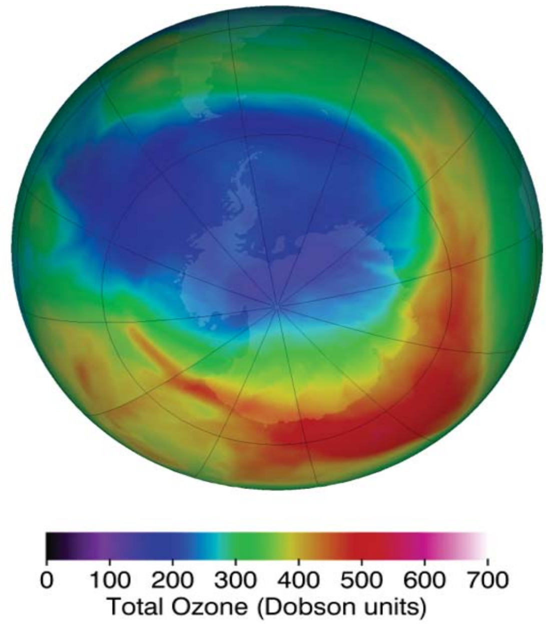


Changes in Ozone concentration over Antarctica (1970-2013)

The Antarctic ozone hole grew to 28.4 million sq. km in 2000. In the year 2002, a peculiar effect was seen, the ozone hole split into two but the total coverage was only 15 million sq. km. In the year 2005, the size of ozone hole again increased to 27.0 million sq. km. The ozone hole further grew to an extraordinary size, 29.3 million sq. km in 2006. The size of ozone hole slightly started declining and in 2008 became equivalent to the size of North America and NOAA reported that ozone hole reached to 26.5 million sq. km. in September, 2008. It was also observed that the total column of ozone dropped to its lowest count of 100 DU in September, 2008. The size of Antarctic ozone hole in September, 2009, September, 2010, September, 2011, September, 2012, September, 2013 and September, 2014 were reported to be 24 million sq. km., 22.2 million sq. km., 25 million sq. km., 18.5 million sq. km., 21 million sq. km. and 24.3 million sq. km. respectively.

The latest false-color view of total ozone over the Antarctic pole. The purple and blue colors are where there is the least ozone, and the yellows and reds are where there is more ozone.

9 September, 2019

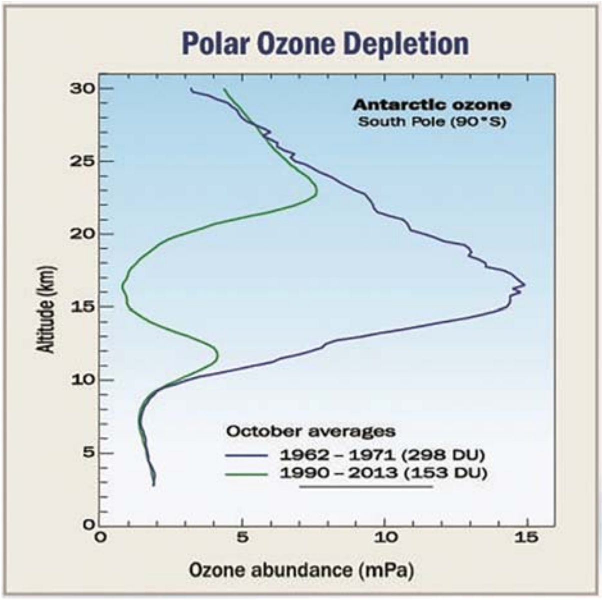


This indicates that the Montreal Protocol is working effectively and there is a gradual recovery of ozone layer.

The decline of ozone layer over North Pole has also been reported. The effect has been ascribed to solar flares and record frigid temperatures working with manmade chemicals.

In addition, research has shown that ozone depletion occurs over the latitudes that include North America, Europe, Asia, and much of Africa, Australia and South America. Thus, ozone depletion is a global issue and not just a problem at the South Pole. It was also reported that some ozone depletion also occurs in the Arctic during the Northern Hemisphere spring (March-May). Wintertime temperatures in the Arctic stratosphere are not persistently low for many weeks and these results in less ozone depletion.

Recent observations and several studies have shown that the size of annual ozone hole has stabilized and the level of ODSs has decreased

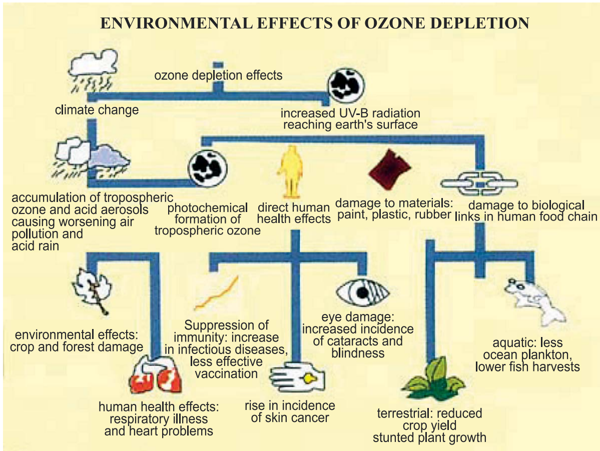


by 4 percent since 2001. But chlorine and bromine compounds have long atmospheric life. Recovery of stratospheric ozone is not likely to be noticeable until 2020 or little later.

Environmental Effects of Ozone Depletion

As explained earlier, ozone acts as a shield to protect the Earth's surface by absorbing harmful UV-B and UV-C radiation. If this ozone is depleted, then more UV rays will reach the earth surface. Exposure to higher doses of UV-B radiations will have effects on human health and impact on flora and fauna of terrestrial as well as aquatic eco-systems.

- **Human health effects:**
  - Sunburns, premature ageing of the skin.
  - UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva.
  - As per World Health Organization (WHO), 2002 report, a 10% decrease in stratospher ic ozone could cause an additional 300,000 non-melanoma and 4500 melanoma skin cancers in the world.
  - More cataracts leading to damage to the eye vision resulting in blindness. Cataracts (a clouding of the lens) are the major cause of blindness in the world. Ten percent thinning of the ozone layer could cause 1.6 to 1.75 million more cases of cataracts worldwide every year (WHO, 2002).
  - Early findings suggest that exposure to UV radiation results in suppression of the human immune system, which may cause non-melanoma and skin cancer.
- **Adverse impact on agriculture, forestry and natural ecosystems:**
  - Several of the world's major crop species are particularly vulnerable to increased UV radiation, resulting in reduced growth, photosynthesis and flower ing. Food production may reduce by about 1% for every 1% increase of UV-B radiation.
  - The effect of ozone depletion on the agricultural sector could be significant. Many agricultural crops sensitive to the UV-B radiation of the Sun are rice, wheat, soybean, corn, sweet corn, barley, oats, cowpeas, peas, carrots, cauliflower, tomato, cucumber, broccoli etc.
  - A few commercially important trees have been tested for UV-B radiation sensitivity. Results indicate that plant growth, especially in seedlings, is more vulnerable to intense UV radiation.
- **Damage to marine life:**
  - Planktons are the first vital step in aquatic food chains. In particular, plankton (tiny organisms on the surface layer of oceans) is threatened by increased UV-B radiation.
  - Decreases in plankton could disrupt the fresh and saltwater food chains, and lead to species shift.
  - Marine fauna like fish lings, juvenile stages of shrimp and crab have been threatened in recent years by increasing UV-B radiation under the Antarctic region. Loss of biodiversity in oceans, rivers and lakes could impact on aquaculture prospects.
- **Materials:**
  - Wood, plastic, rubber, fabrics and many construction materials are degraded by UV-B radiation.



- The economic impact of replacing and/or protecting materials could be significant.

The Real Alarm

In 1974, two United States (US) scientists Mario Molina and F. Sherwood Rowland at the University of California were struck by the observation of a British scientist, James Lovelock that CFCs were present in the atmosphere all over the world more or less evenly distributed by appreciable concentrations. They suggested that these stable CFC molecules could drift slowly up to the stratosphere where they may breakdown into chlorine atoms by energetic UV-B and UV- C radiations of the Sun. The chlorine radicals thus produced can undergo complex chemical reaction producing chlorine monoxide, which can attack an ozone molecule converting it into oxygen and in the process regenerating the chlorine atom again. Thus, the ozone-destroying effect is catalytic and a small amount of CFCs would be destroying large number of ozone molecules. Their basic theory was put to test by the National Aeronautics and Space Administration (NASA) scientists and found to be valid, ringing alarm bells in many countries and laying the foundation for international action.

International Action

The first international action to focus attention on the dangers of ozone depletion in the stratosphere and its dangerous consequences in the long run on life on earth was initiated in 1977. A meeting of 32 countr ies in Washington D.C., USA initiated a Work Plan on action on protection of ozone layer with UNEP as the coordinator.

As experts began their investigation, data piled up and in 1985, in an article published in the prestigious science journal, "Nature" by Dr. Farman, pointed out that although, there is overall depletion of the ozone layer all over the world, the most severe depletion had taken place over the Antarctic. His findings were confirmed by Satellite observations and offered the first proof of severe depletion of ozone layer. These findings stirred the scientific community to take urgent remedial actions. A framework for such actions was designed and agreed in an international convention held in Vienna on 22nd March, 1985.

This, subsequently, resulted in an international agreement on 16th September, 1987 on specific measures to be taken in the form of an international treaty known as the Montreal Protocol on Substances that Deplete the Ozone Layer. Under this Protocol, the first concrete step to save the ozone layer was taken by immediately agreeing to completely phase out the production and consumption of CFCs, halons, CTC and methyl chloroform as per the agreed schedule by the Parties to the Montreal Protocol.

Evolution of the Montreal Protocol

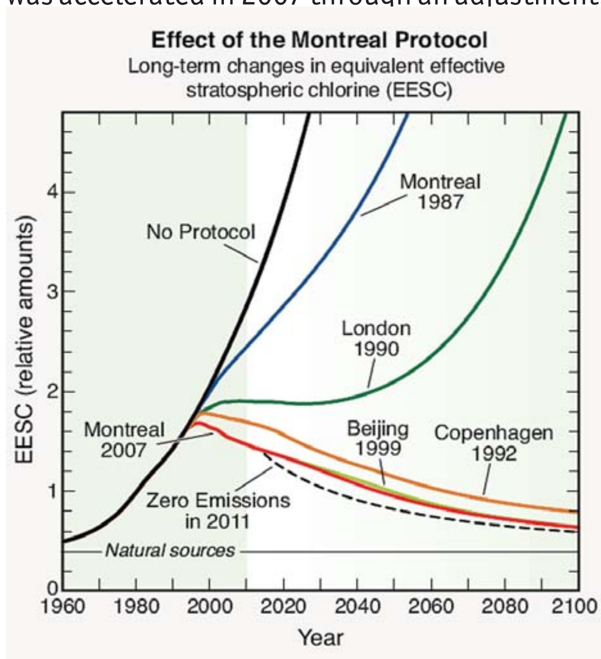
The urgency of controlling the ODSs, particularly CFCs was slow to pick up. The CFCs were so useful that the society and the industry, all over the world, were reluctant to give up the use of CFCs. However, even as the nations adopted the Montreal Protocol in 1987, new scientific findings indicated that the Protocol's control measures were inadequate to restore the ozone layer. In addition, the developing countries had a special situation, as they needed the technical and financial assistance to enable these countries to change over to non-ODS technologies.

In response to the prospect of increasing ozone depletion, the governments of the world crafted the 1987 United Nations Montreal Protocol as an international means to address this global issue.

As a result of the broad compliance with the Protocol and its Amendments and adjustments and, of great significance, industry's development of "ozone-friendly" substitutes for the now-controlled chemicals, the total global accumulation of ODSs has slowed and begun to decrease. In response, global ozone depletion is no longer increasing, and initial signs of recovery of the ozone layer have been identified. With continued compliance, we can expect substantial recovery of the ozone layer by the middle of the 21st century. The day the Montreal Protocol was agreed upon, 16 September, is now celebrated as the International Day for the Preservation of the Ozone Layer.

Meanwhile, the report of the Scientific Assessment Panel (SAP) of the Montreal Protocol, entrusted with the task of finding the extent of ozone depletion, showed that the actual harm to the ozone layer was much more than predicted by theoretical models and the control measures envisaged by the Protocol in 1987 would not be sufficient to arrest the depletion of ozone layer. More urgent action was, therefore, necessary. Therefore, at the 2nd Meeting of the Parties (MOP) to the Montreal Protocol, in London, in 1990, 54 Parties as well as 42 non-Party countries agreed on a package of measures satisfactory to all. It was agreed in this meeting that the widely used and having high Ozone Depleting Potential (ODP) of 5 CFCs and 3 halons would be phased out by the year 2000 and other minor CFCs and CTC would be controlled and eventually phased out. A special provision was made to provide financial and technical assistance to the developing countries with an annual consumption of CFCs and halons less than 0.3 kg per capita (also called as Article 5 countries) in their efforts to phase out these harmful chemicals. These countries were also given a grace period of 10 years to phase out ODSs.

In 1991, more alarming reports came up to show that the depletion of ozone is continuing in all altitudes except over the tropics. It was recognized that the phase-out of production and consumption of CFCs and halons is not enough to control the depletion of ozone layer. Other fluorocarbon chemicals like Hydrochlorofluorocarbons (HCFCs) and methyl bromide, which are also ODSs, need to be controlled. They have also been brought under the ambit of the Montreal Protocol in 1992 through Copenhagen amendment and defining the schedule of phase-out of HCFCs in 1999 through Beijing amendment. Further, the phase-out of production and consumptions of HCFCs was accelerated in 2007 through an adjustment.



Recovery of Ozone Layer

As a result of implementation of provisions/ measures under the Montreal Protocol, the atmospheric concentration of the man-made chlorine and bromine containing substances has begun to decline. Chlorine/bromine have reached to the maximum levels in the stratosphere in the first decade of the 21st century, and ozone concentrations should correspondingly be at their minimum levels during that time period. It is anticipated that the recovery of the Antarctic ozone hole has begun. But there is a slow rate of healing because of long atmospheric life of these manmade chemicals like CFCs, CTC, halons, methyl chloroform, methyl bromide etc. January 2010 marked the end of global production of CFCs and halons under the Protocol, and January

2013 the universal control of ODS production and consumption. In the early 2010s, the first signs of ozone recovery were detected. It is expected that the beginning of this recovery will not be conclusively detected for a decade or more, and that complete recovery of the Antarctic ozone layer will not occur until the year 2060 or little later. The exact date of recovery will depend on the effectiveness of present and future regulations on the emission of ODSs from banks (CFCs, halons etc.).

Status of Ratification of Vienna Convention, Montreal Protocol and Amendments

S. No.	Particulars	Date of Enforcement	No. of Parties
1	Vienna Convention 1985	22.09.1988	198
2	Montreal Protocol, 1987	01.01.1989	198
3	London Amendment, 1990	08.10.1992	197
4	Copenhagen Amendment, 1992	14.06.1994	197
5	Montreal Amendment, 1997	10.11.1999	197
6	Beijing Amendment, 1999	25.02.2002	197
7	Kigali Amendment, 2016	01.01.2019	81

Multilateral Fund

With a view to assist the developing countries in their phase out efforts, a Multilateral Fund (MLF) for the implementation of the Montreal Protocol was established in June, 1990. The Fund is supported by a Secretariat, co-located with UNEP, but directly accountable to an Executive Committee (Ex-Com) consisting of seven non-Article 5 Parties and seven Article 5 Parties. This governance structure accomplished several key objectives. First, by co-locating the MLF Secretariat with UNEP but retaining its independence in a policy context, the Parties and their appointed Ex-Com were provided with direct control over the Fund's policies. Second, the balance of non-Article 5 and Article 5 Parties on the Ex-Com signalled a major departure from the historic donor-driven nature of funding bodies that reflected the spirit of equality.

The Fund is financing incremental costs for ODS phase out in Article 5 Parties. The incremental costs, including cost of transfer of technology, incremental capital costs and incremental operating costs for switching over from ODS to non-ODS technologies enabling the developing countries to phase out controlled substances. Enterprises which were using ODS based technologies prior to cut of dates are eligible for funding for conversion from ODS to non-ODS technology from the MLF for the implementation of the Montreal Protocol.

India being an Article 5 Party is eligible for receiving technical and financial assistance from MLF to phase out ODSs and switchover to non-ODS technologies.

Alternatives to Currently Used Ozone Depleting Substances

During the last two decades intensive research has yielded a large number of substitute chemicals as replacements to CFCs, halons, CTC, methyl chloroform, methyl bromide and HCFCs. These are summarised below on end- use basis:

Technology Options for Phase-out in Refrigeration and Air-conditioning (RAC) Sector

Sub-sector	ODS used	Preferred alternatives / substitutes
Domestic refrigerators	Refrigerant: CFC-12 Foam: CFC-11 HCFC-141b	Refrigerant: HFC-134a, HC-600a, Isobutane, HC blend, HFO-1234yf Foam Blowing Agents: Cyclopentane HFC-245fa, HFC-365mfc, HFO-1234ze Methyl Formate, Methylal, Solstice-LBA, FEA-1100

Refrigerated Cabinets (Deep Freezer, Ice-cream cabinets, Bottle coolers, Visi coolers)	Refrigerant: CFC-12 Foam: CFC-11 HCFC-141b	Refrigerant: HFC-134a, HC-600a HC-blend, CO_2 Foam Blowing Agents: Cyclopentane, HFC-245fa, HFC-365mfc, HFO-1234ze, Methyl Formate, Methylal, Solstice-LBA, FEA-1100
Water Coolers	CFC-12 HCFC-22 (for bigger capacity)	HFC-134a, HC-blend, HC-290, HFO-1234yf
Mobile (car, bus, van, refrigerated trucks, train)	CFC-12 HCFC-22 (train)	HFC-134a, HFC-1234yf HFC-152a, CO_2 R-290, HFC-134a, HFO-1234yf, R-407C, blends of HFCs & HFOs
Central A/C plants	CFC-11, CFC-12, HCFC-123, HCFC-22	HFC-134a, R-410A, R-407C, HFO-1234yf, HC-600a, Ammonia, HC-290
Process Chillers	CFC-12, HCFC-22	HFC-134a, R-404A, R-407F, Ammonia
Ice Candy Machines	CFC-12, HCFC-22	HFC-134a, R-407F, R-290, R-404A
Walk-in Coolers	CFC-12, HCFC-22	HFC-134a R-407F R-404A
Room A/C	HCFC-22	R-410A, HC-290, HFC-32, blends of HFCs and HFOs
Packaged A/C	HCFC-22	R-410A, R407C, HFC-32, HC-290, HC-1270
Shipping	CFC-12, HCFC-22	HFC-134a, R-410A , CO_2

Alternatives with zero ODP viz. Hydrofluorocarbon - 134a (HFC-134a) R-404A, R-407C, R-410A and R-507A have been used in various applications in many countries, especially in non-Article 5 countries. The low-Global Warming Potential (GWP) refrigerants like ammonia, Carbon-dioxide (CO2) and hydrocarbons are also used in some applications. Attempts are being made to use Hydrocarbons like HC-290 and HC-1270 in a number of applications, including small capacity Room Air-Conditioners. Recently, low-GWP HFCs, also known as Hydrofluoroolifins (HFOs) are being applied in some applications.

Technology Options for Phase-out in Aerosol Sector

Sub-sector	ODS used	Preferred alternatives / substitutes
Perfumes, shaving foams, insecticides, paints, etc.	CFC-11/ CFC-12	Hydrocarbon Aerosol Propellant (HAP), destenched LPG, Di-methyl Ether
Metered Dose Inhalers	CFC-11 CFC-12	Hydrofluoro-alkanes (HFAs)

Technology Options for Phase-out in Foam Sector

Sub-sector	ODS used	Preferred alternatives / substitutes
Flexible Polyurethane foam (PUF) Slabstock	CFC-11	Methylene Chloride
Flexible Moulded PUF	CFC-11	Water blown technology
Rigid PUF General Insulation	CFC-11 HCFC-141b	Cyclopentane, HFC-245fa, HFC-365mfc, HFO-1234ze, HFO-1233zd(E), Methyl Formate, Methylal , Solstice-LBA, FEA-1100
Thermoware	CFC-11 HCFC-141b	HFC-245fa, HFC-365mfc, Water, Methyl Formate, Solstice-LBA, FEA-1100

Integral Skin PUF	CFC-11 HCFC-141b	HFC-245fa, water, hydrocarbons Solstice-LBA, FEA-1100
Thermoplastic Foams -EPE/EPPN Foams -Phenolic Foams	 CFC-11, CFC-12 CFC-11	Hydrocarbons, CO_2
Phenolic Foams	CFC-11	Hydrocarbons

CFC-11 with ODP of 1.0 as a foam blowing agent was substituted first by a transitional technology based on HCFC-141b with 0.11 ODP. The HCFC-141b is now being replaced by zero-ODP and low-GWP foam blowing agents like cyclopentane, methyl formate and methylal. HFC based blowing agents like HFC-245fa and HFC-365mfc have also been used in non-Article 5 countries. The proposed next generation of low-GWP foam blowing agents are likely to be HFOs-1234ze, HFO-1233zd(E), methyl formate, methylal, Solstice-LBA, FEA-1100 and Hydrocarbons.

Technology Options for Phase-out in Fire Extinguishing Sector

Sub-sector	ODS used	Preferred alternatives / substitutes
Fire Extinguishers	Halon-1211, Halon-1301, Halon-2402	Portable type ABC powder, CO_2 Fixed type FM200,HFCs, NAF- SI/SIII

Substitutes like ABC powder and HFC based for halon-1211 used in portable fire extinguishers have also been developed and used. Some global chemical producers have developed hexafluoro propane (HFC-236fa) as an excellent substitute for halon-1211 fulfilling a long felt need. It is now being manufactured commercially.

Technology Options for Phase-out in Solvent Sector

Sub-sector	ODS used	Preferred alternatives / substitutes
Electronic and precision cleaning	CFC-113 CTC Methyl chloroform	DI Water Aqueous cleaning process Semi-acqueous cleaning process, organic non-halogenated, solvents, perfluorocarbons
Coatings	CFC-113 Methyl chloroform	Aqueous solvents Trichloro ethylene
Manufacture of pesticides and pharmaceuticals	CTC	Ethylene-dichloride Monochloro-benzene
Metal cleaning	CTC	Trichloroethylene
Chlorinated	CTC	Aqueous rubber
Textile cleaning	CTC	Aqueous system, chlorinated solvents

During the last several years, due to intensive Research and Development (R&D) efforts, new solvents have been discovered and used as alternatives to ODSs. First Hydroflouroethers (HFEs) were considered as alternative solvents. Although, satisfactory in many respects, these were very high cost alternatives. Some patented non-ODS products have also been promoted as alternative solvents for electrical cleaning especially for tape head and disk drives (Video 40), flux removal and PCB cleaner (Deflex 160); degreasing agent (Cold kleen 110); adhesive sticker removing, computer disk cleaning (CD-150) etc. Although, these are patented products and their chemical compositions are not available but the trend is good.

2. INDIA'S COMMITMENT TO THE MONTREAL PROTOCOL

India became Party to the Vienna Convention for the Protection of the Ozone Layer on 18th March 1991 and the Montreal Protocol on Substances that Deplete the Ozone Layer on 19th June, 1992. The per capita consumption of the controlled substances in Annex A of the Montreal Protocol did not cross 20 g during 1995-97 (baseline), as against 300 g per capita limit for Article 5 Parties under the Protocol. India was self-sufficient in production of chemicals like CFCs, CTC, halons and HCFCs. India was mainly producing and using 9 of the 96 substances controlled under the Montreal Protocol. These are CFC-11, CFC-12, CFC-113, HCFC-22 halon-1211, halon-1301, CTC, Methyl Chloroform and Methyl Bromide.

India played a key role in the establishment of the Multilateral Fund, a financial mechanism established under the Montreal Protocol through its London Amendment in 1990. India also played a pro-active role in the implementation of Montreal Protocol in the country. India had prepared a detailed Country Program (CP) in 1993 to phase-out ODSs in accordance with its National Industrial Development Strategy. The objectives of the CP were to phase-out ODSs by accessing the Protocol's financial mechanism without undue economic burden to consumers, producers and equipment manufacturers using ODSs. The other objectives of the CP were minimization of economic dislocation as a result of conversion to non-ODS technologies, maximization of indigenous production, preference to one-time replacement, emphasis on decentralized management and minimization of obsolescence. The CP was updated in 2006 taking into account the decisions of the Montreal Protocol and national policies.

The Government of India has entrusted the work relating to ozone layer protection and implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer to the Ministry of Environment, Forest and Climate Change (MoEF&CC). The MoEF&CC has set up an Ozone Cell as a National Ozone Unit (NOU) to render necessary services for effective and timely implementation of the Protocol and its ODS phase-out activities in India.

The MoEF&CC also constituted an Empowered Steering Committee (ESC), which is supported by two Standing Committees, namely the Technology and Finance Standing Committee (TFSC) and the Standing Committee on Monitoring. The ESC is Chaired by the Secretary of the MoEF&CC. The ESC oversees the implementation of the Montreal Protocol provisions, review of policies and implementation of projects/plans and monitoring.

Although, ODSs, especially CFCs and HCFCs were used in large scale in the developed countries since 1930s, India was slow to adopt these chemicals. The early use of these chemicals in India was in RAC sector and CFCs and HCFCs needed for this sector were imported in the country. The use of CFCs and HCFCs in refrigeration industry can be traced back to 1960s. Other industries using CFCs and HCFCs, such as foam manufacturing industry, aerosol industry etc., were developed only during last 35 to 40 years in the country. With the availability of CFC-11 and CFC-12 from indigenous production, started in 1968, the growth of consumption of CFCs and industry increased very rapidly.

When the CP was prepared, use of ODS as solvents is estimated to account for the maximum consumption, both in MT as well as ODP tonne. RAC and Foam were the next large user sectors, followed by Aerosol sector. The consumption of ODSs in fire extinguishing sector was relatively small in terms of MT.

Status of ODS Phase-out in India

India has phased out the production and consumption of CFCs, CTC and halons as of 1st January, 2010 (except use of pharmaceutical grade CFCs in manufacturing of Metered Dose Inhalers (MDIs) for Asthma and Chronic

Obstructive Pulmonar y Diseases (COPD) patients). India has also phased-out production and consumption of Methyl Chloroform and Methyl Bromide. A total of 378 projects have been approved and funded by the Ex-Com of the MLF for Implementation of the Montreal Protocol. A total amount of US 304,209,305 has been approved by the Ex-Com of the MLF to phase-out 47,693 tonne of ODSs.

Sector-wise Approved Projects as on 31.8.2019

Sector wise break-up of the funds approved by the Ex-Com of the MLF for ODS phase-out projects in India is given in the table below:

Sector	No. of Projects	Funding (US $)	Phase out of ODP (in Tonne)
Aerosols Sector (CFC)	38	13,705,006	1,702
Foams Sector (CFC)	163	37,880,185	5,074
Firefighting Sector (Halons)	21	5,176,701	2,719
Institutional Strengthening	8	2,738,166	31
Refrigeration & Air Conditioning Sector (CFC)	87	31,827,256	3,983
Solvents Sector (including CTC production)	41	61,358,042	12,966
Production Sector (CFC and Halons)	15	84,228,000	20,107
HPMP Stage-I Preparation	1	570,000	—
HPMP Stage-I (HCFC-141b and HCFC-22)	1	21,294,490	342
HPMP Stage-II Preparation	1	490,000	—
Demonstration Project in Foam Sector Preparation (HCFC-141b)	1	30,000	—
HPMP Stage-II (HCFC-141b and HCFC-22)	1	44,911,459	769
Total	**378**	**304,209,305**	**47,693**

Source: MLF Secretariat - Inventory of approved projects.

SECTOR PHASE-OUT PLANS

CFC Production Sector Phase-out Project in India

The Ex-Com of the MLF in its 29th meeting held in November 1999 approved the India's CFC Production Sector gradual phase-out project with a total grant amount of US $82 million to phase-out production of 22,588 ODP tonne of CFCs. The amount US $80 million was to be provided as a performance based grant to CFC producers for meeting the CFC production phase-out targets. The remaining US $2 million was for Technical Assistance (TA) component to establish Project Management Unit (PMU) under the Ozone Cell to develop and implement monitoring, auditing and reporting mechanisms, in addition to conduct awareness and training programs. The World Bank was the lead implementing agency for the project. UNEP has been designated as the implementing agency for TA component. In this project, it was agreed to reduce total CFC production in accordance with the following agreed schedule:

Agreed Schedule for Phase-out of CFC Production

Year	CFC Production Quota (MT)	Phase-out Quantity (MT)
1999	22,588	-
2000	20,706	1,882
2001	18,824	1,882
2002	16,941	1,883
2003	15,058	1,883
2004	13,176	1,882
2005	11,294	1,882
2006	7,342	3,952
2007	3,389	3,953
2008	2,259	1,130
2009	1,130	1,129
2010	0	1,130

Accelerated Phase-out of CFCs

India agreed at the 54th meeting of the Ex-Com of the MLF held from 7th to 11th April, 2008 in Montreal, Canada to accelerate the phase-out of production of CFCs by 1st August, 2008 with an additional grant of US $3.17 million to the CFC producers. As per the decision, India agreed that it will produce not more than 690 MT of CFCs until 1st August, 2008 primarily for the manufacturing of MDIs. India's CFC producers would sell no more than 825 MT of CFCs for MDI production in the years 2008 and 2009, comprising 690 MT of new production and 135 MT reprocessed from existing stock. In addition, India would not import any more CFCs.

India has completely phased-out the production and consumption of CFCs with effect from 1st August, 2008, 17 months ahead of the agreed phase-out schedule except the use of pharmaceutical grade CFCs in manufacturing of MDIs. The Ex-Com of the MLF has released the total grant of US $3.17 million, the grant approved for accelerated phase-out of CFCs.

The National Strategy for Transition to Non-CFC MDIs and Plan for Phase-out of CFCs in the Manufacture of Pharmaceutical MDIs has been implemented successfully by United Nations Development Program (UNDP) as lead implementing agency, UNEP and Government of Italy as cooperating agencies in close cooperation with the MDI manufacturing industry under the guidance of Ozone Cell, MoEF&CC.

Halon Production and Consumption Phase-out in India

The phase-out of consumption of halons in India was initiated as early as 1994. The 13th meeting of the Ex-Com of the MLF approved a demonstration project for evaluation of alternative technologies for halon, fire protection system and technical assistance for sectoral strategy with a funding of US $ 309,000. It followed with the approval of 14 individual investment projects by the Ex-Com of the MLF from 1995 to 1999 which resulted in phase-out of 1768 ODP tonne of halons. These projects were successfully completed in 2001.

Subsequently, the Ex-Com of the MLF in its 34th meeting held in 2001 at Montreal approved US $2.6 million for complete phase out of the production and remaining consumption of halons in the country. This project was successfully implemented and achieved the objective of complete phase-out of production and consumption of halons in India, as early as 2003.

The enterprises, producing halons have dismantled their production plants. At present, there is no halon production in India. The phase-out activities of production and consumption of halons in all the enterprises have been successfully completed.

Fire Extinguishing Industry Structure: There were two halon production facilities in India at M/s Navin Fluorine International Ltd. (NFIL) and M/s SRF Ltd. M/s SRF was producing halon-1211 and halon-1301, while M/s NFIL was producing only halon-1211. The total production capacity of halon in the country was 800 MT.

There were about 200 manufacturers of fire extinguishing equipments, of which over 85% were manufacturers of portable fire extinguishers in the country. Halons, which are potent ODSs, were used only in about 5% of the fire extinguishing applications.

Halon Consumption: In 1991, the total consumption of halons in India was 750 MT, equivalent to 3,650 ODP tonne. This constituted 7.2% of India's total ODS consumption and almost 28% of the total consumption in ODP tonne. Imports accounted for 550 MT of the total, while 200 MT was indigenously produced. The growth rate in this sector was forecasted at 15% annually.

Technology: As noted earlier, the use of halons in fire-fighting equipments constituted only about 5% of the fire-fighting applications in India. There were no drop-in replacement technologies identified. However, a wide variety of fire extinguishing technologies were identified at the time of preparation of the CP, viz., ABC powder, CO2-based systems, foam based systems, inert gases, HFC-based systems, fast response sprinklers, etc. Among the priority actions identified to address the ODS phase-out in this sector were:

- Revision of national fire-extinguisher codes and standards to promote halon alternatives;
- Halon conservation program to limit emissions;
- Establishment of a halon management program, including halon banking.

Establishment of Halon Banking Facility: The production of halons has been phased-out globally at the early stage of the Protocol because of high ODP values of halons. Moreover, there is a large quantity of halons banked in fire extinguishing equipments. The MoEF&CC has established National Halon Banking Facility at Centre for Fire, Explosive and Environment Safety (CFEES), Defence Research and Development Organization (DRDO), Ministry of Defence, New Delhi with the f inancial assistance from the MLF of the Montreal Protocol. This facility has the capability to recover, recycle and store the halons for future use in the existing equipment. It is worth mentioning that all the three Defence forces have also established their own Halon Banking Facilities to meet the future requirements.

CFC Phase-out in Foam Manufacturing Sector

The Foam Manufacturing sector was one of the major ODS consuming sectors in India predominantly using CFC-11 as blowing agent. As of June 2002, 158 projects and activities were approved by the Ex-Com of the MLF to phase-out 4401 ODP tonne of CFCs with a funding of US $29.36 million. These projects/ activities were successfully implemented and achieved the phase-out of CFCs in this sector.

The Ex-Com of the MLF, at its 37th meeting held in July 2002 approved the foam sector phase-out plan with a total funding of US $5.42 million to phase-out the remaining 612 ODP tonne of CFC-11 in foam manufacturing sector. UNDP was responsible for implementation of this plan. A total of 122 foam manufacturing enterprises under this sector plan have phased-out 702 MT of CFCs from their processes. The foam sector CFC phase-out plan has been successfully implemented and use of CFCs has been completely eliminated in foam manufacturing sector in the country.

Industry Structure: The survey of the Foam Manufacturing sector carried out at the time of preparation of CP in 1993 identified about 235 foam manufacturers in India using CFCs as blowing agents. About 20% of the enterprises were large/medium size, while the rest were Micro, Small and Medium Enterprises (MSMEs) in the unorganized and informal sector.

The sub-sectors identified were rigid polyurethane foam, flexible polyurethane foam, integral skin polyurethane foams, thermoplastics foams (extruded polyethylene and polystyrene foams) and phenolic foams. An important sub-sector in the Foam sector, namely, the flexible slab-stock foam mostly converted from CFCs to methylene chloride as the blowing agent during 1980s due to economic reasons. The domestic refrigerator manufacturers were large and main users of CFCs in the rigid polyurethane foam sub-sector. Another important sub-sector within the Foam Manufacturing sector, the rigid polyurethane foam used in the production of insulated thermo-ware (flasks, casseroles, water-bottles, lunch-boxes, etc), was considered important due to the large number of MSMEs involved.

There were four major producers of polyol systems, who formed the main upstream source of raw materials for the polyurethane foam manufacturers and were meeting about half of the total demand. The remaining half of the demand was met through imports.

ODS Consumption in Foam Sector: In 1991, the consumption of CFCs in foam manufacturing sector was 1,580 MT, predominantly CFC-11, which amounted to about 31% of India's total CFC consumption in the country. It was estimated that the demand for foam products would grow at 15-20% annually until 2010. The Foam sector was therefore identified as a priority sector in India for initiating phase-out activities.

Technology: The following technology options have been identified for phasing out ODSs in the foam manufacturing sector. Some of the technologies, especially the low GWP technologies are still emerging.

Technological Options in Foam Sector

Sub-sector	Interim Technology	Long Term Technology
PU RIGID FOAM		
Domestic refrigerators - freezers	HCFC-141b	hydrocarbons, HFC-245fa, HFC-134a, HFOs Solstice-LBA, FEA-1100
Other appliances	HCFC-141b	hydrocarbons, HFC- 245fa, HFC-365mfc/ HFC-227ea blends, HFC-134a, methyl formate, CO_2 (water), HFOs
Transport & reefers	HCFC-141b	hydrocarbons, HFOs HFC-245fa, HFC-365mfc/ HFC-227ea blends, HFC-134a
Continuous Panels	HCFC-141b	hydrocarbons, HFC-245fa, HFC-365mfc/ HFC-227ea blends
Discontinuous panels	HCFC-141b	HFC- 245fa, HFC-365mfc/ HFC-227ea blends, HFC-134a, hydrocarbons, CO_2 (water), formic acid, methyl formate
Spray	HCFC-141b	HFC-245fa, HFC-365mfc/ HFC-227ea, Supercritical CO_2, CO_2 (water), HFOs
Pipe-in-pipe	HCFC-141b	hydrocarbons, HFC- 245fa, HFC-365mfc/ HFC-227ea blends, CO_2 (water), methyl formate
EXTRUDED POLYSTYRENE		
XPS Sheet	HCFC-142b, HCFC-22	Hydrocarbons (butane, isobutane, pentane, isopentane), HFCs (HFC-134a, HFC-152a) & hydrocarbon / CO_2 (LCD) blends
XPS Board	HCFC-142b, HCFC-22	HFCs + blends, CO_2 (or CO_2/alcohol), hydrocarbons
PU FLEXIBLE FOAM		
Integral Skin	HCFC-141b, blends of HCFC-142b and HCFC-22	CO_2 (water), HFC-134a, HFC- 245fa, HFC-365mfc/ HFC-227ea blends, n-pentane, methyl formate
Shoe Soles	HCFC-141b, HCFC-142b	CO_2 (water), HFC-134a
Flex moulded	HCFC-141b, HCFC-142b	CO_2 (water), methyl formate
Flexible Slab Stock	HCFC-141b, HCFC-142b	CO_2 (water), methylene chloride

It was considered strategically important to support the conversion of manufacturing facilities of the polyol systems house(s) on a priority basis, to enable them to customize non-CFC formulations, thus facilitating CFC phase-out in the downstream foam manufacturers more economically. It was also recognized that there were large number of MSMEs operating in this sector, which could not be identified at the time of preparation of the CP. However, these were addressed subsequently.

The HCFCs like HCFC-141b, HCFC-142b and HCFC-22 are commonly used as interim substitutes to phase-out CFCs in foam manufacturing sector. The accelerated phase-out of HCFCs, as agreed at the 19th MOP held in September, 2007, would require conversion of foam manufacturing facilities from HCFCs to non-ODS technologies viz. hydrocarbons, HFOs, Methyl Formate, Methylal etc. Phase-out of HCFC-141 b as a foam blowing agent has been inter alia proposed to be taken up under the HCFC Phase out Management Plan (HPMP) Stage II.

CFC Phase-out in RAC Sector

The phase-out of CFCs in RAC sector in India was initiated as early as 1993. As of July, 2002, a total of 47 investment and technical assistance projects were approved with a total funding of US $22.3 million leading to a total phase-out of 1821 ODP tonne of CFCs. Subsequently, the Ex-Com of the MLF in its 38th meeting held in November 2002 approved a multi-year performance based sector phase-out plan cover ing the refrigeration (manufacturing) sector with a total funding of US $3.6 million to phase-out the remaining CFC consumption of about 535 ODP tonne. UNDP was responsible for implementation of the commercial refrigeration component and United Nations Industrial Development Organization (UNIDO) was responsible for implementation of the transport refrigeration sub-sector under this sector-plan. A total of 157 enterprises for commercial refrigeration (manufacturing) sector and 39 enterprises in transport refrigeration (manufacturing) sector were identified during the implementation of the plan. The sector phase-out plan has been successfully implemented and phased out the use of CFCs completely in refrigeration (manufacturing) sector in the country.

RAC Industry Structure: The RAC sector in India has a long history from the early years of last century. Major investments in establishing manufacturing capacities started in 1950s. On the upstream side, there were only two compressor manufacturers exclusively for hermetic compressors. In addition, there were some appliance manufacturers, which also had the dedicated facilities for manufacturing of hermetic compressors. However, there were several manufacturers of open-type compressors. Many other components of refrigeration systems were also manufactured in the country.

ODS Consumption in RAC Sector: In 1991, the total ODS consumption in the RAC sector in India was 1,990 MT. This constituted about 39% of India's total consumption of CFCs. About two-third of this consumption was estimated to be used in servicing of existing equipment. The growth rate in this sector was forecasted at 10-20% annually until 2010. The RAC sector was, therefore, identified as another priority sector in India for initiating phase-out activities.

National CFC Consumption Phase-out Plan (NCCoPP)

The Ex-Com of the MLF at its 42nd meeting held in April, 2004 approved the NCCoPP for the RAC servicing sector at a total funding level of US $6.388 million to phase-out 1502 ODP tonne of CFCs. The Government of Germany (bilateral implementing agency) was responsible for implementation of this project as the lead Implementing Agency along with UNDP, UNEP, UNIDO and Government of Switzerland as cooperating implementing agencies. The Government of Switzerland was responsible for training activities and UNDP was responsible for equipment support. UNEP was responsible for creation of awareness activities. Besides, UNEP was organizing customs and policy training activities in collaboration with National Academy for Customs, Excise and Narcotics (NACEN). UNIDO jointly with UNDP was responsible for implementation of CFC phase-out activities in transport refrigeration.

The project's main focus was on training of refrigeration servicing technicians who were involved in servicing of RAC equipments based on CFCs and non-ODS alternatives. It also covered training for Mobile Air-Conditioning (MAC), RAC equipments using Open Type Compressor (OTC) and specifically targeted the Railways as a key institutional user of CFC refrigerants. The project adopted a multi-pronged approach to achieve its targets. In addition to training, equipment support, awareness creation among the stakeholders and capacity building of customs officers on illegal ODS trade were included.

Information dissemination and creating awareness regarding CFC phase-out in India is of utmost importance to ensure the project's success. Various methods were employed to create awareness viz. video film, posters, newsletter, flyers, dealer workshops, equipment support workshops, articles in newspapers and a dedicated website.

NCCoPP was funded by the MLF for implementation of the Montreal Protocol. NCCoPP took over from the Indo-Swiss-German Project "Ecological Refrigeration (ECOFRIG)" and Indo-Swiss Project "Human and Institutional Development in Ecological Refrigeration (HIDECOR)". ECOFRIG began within the framework of Indo-Swiss-German Cooperation in 1992 with an objective to evaluate the hydrocarbon technology in RAC appliances for replacing CFCs. ECOFRIG project and the HIDECOR established a training setup including well-developed excellent training modules and a pool of trained trainers throughout the country. The HIDECOR activities, initiated in 1998, were geographically restricted to selected states and the target group was limited to Micro, Small and Medium size Servicing Enterprises in the RAC sector. NCCoPP established training infrastructure including training cells in 15 states of India. It aimed to encourage good servicing practices among all RAC servicing enterprises, with a special focus on those firms which were consuming more than 50 kg of CFCs per annum. A total of 955 recovery, recycling units were provided to the enterprises in four stages. Equipment support to 120 Industrial Training Institutes (ITI) was also provided.

Awareness generation workshops were conducted for servicing enterprises, so that most of the enterprises across the country could participate in the project and get the advantage of assistance provided under the Montreal Protocol to phase-out CFCs in servicing sector.

As stated earlier, the focus of activities of NCCoPP was training of RAC servicing technicians. During training, the participants/ technicians were taught how to handle the alternative refrigerants, good servicing practices and emphasis was laid on recovery, recycle, reclamation and reuse of CFCs. Therefore, the training programs have helped in creating a demand for recovered and reclaimed refrigerants. Over 20,000 technicians were trained under NCCoPP and its forerunner projects, ECOFRIG and HIDECOR. The requirement of CFCs was substantially decreased because of training on good service practices. The remaining requirement for servicing was addressed through reclamation and reuse of CFCs. A number of reclamation centres have been established at various locations in the country, viz. Bangalore, Chandigarh, Hyderabad, Ahmedabad, Jaipur, Kolkata, and Lucknow. The reclamation units have also been provided to Indian Railways and Defence forces.

The NCCoPP has been successfully implemented as per the schedule and achieved its objective of complete phase-out of CFCs.

Strategy for Solvent Sector to Phase-out ODS in MSMEs in India

The Ex-Com of the MLF in its 35th meeting held in December, 2001 approved a project to prepare "Overall Strategy for the Solvent Sector to support the phase out of ODS in MSMEs in India" at a total cost of US $169,500 implemented by UNEP in consultation with the World Bank and UNIDO. This project was to assist India in developing an overall strategy for the solvent sector which would cover both non-investment and investment activities to support the phase-out of ODS in the solvent sector in India and assist India in meeting its 2005, 2007 and 2010 commitments for the solvent sector. The aim of the project, at the operational level, was to develop approaches for assisting MSMEs which use solvents in India through training, Solvent Alternative Technology Service (SATS), information dissemination and investment and non-investment activities.

The project was completed successfully by UNEP and submitted the report to the Ozone Cell and the World Bank. The outcomes of the strategy document were incorporated in the preparation of the National CTC Phase-out Plan prepared by the World Bank.

National CTC Phase out Plan

The Ex-Com of the MLF at its 40th meeting held in July, 2003 approved the National CTC Phase out Plan at a total funding level of US $52 million to phase-out 11553 ODP tonne of CTC production and 11505 ODP tonne of CTC consumption. This included US $10 million under the bilateral assistance program with the Governments of Germany, France and Japan contributing US $2 million, US $3 million and US $5 million respectively.

Out of the total amount, US $28.5 million was allocated for CTC production phase-out, US $21.5 million for CTC consumption phase-out and US $2 million were allocated for TA component. The World Bank is the lead implementing agency, the Governments of Germany, France and Japan (bilateral agencies) and UNIDO were cooperating agencies for implementation of the National CTC consumption phase-out activities. Besides, UNDP, on behalf of Government of Japan, is responsible for executing conversion activities from CTC to non-ODS technologies in large and medium enterprises in metal cleaning sub-sectors.

Production Sector: The CTC producing enterprises, M/s. SRF Ltd., New Delhi, M/s. Chemplast Sanmar Ltd., Chennai, M/s. Gujarat Alkalies and Chemicals Ltd., Vadodara signed the performance agreement and submitted an Indemnity bond for meeting the production phase-out targets. M/s. Shriram Rayons Ltd., Rajasthan and M/s. NRC Ltd., Mumbai have already closed down their production facilities. The production of CTC in the country has successfully been phased out as of 1st January, 2010 except co-production of CTC during the production of chloromethane and the co-produced CTC is being used only for feedstock applications.

Consumption Sector: CTC was used as feedstock primarily in the production of CFCs and DV Acid chloride. CTC was also used in India as a process agent and a solvent. For process agents, CTC was used in sectors such as chlorinated rubber, chlorinated paraffin, pharmaceutical, and agro-industries. CTC was used as a solvent in the textile, garment industries, metal cleaning etc.

In 2006, a total of 103 CTC projects, covering both process agent and solvent applications were identified and the phase-out of CTC in these applications was taken up by the implementing agencies. The CTC consumption phase-out projects have been successfully implemented and resulted in phase out of 2,080 ODP tonne of CTC. The consumption of CTC had been phased out completely in the country since 1st January 2010 as per the Montreal Protocol schedule.

Technical Assistance was provided to replace CTC used in stain removal work for small garment manufacturers and metal cleaning. The fast reduction in the supply of CTC had increased the CTC price significantly in the country and that motivated the MSMEs to move away from CTC. GIZ carried out extensive work in testing of alternatives that meet health, safety and environmental standards. A countrywide survey was carried out to identify MSMEs using CTC in the metal cleaning sub-sector. The survey identified 51 eligible MSMEs which were using CTC in metal cleaning. These enterprises were provided funding towards incremental capital and operating costs for phasing out of CTC in metal cleaning sector.

The achievement of CTC phase-out in two widely dispersed industry sectors, namely, the garment manufacturing and metal cleaning has also been realized through awareness programmes and policy measures, especially those which influenced the availability and pricing of CTC and its alternatives.

The production and consumption of CTC have been completely phased-out as of 1st January, 2010.

Since 2011, the Ozone Cell, MoEF&CC carried out technical assistance activities, including awareness for sustaining the phase- out of CTC in different applications, except in feedstock use.

As part of the remaining activities under the Technical Assistance component of the project the following activities were carried out:

a) 12 stakeholder consultative workshops were organized across the country with the objective to create awareness to all the concerned stakeholders on all issues relating to ODS, including sustainability of ODS phase out, particularly CTC, issues related to reporting mechanisms, including for CTC, which continues to be produced, primarily from DV acid chloride production, to be used for feed stock applications.

b) A study on CTC usage in India for feedstock applications was carried out to assess the co-production of CTC during production of Chloromethane and document the use of CTC in various feed stock applications.

c) A publication of National CTC Phase out: India's Success Story was developed highlighting India's achievements in the phase out of production and consumption of CTC as per the Montreal Protocol schedule. The proactive steps taken as well as measures taken to address the challenges during implementation are also highlighted.

CFC phase-out in Aerosol Sector

Aerosols are widely used in several applications involving propellants, including perfumes, shaving foams, insecticides, pharmaceuticals, paints and inhalers. CFC-11 and CFC-12 were commonly used as propellants in this sector. By the end of 2002, a total of 26 investments and technical assistance projects were completed with a total funding of US $6.5 million, leading to a total phase-out of 637 ODP tonne of CFCs in Industrial Aerosol Sector. The Ex-Com of the MLF in its 38th meeting held in November, 2002 approved a terminal umbrella project in this sector with a funding of US $0.58 million to phase-out remaining CFC consumption of about 52 ODP tonne in this sector. The consumption of CFCs in aerosol sector had been completely phased-out as early as December, 2003.

Industry Structure: The total production of aerosol containers in 1991 was estimated to be 45 million, of which over 90% used CFCs as propellants. About 200 aerosol manufacturers were identified, concentrating mainly in the western and northern parts of India. All enterprises were in the private-sector. A significant majority of these enterprises (about 70%) were MSMEs, many of which were in the informal sector, principally, manufacturing personal care products such as perfume and deodorant sprays.

ODS Consumption in Aerosol Sector: In 1991, the Aerosol sector consumed 1,100 MT of CFCs (about 40% CFC-11 and 60% CFC-12), which amounted to about 22% of India's total CFC consumption at that time. It was estimated that the demand for aerosol products would grow at 20% annually until 2000, 18% annually until 2005 and 15% annually until 2010. These estimates were based on considerations such as emerging customer base for personal care products, entry of multinational corporations in India leading to expansion of the manufacturing base in this sector, reduction in taxes on cosmetic aerosols, etc.

Technology: Hydrocarbon based aerosol propellants were identified in most of the aerosol sub-sectors as the preferred substitute technology for phasing out CFCs, specifically, butane, destenched Liquefied Petroleum Gas (LPG), etc.

The MSMEs predominantly used locally developed manual propellant filling machines, which were suitable for CFC propellants, but considered unsafe and unsuitable for hydrocarbon-based substitute propellants. Moreover, many of the MSMEs had manufacturing facilities in locations which could be considered unsafe for handling hydrocarbon-based propellants. Thus, safety measures for handling hydrocarbons including safety training and audits were identified as important inputs, in addition to investments needed for conversions.

The consumption of CFCs in Aerosol Sector has already been completely phased out as early as December, 2003 except use of pharmaceutical grade CFCs in manufacturing of medical aerosols, MDIs for Asthma and COPD patients.

National Strategy for Transition to non-CFC MDIs and Plan for Phase-out of CFCs in Manufacturing of Pharmaceutical MDIs

The National Strategy for Transition to Non-CFC MDIs and Plan for Phase-out of CFCs in manufacturing of Pharmaceutical MDIs was approved by the Ex-Com of the MLF in its 56th meeting held in November, 2008 with a total funding of US $10.2 million to phase-out 704.03 ODP tonne of CFCs. This project articulated India's national strategy for transition to non-CFC MDIs gradually without affecting the Asthma and COPD patients and the elimination of CFC consumption in manufacturing of MDIs in India.

The National Strategy for phase-out of CFCs in MDIs had been implemented successfully by UNDP as lead implementing agency in association with Government of Italy (bilateral agency) and UNEP, in close cooperation with the MDI manufacturers under the guidance of Ozone Cell, MoEF&CC.

National Awareness Workshops were organized for the stakeholders, especially the MDI manufacturers and physicians treating the asthma and COPD patients. A workshop on "Phase-out of CFCs in MDIs Transition Strategy Implementation and Adoption of CFC free Alternatives in India" was held on 5th October, 2009 at the All India Institute of Medical Sciences (AIIMS), New Delhi in collaboration with Ministry of Health and Family Welfare (MoHFW) and UNEP. Another National Consultative Workshop on Policy and Regulations was organized on 20th May, 2010 at Central Drugs Standard Control Organization, MoHFW, New Delhi. A regional awareness workshop on phase-out of CFCs in manufacturing of MDIs was organised on 1st October, 2010 at Pune. These workshops were well attended by the stakeholders including medical representatives. The medical representatives are the key stakeholders to create awareness among the physicians across the country. During the workshops the MDI manufacturers shared that a number of CFC free MDIs have been developed and placed in the market.

The pharmaceutical grade CFCs were needed during transition phase in 2010 and beyond by the MDI manufacturing industry. The same were obtained through the Essential Use

Nomination (EUN) process of the Montreal Protocol for 2010. India submitted the EUN for 2010 for 350.6 MT of pharmaceutical grade CFCs and the 21st MOP held in November, 2009 approved 343.6 MT of CFCs for India for 2010. India had also submitted the EUN for the year 2011 for 192.3 MT, but the same was withdrawn in consultation with MDI manufacturers as the progress made by MDI manufacturers was commendable and the MDI manufacturers decided not to seek any CFCs for manufacturing of MDIs for 2011 and beyond. The MDI manufacturers have converted all the CFC based MDI formulations to CFC-free and placed in the market. Currently, all the formulations of MDIs available in the market are CFC-free since 2011.

The 22nd MOP held in November, 2010 congratulated India for its outstanding achievement in early phase-out of the use of pharmaceutical grade CFCs in manufacturing of MDIs.

UNDP, as lead implementing agency, carried out an independent verification through a MDI International Expert in November, 2012 for all the 4 MDI manufacturing facilities to verify the phase-out of use of CFCs in manufacturing of MDIs. The verification confirmed that conversion from CFC based MDIs to CFC-free MDIs has already been achieved in India.

A verification-cum-review of progress made by each of the manufacturers was undertaken by the MLF through an independent expert along with UNDP to ascertain the implementation of CFC phase-out in the manufacturing of MDIs in February, 2014. It was reported that CFCs have been phased-out in manufacturing of MDIs in the country.

UNEP under the guidance of Ozone Cell, MoEF&CC organized two awareness workshops, one at Sri Ramaswamy Memorial (SRM) University, Chennai on 19th August, 2014 and another at Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGI), Lucknow on 25th August, 2014 with the objective to create awareness for sustaining the phase-out of pharmaceutical grade CFCs in a critical medical use. Both these workshops were well attended by the physicians and pharmaceutical representatives who are the key stakeholders for promoting CFC-free MDIs among the asthma and COPD patients.

Recognizing the efforts and the pro-active role played by the MDI manufacturers in the phase out of CFCs in the manufacturing of MDIs, all the 4 MDI manufacturers were presented a plague during the awareness workshop on 19th August 2014.

Accelerated Phase-out of HCFCs

The control schedule of the Montreal Protocol for Article 5 Parties for phase-out of HCFCs prior to the 19th MOP was as follows:

Consumption

- Base level: 2015
- Freeze: January 1, 2016
- 100% reduction: January 1, 2040

Production

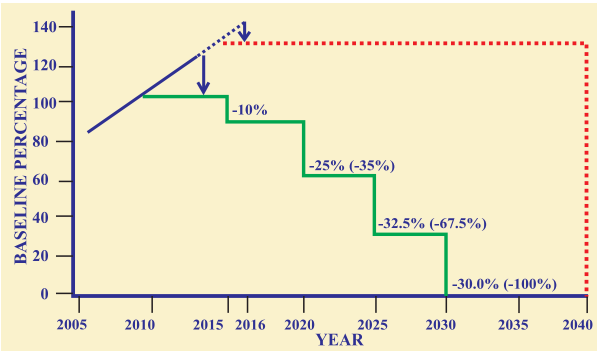
- Base level: Average of production and consumption in 2015
- Freeze: January 1, 2016, at the base level for production
- 100% reduction: January 1, 2040.

The 19th MOP held in September, 2007 took a decision to accelerate the phase-out of production and consumption of HCFCs for developed and developing countries. The new phase-out schedule for Article 5 Parties as per the decision of the 19th MOP is as follows:

- Base level: average of 2009 and 2010.
- Freeze: January 1, 2013
- 10% reduction: January 1, 2015
- 35% reduction: January 1, 2020
- 67.5% reduction: January 1, 2025

- 100% reduction: January 1, 2030 with a service tail of 2.5% annual average during the period 2030-2040.

The accelerated phase-out schedule of HCFCs for Article 5 parties is also depicted below:-



Allowing for servicing an annual average of 2.5% during the period 2030-2040

The implementation of the accelerated phase out schedule for HCFCs was a challenging task, especially the Stage-I targets, the 2013 freeze and 10% reduction in 2015, in emerging economies like India where there was growth in the use of these chemicals. These chemicals are widely used in various applications including RAC manufacturing, foam manufacturing, RAC servicing and other sectors. There was a lack of availability of technically proven, economically viable and environment friendly technologies. The annual consumption growth of these chemicals has been in the range of 10% to 15%. In actual sense, this amounted to phase-out of 30% to 40% by 2015, which was quite significant reduction in a very short time frame. This necessitated a long term vision and planning to successfully meet the obligations of the accelerated phase- out schedule of HCFCs.

Based on the decision of the 19th MOP, the Ex- Com of the MLF in its 54th meeting held in April 2008 vide its decision 54/39 approved the guidelines for preparation of HPMP Stage-I in Article 5 Parties. The 60th Ex-Com held in April 2010 finalized the guidelines for phase-out of HCFCs, except for the production sector which is still under consideration by the Ex-Com of the MLF.

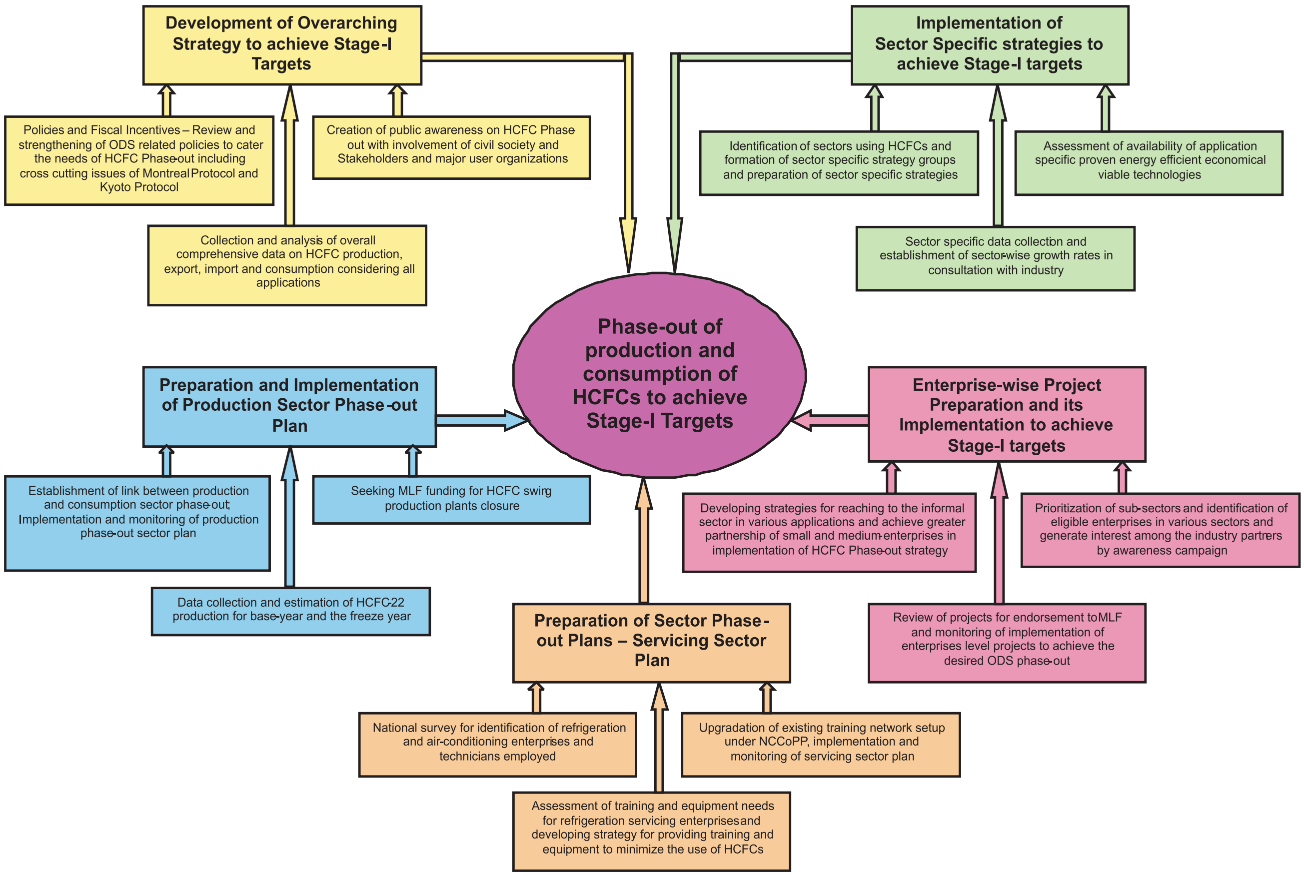
India's HPMP

The implementation of the accelerated phase out schedule for HCFCs was a challenging task, especially the Stage-I targets, the 2013 freeze and 10% reduction in 2015, in emerging economies like India where there was growth in the use of these chemicals. These chemicals are widely used in various applications including RAC manufacturing, foam manufacturing, RAC servicing and other sectors. There was a lack of availability of technically proven, economically viable and environment friendly technologies. The annual consumption growth of these chemicals has been in the range of 10% to 15%. In actual sense, this amounted to phase-out of 30% to 40% by 2015, which was quite significant reduction in a very short time frame. This necessitated a long-term vision and planning to successfully meet the obligations of the accelerated phase-out schedule of HCFCs.

Considering the future activities relating to phase-out of HCFC production and consumption in India to meet the compliance target as per the accelerated phase-out schedule, the UNDP was designated as the Lead Implementing Agency for HCFC phase-out in consumption sector and the UNEP, UNIDO, The World Bank and bilateral agencies comprising of Government of Germany and France etc., as cooperating implementing agencies.

HPMP Stage-I

The 56th meeting of the Ex-Com of the MLF held in November 2008 approved the preparation of HPMP Stage-I for India. Soon thereafter, detailed stakeholder consultative meetings including sectoral working group meetings for the foam manufacturing, RAC manufacturing and RAC servicing sectors were held. Based on the outcome of these meetings, a **"Roadmap for phase-out of HCFCs in India"** describing the long-term vision and action plan including the policy instruments for phasing



ROADMAP FOR PHASE-OUT OF HCFCs IN INDIA AT A GLANCE

out of production and consumption of HCFCs in India was developed and launched in October 2009.

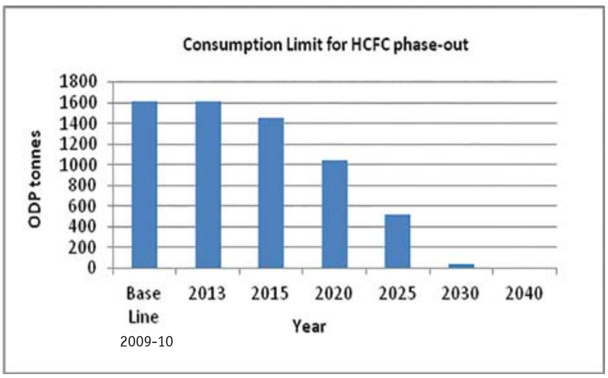
The Indian Polyurethane Association (IPUA) which represents key manufacturers and suppliers in polyurethane industry for furthering the interest of the polyurethane industry in India and the Refrigeration and Air-conditioning Manufacturing Association (RAMA), which represents key manufacturers and suppliers in RAC industry for furthering the interest of the RAC industry in India, were entrusted with the responsibility of preparation of sectoral strategies in the foam and RAC manufacturing sectors, in close cooperation with the UNDP and Ozone Cell, MoEF&CC. Both IPUA and RAMA conducted surveys involving market research consulting agencies and collected data, based on questionnaire developed for the purpose.

The sectoral strategies for phase out of HCFCs in foam and RAC manufacturing sectors were developed after analysis of the data and taking into account the phase-out targets to be achieved for HCFCs as per the accelerated phase out schedule of the Montreal Protocol, the policy guidelines of the Ex-Com of the MLF and the present and likely future industry structure in the respective sectors. India prioritized phase-out of HCFC141b (having high Ozone Depleting Potential (ODP) in foam manufacturing sector in the large HCFC consuming enterprises. The RAC Servicing strategy was prepared by GIZ, Govt. of Germany as implementing agency. All the sectoral strategies were developed in close cooperation with the Ozone Cell, MoEF&CC and the Implementing agencies.

The consumption phase out limits for India are as follows:

HCFC Phase-out Limits for India

Montreal Protocol Maximum Allowable Consumption of Levels of Annex C Group 1 Substances	Consumption Limit (ODP tons)
Baseline (2009-2010 average)	1608.20
2013- Freeze on baseline levels	1608.20
2015- 90% of the baseline	1447.38
2020- 65% of the baseline	1045.33
2025- 32.5% of the baseline	522.67
2030- 2.5% of the baseline	40.21
2040- No consumption	0



A two-day stakeholder workshop was organized in October, 2011 for finalization of sectoral strategies and overarching HPMP Stage-I. Based on the inputs received during the workshop and keeping in view the phase out targets to be achieved as per the accelerated phase out schedule for HCFCs, the domestic and international requirements for accelerated phase-out and the Ex-Com prioritization policy of substances to be phased-out based on Ozone Depleting Potential (ODP), availability of alternative technologies and the capability of the industry to adapt to these alternative technologies, India prioritized phase out of HCFC 141b in the foam manufacturing sector in large manufacturing enterprises, who could effectively handle cyclopentane as a blowing agent, the available low GWP alternative having negligible ODP.

The HPMP Stage-I was finalized to address phase out of HCFC 141 b in 15 large enterprises in the domestic refrigeration, continuous sandwich panel and discontinuous sandwich panel subsectors. Also, technical and financial assistance was secured for 15 systems houses for developing HCFC free polyol formulations, which would assist the Micro Small and Medium Enterprises (MSMEs) to cost-effectively phase-out HCFCs as this was critical for phase-out of HCFCs in the foam sector during HPMP Stage-II. In addition, in the RAC servicing sector activities comprising technicians training, institutional strengthening for effective use of HCFC based equipment and awareness and enforcement training as part of the enabling component, were also included.

The HPMP Stage-I was approved by the Ex-Com of the MLF in its 66th Meeting held in April, 2012 to reduce 341.77 ODP tonne of HCFC from the starting point of 1691.25 ODP tonne with a total funding of US $ 23,011,537 including implementing agency support costs.

Since the approval of the HPMP Stage-I, several activities have been undertaken by the Ozone Cell, MoEF&CC in close cooperation with the implementing agencies and stakeholders. A Stakeholders Workshop was organized in February, 2013 during which the HPMP Stage-I was launched and implementation of activities was initiated towards achieving the compliance targets for the HPMP Stage-I in accordance with the agreement signed between the Ex-Com of the MLF and the Government of India.

Phase-out activities in the Foam manufacturing sector

Conversion projects from HCFC 141b to non-ODS blowing agents have been successfully implemented in 8 domestic refrigeration, 2 continuous sandwich panel and 5 discontinuous sandwich panel sub-sectors. All the 15 enterprises have stopped using HCFC-141b as a blowing agent in the foam manufacturing sector from 1.1.2015. The phase-out as well as project implementation has also been independently monitored and verified through a third-party consultant appointed by the UNDP.

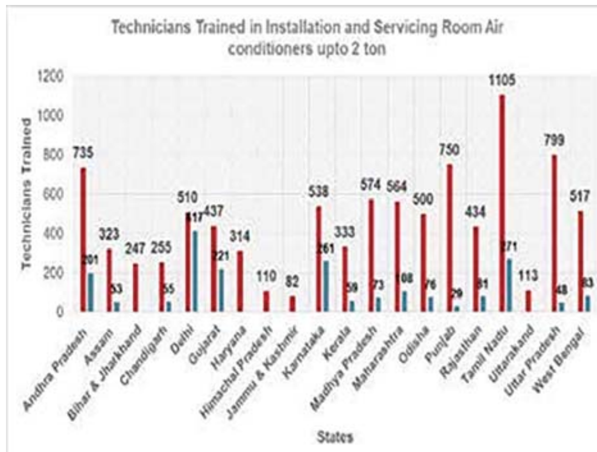
Systems Houses assisted under the project have developed formulations based on HCFC free alternatives that can be adopted by the user enterprises. The use of non-ODS pre-blended polyols is finding acceptability and its penetration is determined by commercial factors. The System Houses have used Ecomate, Methylal and cyclopentane as blowing agents for developing pre-blended polyols.

Phase-out activities in the RAC servicing sector

GIZ Proklima and UNEP are cooperating agencies for implementation of activities under the servicing sector, which includes technicians training and awareness generation under the HPMP. GIZ Proklima has been entrusted with the responsibility to coordinate with UNEP for the enabling component.

Implementation of technicians training programs

The training programs for the RAC technicians in room air conditioners up to 2 ton were conducted in the country, through two training modules, one module was for installers and the other module for service technicians. Both the training modules included theory classes and practical sessions. The trainings were conducted in urban and semi urban cities / towns in the country. The trainings were organized through the network of Training Partners and the team of trainers in the country. The trainers were trained through three Training of Trainers programs by leading international faculty/ consultants, wherein, 50 trainers were trained. Training materials comprising presentations, handbook, to be used as a reference material, posters and stickers were developed for the technicians and the trainers. The handbook was prepared in English and Hindi. The performance of the trainers and the quality of the training programs were monitored by external consultants. About 10% of the training programs were monitored. Each Training Partner was supported by set of equipment and tools required for conducting the practical / hands on training during the training programs. Under HPMP I, a total of 11,276 technicians through 408 training programs. Under the module for servicing - a total 9,240 technicians were trained through 332 training programs and under the module for installers - a total 2,036 technicians were trained through 76 training programs.



Strengthening of training for institutional users

Institutional users like Defence sector and Indian Railways have a substantial inventory of all their HCFC based equipment / appliances. Both defence sector and Indian Railways undertake phase-out measures as part of their institutional policy. Training programs were organized for technicians of both these users. One training program for the Defence sector and three training programs for the Indian Railways have been organized. The Government Industry Training Institutes (ITIs) trains students in the trade of RAC. Their present syllabus is proposed to be adapted to ODS free servicing and Good Service Practices for HCFC based systems. Discussions with the Directorate General for Employment and Training (DGET) officers were held for syllabus updation.

Reclamation Centres

Promotion of recovery and reclamation in the private sector on a pilot basis was initiated. This would facilitate assessment of loop holes and support required by the reclamation centres. Two regional workshops were organized. Observations and findings from these meetings and regional workshops were shared with the Core Group constituted for monitoring the implementation of the Montreal Protocol activities in the country.

Enabling Component (awareness and communication, enforcement training, capacity building and trade controls

The UNEP has been implementing activities under the enabling component for the servicing sector, building sector interventions, enforcement training, trade controls, policy and regulation and awareness generation. The following are the main activities that have been implemented:

Creating awareness among the RAC sector stake holders by organizing workshops for RAC spare parts dealers, refrigerant suppliers, Heating, Ventilation and Air-Conditioning (HVAC) contractors, RAC associations viz. RAMA, Indian Society of Heating, Air-conditioning & Refrigeration Engineers (ISHARE), Academia, Customs, Environmental Non-Governmental Organizations (NGOs), Government officers and officials, service sector technicians, railways. The workshops covered topics relating to Good Servicing Practices, recovery, recycling and reclamation of refrigerants, alternative technologies and refrigerants, phase-out of HCFC, impact of ODS on the environment. The workshops highlighted on the upcoming challenges with respect to technology and emerging alternative refrigerants like Hydrocarbons and Hydrofluorocarbons (HFCs) and HFC blends, tools and equipment for good servicing and their demand by service technicians, strengthening adequate knowledge on issues of flammability, toxicity coupled with impact on best operating practices of alternative refrigerants, preventing leakage of refrigerants during transfer from larger to smaller cylinders.

Refrigerant identifiers worth US$140,000 were procured and supplied to the Customs. Refrigeration and Air-conditioning Service Sector Society (RASSS) was established and registered as a society under the Societies Registration Act (XXI of 1860) and as amended by Punjab Amendment Act, 1957. Presently RASSS has about 1800 members in 6 chapters across the country.

Flyers, Posters and Stickers were designed, printed and distributed during the technicians training programs to get them acquainted with the Good Servicing Practices, which have been explained through easy to understand caricatures.

To disseminate information about the project, its activities and other relevant information a website has been developed (www.rasss.org).

Preparation of videos on Good Servicing Practices, newsletter to keep the technicians and concerned stakeholders up to date on upcoming alternative refrigerants, development of amendments for non-HCFC building codes and template for amending curriculum of architectural colleges to include ODS issues were also undertaken.

The enforcement capacity building with respect to mainstreaming HCFC issues/subjects in the general training curricula of National Academy of Customs Indirect Taxes and Narcotics (NACIN) was also undertaken.

Impacts of HPMP Stage-I

India successfully met the 2013 target of freeze of HCFC production and consumption and 10 % phase-out targets of HCFCs in 2015, as per the accelerated phase out schedule of the Montreal Protocol.

Through the HPMP Stage-I, a total of 341.77 ODP tonne of HCFCs have been phased out, of which 310.53 OPD tonne is of HCFC 141b in the foam manufacturing sector and 31.24 ODP tonne is for HCFC-22 in the RAC servicing sector, in accordance with the agreement between the Government of India and the Ex-Com of the MLF. The net direct emission reductions are thus 3,071,260.5 CO_2 eq.tonne.

HPMP Stage-II

The Ex-Com of the MLF in its 72nd meeting held in May, 2014 has approved US $ 490,000 for the preparation of HPMP Stage-II for India with UNDP as the lead implementing agency in association with UNEP and GIZ, Government of Germany as cooperating agencies. The HPMP Stage-II would address phase-out of HCFCs in various sub-sectors of foam manufacturing, RAC manufacturing and RAC servicing sector. The HPMP Stage-II would also include strategy for awareness among the stakeholders and training of enforcement officers across the country.

The Ex-Com of the MLF during its 74th meeting held in May, 2015 approved the policy guidelines for HPMP Stage-II in the consumption sector.

In order ensure proactive involvement and ownership of HCFC phase-out by the industry, industry associations, namely, RAMA and IPUA, were involved in the HPMP Stage-II preparation process. Under the overall supervision and guidance of the, MoEF&CC, IPUA and RAMA were responsible for providing sector inputs for achieving HPMP Stage-II targets. They also had the responsibility for carrying out survey of the Foam and RAC sectors respectively and for information out-reach at the sector-level. The Implementing and bilateral agencies provided technical inputs, guidance for HPMP preparation process and inputs for HCFC phase-out.

To adequately inform the stakeholders of the challenges and opportunities in complying with the phase-out schedule for HCFCs, 3 workshops each in foam and RAC sectors were held in Delhi, Mumbai and Chennai during October 2015 by the IPUA and RAMA for their respective sectors. The workshops were well-attended and served as a platform for both information outreach and exchange with participants on data collection process and the prevailing policy guidelines for HPMP. Inputs were provided by technical experts on industry trends and status of alternatives for various applications.

Appropriate questionnaires and formats for reporting information and data were developed in cooperation with the implementing agencies. IPUA and RAMA were engaged for collecting data at sectoral/sub-sectoral level and for developing sector-level strategies and recommendations, for achieving reductions in HCFC consumption. IPUA and RAMA engaged professional survey agencies for data collection at enterprise-level.

The data analysis at the sector level included classification based on historical and present HCFC consumption by sub-sector and application, eligible and ineligible enterprises and their consumption, projected growth trends until baseline and thereaf ter, required reductions in HCFC consumption for meeting the phase out targets as per the accelerated phase out schedule for HCFCs and availability of deployable alternative technologies for each sector/subsector. At the national level, data reconciliation was carried out through interactions with DGFT and Directorate General of Commercial Intelligence and Statistics (DGCIS), Ministry of Commerce and Industry and a draft HPMP stage-II was developed. A stakeholder's workshop was held on 5th August 2016 at New Delhi where in the draft HPMP Stage-II was presented. Based on the inputs from the workshop, the HPMP Stage-II was finalised and submitted to the Ex-Com of the MLF.

Approval of India's HPMP Stage II

India's HPMP Stage-II was considered and approved at the 77th meeting of the Executive Committee (Ex-Com) meeting of the MLF for Implementation of the Montreal Protocol held from 28th November to 2nd December, 2016 at Montreal, Canada.

Under HPMP Stage-II, India has secured 48.3 million USD form the MLF including implementing agencies support costs for the implementation of the Montreal Protocol for phasing out 8,190 MT of HCFC consumption between 2017 to 2023, in order to meet the compliance target under Montreal Protocol for 2020. Around 400+ enterprises including 300+ Micro, Small and Medium Enterprises (MSMEs) in the foam manufacturing sector and 6 large air conditioning manufacturing enterprises, who volunteered to participate, would be supported under HPMP Stage-II for conversion from HCFCs to non-HCFCs technologies.

Launch of HPMP Stage-II

The HPMP-II was launched on 6th March, 2017 at New Delhi by late Shri Anil Madhav Dave, the then Hon'ble Minister of Environment, Forest and Climate Change in a stakeholder meeting where officers of the Ministries and Organizations of the Central Government, State Governments, representatives from industries, stakeholders including NGOs and implementing agencies associated with the implementation of the HPMP II viz. UNDP, GIZ and UNEP, were present.

Launch of the HCFC Phase-Out Management Plan Stage - II in a function held on 6th March, 2017, at New Delhi, India

Salient features of HPMP Stage-II

The HPMP Stage-II specifically focusses on the MSME sector in foam manufacturing. Adequate attention has also been given to synergize the RAC servicing sector training under HPMP Stage-II with the Skill India Mission of the Government of India, in order to multiply the impact of skilling and training. It is estimated that nearly, 16000 service technicians will be trained under HPMP-II.

The HPMP-II also provides for promotion of energy efficiency, development building codes integrating HCFC phase out issues, cold chain development with non-HCFC alternatives and development of standards for new non-ODS and low GWP alternatives, while transitioning away from HCFCs. It is expected that there would be a net direct CO_2-equivalent emission reductions of about 8.5 million metric tonne annually from 2023 onwards.

Under the Montreal Protocol, the accelerated phase out of HCFCs is underway with a phase out of HCFCs by 2030. HCFCs presently are being used in various sectors, inter alia including Refrigeration and Air conditioning sector, foam manufacturing sector etc. These sectors, as such, are cross-cutting and are directly related to sectors such as urban development, agriculture through cold chain sector, and industrial development. India is undertaking phase-out of HCFCs through the implementation of HPMP.

HCFC Reductions through HPMP Stage-II

The required level of reduction in HCFCs consumption in the year 2020 as per the target under the Protocol and the allowable consumption of HCFCs in different years in the range of 2017 - 2023, as per the approved HPMP-II is given in Table 18.

Table 18: Reductions for Compliance with 2020 and approved targets as per HPMP Stage-II

S.No.	Particulars	2016	2017	2018	2019	2020	2021	2022	2023
1	Montreal Protocol Reduction Schedule (ODP tons)	1447.38 90% of baseline	1447.38 90% of baseline	1447.38 90% of baseline	1447.38 90% of baseline	1045.33 65% of baseline	1045.33 65% of baseline	1045.33 65% of baseline	1045.33 65% of baseline
2	Maximum allowable consumption as per HPMP-II (ODP tons)	1447.38 90% of baseline	1447.38 90% of baseline	1433.63 89.15% of baseline	1103.85 68.64% of baseline	832.32 51.75% of baseline	799.76 49.73% of baseline	698.82 43.45% of baseline	643.28 40% of baseline
l	Reductions Required (ODP tons)	—	—	13.75	329.78	271.53	32.50	100.94	55.54

Implementation of HPMP Stage-II

The Local Project Appraisal Committee, in its meeting held during September 2018 and Chaired by Department of Economic Affairs, Ministry of Finance, gave in principle approval for HPMP Stage-II.

The UNDP appointed a third party for carrying out due diligence of the enterprises that participated in the survey carried out by IPUA for the foam manufacturing sector and the 6 enterprises that volunteered to participate in the HPMP Stage-II. Based on recommendations of UNDP on the third-party verification reports of enterprises, the Ozone Cell has initiated signing of Memorandum of Agreements (MOAs) with the enterprise in both foam manufacturing and air conditioning manufacturing sectors.

More than 400 enterprises, including 300+ Micro, Small and Medium Enterprises (MSMEs) in the foam manufacturing sector and 6 large air-conditioning manufacturing enterprises were surveyed for participation under HPMP-II for conversion from HCFCs to non-HCFC technologies. Eight Stakeholder consultative meetings with foam manufacturing sector enterprises were held on 1st November 2018, 15th November 2018, 19th November 2018, 20th November 2018, 13th December 2018, 24th December 2018, 8th February 2019, and 5th March 2019 with all the 400 plus enterprises surveyed earlier for participation in HPMP Stage II and to explain the documentation requirements for the enterprises for participation in HPMP Stage-II.

Third party verification of these enterprises is being carried out with respect to their eligibility for participation in HPMP Stage-II. Further, additional enterprises in order to have maximum participation of foam manufacturing enterprises in HPMP Stage-II efforts have been additional enterprises based made to identify upon data available from CFC phase-out programme, market information, additional applications received from enterprises. These enterprises were also subjected to third party verification with respect to their eligibility for participation in HPMP Stage-II.

Memorandum of Agreements have been entered with some enterprises after third party verification and recommendation of UNDP in Refrigeration and Air Conditioning (RAC) and foam manufacturing sector for conversion from HCFC to non-HCFC technologies.

Project implementation agreements have been signed with the UN environment for the enabling activities and with the GIZ, Proklima, Government of Germany for activities in the RAC Servicing Sector.

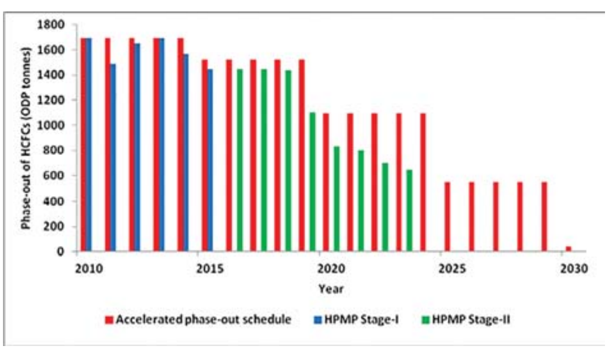
As part of the implementation of activities in the servicing sector, two Training of Trainers (TOT) workshops have been organized in Bengaluru and Jaipur during August 2018. The training programmes for the RAC technicians will commence from October 2018.

The request for second tranche of approximately USD 18 million was submitted by UNDP on behalf of India for the consideration of 82nd meeting of the Executive Committee (Ex-Com) of the Multilateral Fund (MLF). Based upon the discussions held in 82nd meeting of the Ex-Com in December, 2018 the second tranche of US $18,190,815 was approved under HPMP Stage-II.

Impact of HPMP Stage-II

Ozone Layer Protection

Successful implementation of the HPMP Stage-II in India will result in a sustainable phase-out of 769.49 ODP tons of HCFCs.



Impact of HPMP Stage-I And HPMP Stage-II in Phase-out of HCFCs

Direct GHG emissions

Due to the relatively high GWP of HCFCs, their phase-out will result in reduced direct GHG emissions. The net contribution towards reduction of direct CO_2 emissions due to successful implementation of HPMP Stage-II are 4,262,100 MT CO2 Eq. per year from 2020 and 7, 697, 600 MT CO2 Eq. per year from 2023.

Fiscal Measures

The Government of India has granted exemption from payment of Customs and Excise duties on capital goods required for ODS phase out projects funded by the MLF since 1995. In 1996, the Government of India further extended the benef it of Customs and Excise duty exemptions for ODS phase-out projects which were not funded by the MLF. The benefit is available subject to the condition that enterprise gives clear commitment for stop using the ODSs in all future manufacturing operations after the completion of implementation of project(s).

The benefit of duty exemption has been extended for new capacity as well as expansion of capacity with non-ODS technologies since 1997.

The Indian financial institutions have decided not to finance/re-finance new ODS producing/ consuming enterprises.

The Tariff Advisory Committee (TAC), a statutory body under the Insurance Act, 1938 has decided to grant suitable discounts on fire insurance premiums if alternative fire extinguishing agents are used in place of halons in fire extinguishing systems.

Ozone Depleting Substances (Regulation and Control) Rules, 2000

In accordance with the National Strategy for ODS phase-out, the MoEF&CC, Government of India, has notified Ozone Depleting Substances (Regulation & Control) Rules, 2000 in the Gazette of India on 19th July, 2000, covering various aspects viz. production, consumption, export and import of ODSs. These rules have been subsequently amended from time to time. Most recent amendment being in 2014.

Important provisions of the Ozone Depleting Substances (Regulation and Control) Rules, 2000

These Rules prohibit the use of CFCs in manufacturing various products beyond 1.1.2003 except in MDIs and for other medical purposes. Similarly, use of halons is prohibited after 1.1.2001 except for servicing. Other ODSs such as CTC and methyl chloroform and CFC for MDIs were allowed to be used upto 1.1.2010. Further, the use of methyl bromide has been allowed upto 1.1.2015. Since HCFCs are low-ODP substances and are also used as interim substitutes to replace CFCs, these are allowed to be used upto 1.1.2030 as per the Montreal Protocol accelerated phase-out schedule.

As per Rules, there is a need for compulsory registration of ODS producers, manufacturers of ODS based products, importers, exporters, stockists and sellers and the same provision is applicable to manufacturers, importers and exporters of compressors and other products containing ODSs. They are also required to maintain records and file periodic reports for monitoring production and consumption of ODSs. Enterprises which have received financial assistance from MLF for the implementation of the Montreal Protocol for switchover to non-ODS technology have to register the date of completion of their project(s) and declare that the equipments used for ODS have been destroyed. Creation of new capacity or expansion of capacity of manufacturing facilities of ODSs and ODS based equipment have been prohibited. Purchasers of ODSs for manufacturing products containing ODSs, are required to declare the purpose for which ODSs are purchased. All imports and exports of ODSs and products containing ODSs require a license.

The recommendation of the MoEF&CC is essential before issuing any license for import and export of ODSs and products containing ODSs by the Directorate General of Foreign Trade (DGFT), Ministry of Commerce and Industry.

These rules also specify phase-out dates for different ODSs in manufacturing of products using these ODSs. In addition, these Rules also ban trade in ODSs with non-Parties.

Amendments

The Ozone Depleting Substances (Regulation & Control) Rules, 2000 have been amended in 2001, 2003, 2004, 2005, 2007 and 2014.

The 2001 Amendment extended the last date of registrations from one year to two years after the commencement of the Rules. The Amendment 2003 refers to a correction of a typographic error. The amendment 2004 specified the date of registration for substances listed in Group IV of Schedule I (CTC) and for substances listed in Group VI of Schedule I (HCFCs) on or before 31st December, 2004 and on or before 19th July, 2007 respectively. Subsequently, the Rules were amended in 2005, the registration date for substances listed in Group IV of Schedule I (CTC) was extended upto 31st December, 2005. The Rules were further amended on 18th September, 2007. As per the amended rules, registration has been extended for substances listed under Group I, Group II, Group III and Group IV upto 31st December, 2009, in case of substances in Group VI upto 31st December, 2039 and in case of substances in Group VIII upto 31st December, 2014 and the existing registered enterprises need not apply for renewal.

The Ozone Depleting Substances (Regulation and Control) Rules, 2000 have been amended to align with the accelerated phase-out of HCFCs. A draft amendment of ODS Amendment Rules, 2014 was prepared by the Ozone Cell, MoEF&CC and circulated among the concerned stakeholders, including industry associations, DGFT etc. Subsequently, a consultative meeting was organized in October, 2012 where a large number of stakeholders participated in the meeting to further discuss the salient features of the amendment.

The draft amendment was updated incorporating the inputs received from the participants during the meeting and written comments sent by the par ticipants. The draf t amendment was submitted to the Ministry of Law and Justice for vetting after due approval of the then Hon'ble Minister for Environment, Forest and Climate Change.

The draft of amendment of Ozone Depleting Substances (Regulation and Control) Rules was published in the Gazette of India in May, 2013 for inviting comments/suggestions from the public on the draft Rules. Subsequently, the Ozone Depleting Substances (Regulation and Control) Amendment Rules, 2014 were published on 4th April, 2014 in the Gazette of India. The salient features of the Ozone Depleting Substances (Regulation and Control) Amendment Rules, 2014 are:

- The production and consumption of Group VI substances (HCFCs) has been proposed to be controlled according to the accelerated phase-out schedule of the Montreal Protocol.

- Introduction of quota system by the Government for production and consumption of Group VI substances (HCFCs) for non-feedstock applications and monitoring and reporting system for all feedstock applications including use of Carbontetrachloride in order to comply with phase-out targets of the production and consumption of Group VI substances (HCFCs).

- Prohibition of issuance of license for import and export for Group I, Group II, Group III, Group IV and blends containing ODSs including Group VI substances except recovered, recycled and reclaimed ODSs or for EUN, if any or ODSs for destruction or for feedstock applications.

- Prohibition of issuance of license for import of pre-blended polyols containing Group VI substances (HCFCs).

- Ban on creating new capacities to manufacture products made with or containing Group VI substances (HCFCs).

- In order to control the inventory of HCFC based refrigeration and air-conditioning equipments and reduce the consumption of HCFCs in servicing of these equipments in future years, import of air-conditioning and refrigeration equipments and other products using HCFCs from 1st July, 2015 has been prohibited.

- Exemption for production of Group VI substances (HCFCs) for the Protocol approved feedstock uses in manufacturing of other chemicals, with negligible emissions, if any.

Kigali Amendment to the Montreal Protocol

HFCs do not deplete the Ozone layer. However they have high GWP. It is significant to note that the negotiations for phasing down of HFCs under the Montreal Protocol were initiated way back in 2009, but these negotiations gathered momentum only after India submitted an amendment proposal for phase down of HFCs under the Montreal Protocol in April, 2015. The Indian Amendment proposal was crafted in a way to balance the needs of our rapidly growing economy and achieve maximum climate benefit. There were 4 amendment proposals viz (i) North American Proposal (Canada, USA and Mexico), Micronesia And Island States Proposals, Indian Proposal and (iv) European Union Proposal.

The issue of phase down of HFCs under the Montreal Protocol was also brought into focus through Joint Statement of Prime Minster of India and President of United State of America (USA) in June, 2016, wherein, it was resolved to work to adopt an HFC amendment in 2016 with increased financial support from donor countries to the MLF to help developing countries with the implementation, and an ambitious phase down schedule, under the Montreal Protocol pursuant to the Dubai Pathway, agreed by the 27th Meeting of Parties held at Dubai, United Arab Emirates from 1st to 5th November, 2015.

The 27th MOP decided to work within the Montreal Protocol to the HFC amendment in 2016 by first resolving challenges by generating solutions in the contact group on the feasibility and ways of managing HFCs at the Montreal Protocol meetings and then address the amendment proposals. It was also decided by the 27th MOP to hold a series of Open Ended Working Group (OEWG) and other meetings including an Extraordinary MOP in 2016.

In the two OEWG meetings (37th OEWG and Resumed 37th OEWG) the parties were able to address identified challenges for managing HFCs. During the 3rd Extraordinary MOP held in Vienna, a new joint proposal was submitted by USA, European Union, Japan, New Zealand, Australia (JUSSCANZ) according to which the developed countries had suggested one single common baseline years for production and consumption of HFCs for developing countries i.e. 2017-2018-2019 and freeze year as 2021. However, various developing countries proposed as many as six different baselines range from 2017 to 2030, and freeze year ranging from 2021 to 2031.

India represents only around 2% of the global production and consumption of HFCs but our manufacturing and consumption sector is expected to grow at a rapid pace in future. Our challenge, therefore, was to secure international agreement on a regulatory regime that served the global expectations and yet protect our national interest.

India has been a strong advocate of the principle of Common but Differentiated Responsibility in the matter of global actions to protect environment and also that national circumstances need to be factored in for arriving at any durable agreement related to climate.

At the commencement of negotiations in Kigali, India piloted realistic baseline of 2024-2026 for developing countries and which protects India's interests. As per the agreement reached in Kigali, India will freeze its manufacturing and consumption of HFCs in 2028 and start reducing it from 2032 to 2047 with reference to the baseline years 2024, 2025 and 2026. The Freeze year is subject to technology review and could be further deferred to 2030. The agreement facilitates adequate carbon space for growth on domestic industry while minimizing the cost to the economy during the transition period.

India had consistently taken a position that the baseline and freeze years should be at such a future date which allows for growth of economy while minimizing cost to the economy. The Indian delegation also had steadfastly raised the issues of Intellectual Property Rights of non-HFC technologies, the high cost of these technologies and resultant cost to economy in transitioning away from HFCs.

The 28th MOP held in Kigali from 10-15 October, 2016 adopted the amendment to the Montreal Protocol for phase down of HFCs.

In the Kigali Amendment, it has been agreed that the developing countries will have two set of baselines - one for the early movers in which case it will be 2020-2021-2022 and the other for those whose national circumstances were different and the manufacturing of HFCs and consumption in whose case was still rising in the absence of clear alternative technologies. In case of such countries the agreed baseline years are 2024, 2025 and 2026. An allowance of HCFC component of 65% was also added in the baseline of India in order to compensate for the upward movement of baseline years in Indian amendment proposal, the HCFC component was only 32.5%.

At the same time, it has also been agreed that the developed countries will reduce their production and consumption of HFCs by 70% in 2029. India will complete its phase down in 4 steps from 2032 onwards with cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

The Montreal Protocol had no arrangement till date to incentivise improvement in energy efficiency in case of use of new refrigerants and technology. On India's initiative, it was agreed in Kigali that the MLF under the Montreal Protocol will pay for maintaining or increasing the energy efficiency with new technology. Funding for R&D and servicing sector in developing countries has also been included in the agreed solutions on finance.

The amendment to Montreal Protocol agreed in Kigali has facilitated the creation of an international regime of regulatory actions and financial support for treating this set of chemicals in the same manner and with the same urgency as was accorded to other Ozone Depleting Substances in the past.

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

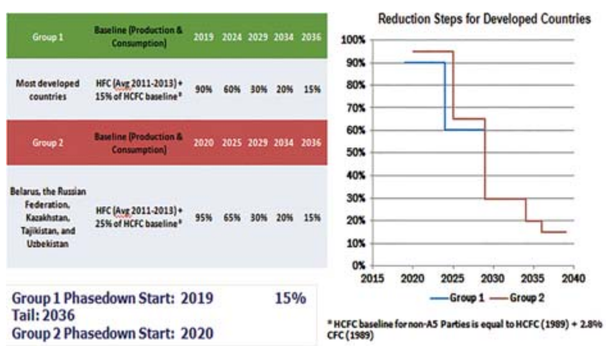
	A5 parties (developing countries) - Group 1	A5 parties (developing countries) - Group 2	Non-A5 parties (developed countries)
Baseline formula	Average HFC consumption for 2020-2022+65% of hydrochloro-fluorocarbon (HCFC) baseline	Average HFC consumption for 2024-2026+65% of HCFC baseline	Average HFC consumption for 2011-2013 + 15% of HCFC baseline*
Freeze	2024	2028	-
1st step	2029 - 10%	2032 - 10%	2019 - 10%
2nd step	2035 - 30%	2037 - 20%	2024 - 40%
3rd step	2040 - 50%	2042 - 30%	2029 - 70%
4th step	-	-	2034 - 80%
Plateau	2045 - 80%	2047 - 85%	2036 - 85%

** For Belarus, Russian Federation, Kazakhstan, Tajikistan, Uzbekistan, 25% HCFC component of baseline and different initial two steps (1) 5% reduction in 2020 and (2) 35% reduction in 2025*

Notes

1. Group 1: Article 5 parties not part of Group 2
2. Group 2: Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates
3. Technology review in 2022 and every five years.
4. Technology review four to five years before 2028 to consider the compliance deferral of two years from the freeze of 2028 of Article 5 Group 2 to address growth in relevant sectors above certain threshold.

HFC Phase-down Schedule for Developed Countries



Group 1	Baseline (Production & Consumption)	2019	2024	2029	2034	2036
Most developed countries	HFC (Avg 2011-2013) + 15% of HCFC baseline*	90%	60%	30%	20%	15%
Group 2	**Baseline (Production & Consumption)**	**2020**	**2025**	**2029**	**2034**	**2036**
Belarus, the Russian Federation, Kazakhstan, Tajikistan, and Uzbekistan	HFC (Avg 2011-2013) + 25% of HCFC baseline*	95%	65%	30%	20%	15%

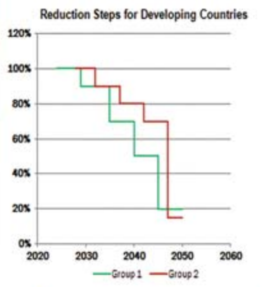
Group 1 Phasedown Start: 2019 15%
Tail: 2036
Group 2 Phasedown Start: 2020

* HCFC baseline for non-A5 Parties is equal to HCFC (1989) + 2.8% CFC (1989)

HFC Phase-down Schedule for Developed Countries

Group 1	Baseline (Production & Consumption)	2024	2029	2035	2040	2045
Most developing countries	HFC (Avg 2020-2022) + 65% of HCFC baseline*	100%	90%	70%	50%	20%
Group 2	Baseline (Production & Consumption)	2028	2032	2037	2042	2047
Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and UAE	HFC (Avg 2024-2026) + 65% of HCFC baseline*	100%	90%	80%	70%	15%

Group 1 Compliance Start: 2024 20% Tail: 2045
Group 2 Compliance Start: 2028 15% Tail: 2047



* HCFC baseline for A5 Parties is equal to average of 2009-2010

After the Kigali meeting a Note seeking ex-post facto approval of the Cabinet for the negotiating position of India with respect to the proposals for amendment to the Montreal Protocol of the Vienna Convention for Protection of Ozone Layer was submitted on 7th November, 2016.

The Cabinet considered the note and approved the proposals contained in of the Cabinet Note as 30th November 2016.

The success of negotiations at Kigali is a result of the spirit of collective action, accommodation and flexibility by all the parties to ensure the best possible outcome which addresses the needs of all countries and leads to maximum climate benefits.

India has been able to secure an agreement that provides adequate space for growth of our economy, while providing adequate time for industry to shift to sustainable alternatives in the interest of environment. The agreed arrangements will minimize the cost to consumers in transitioning away from HFCs and provide for domestic innovation to develop in the sector of new generation refrigerants and related technologies.

Kigali Amendment and Energy Efficiency

The Montreal Protocol had no arrangement to incentivise improvement in energy efficiency in case of use of new refrigerants and technology. On India's initiative, it was agreed in Kigali that the MLF under the Montreal Protocol will pay for maintaining or increasing the energy efficiency with new technology. Funding for R&D and servicing sector in developing countries has also been included in the agreed solutions on finance.

Energy efficiency while transitioning from HFCs have been addressed specifically in Decision XXVIII/2, of the 28th MOP, where the MOP has specifically asked Ex-Com to develop cost guidelines on the subject.

During the 39th meeting of the OEWG held at Bangkok from 11-14 July 2017, India, supported by Bahrain, Kuwait, Lebanon and Saudi Arabia, introduced a Conference Room Paper (CRP) requesting the Technology and Economic Assessment Panel (TEAP) to assess the technology and funding requirements of the parties operating under paragraph 1 of Article 5 to maintain and/or enhance energy efficiency in the Refrigeration, Air-Conditioning and Heat Pump (RACHP) sectors while phasing down HFCs under the Kigali Amendment to the Montreal Protocol, as well as to develop scenarios and to assess the elements of incremental capital and operating costs for maintaining and/or enhancing energy efficiency on transitioning to low-GWP alternatives from high-GWP HFCs, drawing on international experience. The CRP also proposed the Ozone Secretariat to organize a workshop on energy efficiency opportunities. During the 29th MOP held from 20-24 November 2017 at Montreal, Canada, India, after sustained and intensive negotiations, was able to pilot a decision on the adoption of the CRP, which is embodied in Decision XXIX/10 of the MOP. The decision is a significant first step towards maintaining and/or enhancing energy efficiency of RAC equipment with refrigerant transition under HFC phase down, which will enhance the overall climate benefit.

The report of TEAP, presented to the 40th OEWG held in Vienna from 11th to 14th July, 2018 acknowledged that by the use of more energy-efficient equipment during phase down of HFCs will lead to doubling the total reduction of GHGs emissions both from direct and indirect sources. This reemphasized the position of India that dovetailing energy efficiency and refrigerant transition under the Montreal Protocol will enhance overall climate benefit. The Scientific Assessment Panel (SAP) of the Montreal Protocol also stated "Improvements in energy efficiency in RAC equipment during the transition to low-GWP alternative refrigerants can potentially double the climate benefits of the HFC phase down of the Kigali Amendment."

Based upon the inputs provided by the Indian delegation, the updated final report of TEAP presented in the 30th MOP held from 5th to 9th November 2018 in Quito, Ecuador acknowledged that by the use of more energy-efficient equipment during phase down of HFCs will lead to doubling the total reduction of GHGs emissions both from direct and indirect sources. India further along with Africa and GCC countries piloted decision XXX/5, proposing access of Article 5 parties to energy-efficient technologies in the RACHP sector, in particular, domestic air-conditioning and commercial refrigeration taking into account geographical regions, including countries with high ambient temperature (HAT) conditions.

The 83rd meeting of the Ex-Com held from 27-31 May 2019, deliberating on the issue recognized that there is a need for the Ex-Com to be more indulgent on this topic and that there is a requirement for additional sources of funding for energy efficiency.

Decision XXIX/10, followed by XXX/5 are significant steps towards maintaining and/or enhancing energy efficiency of RAC equipment with refrigerant transition under HFC phase down, which will enhance the overall climate benefit.

NEW INITIATIVES

India Cooling Action Plan

Cooling is an essential part for economic growth and development. in Article 5 countries. The Refrigeration and Air-conditioning sector is a major consumer of electricity. The direct and indirect emissions of the RAC Sector relate to use of refrigerants and energy consumed by the equipment. It is a widely known fact that about 90% of the total emissions from refrigeration and air conditioning equipment is because of energy consumption. The Kigali Amendment to the Montreal Protocol, for the first time, has recognized linkages between maintaining and/or improving energy efficiency of the RAC equipment with refrigerant transition under the Montreal Protocol.

Keeping in view that energy efficiency is a major driver for technology choice under the Kigali Amendment and considering the need for an integrated view to be taken with respect to cooling for maximization of climate benefits under the Kigali amendment, the Government of India has initiated the development of India Cooling Action Plan (ICAP), which provides a long-term perspective and guidance with respect to cooling needs. The proposed plan would integrate issues of energy efficiency, refrigerant transitions, technology choices, reduction of cooling load, focus on servicing sector, and having an innovation ecosystem for development low GWP technologies.

In order to develop the ICAP, a Focused Group Discussion with industry and think tanks on the way forward was held on 16th October 2017, which was followed by stakeholder discussion on ICAP framework on 20th Dec. 2017. A national level stakeholder consultation was held on 17th January 2018 where more than 80 experts from industry, academia, think tank, and different ministries participated.

After these detailed stakeholder consultations, the Ministry constituted seven thematic working groups on 6th February 2018 with detailed terms of reference to prepare thematic documents / reports on the following (i) space cooling, (ii) cold chain, (iii) air conditioning and refrigeration technology, (iv) R&D and Production Sector - Alternative Refrigerants and technologies, (vi) Servicing Sector, (vii) Transport Air conditioning (car, bus, train and Metro air conditioning) and (viii) Cross cutting policy regulation and other international Conventions. The thematic groups met regularly for development of documentation along with an action Plan for Short, medium and long-term interventions, which would then be integrated into the NCAP. Each of the thematic groups comprise representatives from government Departments/ organizations, industry, R&D institutions, academia, individual experts and think tanks.

The ICAP aims to provide a 20- year perspective plan (2018-2038) and policy recommendations, to address the cooling requirement across sectors while providing for ways and means to provide thermal comfort and access to sustainable cooling to all, involving multi-stakeholders to synergize actions for addressing cooling demand across all areas: technology, manufacturing, energy efficiency and the environment, while reemphasizing the principles enshrined in the Country Programme of India for phase out of ODSs, i.e. to have minimum economic dislocation and obsolescence cost and maximize indigenous production to twin environment and economic gains.

Given the cross-cutting nature of cooling demand, the ICAP implementation proposes active collaboration among the relevant ministries as well as the private sector entities.

Dr. Harsh Vardhan, the then Minister for Environment, Forest and Climate Change released the ICAP on 8 March 2019. India is the first country in the world to develop a Cooling Action Plan for the country. The implementation modalities for the recommendations of the ICAP are being worked out.

Training and Certification of Refrigeration and Air-conditioning Service technicians under Skill India Mission

Air conditioning and refrigeration is an important and critical sector both for social and economic development in the country. Air conditioning is becoming a necessity for healthy working and living environment, and refrigeration is an essential component of the cold chain for the preservation and distribution of perishable food. Servicing sector is important not only because it consumes a large proportion of the total consumption of refrigerants like HCFCs and HFCs but also it has been the major source of emissions of these chemicals to the environment in the country. The quality of servicing would also maintain the energy efficiency of the serviced equipment resulting in saving in electricity consumption. The use of proper servicing practices would not only result in savings in refrigerant and consumption and emissions but also reduce electricity consumption in the serviced equipment. Most of the technicians engaged in this sector are from the unorganized sector without formal technical education and/or training and these technicians have learnt by working in the field over several years.

It is estimated that there are more than 200,000 RAC service technicians in the country with most of them being in the informal sector. The current penetration of ACs in the country is around 4-6%. It is projected that there would be a rapid increase in the AC penetration. This would also lead to increase in the number of RAC technicians.

The Ozone Cell, MoEFCC had developed a project jointly with the Electronic Sector Skill Council of India (ESSCI) for upskilling and certifying 100,000 RAC service technicians under the Skill India Mission - Pradhan Mantri Kaushal Vikas Yojana (PMKVY) of Ministry of

Skill development. Through this proposal not only the livelihood opportunities of the RAC service technicians working in the informal sector would be enhanced though upskilling and certification, but most importantly this would have significant positive environmental impacts through reduction leakage of refrigerants and increase in the energy efficiency in the operation of RAC equipment.

The project was launched on 2 August 2018 in the presence of Hon'ble Minister for Environment, Forest and Climate Change, Hon'ble Minister for Skill Development and Entrepreneurship (MSDE) and the Hon'ble Minister of State for Environment, Forest and Climate Change. A Memorandum of Understanding between the MoEF&CC and MSDE for implementing the project was signed by the Joint Secretaries of the two ministries during the launch function. Implementation of the project has begun and Training of Trainers programmes are currently under implementation.

Signing of Memorandum of Understanding between Ministry of Environment, Forest and Climate Change and Ministry of Skill Development and Entrepreneurship in the presence of Hon'ble Ministers Dr. Harsh Vardhan and Shri Dharmendra Pradhan

Competency Enhancement of System Houses and Micro, Small and Medium enterprises (MSMEs) in foam manufacturing sector

A Memorandum of Agreement (MOA) has been signed between the Central Institute of Plastics Engineering & Technology, Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Govt. of India and the Project Management Unit, Ozone Cell, Ministry of Environment Forest and Climate Change (MoEF&CC), Government of India to develop Competency Enhancement framework and facilities for System Houses and foam manufacturing enterprises especially MSMEs.

CIPET is a premier institute in the country in the area of plastic engineering and technology and has emerged as a global institution renowned for its research & development in the niche areas of Polymer Science & Technology and high-quality Education & Skill development in the field of plastics. Through the MoA, CIPET and Ozone Cell have agreed to undertake Competency Enhancement of System Houses and Micro, Small and Medium enterprises in the foam manufacturing sector for ensuring smooth and sustainable phase out of HCFC-141b.

A meeting was convened between Ozone Cell and CIPET on Competency Enhancement of System Houses and Micro, Small and Medium enterprises in the foam manufacturing sector for ensuring smooth and sustainable phase out of HCFC-141b, on 3rd January, 2019 at Indira Paryavaran Bhawan, New Delhi.

A Technical Assistance facility is being established at Laboratory for Advanced Research in Polymeric Materials (LARPM) CIPET, Bhubaneshwar for providing training and testing facilities to System Houses and foam manufacturing enterprises covered under HPMP as part of MoA signed between CIPET, DCPC and Ozone Cell MoEFCC. In this regard, a meeting and visit to LARPM, CIPET was made on 31st January, 2019 at LARPM, CIPET, Bhubaneswar.

A Stakeholder Workshop on "Alternative Technologies to HCFC-141b in Foam Manufacturing Sector" was organized on 8th February, 2019 in association with CIPET, Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Government of India. The main objective of the workshop was to make aware the foam manufacturing enterprises about the HCFC free alternative technologies and the process of technology conversion. The workshop included technical presentations from national & international experts on alternative technologies available with special focus on Micro, Small and Medium Enterprises (MSMEs). As a follow up, 3 more workshops were organised for the foam manufacturing enterprises.

PARTICIPATION IN MONTREAL PROTOCOL MEETINGS

Meetings of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol - Significant Outcomes

As per the Kigali Amendment to the Montreal Protocol, the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol is to develop cost guidelines for phasing down of Hydrofluorocarbons (HFCs) in the production, consumption and servicing sectors in the developing countries by 2018. These cost guidelines shall operationalize the funding solutions agreed as part of the KigaliAmendment and shall determine the quantum of funding, which shall be made available by the developed countries to the Multilateral Fund for supporting HFC phase down activities in the developing countries.

The negotiations on the cost guidelines started since April 2017, India actively participated in the deliberations on the cost guidelines and has in the 82nd and 83rd meetings, able to secure the incorporation of provision for adequate funding for energy efficiency and servicing sector in the negotiating text of the cost guidelines. In addition, India was able to make the ExCom agree for undertaking comprehensive deliberations on phaseout of HFCs in the production sector. The importance of these negotiations is that these cost guidelines when developed shall be used to provide funding to projects from developing countries including form India by MLF under HFC phase down. India also actively pursued for an assessment to be undertaken by the MLF Secretariat the issue relating to closure of HCFC-22 Production swing plants and while doing so, there should be no disincentive for pro-active actions taken by any Party.

India piloted the adoption of Decision 82/83 by the Executive Committee for Multilateral Fund for the Implementation of the Montreal Protocol in December 2018 where inter alia it had been decided to discuss the operationalization development cost guidance with respect to maintenance and / or enhancement of energy efficiency while phasing down hydrofluorocarbons.

Meeting of the parties (MOP) to the Montreal Protocol - Significant Outcomes

The 30th Meeting of the Parties (MOP) to the Montreal Protocol was held from 5th to 9th November, 2018 in Quito, Ecuador.

The following are the major achievements:

- India submitted a Conference Room Paper (CRP) along with other proponents on the progress by the Executive Committee of the Multilateral Fund in the development of guidelines for financing the phase-down of hydrofluorocarbons. India piloted the Decision XXX/4 of the Meeting of Parties for the Executive Committee to keep presenting the progress in the development of the guidelines to the Parties annually and also obtain comments and views of the parties before finalization of the guidelines.

- The Indian Delegation played an important role in finalization and approval of Data Reporting formats to be used under the Kigali Amendment to the Montreal Protocol for production, export, import etc.

- In the adjustment to the Montreal Protocol agreed by the Parties during the 30th MOP, India was able to secure the same end uses of HCFCs for the developing countries as were proposed for the developed countries in the 2.5 % service tail of HCFCs to come into effect in 2030 for developing countries after technical review by Technology and Economic Assessment Panel of the Montreal Protocol.

Meeting of the 41st Open-Ended Working Group of the Parties to the Montreal Protocol

TOR for the study on the 2021-2023 replenishment of the MLF for the Implementation of the Montreal Protocol

Parties to the Montreal Protocol created the MLF under Article 10 of the Montreal Protocol. Since its inception in 1990, the MLF has operated with three-year funding cycles. To estimate the funds necessary to achieve compliance during the period 2021-2023 and the indicative figures for the period 2024-2026, the TOR was discussed at the 41st OEWG. During the discussions in the contact group inter alia the following were suggested:

(i) To allocate resources for maintaining and/or enhancing energy efficiency of low-GWP or zero-GWP technologies and equipment while phasing-down HFCs;

(ii) To allocate resources for the introduction of zero- or low-GWP alternatives to HFCs and maintaining energy efficiency in the servicing/end-users sector.

The TOR will be finalized during the 31st MOP scheduled to be held at Rome in November 2019.

TOR, Composition and Balance as well as Fields of Expertise Required of the Assessment Panels and their Subsidiary Bodies

Continuing discussions on the issue from the MOP 30, a CRP was submitted by Argentina, Bahrain, India, Kuwait, Nigeria, Oman, Saudi Arabia and the United Arab Emirates, proposing to provide a summary of actions taken in adherence to decision XXIV/8, of the 24th MOP, with specific reference to the nomination and appointment of members and co-chairs of the TEAP and the appointment of members of its TOCs and temporary subsidiary bodies, with full consultation and agreement of the national focal point of the relevant party. It was also proposed that termination of appointment and replacement, including limitations and constraints noted in adherence, if any, in the annual progress report, should be placed for the consideration of the parties. It was further proposed to ensure clear and transparent procedures for the selection of experts by, inter alia, preparing guidelines and objective criteria for the nomination of experts, as well as providing a detailed matrix of expertise.

Awareness Generation

The National Ozone Unit (NOU) has undertaken comprehensive public awareness campaign to ensure that the industries and public at large are aware about the ill effects of ozone depletion, and undertake necessary ODS phase-out activities and support the policies to protect the ozone layer.

Ozone Cell has made available awareness generation material to the public on its website. Instructional training videos for RAC service technicians in 6 different languages viz. English, Hindi, Bengali, Kannada, Tamil and Gujarati have also been made available. Separately, as part of awareness generation and information dissemination activates the

Ozone Cell has set up YouTube channel, Facebook and Twitter pages.

World Ozone Day

World Ozone Day is organized every year in the country on 16th September, since 1995.

The 24th World Ozone Day was organized on 17th September, 2018 at New Delhi with the theme: "Keep Cool and Carry on : The Montreal Protocol". A large number of stakeholders and school children participated in the event.

A large number of stakeholders including participants from multilateral and bilateral agencies including UNEP, United Nations Development Programme (UNDP), Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ), representatives of various government departments, industry and industry associations and school children participated in the event.

The following publications were launched by the Hon'ble Minister on the occasion:

- Draft India Cooling Action Plan (ICAP) - India is the first country in world to develop such a document (ICAP), which addresses cooling requirement across sectors and lists out actions which can help reduce the cooling demand.

Address of the then Hon'ble Minister during "24th World Ozone Day for the Preservation of the Ozone Layer" function held on 17th September, 2018 at New Delhi, India

- A refurbished website on the Ozone Cell of the Ministry.
- Management Information System (MIS) for Ozone Cell was also launched by the Hon'ble MEF&CC.
- A Guide for Integration of Topics related to HCFC Phase Out and Energy Efficiency in Architectural Curriculum.
- A Technicians Handbook for Good Service Practices and Installation of Room Air-conditioners with HCFC-22 and Flammable Refrigerants.
- A Trainers Handbook for Good Service Practices and Installation of Room Air-conditioners with HCFC-22 and Flammable Refrigerants.
- On this occasion, the publication "Montreal Protocol: India's Success Story" was released by the Chief Guest and distributed to the participants. In addition, poster design, painting, slogan writing competitions were organized among school children. Prizes for the winning entries in each category of the competitions were awarded by the Chief Guest.

Newsletter

Six issues of the newsletter for service technicians in Refrigeration and Air-conditioning (RAC) - newsTRAC- have been published and widely circulated.

Meetings

- Meeting of the Local Project Appraisal Committee, under the Chairmanship of Department of Economic Affairs, Ministry of Finance, was during which the in principle approval for HPMP Stage-II was accorded.
- Meeting of the Standing Committee on Monitoring was held under the Chairmanship of Additional Secretary,

MoEF&CC and Chairman, Central Pollution Control Board (CPCB), in which the Article-7 and Country Program Progress Report (CPPR) data were recommended for approval.

- Around 40 meetings of the ICAP Thematic Groups viz. Transport, Space Cooling & Cold Chain Sector and Servicing Sector, R&D were held.
- Steering Committee meetings of the ICAP were held on 24th January, 2019 and 26th February, 2019.
- Two meetings of the TFSC were held on 16th November, 2018 and 21st June, 2019 respectively.
- Meetings of Production Quota were held on 29th March, 2019 and 9th May, 2019.
- Several consultative meetings were organized on a regular basis for interaction with industry, Government departments etc., on issues relating to Montreal Protocol Implementation.
- Review meetings with UNDP to discuss progress of MLF Projects implemented by UNDP were held from time to time.
- Several meetings were held with the officials of Electronics Skill Sector Council of India on the Project for upskilling and certifying 100,000 RAC service technicians under the Skill India Mission.
- A meeting and visit to LARPM, CIPET was made on 31st January, 2019 at LARPM, CIPET, Bhubaneswar, as part of MoA signed between CIPET, DCPC and Ozone Cell MoEFCC.

Workshops

- Four Stakeholder Workshops on "Alternative Technologies to HCFC-141b in Foam Manufacturing Sector" was organized on 8th February, 2019 at Delhi, 24th May, 2019 at Murthal, Sonipat, 21st June, 2019 at Ahmedabad, 2nd August, 2019 at Chennai in association with CIPET, Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Government of India. The main objective of the workshops was to make aware the foam manufacturing enterprises about the HCFC free alternative technologies and the process of technology conversion. The workshops included technical presentations from national & international experts on alternative technologies available with special focus on MSMEs.
- One workshop at Ahmedabad was organized by the RASSS wherein the new chapter was started.
- Training, workshops were organized across the country for RAC servicing technicians by GIZ, Government of Germany as part of the activities in the RAC Servicing Sector.
- Stakeholder Consultation for Strengthening of RAC Certification System was held on 27th August, 2019 at New Delhi in association with GIZ Proklima.
- Workshop on Facilitating the Implementation of the ICAP was held on 28th August, 2019 at New Delhi in association with The Energy Research Institute (TERI).

RASSS

The servicing sector comprises of servicing enterprises and service technicians which are mostly from unorganized and informal sector and are spread all over the country.

UNEP Regional Office for Asia and the Pacific under the guidance of the Ozone Cell, MoEF&CC encouraged the servicing sector to form RASSS. Presently RASSS has about 1800 members and 6 chapters.

Website

The Ozone Cell first launched its website www.ozonecell.com in the year 1999. An interactive website of Ozone Cell has been re-developed and launched on the occasion of the World Ozone Day 2018.

MIS System for ODS phase-out activities

A comprehensive MIS system for all activities relating to ODS phase-out including the regulatory framework under the ODS Rules, project implementation and monitoring has been developed. The MIS system was launched on the occasion of the World Ozone Day 2018.

Monitoring System in India

A detailed monitoring mechanism has been established by the Ozone Cell, MoEF&CC to ensure that the funding support provided from the MLF through implementing agencies is being fruitfully utilized by the enterprises. The key aspects relating to monitoring mechanism are as follows:

The MoEF&CC has constituted a Standing Committee on Monitoring under the Chairmanship of Chairman, CPCB with Members from concerned Departments, Industry Associations and the Ozone Cell, MoEF&CC. The Committee reviews the data collected and analysed by the Ozone Cell, MoEF&CC from ODS producers, DGFT, DGCIS, etc., on production, imports, exports and user industry in the country. The production, import and export data is collated in the Article 7 format of the Montreal Protocol for submission to the Ozone Secretariat. The Standing Committee on Monitoring is an advisory body to the ESC. The Article 7 data thus vetted by the Standing Committee on Monitoring is submitted to the ESC for its approval and then it is submitted to the Ozone Secretariat.

The Ozone Cell has been convening regular meetings with representatives of the World Bank, UNDP, UNEP, UNIDO and Bilateral Agencies with a view to note the progress of implementation and to sort out short term problems, which might occur during the implementation process. Further, Director, Ozone Cell, MoEF&CC is holding periodic meetings with industries to monitor their implementation progress for ODS phase-out.

Awards and Recognitions

The Ozone Cell of India has been conferred with several awards/appreciations/recognitions for successful implementation of the Montreal Protocol and its ODS phase out activities.

Other activities

- Recommendations were issued to enterprises for import and export of ODSs and ODS based equipment for getting license from the DGFT.
- Data on production, consumption, export and import of ODSs is being collected from various sources, collated and submitted to the Secretariat for the Vienna Convention and the Montreal Protocol (The Ozone Secretariat) and the CPPR to the Secretariat of the MLF for the implementation of the Montreal Protocol by the end of September each year as per the Article 7 of the Montreal Protocol.

Key to Success

India attributes its success in achieving rapid progress of ODS phase out on the following:

- Identifying the priority sub-sectors for early phase-out.
- Choosing wisely a project portfolio with the right mix of investment and non-investment activities.
- Involving key stakeholders early in the phase-out process at both planning and implementation levels.
- Sending clear messages from the Government to various stakeholders by

notifying appropriate regulations and policies.

- Awareness raising activities for key target groups.
- Increasing the capacity of the Ozone Cell by its active involvement in the Regional Network of ODS officers and other international fora.
- To create awareness among the stakeholders producing and consuming HCFCs.
- Monitoring of production and consumption sectors for complete phase-out of ODS.
- Mechanism for more involvement of State level organizations in ODSs phase-out activities.

3. INDIA'S ACHIEVEMENTS TO DATE OF THE MONTREAL PROTOCOL REGIME

Achievements

Contribution and achievements of India for the protection of the stratospheric ozone and implementation of the Montreal Protocol are multi-fold. ODS producing and consuming industry in the country were motivated by creating extensive awareness about the ill effects of the ozone layer depletion in the early stage of the Montreal Protocol. Simultaneously, activities related to the Montreal Protocol were initiated as early as in 1989 by establishing a task force for evaluating the use of ODSs and estimating sector wise consumption of ODSs.

India not only developed and put in place policies/regulations for phase-out of ODSs as per the Montreal Protocol Schedule within the country, but also played a visionary role since the inception of the Montreal Protocol including in the key policy negotiations on behalf of the developing nations.

India debated extensively to make industrialized countries to realize their historic responsibility for production, consumption and emissions of ODSs, that has caused the stratospheric ozone hole. Subsequently, India played a vital role for setting up the financial mechanism as early as 1990 to provide technical and financial assistance to the developing countries. Today, the financial mechanism has proved to be the key element in making the Montreal Protocol a successful Environmental Treaty.

India became a Party to the Vienna Convention for the Protection of the Ozone Layer on 18th March, 1991 and the Montreal Protocol on Substances that Deplete the Ozone Layer on 19th June, 1992. India, during the last 23 years has made outstanding contributions for the protection of ozone layer.

Comprehensive Ozone Depleting Substances (Regulation and Control) Rules, 2000 were developed and put in place under the Environment (Protection) Act 1986, which were utmost important for the successful implementation of ODS phase-out in a vast country like India. These rules set the deadlines for phasing-out of various ODSs. The unique feature of these Rules was banning the use of CFCs and halons in manufacturing of new equipment as early as from 1st January, 2003. This has not only achieved the early phase-out of CFCs and halons in the country, but also reduced the inventory of ODS based equipment which resulted in reduction of servicing requirements.

Another significant achievement was phase-out of production and consumption of virgin halons as early as 2002, being high-ODP chemicals.

India had successfully organized the 18th MOP to the Montreal Protocol, 50th Meeting of the Ex-Com of the MLF and 37th Meeting of the Implementation Committee during October-November 2006. The High Level Segment of the MOP was inaugurated by the then Hon'ble Prime Minister of India and the preparatory segment by the then Hon'ble Minister of Environment, Forest and Climate Change. A large number of Ministers of various countries headed their delegations to the MOP. The Ozone Secretariat and the Parties to the Montreal Protocol appreciated the arrangements of the meeting and hospitality of the country.

India accelerated the phase-out of production and consumption of CFCs with effect from 1st August, 2008, 17 months ahead of the Montreal Protocol schedule except use of pharmaceutical grade CFCs in manufacturing of MDIs for Asthma, COPD and other respiratory ailments within the country and other Article 5 Parties.

The Ozone Cell, MoEF&CC received "The Montreal Protocol Implementers Award, 2007" on the occasion of 20th Anniversary of the Montreal Protocol, for its extraordinary contributions in the effective implementation of the Montreal Protocol and the global effort to protect the ozone layer. "The Stratospher ic Ozone Protection Award, 2008" was also conferred on Dr. A. Duraisamy, Director, Ozone Cell in recognition of his exceptional contribution to global environmental protection and for leadership in ozone layer protection by United States Environmental Protection Agency, Washington, DC.

The phase-out of ODSs in MSMEs, which were widely scattered were handled using an innovative approach, realizing that MSMEs are having relatively a large share in Indian economy. Several sector-wise umbrella projects were formulated in a number of sectors viz. aerosol sector, foam manufactur ing, refrigeration manufacturing, to cater to the needs of MSMEs. These enterprises were provided need based appropriate equipment for converting their operations from ODS to non-ODS technologies. Safety issues in using flammable propellants like Hydrocarbon Aerosol Propellant (HAP) by small aerosol fillers were addressed adequately.

The phase-out of use of CFCs in RAC Servicing Sector was an extremely challenging task because it involved the informal sector comprising of a large number of very tiny enterprises. These enterprises were located throughout the country, including in small towns and rural areas. NCCoPP and its forerunning projects (ECOFRIG and HIDECOR) not only addressed this sector in a very effective manner by training more than 20,000 servicing technicians but also provided equipment support to a large number of enterprises. This was one of the significant achievements addressing the informal sector in the country.

Another challenging task was to phase-out the production and consumption of CTC, especially in the consumption sector which involved a large number of MSMEs and tiny enterprises using CTC as solvent. This sector was successfully addressed through an umbrella project and provided technical assistance to replace CTC used in garment manufacturing as well as metal cleaning.

India successfully phased-out the production and consumption of CFCs, CTC and halons as of 1st January, 2010.

Another critical challenge was to phase out the use of pharmaceutical grade CFCs in manufacturing of MDIs. The National Strategy for Transition to Non-CFC MDIs and Plan for Phase-out of CFCs in the Manufacture of Pharmaceutical MDIs was implemented by UNDP as lead implementing agency, in association with UNEP and Government of Italy in close cooperation of MDI manufacturers under the guidance of Ozone Cell, MoEF&CC. The MDI manufacturers have done a commendable work and converted all the CFC based formulations of MDIs to CFC-free and placed in the market as early as in 2011 with the due approval of Central Drug Standard Control Organization, MoHFW. India sought pharmaceutical grade CFCs through EUN only for 2010 and withdrew the nominations for 2011 in consultation with MDI manufacturers. Accordingly, India informed the 22nd MOP to the Montreal Protocol that India would not seek any CFCs for manufacturing of MDIs through EUN for 2011 and beyond. The 22nd MOP congratulated India for its outstanding contribution and achievement in this area.

The implementation of National Strategy for Transition to non-CFC MDIs and Plan for Phase-out of CFCs in Manufacturing of Pharmaceutical MDIs has resulted successful phase-out of pharmaceutical grade CFCs in manufacturing of MDIs as of December, 2012, 11 months prior to the schedule approved by the Ex-Com of the MLF. India was one of the first countries to switch over from CFC to non-ODS in MDI manufacturing.

Recognizing the importance and challenges in implementation of the accelerated phase-out of HCFCs as per the decision of the 19th MOP held in September, 2007, India initiated activities as early as 2008 and developed and launched the Roadmap for Phase-out of HCFCs in India in October, 2009 describing the long term vision and action plan. Since then, a number of activities have been carried out, including awareness workshops, collection and collation of data on consumption of HCFCs, preparation of sectoral strategies. UNDP on behalf of India prepared the HPMP Stage-I taking into account the sectoral strategies and availability of low-GWP technologies. The HPMP Stage-I was submitted to the MLF Secretariat for the consideration and approval of the 66th Ex-Com of the MLF for the Implementation of the Montreal Protocol with due approval of the MoEF&CC.

India's HPMP Stage-I was approved by Ex-Com in its 66th meeting held in April, 2012 for the period 2012-2015 to meet the 2013 and 2015 phase-out targets of HCFCs.

India successfully met the 2013 target of freeze of HCFC production and consumption and 10 % phase-out targets of HCFCs in 2015, as per the accelerated phase out schedule of the Montreal Protocol.

Through the HPMP Stage-I, a total of 341.77 ODP tonne of HCFCs have been phased out, of which 310.53 OPD tonne is of HCFC 141b in the foam manufacturing sector and 31.24 ODP tonne is for HCFC-22 in the RAC servicing sector, in accordance with the agreement between the Government of India and the Ex-Com of the MLF. The net direct emission reductions are thus 3,071,260.5 CO2 eq.tonne.

HPMP Stage II

The 72nd meeting of the Ex-Com held in May, 2014 has approved the preparation of HPMP Stage-II for India with UNDP as the lead implementing agency in association with UNEP and GIZ, Proklima, Government of Germany as cooperating agencies.

HPMP Stage-II of India has been prepared for assisting the country in achieving compliance with the Montreal Protocol phase out target for consumption of HCFCs inter alia with complete phase-out of HCFC-141b, consumed exclusively in foam manufacturing sector. India's HPMP-II also includes activities that build on already implemented HPMP Stage-I activities.

The 77th meeting of the Ex-com held from 28th November to 2nd December, 2016 approved the HCFC Phase-out Management Plan (HPMP) Stage-II for India. Under HPMP II, India has secured 48.3 million USD from the Multilateral Fund including implementing agencies support cost for phasing out 8,190 MT or 769.49 ODP tonne of HCFC consumption between 2017 to 2023, in order to meet the compliance targets under Montreal Protocol for 2020.

India has voluntarily followed a low carbon development path in HPMP Stage II, while phasing out HCFCs by adopting non-ODS, low GWP and energy-efficient technologies in its HPMP, which is unlike growth paths taken by many countries in the developed world. The HPMP has been developed in a manner that industrial obsolescence and adverse economic impacts to the industry are minimized and the compliance targets of the Montreal Protocol are achieved.

India's HPMP has may unique initiatives both in the choice of conversion technologies adopted and in having a specific component on sector based policy development for phase out of HCFCs. The cross sectoral nature of HCFC phase-out activities has been recognized. Enabling Activities for policy development in energy efficiency, green procurement, standard development for new HCFC alternatives, cold chain development, building sector will be undertaken.

Successful implementation of the HPMP Stage-II in India will result in a sustainable phase-out of 769.49 ODP tons of HCFCs. Due to the relatively high GWP of HCFCs, their phase-out will result in reduced direct GHG emissions. The net contribution towards reduction of direct CO2 emissions due to successful implementation of HPMP Stage-II are 4,262,100 MT CO2 Eq. per year from 2020 and 7, 697, 600 MT CO2 Eq. per year from 2023.

The HPMP II also provides for promotion of energy efficiency, development building codes integrating HCFC phase out issues, cold chain development with non-HCFC alternatives and development of standards for new non-ODS and low GWP alternatives, while transitioning away from HCFCs. It is expected that there would be a net direct CO2-equivalent emission reductions of about 8.5 million metric tonne annually from 2023.

The Local Project Appraisal Committee, Chaired by Department of Economic Affairs, Ministry of Finance gave in principle approval for HPMP Stage-II.

Memorandum of Agreements have been entered with some enterprises after third party verification and recommendation of UNDP in Refrigeration and Air Conditioning (RAC) and foam manufacturing sector for conversion from HCFC to non-HCFC technologies.

The First meeting of the Project Steering Committee (PSC) for implementation of the HPMP Stage-II and the Institutional Strengthening Project (ISP) was held on 22nd March 2019 at Indira Paryavaran Bhavan.

The Ozone Depleting Substances (Regulation and Control) Rules, 2000 have been amended to align with the accelerated phase-out of HCFCs. The Ozone Depleting Substances (Regulation and Control) Amendment Rules, 2014 were published on 4th April, 2014 in the Gazette of India.

HFC - 23 incineration

India has taken a lead and issued an order for incinerating the HFC-23, a by-product of HCFC-22 refrigerant production, voluntarily by the producers of HCFC - 22. HFC-23 gas, a potent greenhouse gas, with GWP of 14800, is produced as a by-product of HCFC-22 manufacturing, and if vented out in environment, is a threat to the environment. India announced this step voluntarily without a commitment of financial support from the MLF, which shows the determination and commitment of the country on climate issues.

India Cooling Action Plan

Recognizing the cross cutting use of refrigeration and air conditioning technologies in various sectors and close linkage of energy efficiency with refrigerant transitions while phasing down HFCs, it has been decided to develop a India Cooling Action Plan. This plan would inter-alia integrate the phase out of ODSs/phase down of HFCs while maximizing energy efficiency of air-conditioning equipment's.

The ICAP shall provide a perspective plan 20-year perspective plan (2018-2038) and policy recommendations, to address the cooling requirement across sectors while providing for ways and means to provide thermal comfort and access to sustainable cooling to all, involving multi-stakeholders to synergize actions for addressing cooling demand across all areas: technology, manufacturing, energy efficiency and the environment, while reemphasizing the principles enshrined in the Country Programme of India for phase out of ODS i.e. to have minimum economic dislocation and obsolescence cost and maximize indigenous production to twin environment and economic gains.

Given the cross-cutting nature of cooling demand, the ICAP implementation proposes active collaboration among the relevant ministries as well as the private sector entities.

India is the first country in world to develop a Cooling Action Plan, which addresses cooling requirement across sectors and lists out actions which can help reduce the cooling demand. On 8th March, 2019, the then Minister of Environment, Forest and Climate Change (MoEF&CC) released the India Cooling Action Plan (ICAP). The ICAP aims to reduce both direct and indirect emissions. The thrust of the ICAP is to look for synergies in actions for securing both environmental and socio-economic benefits. The overarching goal of ICAP is to provide sustainable cooling and thermal comfort for all while securing environmental and socio-economic benefits for the society.

Launch of India Cooling Action Plan by the then Hon'ble Minister of Environment, Forest and Climate Change on 8th March, 2019 at New Delhi, India

The India Cooling Action seeks to

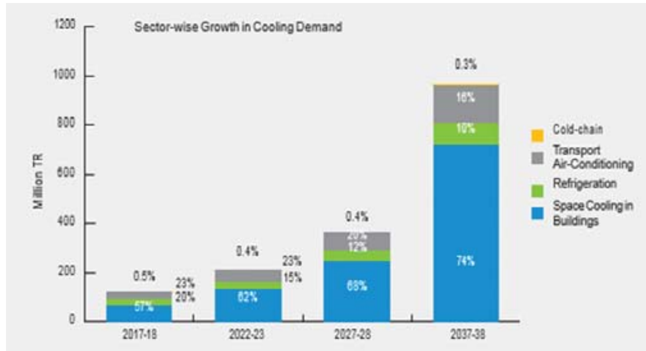
(i) reduce cooling demand across sectors by 20% to 25% by 2037-38,

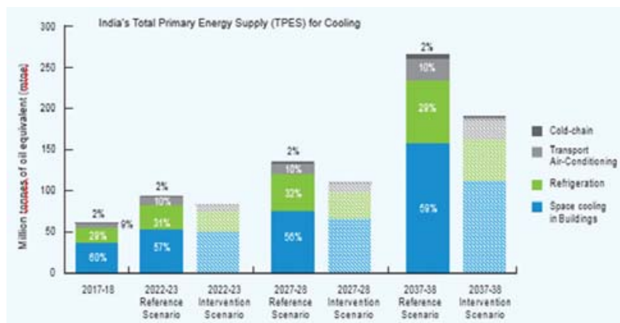
(ii) reduce refrigerant demand by 25% to 30% by 2037-38,

(iii) Reduce cooling energy requirements by 25% to 40% by 2037-38,

(iv) recognize "cooling and related areas" as a thrust area of research under national S&T Programme,

(v) training and certification of 100,000 servicing sector technicians by 2022-23, synergizing with Skill India Mission. These actions will have significant climate benefits.





The following benefits would accrue to the society over and above the environmental benefits:

(i) Thermal comfort for all - provision for cooling for EWS and LIG housing,

(ii) Sustainable cooling - low GHG emissions related to cooling,

(iii) Doubling Farmers Income - better cold chain infrastructure - better value of produce to farmers, less wastage of produce,

(iv) Skilled workforce for better livelihoods and environmental protection,

(v) Make in India - domestic manufacturing of air-conditioning and related cooling equipment's,

(vi) Robust R&D on alternative cooling technologies - to provide push to innovation in cooling sector.

Cooling is also linked to human health and productivity. Linkages of cooling with Sustainable Development Goals (SDGs) are well acknowledged. The cross-sectoral nature of cooling and its use in development of the economy makes provision for cooling an important developmental necessity. The development of ICAP has been a multi-stakeholder inclusive encompassing different Government Ministries/Departments/ Organizations, Industry and Industry Associations, Think tanks, Academic and R&D institutions.

India Cooling Action Plan may accessed at http://ozonecell.in/wpcontent/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

Training and Certification of Refrigeration and Air-conditioning Service technicians under Skill India Mission

The Ozone Cell, MoEFCC had developed a project jointly with the Electronic Sector Skill Council of India (ESSCI) for upskilling and certifying 100,000 RAC service technicians under the Skill India Mission - Pradhan Mantri Kaushal Vikas Yojana (PMKVY) of Ministry of Skill development. Through this proposal not only the livelihood opportunities of the RAC service technicians working in the informal sector would be enhanced though upskilling and certification but most importantly this would have significant positive environmental impacts through reduction leakage of refrigerants and increase in the energy efficiency in the operation of RAC equipment.

Upskilling air-conditioner service technicians under Pradhan Mantri Kaushal Vikas Yojana

A Memorandum of Understanding (MoU) was signed between the Ministries of Environment, Forest and Climate Change and Skill Development and Entrepreneurship on 2nd August, 2018. The two Ministries have agreed to jointly undertake upskilling and certification of 100,000 RAC service technicians on good servicing practices and knowledge of alternative refrigerants to ozone-depleting chemicals. The project will be funded under the Skill India Mission - Pradhan Mantri Kaushal Vikas Yojana (PMKVY).

A mobile application developed by Electronic Sector Skill Council of India and Ozone Cell for the trainees under the project for continuous information exchange with the service technicians was also launched on the occassion. The mobile app will host training material and instruction videos for the service technicians. In addition, instructional videos were also launched on the occasion. The videos have been developed for the service technicians on various aspects of good servicing practices prepared in four regional languages and Hindi to have a wider accessibility. The videos have been jointly developed by the Ozone Cell and Energy Efficiency Services Ltd in collaboration with UNEP.

The skilling and certification of technicians under PMKVY will have twin benefits of significant environmental benefits and a positive influence on the livelihoods of technicians.

The project will also include train-the-trainer programmes, updating of National Occupational Standards, and certification. The project is being implemented by the Electronic Sector Skill Council of India (ESSCI) and the Ozone Cell, MoEFCC and supported by industry and service sector associations for creating awareness and mobilisation of candidates.

Since India is party to the Montreal Protocol on Substances that Deplete the Ozone Layer, the country is in the process of phasing out Ozone Depleting Substances (ODS) and in the future, even non-ODS gases with high global warming potential will be phased down. The alternative refrigerants have issues like flammability and toxicity concerns. As a result, skill training for technicians is of paramount importance, not only for improving employment opportunities, but also in educating them about safety requirement, energy efficiency and refrigerant leak minimisation.

Competency Enhancement of System Houses and Micro, Small and Medium enterprises (MSMEs) in foam manufacturing sector

A Memorandum of Agreement (MOA) has been signed between the Central Institute of Plastics Engineering & Technology, Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Govt. of India and the Project Management Unit, Ozone Cell, Ministry of Environment Forest and Climate Change (MoEF&CC), Government of India to develop Competency Enhancement framework and facilities for System Houses and foam manufacturing enterprises especially MSMEs.

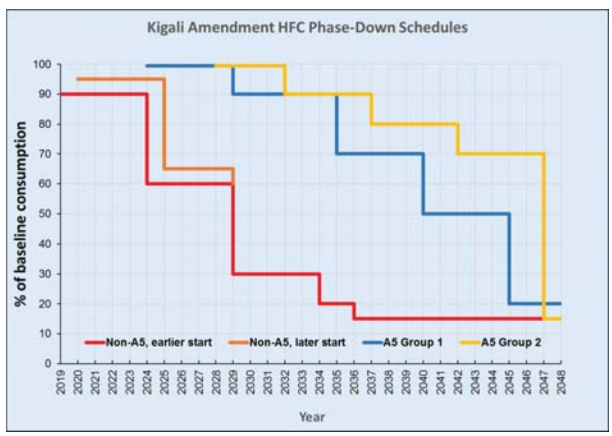
CIPET is a premier institute in the country in the area of plastic engineering and technology and has emerged as a global institution renowned for its research & development in the niche areas of Polymer Science & Technology and high-quality Education & Skill development in the field of plastics. With the MoA, CIPET and Ozone Cell have agreed to undertake Competency Enhancement of System Houses and Micro, Small and Medium enterprises in the foam manufacturing sector for ensuring smooth and sustainable phase out of HCFC-141b.

A Technical Assistance facility is being established at Laboratory for Advanced Research in Polymeric Materials (LARPM) CIPET, Bhubaneshwar for providing training and testing facilities to System Houses and foam manufacturing enterprises covered under HPMP as part of MoA signed between CIPET, DCPC and Ozone Cell MoEFCC. In this regard, a meeting and visit to LARPM, CIPET was made on 31st January, 2019 at LARPM, CIPET, Bhubaneswar.

Kigali Amendment

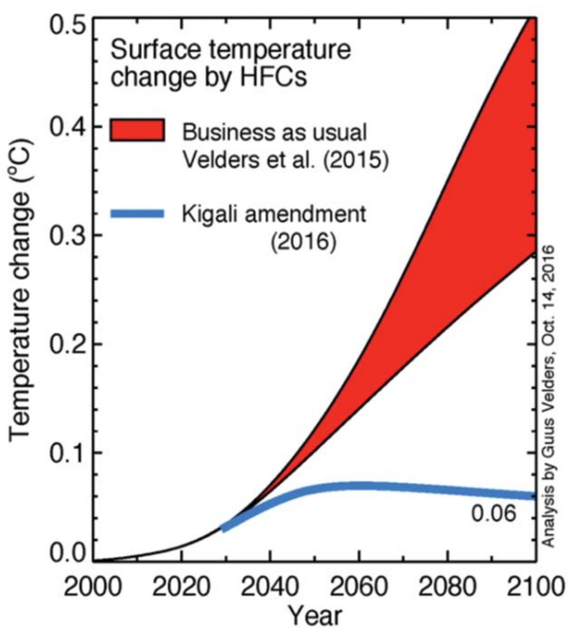
India provided strong political and policy leadership during the negotiations for the Kigali Amendment to the Montreal Protocol. The role of India was crucial in the adoption of the Kigali Amendment to the Montreal Protocol. The success of negotiations at Kigali is a result of the spirit of collective action, accommodation and flexibility by all the parties to ensure the best possible outcome which addresses the needs of all countries and leads to maximum climate benefits.

India piloted the concept of two base lines for the developing countries (group 1: 2020-2021-2022; China and others, and group 2: 2024-2025-2026; India and others) and a differentiated phased down time schedule to factor in the needs of developing countries. This was the first time in the Montreal Protocol that the concept of two baseline has been adopted both for developed and developing countries.



The freeze for the production and consumption of HFCs for India would be in 2028. The freeze year can be deferred to 2030 subject to technology review. In addition to production and consumption of HFCs in the baseline year, 65% of HCFC baseline has also been added to provide for adequate carbon space for the development of the country. India has undertaken to complete its phase down in 4 steps from 2032 onwards with cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047. This agreement facilitates adequate carbon space for growth on domestic industry while minimizing the cost to the economy and consumers during the transition period.

On India's initiative, energy efficiency was included for the first time in the Montreal Protocol as an agreed finance solution while phasing down HFCs. India provided strong political and policy leadership during the negotiations for the Kigali Amendment to the Montreal Protocol. Funding for R&D and servicing sector in developing countries has also been included in the agreed solutions on finance.



Estimated Climate Impact of Kigali Amendment by 2100

India has been able to secure an agreement that provides adequate space for growth of our economy, while providing adequate time for industry to shift to sustainable alternatives in the interest of environment. The agreed arrangements will minimize the cost to consumers in transitioning away from HFCs and provide for domestic innovation to develop in the sector of new generation refrigerants and related technologies.

Negotiations in Montreal Protocol Meetings

India actively participated in the deliberations on the cost guidelines and has in the 82nd and 83rd meetings, able to secure the incorporation of provision for adequate funding for energy efficiency and servicing sector in the negotiating text of the Cost Guidelines.

On India's initiative, it was agreed in 2016 at Kigali, Rwanda that the MLF shall develop a cost guidance for maintaining or increasing the energy efficiency in the RAC equipment while making refrigerant transition while phasing down HFCs under the Montreal Protocol.

India piloted Decision XXIX/10 in the 29th MOP on Issues related to energy efficiency while phasing down HFCs Vide the Decision of the MOP the TEAP of the Montreal Protocol shall submit a focused report inter alia on technology and capacity building requirements, Related costs including capital and operating costs 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 HFCs under the Kigali Amendment to the Montreal Protocol. This is an important step for moving towards integration of Energy efficiency issues under Montreal Protocol. India further along with Africa and GCC countries piloted decision XXX/5, proposing access of Article 5 parties to energy-efficient technologies in the RACHP sector, in particular, domestic air-conditioning and commercial refrigeration taking into account geographical regions, including countries with HAT conditions. Decision XXIX/10, followed by XXX/5 are significant steps towards maintaining and/or enhancing energy efficiency of RAC equipment with refrigerant transition under HFC phase down, which will enhance the overall climate benefit.

India submitted a CRP along with other proponents on the progress by the Ex-Com of the MLF in the development of guidelines for financing the phase-down of HFCs. India piloted the Decision XXX/4 of the MOP for the Ex-Com to keep presenting the progress in the development of the guidelines to the Parties annually and also obtain comments and views of the parties before finalization of the guidelines.

India piloted the adoption of Decision 82/83 by the Ex-Com of MLF for the Implementation of the Montreal Protocol in December 2018 where inter alia it had been decided to discuss the operationalization development cost guidance with respect to maintenance and /or enhancement of energy efficiency while phasing down HFCs.

The Indian Delegation played an important role in finalization and approval of Data Reporting formats to be used under the Kigali Amendment to the Montreal Protocol for production, export, import etc.

In the recent adjustment to the Montreal Protocol agreed by the Parties during the 30th MOP, India was able to secure the same end uses of HCFCs for the developing countries as were proposed for the developed countries in the 2.5 % service tail of HCFCs to come into effect in 2030 for developing countries after technical review by TEAP of the Montreal Protocol.

Awards & Appreciations received

The Ozone Cell of India has been conferred with several awards/appreciations/recognitions for successful implementation of the Montreal Protocol and its ODS phase out activities.

On the 30th anniversary of the Montreal protocol, the Ozone Secretariat in cooperation with Government of Canada, hosted the Award distribution ceremony on 23rd November 2017. The Award were handed over by Ms Catherine Mckenna, Minister of Environment, Government of Canada, at the glittering Award Ceremony.

Late Shri Anil Madhav Dave, the then Hon'ble Minister for State (independent charge) environment, forest and climate change, Government of India was given the Ozone Award under the Political Leadership category for the Leadership provided by India during the Kigali Amendment Negotiations.

4. HOW CAN YOU HELP TO PROTECT THE OZONE LAYER?

"Being Ozone friendly" means taking individual action to reduce and eliminate impacts on the stratospheric ozone layer caused by the products that you buy, the appliances and equipment that your household or business uses, or the manufacturing process used by your company. Products made with, or containing ODSs such as CFCs, CTC, HCFCs, halons, methyl chloroform and methyl bromide can contribute to ozone layer depletion.

Actions that an individual can take to protect the ozone layer:

Be an Ozone-friendly consumer

Buy products (aerosol spray cans, refrigerators, air-conditioners, MDIs, fire extinguishers, etc.) that are labelled "ozone friendly" or "CFC free". The product labels should indicate that they do not contain ODSs such as CFCs or halons. Ask for more information from the seller to ensure that the product is ozone friendly. Tell your neighbour that you are the proud owner of "ozone friendly" products.

Be an ozone-friendly homeowner

Dispose of old refrigerators and appliances responsibly. CFC and HCFC refrigerants should be removed from an appliance before it is discarded. Portable halon fire extinguishers that are no longer needed should be returned to your fire protection authority for recycling. Consider purchasing new fire extinguishers that do not contain halon (e.g. dry powder) as recommended by your fire protection authority.

Be an ozone-friendly farmer

If you use methyl bromide for soil fumigation, consider switching to effective and safe alternatives that are currently being used in many countries to replace this ozone damaging pesticide. Consider options such as integrated pest management that do not rely on costly chemical inputs. If you don't currently use methyl bromide, don't begin to use it now (you will have to get rid of it in the future).

Be an ozone-friendly refrigeration servicing Technician

Ensure that the refrigerant you recover from air conditioners, refrigerators or freezer during servicing is not "vented" or released to the atmosphere. Regularly check and fix leaks before they become a problem. Start refrigerant recovery and recycling programme in your area.

Be an ozone-friendly office worker

Help your company in identifying which of the existing equipments (e.g. water coolers, air-conditioners, cleaning solvents, fire extinguishers etc.) are based on ODSs. Develop a plan replacing them with cost-effective non-ODS based equipments/eproducts. Become an environmental leader within your office.

Be an ozone-friendly company

Replace ODSs used in your premises and in your manufacturing processes. Contact your NOU to see if you are eligible for financial and technical assistance from the MLF. The products manufactured in your company are based on ODSs, plan and implement conversion of production line to non-ODSs technologies that do not destroy ozone layer.

Be an ozone-friendly teacher

Inform your students about the importance of protecting the environment and in particular, the ozone layer. Teach students about the damaging impact of ODSs on ozone layer, health and what steps are being taken internationally and nationally to solve this problem. Encourage your students to spread the message to their families.

Be an ozone-friendly community organizer

Inform your family, neighbours and friends about the need to protect the ozone layer and help them get involved. Work with NGOs to help the community. Start information campaigns and technical assistance projects to phase out ODSs in your city, town or village.

Be an ozone-friendly citizen

Read and learn more about the effects of ozone depletion on people, animals and the environment. Also learn about your national strategy and policies to implement the Montreal Protocol and ODS phase-out program in your country. Get in touch with your country's NOU and learn how you can get involved on an individual level.

Website: **www.ozonecell.com**

5. OZONE IN OUR ATMOSPHERE

Twenty Questions and Answers about the Ozone Layer

Q.1. : What is ozone and where is it in the atmosphere?

Ozone is a gas that is naturally present in our atmosphere. Each ozone molecule contains three atoms of oxygen and is denoted chemically as O3. Ozone is found primarily in two regions of the atmosphere. About 10% of atmospheric ozone is in the troposphere, the region closest to Earth (from the surface to about 10-16 kilometers (6-10 miles)). The remaining ozone (about 90%) resides in the stratosphere between the top of the troposphere and about 50 kilometers (31 miles) altitude. The large amount of ozone in the stratosphere is often referred to as the "ozone layer."

Q.2. : How is ozone formed in the atmosphere?

Ozone is formed throughout the atmosphere in multistep chemical processes that require sunlight. In the stratosphere, the process begins with an oxygen molecule (O2) being broken apart by UV radiation from the Sun. In the lower atmosphere (troposphere), ozone is formed by a different set of chemical reactions that involve naturally occurring gases and those from pollution sources.

Q.3. : Why do we care about atmospheric ozone?

Ozone in the stratosphere absorbs a large part of the Sun's biologically harmful UV radiation. Stratospheric ozone is considered "good" ozone because of this beneficial role. In contrast, ozone formed at Earth's surface in excess of natural amounts is considered "bad" ozone because it is harmful to humans, plants, and animals. Natural ozone near the surface and in the lower atmosphere plays an important beneficial role in chemically removing pollutants from the atmosphere.

Q.4. : How is total ozone distributed over the globe?

The distribution of total ozone over the Earth varies with location on timescales that range from daily to seasonal. The variations are caused by large-scale movements of stratospheric air and the chemical production and destruction of ozone. Total ozone is generally lowest at the equator and highest in Polar Regions.

Q.5. : How is ozone measured in the atmosphere?

The amount of ozone in the atmosphere is measured by instruments on the ground and carried aloft on balloons, aircraft, and satellites. Some instruments measure ozone locally by continuously drawing air samples into a small detection chamber. Other instruments measure ozone remotely over long distances by using ozone's unique optical absorption or emission properties.

Q.6. : What are the principal steps in stratospheric ozone depletion caused by human activities?

The initial step in the depletion of stratospheric ozone by human activities is the emission, at Earth's surface, of gases containing chlorine and bromine. Most of these gases accumulate in the lower atmosphere because they are unreactive and do not dissolve readily in rain or snow. Natural air motions transport these accumulated gases to the stratosphere, where they are converted to more reactive gases. Some of these gases then participate in reactions that destroy ozone. Finally, when air returns to the lower atmosphere, these reactive chlorine and bromine gases are removed from Earth's atmosphere by rain and snow.

Q.7. : What emissions from human activities lead to ozone depletion?

Certain industrial processes and consumer products result in the emission of ODSs to the atmosphere. ODSs are manufactured halogen source gases that are controlled worldwide by the Montreal Protocol. These gases bring chlorine and bromine atoms to the stratosphere, where they destroy ozone in chemical reactions. Important examples are the CFCs, once used in almost all refrigeration and air conditioning systems, and the halons, which were used in fire extinguishers. Current ODS abundances in the atmosphere are known directly from air sample measurements.

Q.8. : What are the reactive halogen gases that destroy stratospheric ozone?

Emissions from human activities and natural processes represent a large source of chlorine- and bromine containing gases that enter the stratosphere. When exposed to ultraviolet radiation from the Sun, these halogen source gases are converted to more reactive gases containing chlorine and bromine. Some reactive gases act as chemical reservoirs that convert to form the most reactive gases, namely chlorine monoxide (ClO) and bromine monoxide (BrO). The most reactive gases participate in catalytic reactions that efficiently destroy ozone. Most volcanoes emit some reactive halogen gases that readily dissolve in water and are usually washed out of the atmosphere before they can reach the stratosphere.

Q.9. : What are the chlorine and bromine reactions that destroy stratospheric ozone?

Reactive gases containing chlorine and bromine destroy stratospheric ozone in "catalytic" cycles made up of two or more separate reactions. As a result, a single chlorine or bromine atom can destroy many thousands of ozone molecules before it leaves the stratosphere. In this way, a small amount of reactive chlorine or bromine has a large impact on the ozone layer. A special situation develops in Polar Regions in the late winter/early spring season where large enhancements in the abundance of the most reactive gas, chlorine monoxide, leads to severe ozone depletion.

Q.10.: Why has an "ozone hole" appeared over Antarctica when ODSs are present throughout the stratosphere?

ODSs are present throughout the

stratospheric ozone layer because they are transported great distances by atmospheric air motions. The severe depletion of the Antarctic ozone layer known as the "ozone hole" occurs because of the special atmospheric and chemical conditions that exist there and nowhere else on the globe. The very low winter temperatures in the Antarctic stratosphere cause polar stratospheric clouds (PSCs) to form. Special reactions that occur on PSCs, combined with the relative isolation of polar stratospheric air, allow chlorine and bromine reactions to produce the ozone hole in Antarctic springtime.

Q.11.: How severe is the depletion of the Antarctic ozone layer?

Severe depletion of the Antarctic ozone layer was first reported in the mid-1980s. Antarctic ozone depletion is seasonal, occurring primarily in late winter and early spring (August-November). Peak depletion occurs in early October when ozone is often completely destroyed over a range of altitudes, thereby reducing total ozone by as much as two-thirds at some locations. This severe depletion creates the "ozone hole" apparent in images of Antarctic total ozone made using satellite observations. In most years the maximum area of the ozone hole far exceeds the size of the Antarctic continent.

Q.12.: Is there depletion of the Arctic ozone layer?

Yes, significant depletion of the Arctic ozone layer now occurs in most years in the late winter/early spring period (January-March). However, the maximum depletion is less severe than that observed in the Antarctic and is more variable from year to year. A large and recurrent "ozone hole," as found in the Antarctic stratosphere, does not occur in the Arctic.

Q.13.: How large is the depletion of the global ozone layer?

Depletion of the global ozone layer began gradually in the 1980s and reached a maximum of about 5% in the early 1990s. The depletion has lessened since then and now is about 3.5% averaged over the globe. The average depletion exceeds the natural year-to year variations of global total ozone. The ozone loss is very small near the equator and increases with latitude toward the poles. The larger polar depletion is attributed to the late winter/early spring ozone destruction that occurs there each year.

Q.14.: Do changes in the Sun and volcanic eruptions affect the ozone layer?

Yes, factors such as changes in solar radiation, as well as the formation of stratospheric particles after volcanic eruptions, do influence the ozone layer. However, neither factor can explain the average decreases observed in global total ozone over the last three decades. If large volcanic eruptions occur in the coming decades, ozone depletion will increase for several years afterwards.

Q.15.: Are there controls on the production of ODSs?

Yes, the production and consumption of ODSs are controlled under a 1987 international agreement known as the "Montreal Protocol on Substances that Deplete the Ozone Layer" and by its subsequent Amendments and Adjustments. The Protocol, now ratified by all 197 United Nations members, establishes legally binding controls on national production and consumption of ODSs. Production and consumption of all principal ODSs by developed and developing nations will be almost completely phased out before the middle of the 21st century.

Q.16.: Has the Montreal Protocol been successful in reducing ODSs in the atmosphere?

Yes, as a result of the Montreal Protocol, the overall abundance of ODSs in the atmosphere has been decreasing for about a decade. If the nations of the world continue to comply with the provisions of the Montreal Protocol, the decrease will continue throughout the 21st century. Those gases that are still increasing in the atmosphere, such as halon-1301 and HCFC-22, will begin to decrease in the coming decades if compliance with the Protocol continues. Only after midcentury will the effective abundance of ODSs fall to values that were present before the Antarctic ozone hole was observed in the early 1980s.

Q.17.: Does depletion of the ozone layer increase ground-level UV radiation?

Yes, UV radiation at Earth's surface increases as the amount of overhead total ozone decreases, because ozone absorbs UV radiation from the Sun. Measurements by ground-based instruments and estimates made using satellite data provide evidence that surface ultraviolet radiation has increased in large geographic regions in response to ozone depletion.

Q.18.: Is depletion of the ozone layer the principal cause of climate change?

No, ozone depletion itself is not the principal cause of climate change. Changes in ozone and climate are directly linked because ozone absorbs solar radiation and is also a greenhouse gas. Stratospheric ozone depletion and increases in global tropospheric ozone that have occurred in recent decades have opposing contributions to climate change. The ozone-depletion contribution, while leading to surface cooling, is small compared with the contribution from all other greenhouse gas increases, which leads to surface warming. The total forcing from these other greenhouse gases is the principal cause of observed and projected climate change. Ozone depletion and climate change are indirectly linked because both ODSs and their substitutes are greenhouse gases.

Q.19.: Have reductions of ODSs under the Montreal Protocol also protected Earth's climate?

Yes. All ODSs are also greenhouse gases that contribute to climate forcing when they accumulate in the atmosphere.

Montreal Protocol controls have led to a substantial reduction in the emissions of ODSs over the last two decades. These reductions have provided the added benefit of reducing the human contribution to climate change while protecting the ozone layer. Without Montreal Protocol controls, the climate forcing contribution from annual ODS emissions could now be 10-fold larger than its present value, which would be a significant fraction of the climate forcing from current CO_2 emissions.

Q.20.: How is ozone expected to change in the coming decades?

Substantial recovery of the ozone layer from the effects of ODSs is expected near the middle of the 21st century, assuming global compliance with the Montreal Protocol. Recovery will occur as ODSs and reactive halogen gases in the stratosphere decrease in the coming decades. In addition to responding to ODSs, future ozone amounts will increasingly be influenced by expected changes in climate. The resulting changes in stratospheric ozone will depend strongly on the geographic region. During the long recovery period, large volcanic eruptions could temporarily reduce global ozone amounts for several years.

HIGHLIGHTS SCIENTIFIC ASSESSMENT OF OZONE DEPLETION: 2018

Actions taken under the Montreal Protocol have led to decreases in the atmospheric abundance of controlled ozone-depleting substances (ODSs) and the start of the recovery of stratospheric ozone. The atmospheric abundances of both total tropospheric chlorine and total tropospheric bromine from long-lived ODSs controlled under the Montreal Protocol have continued to decline since the 2014 Assessment. The weight of evidence suggests that the decline in ODSs made a substantial contribution to the following observed ozone trends: The Antarctic ozone hole is recovering, while continuing to occur every year. As a result of the Montreal Protocol much more severe ozone depletion in the polar regions has been avoided. Outside the polar regions, upper stratospheric ozone has increased by 1-3% per decade since 2000. No significant trend has been detected in global (60°S-60°N) total column ozone over the 1997-2016 period with average values in the years since the last Assessment remaining roughly 2% below the 1964-1980 average. Ozone layer changes in the latter half of this century will be complex, with projected increases and decreases in different regions. Northern Hemisphere mid-latitude total column ozone is expected to return to 1980 abundances in the 2030s, and Southern Hemisphere mid-latitude ozone to return around mid-century. The Antarctic ozone hole is expected to gradually close, with springtime total column ozone returning to 1980 values in the 2060s.

The Kigali Amendment is projected to reduce future global average warming in 2100 due to hydrofluorocarbons (HFCs) from a baseline of 0.3-0.5 ^{o}C to less than 0.1 ^{o}C. The magnitude of the avoided temperature increase due to the provisions of the Kigali Amendment (0.2 to 0.4 ^{o}C) is substantial in the context of the 2015 Paris Agreement, which aims to keep global temperature rise this century to well below 2 oC above pre-industrial levels.

There has been an unexpected increase in global total emissions of CFC-11. Global CFC-11 emissions derived from measurements by two independent networks increased after 2012, thereby slowing the steady decrease in atmospheric concentrations reported in previous Assessments. The global concentration decline over 2014 to 2016 was only twothirds as fast as it was from 2002 to 2012. While the emissions of CFC-11 from eastern Asia have increased since 2012, the contribution of this region to the global emission rise is not well known. The country or countries in which emissions have increased have not been identified.

Sources of significant carbon tetrachloride emissions, some previously unrecognised, have been quantified. These sources include inadvertent by-product emissions from the production of chloromethanes and perchloroethylene, and fugitive emissions from the chlor-alkali process. The global budget of carbon tetrachloride is now much better understood than was the case in previous Assessments, and the previously identified gap between observation-based and industry-based emission estimates has been substantially reduced.

Continued success of the Montreal Protocol in protecting stratospheric ozone depends on continued compliance with the Protocol. Options available to hasten the recovery of the ozone layer are limited, mostly because actions that could help significantly have already been taken.

Remaining options such as complete elimination of controlled and uncontrolled emissions of substances such as carbon tetrachloride and dichloromethane; bank recapture and destruction of CFCs, halons, and HCFCs; and elimination of HCFC and methyl bromide production would individually lead to small-to-modest ozone benefits. Future emissions of carbon dioxide, methane, and nitrous oxide will be extremely important to the future of the ozone layer through their effects on climate and on atmospheric chemistry. Mitigation of nitrous oxide emissions would also have a small-to-modest ozone benefit.

Text Extracted from "World Meteorological Organization (WMO), Executive Summary: Scientific Assessment of Ozone Depletion: 2018, World Meteorological Organization, Global Ozone Research and Monitoring Project - Report No. 58, 67 pp., Geneva, Switzerland, 2018."

KEY FINDINGS OF TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL (TEAP)-2018

The Montreal Protocol continues to be effective because control measures have created incentives for new technology, because enterprises and organizations have worked diligently to implement new technology and because the Multilateral Fund (MLF) has financed the agreed incremental costs of the transition for Article 5 parties. As each production and consumption phase-out milestone have been achieved, the implementation of new phases of technology have further ratcheted down the production, use, and emissions of ODSs most of which are also potent greenhouse gases. Through these efforts, the world has avoided the substantial economic, environmental and health consequences of increases in both ultraviolet radiation and global warming.

Since the 2014 TEAP Assessment Report, important technical developments have taken place as the parties to the Montreal Protocol continue working toward key ODS production and consumption phase-out milestones. The Kigali Amendment, which was adopted in 2016 and entered into force in 2019, creates new challenges and additional milestones for parties to achieve the phase-down of certain hydrofluorocarbons (HFCs). Regular assessments by TEAP highlight the challenges and provide the necessary information to transition to alternatives and technologies across the various sectors of use. The sector and technology-specific challenges include phase out of remaining uses of ODS in specific sectors, some specific uncontrolled and growing ODS uses, and emerging options for the use of more climate friendly alternatives.

A key message of the Assessment Panels from their 2014 assessment remains relevant today:

"The sustained success of the Protocol hinges on continued vigilance by the parties to fulfil their commitments and prevent any future actions that threaten to nullify the ozone and climate benefits achieved under the agreement. Success also depends on continuing the lessons of collaboration, leadership, innovation, and shared investment in our global environment that was the promise made to future generations under the Protocol."

HFC phase down under the Kigali Amendment

The Kigali Amendment established a strong link between ozone protection and climate and set a clear path in protecting our planet's environment through the control of HFCs. The measures taken to phase-down production and consumption of HFCs is expected to avoid up to 0.4 °C of warming by the end of the century. Improvements in the energy efficiency in the refrigeration and air conditioning sector in parallel with HFC phase-down could double that climate benefit.

The TEAP and TOC expertise is evolving to meet the new challenges dictated by the Kigali Amendment. The planned HFC phase-down under the Kigali Amendment, as well as national and regional regulations, are driving industry towards lower-GWP HFC alternatives or not in kind, particularly in refrigeration, air conditioning, and foam applications. However, the range of new, lower GWP products creates challenges in finding the best solution for each application, considering factors such as flammability, toxicity, availability and operating conditions (e.g., high ambient temperatures, HAT).

Around 90% of the potential improvement in energy efficiency of refrigeration and air conditioning (RAC) equipment comes from technological innovation of equipment, rather than the refrigerant itself. On the other hand, the overall drive to reduce energy demand will lead to increasing energy efficiency of RAC equipment. These twin drivers create an enhanced synergy for HFC phase-down.

Significant technical progress

Progress continues in every consumer, commercial, industrial, agricultural, medical, and military sector, with ODS no longer used in many applications worldwide. CFC-containing MDIs have been successfully phased out worldwide and replaced by a range of CFC-free inhalers.

The phase-out of HCFC-22 in non-Article 5 parties is essentially complete and is progressing in Article 5 parties. The phase-out of ozone depleting refrigerants in new chillers is nearly complete. HCFC-22 in new, small chillers has been phased out in non-Article 5 parties, but limited production continues in Article 5 parties.

The year 2015 marked the final production and consumption phase-out date for controlled uses of methyl bromide (MB) in Article 5 parties, and there only a small number of critical uses still being sought by these parties in 2019. This milestone for A5 parties was reached showing steady progress under the Protocol, the successful conclusion of many investment projects, and clear demonstration of how far key sectors, previously dependent on MB, had come in their transition to alternative options and technologies.

Continuing uses of ODS

Continued vigilance through atmospheric monitoring and regular assessments of ODS consumption and use and inventories (banks) is needed to monitor the progress and achievements under the Montreal Protocol.

Continuing use of already phased out ODS and recent reporting of unexpected emissions of CFC-11 reinforce this importance.CFC-11 remains a major source of ozone-destroying chlorine to the stratosphere. Its concentration in the atmosphere has been declining over several decades because of the Montreal Protocol, but recent measurements indicate that this decline has recently become slower than expected under the Montreal Protocol.

CFC-11 was used primarily as a foam blowing agent, as a refrigerant, and in a range of other smaller uses, including asthma medical inhalers and in tobacco expansion. However, alternative chemicals or products are available as replacements for all applications, and have been from the mid-1980s onwards. Production of CFC-11 in non-Article 5 parties was phased out in 1996; production of CFC-11 in Article 5 parties was phased out in 2010. Production of CFC-11 to supply essential uses was less than 400 tonnes each year after 2010 and ceased altogether after 2014. No feedstock uses of CFC-11 have been reported from parties. Despite these controls, an increase in global CFC-11 emissions after 2012, at least part of which is strongly suggested to originate from eastern Asia, was derived from measurements by two independent networks. In response to Decision XXX/3 (November 2018), SAP and TEAP have coordinated efforts to provide additional information regarding atmospheric monitoring and modelling, with respect to the unexpected emissions, and on potential sources of emissions of CFC-11 and related controlled substances, respectively.

Contrary to the general perception that the halon sector issues are all resolved, in fact the demand from on-going, enduring uses (e.g., civil aviation, oil & gas facilities, nuclear facilities, and military installed base/reserves, etc.), and the growing civil aviation demand of halon-1301 resulting from the lack of replacements for new designs for engine and cargo compartment applications, will likely soon exceed the supply from stockpiles. Emission estimates derived from atmospheric abundances suggest that there were more emissions than previously estimated and therefore there is significantly less stockpiled halon?1301 available to support ongoing needs. It was previously projected that available halon?1301 supplies will run out by the years 2032 to 2054. However, there are regional imbalances, which could mean that for those without dedicated, long-term stockpiles, the run-out date will occur much earlier. Therefore, TEAP anticipates that this will require action under the Montreal Protocol with the strong likelihood that essential use nominations for the production of new halon-1301 will be submitted in the foreseeable future to supply these important fire-fighting uses, and especially for civil aviation.

Atmospheric concentrations of MB have stopped declining, indicating possible continued use of MB larger than is currently reported for QPS (exempted) uses. An estimated 40% of reported QPS uses have immediately available alternatives, but are not being adopted because QPS uses are exempted under the Protocol. Further, around 70% of current MB emissions derived from reported QPS uses could be avoided, by using re-capture or destruction for QPS commodity uses and barrier films for the QPS pre-plant soil fumigation uses. The resulting reductions in atmospheric concentrations of MB would provide near-term benefits for the ozone layer.

Progress and challenges by sector

Foams

There have been significant improvements in the development and availability of additives, co-blowing agents, equipment and formulations enabling the successful commercialisation of foams and foam systems containing low GWP blowing agents.

Growth in the construction sector and the cold chain in Article 5 parties, coupled with the adoption of enhanced energy efficiency criteria for buildings has led to a growth in demand for thermal insulation materials.

Total global production of polymeric foams continues to grow (3.9% per year) at a slightly lower rate than noted last year (4.0%), from an estimated 24 million tonnes in 2017 to 29 million tonnes by 2023. Production of foams used for insulation is expected to grow in line with global construction and continued development of refrigerated food processing, transportation and storage (cold chain).

Based on average blowing agent percentages of 5.5% w/w (weight by weight or mass fraction) for polyurethane and 6%1 w/w for XPS, this leads to an estimated demand of greater than 400,000 tonnes with a further 10,000 tonnes being consumed by other foam types. Further, it is estimated that blowing agent demand would grow to above 500,000 tonnes by 2023 based on the growth rates presented below.

Article 5 parties (A5 parties) face common challenges in phasing out production and consumption of hydrochlorofluorocarbons (HCFCs) and phasing down high global warming potential (GWP) HFC blowing agents.

The conversion from HCFC-141b in insulation foam applications has been largely successful within larger and some medium enterprises where the critical mass of the operation is sufficient to justify investment in hydrocarbon technologies.

Managing foams transition for the multitude of SMEs in both Article 5 and non-Article 5 parties remains a challenge. The low GWP alternatives are mostly flammable, and SMEs may find the necessary fire precautions unaffordable. Unless there is industrial rationalisation, this leaves high GWP solutions as the only option, often with considerable emissions.

The unexpected emissions of CFC-11 requires revisiting previous assessments of this transition in the foams sector and the many factors that may influence selection of foam blowing agent including foam blowing agent cost, safety (flammability, toxicity), ease of use, compatibility with equipment and other raw materials (etc.).

Halons

There is great concern regarding the general perception that the halon sector issues are all resolved. Increasing demand for on-going and enduring uses (e.g., civil aviation, oil & gas facilities, nuclear facilities, and military installed base/reserves, etc.) will soon exceed supply from stockpiles. The stockpile of halon-1301 may be less than previously estimated, because atmospheric abundances suggest higher emissions than previously estimated, and this will be exacerbated by regional imbalances in stocks. Taken together these factors suggest that for users without access to significant stockpiles, halon-1301 supplies will run out well before the previously estimated 2032 to 2054 timeframe. The growing civil aviation demand for halon-1301 will require action under the Montreal Protocol, with likely submission of essential use nominations for the production of new halon-1301 in the foreseeable future.

Implementation of 2-BTP as a halon-1211 replacement in hand-held portable extinguishers on board civil aviation aircraft is currently on-going. (This represents approximately 10% of the halon installed in aircraft.) In contrast, the fact that civil aviation has only implemented a replacement for halon-1301 in lavatory fire extinguishing systems, its smallest use by far, is a remarkably disappointing result, given the level of research and testing efforts performed by governments and fire protection companies for the past 25+ years.

Since the 2014 Assessment Report, little further progress on additional low-GWP alternatives for total flooding systems (to replace halon-1301, HFC-227ea and/or HFC-125) has been reported. Although research to identify potential new fire protection agents continues, it could be five to ten years before a viable agent could have significant impact on the fire protection sector.

Methyl Bromide

MBTOC considers that technical alternatives exist for almost all remaining controlled uses of methyl bromide. Ninety-nine per cent of the reported controlled consumption has been phased out, with only 141 t being presently approved for critical use exemptions. Concern exists that a much greater amount of MB used for controlled purposes is presently unreported.

In recent years some countries have reported steep increases in QPS consumption, whilst others have significantly declined. Owing to this, there has been no overall sustained reduction in QPS use over the last twenty years. MBTOC estimates that alternatives to MB are immediately available for about 40% of QPS uses, particularly pre-shipment.

Methyl bromide used for QPS purposes is almost entirely emitted to the atmosphere. Control of these emissions by use of barrier films (for any remaining pre-plant soil fumigation) or recapture and destruction technologies would eliminate more than 70% of these emissions, providing a significant near-term gain to the reduction of ODS substances in the stratosphere.

Medical and Chemical

CFC-containing metered dose inhalers (MDIs) have been successfully phased out worldwide. A range of alternative treatment methods is available. The choice of the most suitable treatment method is a complex decision and may be enhanced with an increase in publicly available information about the environmental impact, including carbon footprint, of different inhaler products.

Based on a recent study, an increase in CFC-11 emissions of 13,000 ± 5,000 tonnes per year is suggested for the period 2013 to 2016. The increase in emissions of CFC-11 appears unrelated to past production. Losses of 13,000 tonnes per year of CFC-11 are not economical from a chemical production process. At the upper end of possible emission levels (5 per cent losses) for an economically run process, this would equate to production of 260,000 tonnes CFC-11 per year. The fate of any CFC-12 produced as a by-product of CFC- 11 production is not yet clear.

Refrigeration and Air Conditioning

The phase-out of HCFC-22 in non-Article 5 parties is essentially complete and is progressing in Article 5 parties.

There is no single "ideal" refrigerant. Refrigerant selection results from balancing several factors which include: suitability for the targeted use, availability and cost of the refrigerant, the availability and cost of the RAC equipment, the cost and effectiveness of servicing, energy efficiency, safety, ease of use, and environmental issues. Since the publication of the RTOC 2014 Assessment Report, 35 new refrigerants have received a standard designation and safety classification of which five are single-compound refrigerants, and 30 are blends.

The HFC phase-down under the Kigali Amendment, as well as regional and national regulations, are driving the industry towards the use of low GWP refrigerants. Alternatives to high GWP refrigerants exist and new lower GWP refrigerants have been proposed. Finding the best refrigerant for each application is a continuing challenge. Refrigerants with low direct impact on climate change are often flammable and may have higher toxicity. In order to maintain the current safety levels new technologies are being developed and an increased level of training will be needed.

In domestic refrigeration, HC-600a (predominantly) or HFC-134a continue to be the refrigerant options for new production and currently, more than 1 billion domestic refrigerators use HC-600a. In commercial refrigeration, lower GWP HFC/HFO blends and non-halocarbon options like R-744, HC-290, HC-600a and R-717 are growing in use, especially as research and development improves system performance; this trend will further increase with new safety standards and codes which will come into effect in the next few years. In larger industrial refrigeration plants, while R-717 has been extensively used, current technological advances include the use of low charge R-717 systems, as well as cascade systems using R-717 together with R-744. In transport refrigeration, some regions have experienced a significant migration from R-404A to lower GWP alternatives. R-404A has been completely replaced by R-452A in new truck and trailer equipment in Europe. R-744 and R-513A have been introduced in intermodal container applications. R-744 is being field tested on trucks and trailers.

In air-to-air air conditioners and heat pumps, there is an almost continuous introduction of new refrigerants for use, but few match or exceed the performance of HCFC-22 regardless of the GWP. Nevertheless, market transformation for lower GWP refrigerants as replacement to R-22 has occurred; currently millions of R-32 AC are commercially available, especially in Asia. Despite the reported low risk for certain applications, safety standards remain restrictive to several low GWP flammable refrigerants in certain product types, but are under revision for all refrigerants. Water and space heating heat pumps are a dynamic market with a number of lower GWP options.

The phase-out of ozone depleting refrigerants in new chillers is nearly complete. HCFC-22 in new, small chillers has been phased out in non-Article 5 parties, but limited production continues in Article 5 parties.

Due to the enforcement of regulations, HFO-1234yf is rapidly increasing its market share in US and Europe in new AC equipped passenger cars, while HFC-134a remains widely used in other regions. Although the transition away from CFC-12 has been successful, there are still some luxury or special types of vehicles (built before year 2002) in operation in A5 countries with MACs operated on CFC-12. The CFC-12 quantities used are minimal and are resulting from the recycling of CFC-12 contained in old products.

Comprehensive sustainable selection criteria for refrigerants have been introduced and include: energy efficiency, impact on climate and hydrosphere, usage of renewable energy, and other options to reduce GHG emissions and consumption of natural resources, adaptability for thermal energy storage, costs, technological development level, safety, flammability and liability.

Not-In-Kind (NIK) technologies do not primarily use mechanical vapour compression (MVC) technology to produce air conditioning or refrigeration. NIK technologies are expected to provide savings in operating costs. Their unique ability to use waste and renewable energy sources makes their application potentially highly energy efficient.

Research done at HAT conditions has identified viable low-GWP refrigerant alternatives. There is more awareness of the challenges faced at HAT conditions in the design, servicing of equipment using low-GWP refrigerants that are capable of delivering a high level of energy efficiency.

Text Extracted from TEAP. 2019. Technology and Economic Assessment Panel. 2018 Assessment Report. Nairobi: Technology and Economic Assessment Panel, United Nations Environment Programme (UNEP) 100 pp. https://ozone.unep.org/science/assessment/teap

HIGHLIGHTS OF ENVIRONMENTAL EFFECTS ASSESSMENT PANEL ASSESSMENT REPORT, 2018

Stratospheric ozone, climate change, and UV radiation at the Earth's surface

- Depletion of stratospheric ozone leads to increased UV-B radiation at the Earth's surface However, because of the success of the Montreal Protocol, present-day increases in UV-B radiation due to stratospheric ozone depletion have been negligible in the tropics, small (5-10%) at mid-latitudes (30-60°), and large only in polar regions. With the predicted recovery of stratospheric ozone over the next several decades, the clear-sky noontime UV Index is expected to decrease at all latitudes outside the tropics, with the greatest decreases over Antarctica and. New projections of the UV Index for the end of the 21st century relative to the current decade suggest a decrease by 35% over Antarctica, and up to 6% over mid-latitudes. These future projections are, however, uncertain because stratospheric ozone levels will be controlled not only by decreasing ozone depleting substances, but also by climate change due to increases in greenhouse gases for the rest of the 21st century.

- Future changes in surface solar UV radiation of all wavelengths will depend on changes in clouds, aerosols, and surface reflectivity (e.g., from snow and ice cover) . Climate change is altering cloud cover, with some regions becoming cloudier and others less cloudy. Increased cloud cover generally tends to reduce UV radiation at the Earth's surface, but effects vary, for example, with the type of clouds. Aerosols (solid and liquid particles suspended in the atmosphere reduce and scatter UV radiation. The type and amounts of aerosols in the atmosphere are affected by the emissions of air pollutants, volcanic activity, as well as the frequency and extent of wildfires and dust storms, and many other factors that are being affected by climate change. In heavily polluted areas (e.g., in southern and eastern Asia), expected improvements in air quality are predicted to result in levels of UV radiation increasing towards pre-industrial levels (i.e., before the occurrence of extensive aerosol pollution), with the extent of changes contingent on curtailing the emissions of air pollutants.

- High surface reflectance from snow or ice cover can enhance incident surface UV radiation because some of the reflected UV radiation is scattered back to the surface by air molecules, aerosols, and clouds in the atmosphere. However, climate change-driven reductions in ice or snow cover in polar regions and mountains reduce the reflection of UV radiation from the Earth's surface and thus may reduce above-ground UV radiation in these regions.

Exposure to UV radiation and effects of climate change on exposure

- The effect of UV radiation on organisms (including humans), natural organic matter, contaminants and materials depends on their exposure to the radiation. This is determined by several factors besides stratospheric ozone depletion, including the effects of global climate change. Unlike stratospheric ozone depletion, these climate change-driven effects modify exposure not just to UV-B radiation but also to solar radiation in the ultraviolet-A (UV-A; 315-400 nm) and visible (400-700 nm) parts of the solar spectrum. These changes are important as many of the environmental and health effects caused by exposure to UV-B radiation are also influenced, to varying degrees, by UV-A and visible radiation.

- For human health, behaviour is an important regulator of exposure to UV radiation. The exposure of individuals to UV radiation varies from one-tenth to ten times the average for the population, depending on the time people spend indoors vs outdoors and under shade structures. The exposure of the skin or eyes further depends on the use of sun protection such as clothing or sunglasses. Warming temperatures and changing precipitation as a result of climate change will alter human behaviours in relation to sun exposure, but the direction and magnitude of effect is likely to be highly variable across the globe. The dose of UV radiation to biological structures in the skin is mediated by skin pigmentation, with darker skin providing significant protection against skin cancers. If humans are displaced, for example, due to climate-change induced sea-level rise, (e.g., darker-skinned people moving from low to higher latitudes) they will encounter conditions of UV radiation that may be different to those to which they are accustomed.
- Vegetation cover modifies the amount of sunlight reaching many terrestrial organisms e.g., and shading influences the exposure of construction materials to UV radiation. Modifications of that cover, for example, as a result of drought, fire, and pest-induced die-back of forest canopies induced by climate change will have profound effects on the exposure of terrestrial organisms to UV radiation.e.g., In addition, shifts in the seasonal timing of critical life cycle events such as plant flowering, spring bud-burst in trees, and animal emergence and breeding will change exposure to UV radiation as UV radiation naturally varies with season.
- As plants and animals move poleward, into higher elevations, or deeper into lakes, and oceans in response to climate change, they are exposed to conditions of UV radiation that may be different to those to which they are adapted. Furthermore, reductions in ice or snow cover in polar regions as a result of global warming will increase the exposure to UV radiation of soils and aquatic ecosystems that would previously have been below the snow or ice.
- The penetration of UV radiation into aquatic ecosystems depends on the transparency of water, the amount of dissolved organic matter, and ice cover. Increases in extreme weather events that increase the input of dissolved organic matter and sediments into coastal and inland waters can reduce water clarity, reducing exposure of aquatic ecosystems to UV radiation. Reductions in the thickness and duration of snow and ice cover and global changes in the depth of the warmer, surface mixed layers of lakes and oceans, are altering the levels of exposure of aquatic organisms to UV radiation. Previously, climate change was expected to increase exposure to UV radiation by causing shallower mixed layers, but new data show deeper mixed layers in lakes and oceans in some regions and shallower mixed layers in others.
- These climate change-driven effects can result in either increases or decreases in exposures to solar UV radiation, depending on location, time of year, individual

species, and other circumstances. Changes in exposure and sensitivity to solar UV radiation, driven by ongoing changes in stratospheric ozone and climate, have the potential to affect humans, life on Earth and the environment, including materials used in infrastructure and for other purposes, with consequences for the health and well-being of people and ecosystem sustainability. Some of these effects are highlighted below. These findings, together with others described in the current Quadrennial Assessment of 2018, address 11 of the 17 United Nations Sustainable Development Goals.

Consequences of changing exposure to UV radiation on humans and the environment

Effects on human health

- Higher exposure to UV radiation increases the incidence of skin cancers and other UV-induced human diseases, such as cataracts and photosensitivity disorders. Increases in the incidence of skin cancer over the last century appear largely attributable to changes in behaviour that increase exposure to UV radiation; these changes highlight how susceptible human populations are to higher exposure to UV radiation, as would have occurred with uncontrolled depletion of stratospheric ozone. Skin cancer is the most common cancer in many developed countries with predominantly light-skinned populations. For example, there are over 90,000 new skin cancers compared with ca 3000 new cases of colorectal cancer in New Zealand each year. Skin cancer is also the most expensive cancer in many of these countries. The estimated cost of treating cutaneous malignant melanoma in the USA was estimated at ca USD 457 million in 2011 and predicted to increase to ca USD 1.6 billion in 2030. Exposure to UV radiation accounts for 60-96% of the risk of developing cutaneous malignant melanoma in light-skinned populations. It is estimated that ca 168,000 new melanomas in 2012 were attributable to 'excess' exposure to UV radiation (above that of a historical population with minimal exposure), as a result of population changes in lifestyle, from sun avoidance to sun-seeking behaviour. Modelling studies show that implementation of the Montreal Protocol has avoided devastating effects on human health, including large increases in skin cancer incidence in light-skinned populations, resulting from high levels of UV radiation (e.g., UVI > 40 in the tropics by 2065.54).

- Exposure to UV radiation contributes to the development of cataract, the leading cause of vision impairment globally (12.6 million blind and 52.6 million visually impaired due to cataract in 2015). Particularly in low-income countries - often with high ambient UV radiation - access to cataract surgery may be limited, making this not only a major health concern but a major source of loss of livelihood and economic damage. The role of exposure to UV vs visible radiation in age-related macular degeneration remains unclear. Nevertheless, in aging populations worldwide, this is a major cause of visual impairment that currently has limited treatment options. Understanding risk factors and thus potential prevention is of critical importance.

- Concern about high levels of UV-B radiation because of stratospheric ozone depletion was an important driver for the development of programs for sun protection in many countries. These programs focus on promoting changes in people's behaviour, supported by structural and policy-level interventions. Sun protection programs have been shown to be highly cost-effective in preventing skin cancers. Behavioural strategies need to be informed by the real-time level of ambient UV radiation (provided by the UVI) and include controlling time outdoors together with using clothing, hats, sunscreen and sunglasses to reduce exposure to UV radiation. Behavioural changes can be facilitated by providing shade in public spaces such as parks, swimming pools, and schools, and improving access to sunscreen.

- Exposure to UV radiation also has benefits for human health. For example, exposure of the skin to UV radiation results in the production of vitamin D and is the major source of this vitamin for much of the world's population. Vitamin D is critical to healthy bones, particularly during infancy and childhood. There is also growing evidence of a range of other benefits of exposure to UV radiation through both vitamin D and non-vitamin D pathways; for example, for systemic autoimmune diseases, and reducing non-cancer mortality. Recent research suggests that the benefits for reduced mortality may be substantial.

- Gaps in our knowledge prevent calculations of the amount of UV radiation necessary to balance the risks with benefits, particularly as this likely varies according to age, sex, skin type, and location. Projected changes in climate will alter the balance of risks vs benefits for human populations living in different regions. For example, lower ambient UV-B radiation at high latitudes will increase the risk of vitamin D deficiency where this risk is already substantial. Conversely, warmer temperatures may encourage people in cooler regions to spend more time outdoors, increasing exposure to not just UV-B radiation, but all wavelengths of solar radiation, and related risks of skin cancer and cataract.

Effects on air quality

- UV radiation drives photochemical reactions of many emitted chemical compounds, generating secondary pollutants, including ground-level ozone and some types of particulate pollutants. Future recovery of stratospheric ozone and climate may change ground-level ozone via decreases in UV radiation and increases in downward transport of stratospheric ozone,with important consequences for human health and the environment. Modelling studies for the USA indicate that reductions in UV radiation due to stratospheric ozone recovery will lead to decreased ground-level ozone in some urban areas but slight increases elsewhere.

- Changes in UV radiation and climate can have major impacts on human health by affecting air quality. A number of recent international assessments have concluded that poor air quality is a significant global health issue and is estimated to be the largest cause of deaths globally due to an environmental factor; for example, exposure to fine particulate matter (PM2.5) caused 4.2 million deaths in 2015. Because large populations are already affected by poor air quality, even small relative changes in UV radiation can have significant consequences for public health.

Effects on agriculture and food production

- There is little evidence to suggest that modest increases in solar UV radiation have any substantial negative effect on crop yield and plant productivity. How food production would have been impacted by large increases in solar UV radiation in the absence of the Montreal Protocol is unclear. One analysis, based on data from a number of field studies conducted in regions where stratospheric ozone depletion is most pronounced (i.e., high latitudes), concluded that a 20% increase in UV radiation equivalent to a 10% reduction in stratospheric ozone would reduce plant production by only about 6% (i.e., a 1% reduction in growth for every 3% increase in UV radiation). To what extent this relationship would hold for levels of UV radiation > 2-fold higher than present (i.e., the "world avoided" scenario) is uncertain and represents an important knowledge gap.

- It is likely that by contributing to the mitigation of climate change through phasing out of the ozone depleting substances and some of their substitutes that increase global warming, the Montreal Protocol has reduced the vulnerability of agricultural crops to rising temperatures, drought, and extreme weather events. It is now clear that ozone depletion in the southern hemisphere is altering regional atmospheric circulation patterns in this part of the globe which, in turn, affect weather conditions, sea surface temperatures, ocean currents, and the frequency of wildfires.13, 31, 38, 41, 58 At a regional scale, increases in rainfall in the southern hemisphere, driven by stratospheric ozone depletion and climate change, have been linked to increases in agricultural productivity in South America; however, these beneficial effects may reverse as the stratospheric ozone 'hole' recovers. In the northern hemisphere, similar, but smaller, effects of stratospheric ozone depletion on climate may be occurring, but there are no reports as yet linking these changes to environmental effects.

- Climate change factors including drought, high temperatures, and rising carbon dioxide levels can modify how UV radiation affects crop plants, but effects are complex and often contingent on growth conditions. In some cases these factors can increase sensitivity to UV radiation (e.g., elevated carbon dioxide can weaken defenses against UV radiation in maize.87 In other cases, exposure to UV radiation can alter the effects of climate change, such as increasing the tolerances of crop plants to drought.67 Reduced UV radiation resulting from the recovery of stratospheric ozone may lead to increases in ground-level ozone in rural areas that could negatively affect crop yields. Understanding these, and other, UV-climate change interactions can inform growers and breeders as to relevant agricultural practices for maintaining crop yields in the face of evolving environmental change.

- UV radiation can also have beneficial effects on plants and these effects are often mediated by specific photoreceptors that act to regulate plant growth and development. These non- damaging effects include alterations in plant chemistry that then lead to changes in the nutritional quality of food and plant resistance against pests and pathogens. Consequently, decreases in exposure to UV radiation as a result of changes in stratospheric ozone and climate or changing agricultural practices (e.g., planting dates or sowing densities), may reduce plant defenses and thereby affect food security in ways other than just the direct effects on yield. For certain vegetable crops, UV radiation is increasingly being used to manipulate plant hardiness, food quality and pest resistance.

Effects on water quality and fisheries

- Changes in exposure to UV radiation and mixing depths are altering the fundamental structure of aquatic ecosystems and consequently their ecosystem services (e.g., water quality, fisheries productivity) in regionallyspecific ways. The larvae of many commercially important fish species are clear-bodied and sensitive to damage induced by UV radiation. This sensitivity, combined with the distribution of these larvae in surface waters with high exposure to UV radiation, has the potential to reduce the survival of first-year fish and subsequent harvest potential for fisheries. In contrast, reductions in the transparency of clear-water lakes to UV radiation may increase the potential for invasions of UV-sensitive warm-water species that can negatively affect native species.

- Heavy precipitation and melting of glaciers and permafrost associated with climate change are increasing the concentration and colour of UV-absorbing dissolved organic matter and particulates. This is leading to the "browning" of many inland and coastal waters, with consequent loss of the valuable ecosystem service in which solar UV radiation disinfects surface waters of parasites and pathogens. Region-specific increases in the frequency and duration of droughts have the opposite effect, increasing water clarity and enhancing solar disinfection, as well as altering the depth distribution of plankton that provides critical food resources for fish.

Effects on biogeochemical cycles, climate system feedbacks, and biodiversity

- Changes in stratospheric ozone and climate affect biogeochemical cycles driven by sunlight and, in turn, greenhouse gases and water quality. Exposure to solar UV and visible radiation can accelerate the decomposition of natural organic matter (NOM, e.g., terrestrial plant litter, aquatic detritus, and dissolved organic matter), and the transformation of contaminants. Photodegradation of NOM results in the emission of greenhouse gases including carbon dioxide and nitrous oxide., Increases in droughts, wildfires, and thawing of permafrost soils driven by climate change have the potential to increase photodegradation (for example, ref. 1), thereby fueling a positive feedback on global warming; however, the scale of this effect remains an important knowledge gap.

- Species of aquatic and terrestrial organisms differ in their tolerances to UV radiation and these differences can lead to alterations in the composition and diversity of ecological communities under conditions of elevated UV radiation. UV radiation also modifies herbivory and predator-prey interactions, which then alter trophic interactions, energy transfer, and the food webs in ecosystems. Presently, ozone-driven changes in regional climate in the southern hemisphere are threatening the habitat and survival of a number of species that grow in the unique high-elevation woodlands of the South American Altiplano as well as for mosses and other plant communities in Antarctica, but enhancing reproductive success of some marine birds and mammals.To what extent the Montreal Protocol has specifically contributed to the maintenance of biodiversity in ecosystems is unknown, but losses in species diversity in aquatic ecosystems are known to be linked to high exposure to UV radiation and can cause declines in the health and stability of ecosystems and the services they provide to humans.

Effects on contaminants and materials

- Escalating releases of contaminants into the environment combined with changes in climate and stratospheric ozone impact human health and terrestrial and aquatic ecosystems. UV radiation is one of the key factors that influences the biogeochemical cycling of contaminants and their degradation via direct and indirect photoreactions. However, effects of climate change, such as heavy precipitation events or droughts also have large impacts on the photodegradation of contaminants by decreasing or increasing their exposure to solar UV radiation. Moreover, increased or decreased runoff of coloured dissolved organic matter affects the balance between direct and indirect photoreactions in aquatic ecosystems. These effects of climate change depend on local conditions, posing challenges for prediction and management of contaminant effects on human health and the environment.

- Exposure to UV-B radiation plays a critical role in altering the toxicity of contaminants. Exposure to UV radiation increases the toxicity of contaminants such as pesticides and polycyclic aromatic hydrocarbons (PAHs) to aquatic organisms such as fish and amphibians. In contrast, exposure to UV-B radiation transforms the most toxic form of methylmercury to forms that are less toxic, reducing the accumulation of mercury in fish. However, potential long-term increases in dissolved organic matter will decrease underwater exposure to UV radiation in inland waters in some regions, such as southern Norway. This may then contribute to the already observed increases in methylmercury in fish that would likely occur as a consequence of reduced water transparency to UV radiation. Solar radiation also plays a major role in the degradation of many organic pollutants and water- borne pathogens. This process of photodegradation by solar UV radiation may be affected by changes in stratospheric ozone, but other factors such as dissolved organic matter are more important in regulating underwater UV radiation and so have a greater effect on photodegradation. Advances in modeling approaches are allowing improved quantification of the effects of global changes on the fate of aquatic pollutants.

- Sunscreens are in widespread use, including in cosmetics, as part of the suite of approaches to sun protection for humans. However, it is now recognized that sunscreens wash into coastal waters, with potential effects on aquatic ecosystems. The toxicity of artificial sunscreens to corals, sea urchins, fish, and other aquatic organisms, has led the state of Hawaii, USA, to pass legislation banning the use of some sunscreens, and the European Union to consider similar legislation.

- Microplastics (plastic particles < 5mm) are now ubiquitous in the world's oceans and pose an emerging serious threat to marine ecosystems with many organisms now known to ingest them. Microplastics are formed by the UV-induced degradation and breakdown of plastic products and rubbish exposed to sunlight. Microplastic pollutants occur in up to 20% or more of fish marketed globally for human consumption. Although the toxicity of microplastics and smaller nanoplastics is unknown, higher temperatures and levels of UV radiation accelerate the fragmentation of plastics, potentially threatening food security.

- Exposure to solar UV radiation damages the functional integrity and shortens the service lifetimes of organic materials used in construction, such as plastics and wood that are routinely exposed, e.g., in roofing and pipelines. Until very recently, plastics used in packaging and building were selected and optimised on the basis of durability and performance. However, the present focus on increased sustainability, for example, the trend towards 'green buildings', now requires such choices to be environmentally acceptable as well. This includes the increased use of wood, which is renewable, carbon neutral and low in embodied energy, in place of plastics, where appropriate. Some of these materials are vulnerable to accelerated aging under exposure to UV radiation. Current efforts are moving forward to identify and develop novel, safer, effective, and 'greener' additives (colourants, plasticisers, and stabilisers) for plastic materials and wood coatings. Harsher weathering climates, as predicted due to climate change, would require even more effort along this direction.

- Trifluoracetic acid (TFA), a substance regulated under the Montreal Protocol, is produced naturally and commercially. There are multiple anthropogenic sources that will release trifluoroacetic acid (TFA) into the environment. Sources relevant to the Montreal Protocol include the substitutes for CFCs, the HCFCs, HFCs, and HFOs. These chemicals are known to degrade to TFA in the atmosphere but contribute to only a slight increase in TFA concentrations in surface water. This is not expected to pose a risk to humans or the environment.

Conclusions and knowledge gaps

- The Montreal Protocol has been successful in preventing the global depletion of stratospheric ozone and consequently large-scale increases in solar UV-B radiation and has therefore prevented major adverse impacts on human health and the environment.

- We remain confident in our qualitative predictions of the effects on human health and the environment that have been avoided largely because the Montreal Protocol has successfully controlled stratospheric ozone depletion. However, quantification of many of the benefits deriving from the success of the Montreal Protocol remains a major challenge, and the future trends in UV radiation exposure remain uncertain considering climate change and the extent of human response.

- Unexpected increases in emissions of CFC-11 that were recently reported are currently expected to have only small effects on stratospheric ozone depletion, and therefore also on human health or the environment. However, were such unexpected emissions to persist and increase in the future, or new threats emerge, effects on human health and the environment could be substantial. New threats might include "geoengineering" activities proposed to combat the warming caused by greenhouse gases, which could have consequences for UV radiation reaching the Earth's surface. In particular, proposals to inject sulfuric aerosols into the stratosphere to reduce solar radiation at the Earth's surface would likely have important side effects for stratospheric ozone and UV radiation. Sulfate aerosols could accelerate stratospheric ozone loss if substantial amounts of ODSs remain in the atmosphere. The combined changes in absorption by ozone and scattering by sulfate would have spectrally complex consequences for the transmission of UV radiation to ground-level, and the ratio of direct to diffuse UV radiation would be systematically larger.

- Meeting the challenge of improved quantification of the environmental effects of future changes in stratospheric ozone requires addressing several significant gaps in current knowledge. First, we need a better understanding of the relative effectiveness of different wavelengths of solar radiation (i.e. the biological spectral weighting functions) in altering the fundamental responses of a diversity of organisms. This would allow better attribution of changes to exposure, specifically to UV-B radiation (and thus related to stratospheric ozone depletion), rather than to solar radiation more generally. Second, we need a better understanding of dose-response relationships across the breadth of effects on human health and the environment. Taken together, these would support improved scaling and modeling of the effects of stratospheric ozone depletion and climate change on living organisms and their ecosystems, and materials such as plastics, wood structures, and clothing.

- As a result of shifting geographic ranges (including migration of humans and other species that is induced by climate change) and changes in seasonal timing of life-cycle events due to climate change, it is apparent that many organisms, including human populations, will experience different and interactive combinations of UV radiation and other environmental factors. These environmental changes will occur together with alterations in community structure, which will then indirectly affect growth, reproduction, and survival. How humans and ecosystems respond to changes in UV radiation against this backdrop of simultaneous, multi-factor environmental change remains a major knowledge gap. Quantifying these effects is extremely challenging, where many of the outcomes are contingent on human behaviour and societal responses that are difficult to predict.

- The focus of concern regarding elevated exposure to UV radiation has historically been on human health. Beyond the importance of terrestrial and aquatic ecosystems in providing critical 'ecosystem services' for human well-being, environmental sustainability and the maintenance of biodiversity are critical to maintaining a healthy planet. The topics covered by the Environmental Effects Assessment Panel embrace some of the complexity and inter- relatedness of our living planet, while the success of the Montreal Protocol demonstrates that globally united and successful action on complex environmental issues is possible.

Text Extracted from EEAP. 2019. Environmental Effects and Interactions of Stratospheric Ozone Depletion, UV Radiation, and Climate Change. 2018 Assessment Report. Nairobi: Environmental Effects Assessment Panel, United Nations Environment Programme (UNEP) 390 pp. https://ozone.unep.org/science/assessment/eeap.

Release of "The Montreal Protocol: India's Success Story" on the occasion of 24th World Ozone Day" on 17th September, 2018 at New Delhi, India.

Release of "The Draft India Cooling Action Plan (ICAP)" on the occasion of 24th World Ozone Day" on 17th September, 2018 at New Delhi, India.

Launch of a refurbished website and web-based Management Information System (MIS) during "24th World Ozone Day" function held on 17th September, 2018 at New Delhi, India.

Dr. Harsh Vardhan, the then Hon'ble Minister for Environment, Forest & Climate Change, Government of India, addressing the participants during "24th World Ozone Day" function held on 17th September, 2018 at New Delhi, India

Participants during the "24th World Ozone Day" function held on 17th September, 2018 at New Delhi, India.

Award Winning Students on the occasion of 24th World Ozone Day" on 17th September, 2018 at New Delhi, India.

Launch of "India Cooling Action Plan (ICAP)" by Dr. Harsh Vardhan, the then Hon'ble Minister of Environment, Forest and Climate Change, function held on 8th March, 2019 at New Delhi, India.

Participants during the "Launch of India Cooling Action Plan (ICAP)" function held on 8th March, 2019 at New Delhi, India.

Shri Anil Kumar Jain, the then Additional Secretary, Ministry of Environment, Forest & Climate Change, Government of India addressing the participants during the "Stakeholder workshop on Alternatives to HCFC 141b in Foam Manufacturing Sector" held on 8th February, 2019 at New Delhi, India.

Workshop on "R & D and Innovation in Cooling and Refrigeration" held on 6th May, 2019 at New Delhi, India, jointly organized by department of Science and Technology (DST), Government of India, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India and Bureau of Energy Efficiency (BEE), Ministry of Power (MoP), Government of India. From left to right : Dr. Amit Love, Joint Director/ Scientist - D, Ozone Cell, MoEFCC, Dr Sanjay Bajpai, Head (Technology Mission Division : Energy & Water), DST, GoI, Ms Geeta Menon, Joint Secretary, MoEFCC, GoI, Mr Abhay Bakre, Director General, BEE MoP, GoI and Dr JBV Reddy, Principal Scientific Officer/Scientist - D, DST, GoI.

Panel Discussion on "Global Cooling Prize to Kick-Start the Innovation and R&D Ecosystem in India" in Research perspective during Workshop on "R & D and Innovation in Cooling and Refrigeration" held on 6th May, 2019 at New Delhi, India.

Dr. Amit Love, Joint Director/ Scientist - D, Ozone Cell, Ministry of Environment, Forest & Climate Change, Government of India, addressing the participants during the "Training Programme for Stakeholders web-based Management Information System (MIS) for Ozone Depleting Substances (ODS) phase out activities in India" held on 16th July, 2019 at New Delhi, India.

Ms Geeta Menon, Joint Secretary, Ministry of Environment, Forest & Climate Change, Government of India, addressing the participants during the "Stakeholder Consultation on Strengthening of Refrigeration and Air-conditioning Certification System" held on 27th August, 2019 in Delhi.

Participants during the "Stakeholder Consultation on Strengthening of Refrigeration and Air-conditioning Certification System" held on 27th August, 2019 in Delhi.

Group Photograph of some participants of "Stakeholder Consultation on Strengthening of Refrigeration and Air-conditioning Certification System" held on 27th August, 2019 in Delhi.

Panel Discussion on "Strengthening of Refrigeration and Air-conditioning Certification System" during the "Stakeholder Consultation on Strengthening of Refrigeration and Air-conditioning Certification System" held on 27th August, 2019 in Delhi.

Participants during the Workshop on "Alternatives to HCFC-141b in Foam Manufacturing Sector" held on 24th May, 2019 in Murthal, Haryana, jointly organized by Central Institute of Plastic Engineering and Technology (CIPET) and Ozone Cell, MoEFCC.

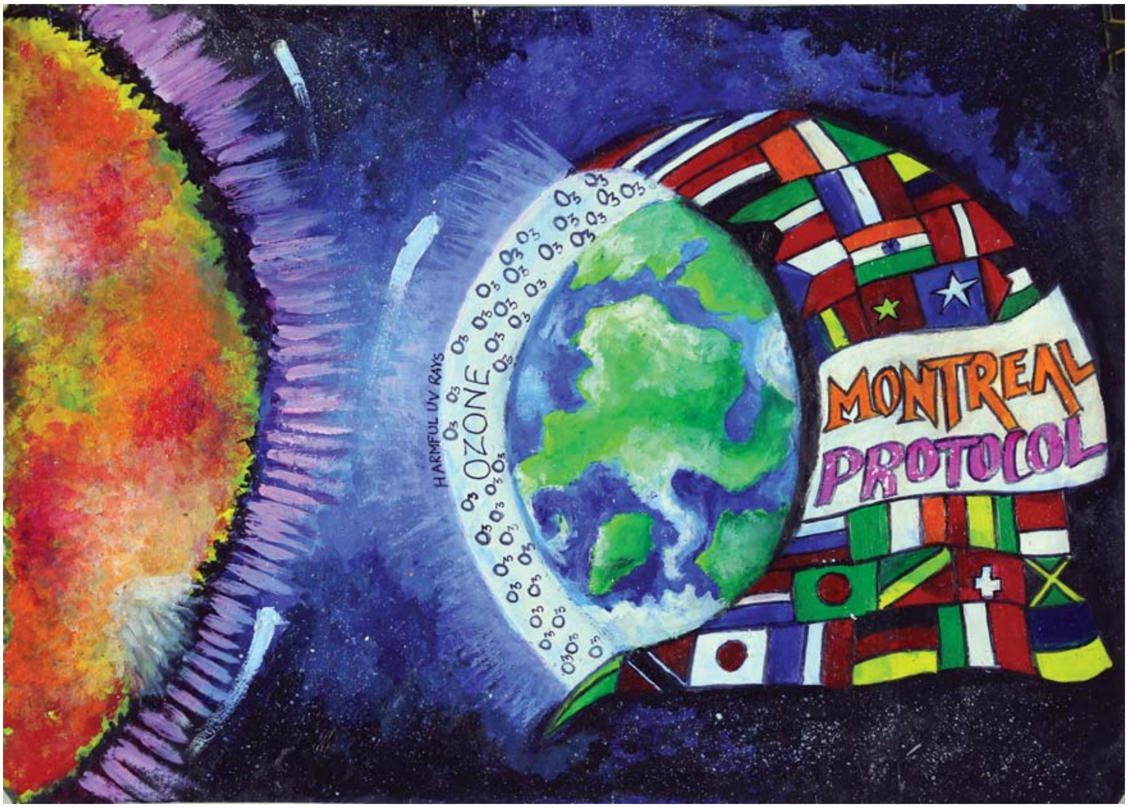
Participants during the Workshop on "Alternatives to HCFC-141b in Foam Manufacturing Sector" held on 21st June, 2019 in Ahmedabad, Gujarat, jointly organized by Central Institute of Plastic Engineering and Technology (CIPET) and Ozone Cell, MoEFCC.

Participants during the Workshop on "Alternatives to HCFC-141b in Foam Manufacturing Sector" held on 2nd August, 2019 in Chennai, jointly organized by Central Institute of Plastic Engineering and Technology (CIPET) and Ozone Cell, MoEFCC.

Participants in practical session during the Workshop on "Alternatives to HCFC-141b in Foam Manufacturing Sector" held on 2nd August, 2019 in Chennai, jointly organized by Central Institute of Plastic Engineering and Technology (CIPET) and Ozone Cell, MoEFCC.

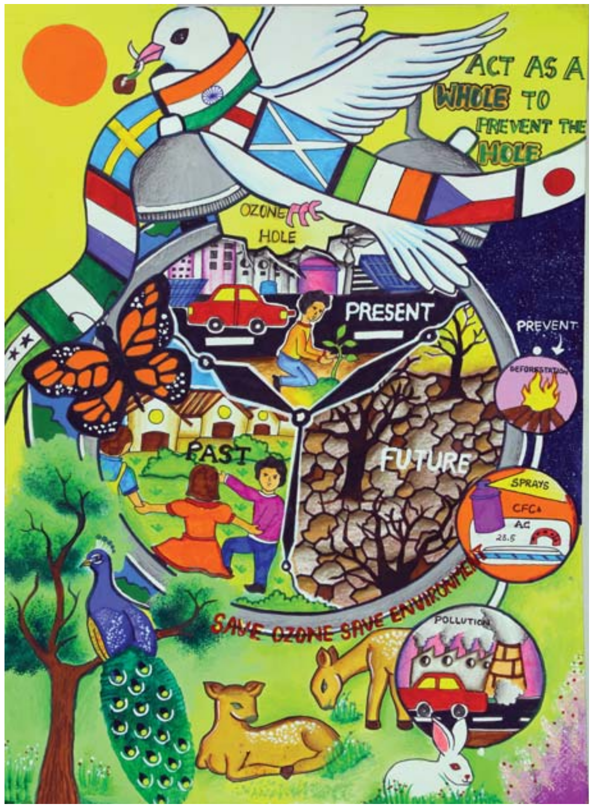
Painting competition First Prize winning entry of Prabhjeet Singh Nanra, Ryan International School, C-8, Vasant Kunj, Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

Painting competition Second Prize winning entry of M. Anto Moses Alexander, St. Columba's School, Ashok Place, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

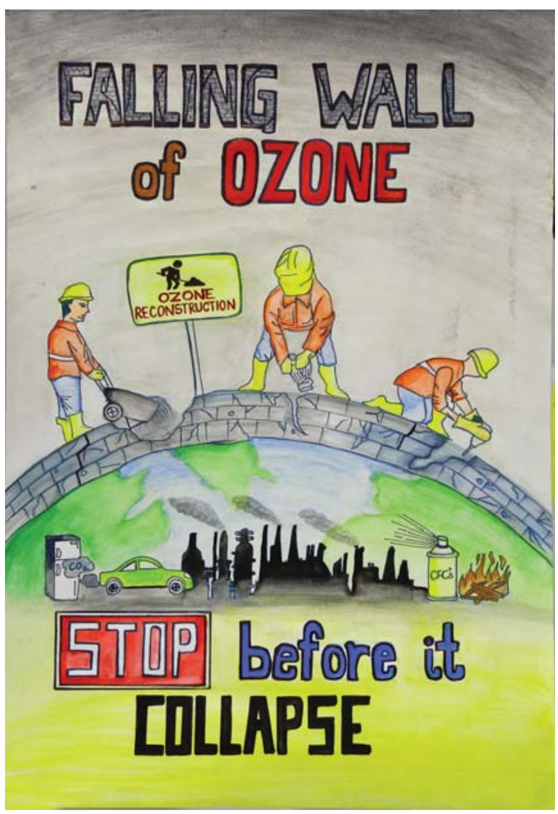


Painting competition Third Prize winning entry of Kuntak Saha, St. Columba's School, Ashok Place, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

Painting competition consolation Prize winning entry of Jiya Sharma, Gita Rattan Jindal Public School, D-Block, Sector-7, Rohini, Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi



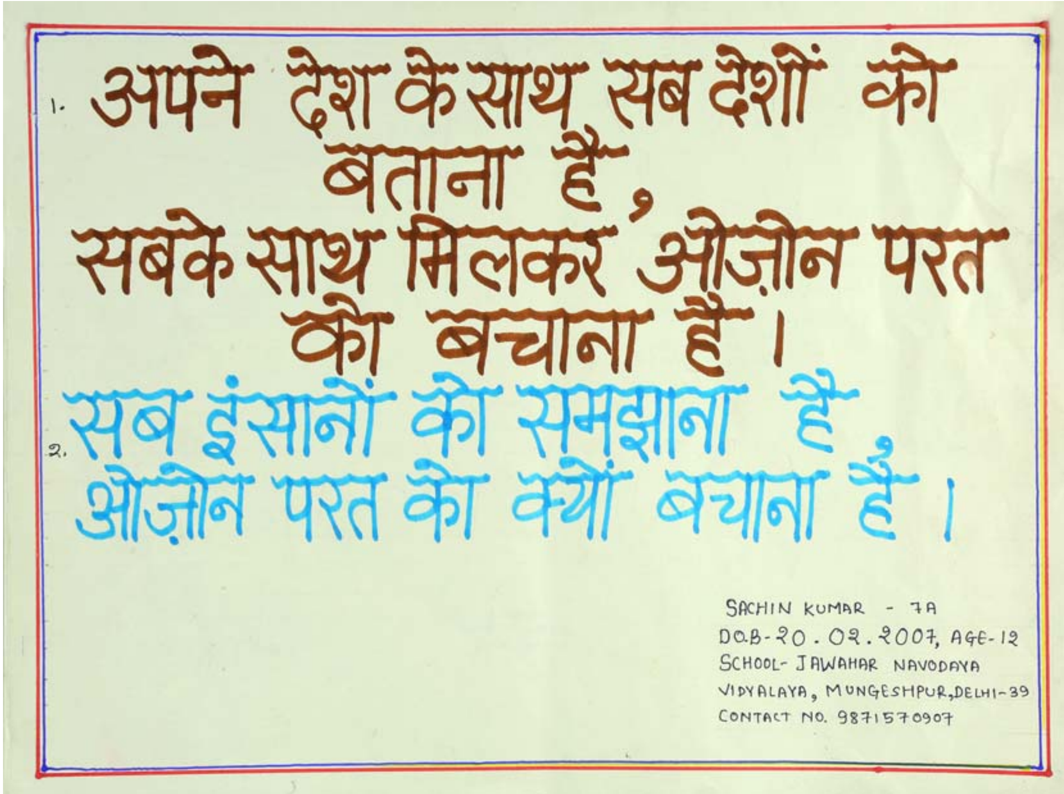
Poster competition First Prize winning entry of Supriya Baital, Birla Vidya Niketan, Pushp Vihar, Sector-IV, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi



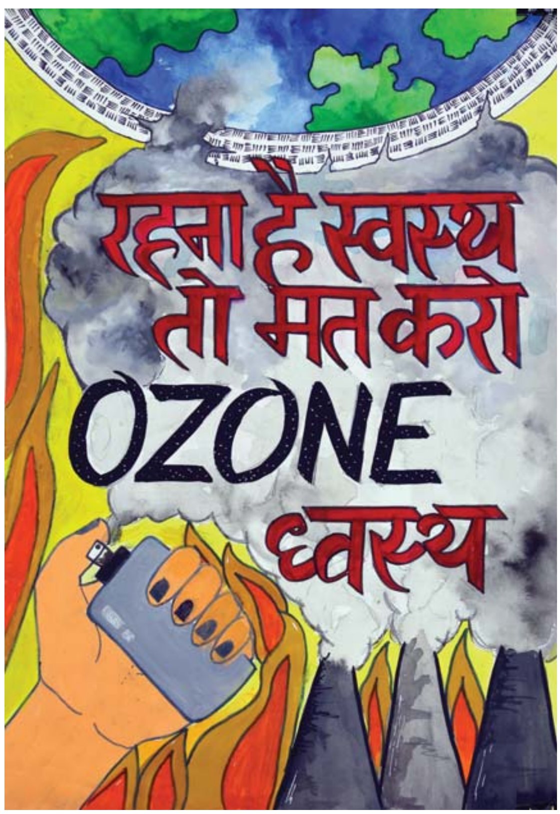
Poster competition Second Prize winning entry of Anita Sharma, Delhi Police Public School, B-4, Safdarjung Enclave, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

Poster competition Third Prize winning entry of Ananya Rastogi, A S N Sr. Sec. School, Mayur Vihar, Phase-1, Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

Poster competition consolation Prize winning entry of Tanisha Singh, Springdales School, Pusa Road, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi



Slogan competition First Prize winning entry of Sachin Kumar, Jawahar Navodaya Vidyalaya, Mungeshpur, Post office - Bawana, Distt.-North West, Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

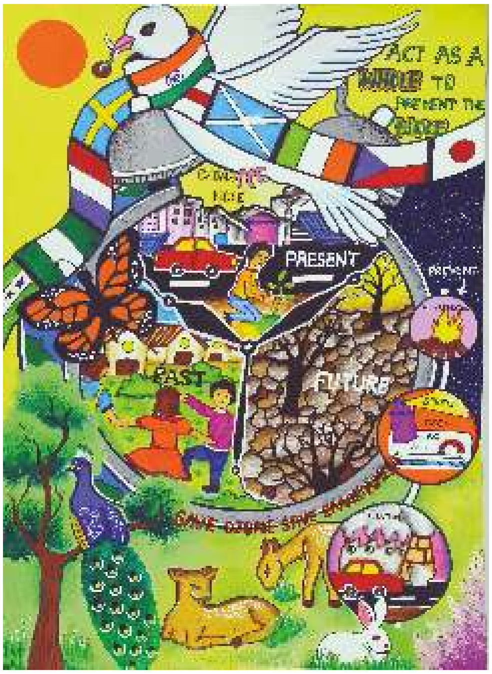


Slogan competition Second Prize winning entry of Sahil Shrivastav, Darbari Lal DAV Model School, ND Block, Pitampura, Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

Slogan competition Third Prize winning entry of Sarthak, Adarsh Public School, C Block, Vikas Puri, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

Slogan competition consolation Prize winning entry of Jyoti Kumari, Sarvodaya Kanya Vidyalaya, Pandara Road, New Delhi organized on the occasion of 25th World Ozone Day, 2019 at New Delhi

POSTER COMPETITION



1ST PRIZE
Supriya Baital
Birla Vidya Niketan, Pushp Vihar, Sector-IV, New Delhi

2ND PRIZE
Anita Sharma
Delhi Police Public School, B-4, Safdarjung Enclave, New Delhi

3RD PRIZE
Ananya Rastogi
A S N Sr. Sec. School, Mayur Vihar, Phase-1, Delhi

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