# THE MONTREAL PROTOCOL
# INDIA'S SUCCESS STORY

सत्यमेव जयते

**OZONE CELL**
**MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE**
**GOVERNMENT OF INDIA**
**NEW DELHI, INDIA**
**2016**

"Ozone and climate : Restored by a world united"

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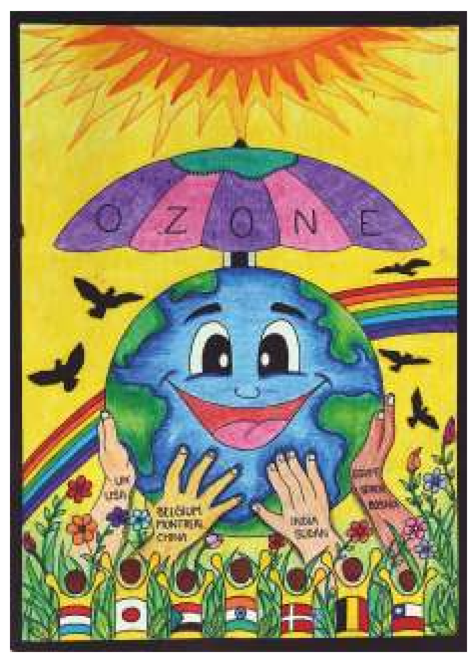


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*"Ozone and climate : Restored by a world united"*

OZONE AND CLIMATE

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अनिल माधव दवे
**Anil Madhav Dave**

सत्यमेव जयते

राज्य मंत्री (स्वतंत्र प्रभार)
**MINISTER OF STATE (INDEPENDENT CHARGE)**
पर्यावरण, वन एवं जलवायु परिवर्तन
**ENVIRONMENT, FOREST & CLIMATE CHANGE**
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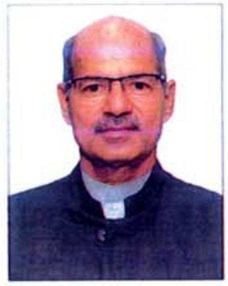

## FOREWORD

The Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer are the only international multilateral agreements, which have universal ratification from all the 197 member countries of the United Nations. The extraordinary international cooperation of Parties to the Montreal Protocol has led to not only the phase-out of production and consumption of around 95 % of the Ozone Depleting Substances (ODSs) worldwide, but has also contributed significantly towards protection of the global climate system. This has made Vienna Convention and its Montreal Protocol the most successful international environmental agreements.

The Montreal Protocol has been built on the principle of Common but Differentiated Responsibility. This is one of the most important factor for global acceptance of the Protocol. A financial mechanism was also created under the Protocol for providing technical and financial assistance to the developing countries to meet their obligations under the Protocol. The Montreal Protocol, thus, has proven to be an example of excellent international cooperation towards addressing other environmental challenges.

India, since it became a Party to the Vienna Convention for the Protection of the Ozone Layer on 18$^{th}$ March, 1991 and the Montreal Protocol on Substances that deplete the Ozone Layer on 19$^{th}$ June, 1992, has played a proactive role in the implementation of ODS phase-out activities in the country. Structured implementation framework supported by regulatory and fiscal measures have led to India successfully meeting all the ODS phase-out targets of the Montreal Protocol including the Stage-I of the Hydrochlorofluorocarbon (HCFC) Phase-out Management Plan (HPMP) as per the accelerated phase-out schedule of the Montreal Protocol. Stage-II of the HPMP has been prepared for achieving the 2020 compliance target of the Montreal Protocol for HCFCs.

The year 2016 is being celebrated globally with the theme **"Ozone and climate: Restored by a world united"**. The theme is supplemented by the tagline ***"Working towards reducing global-warming HFCs under the Montreal Protocol"***. On the occasion of the 22$^{nd}$ International Day for the Preservation of the Ozone Layer, India reiterates its commitment to protect the Ozone layer.

**(Anil Madhav Dave)**

**Paryavaran Bhawan, Jor Bagh Road, New Delhi-110 003**
**Tel.: 011-24695136, 24695132, Fax : 011-24695329**

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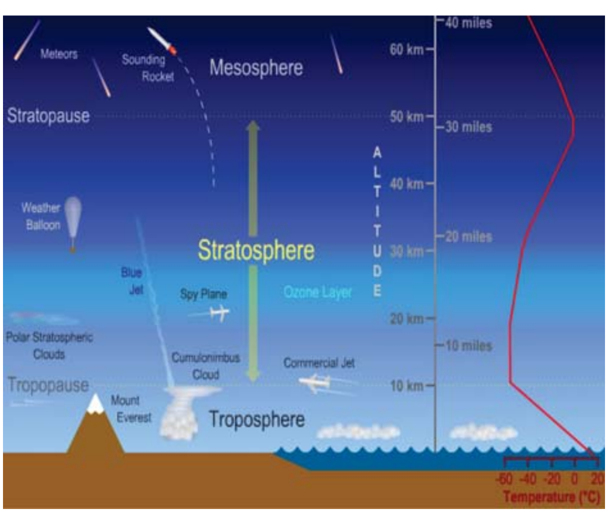
# 1. OZONE LAYER

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.

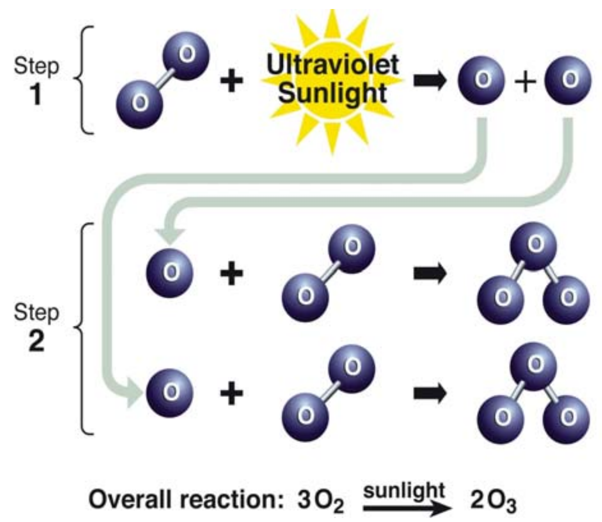
**Earth's Atmospheric Layers**




## 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.

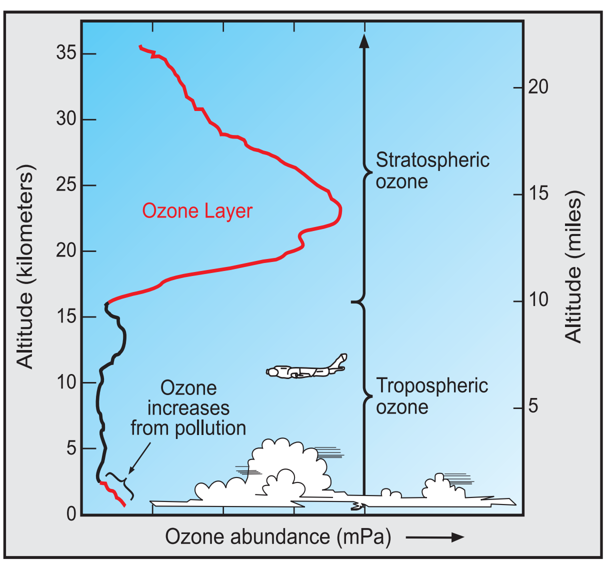
Since solar radiation is the strongest over the tropics, the global ozone is formed in tropics. However, strong solar radiation also causes rise of air to high altitudes and ozone is transported away from the equator towards the poles where it accumulates in the cold subpolar regions. At the equatorial 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**




## 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.

## 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

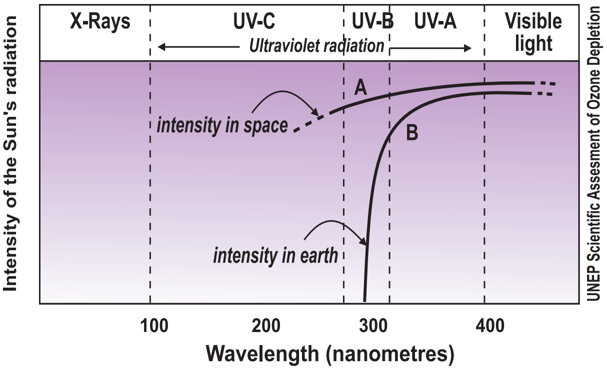
Indian Meteorological Department (IMD) is the nodal agency to measure the ozone levels in India. IMD has established a National Ozone Centre. The centre maintains and control a network of Ozone Monitoring Stations located at New Delhi, Ranichauri, Guwahati, Nagpur, Pune, Kodaikanal, Thiruvananthapuram, 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 Earth'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

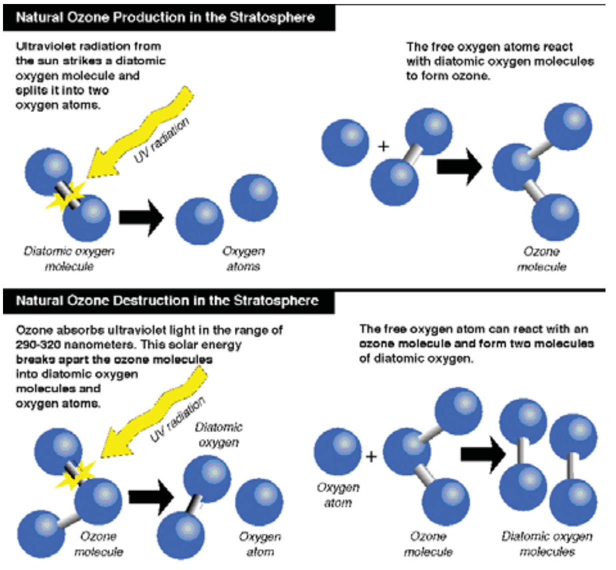



A - Undisturbed Ozone Layer
B - Disturbed Ozone Layer

## Ozone Depletion

At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount, however, remains relatively stable. The 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.

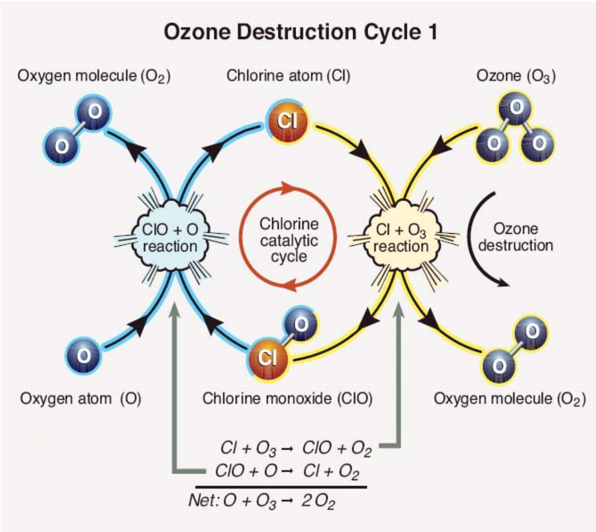
### Natural Formation and destruction of Ozone




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.

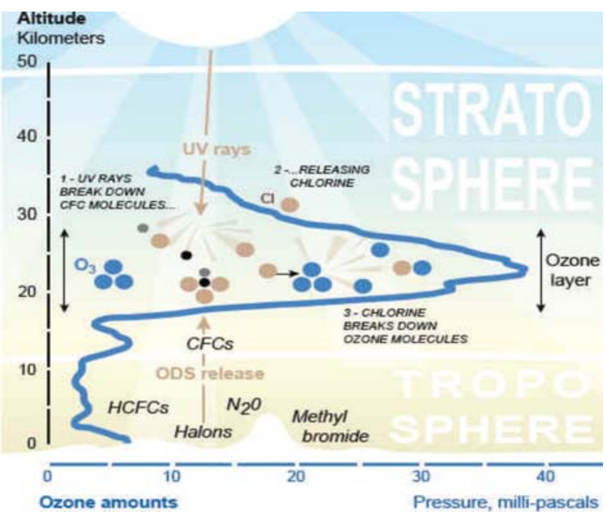
Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is shifted towards destruction. An upset in this balance can have serious consequences for life on Earth, and scientists are finding evidence of the changed balance. As a result, the concentration 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) experiments 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

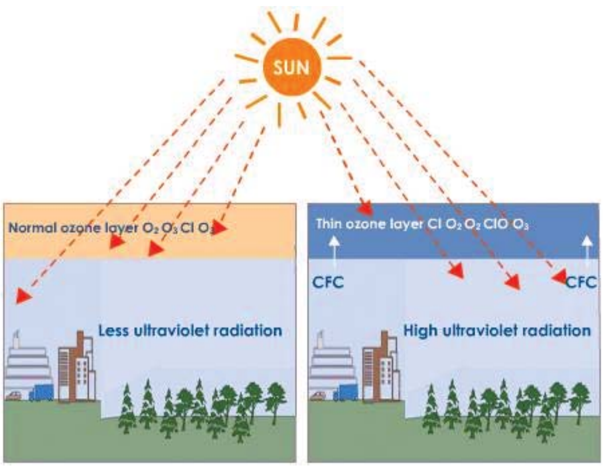
For over fifty years, CFCs were thought of as miracle substances. CFCs were first created in 1928 as non-toxic, non-flammable refrigerants, and were first produced commercially in the 1930's by DuPont. The first Chlorofluorocarbon was CFC-12, a single carbon with two chlorines and two Fluorines attached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

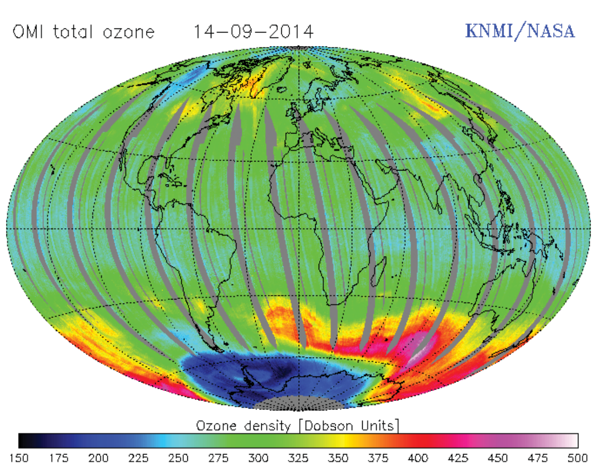
During the past 5 decades, Ozone Depleting Substances (ODSs) including CFCs have been emitted into the atmosphere in large quantity which has resulted in depletion of the ozone layer resulting increased UV-B radiations on the Earth surface.

**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 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.

**Status of Global Stratospheric Ozone : September, 2014**




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 authorized 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.

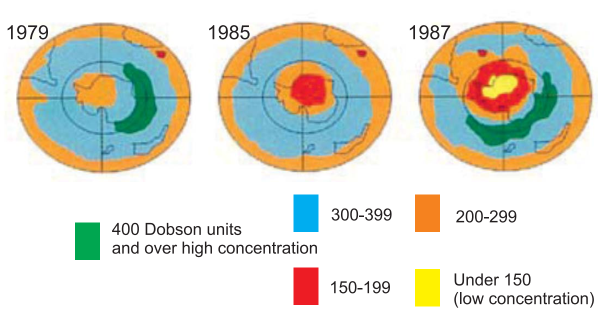
These investigations did not make much headway and were dismissed as false alarms.

## The Antarctic Ozone Hole

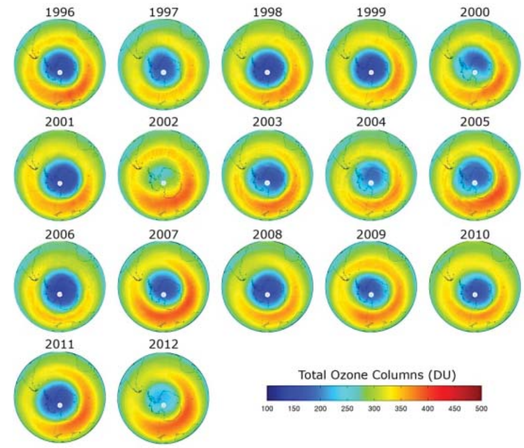
The term "ozone hole" refers to a large and rapid decrease in the concentration of ozone molecules in the ozone layer. "When the concentration of ozone over any area falls below 220 DU, it is called ozone hole". The Antarctic "Ozone Hole" occurs during the southern spring between September and November 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)**

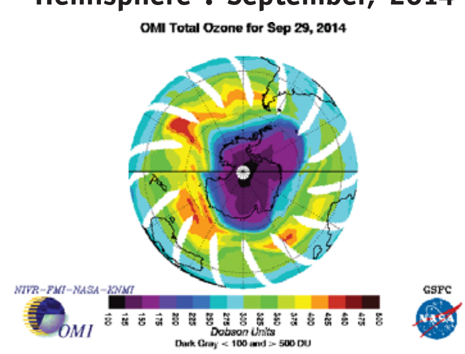



**Monitoring of Antarctic Ozone Hole (1996-2012)**




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.

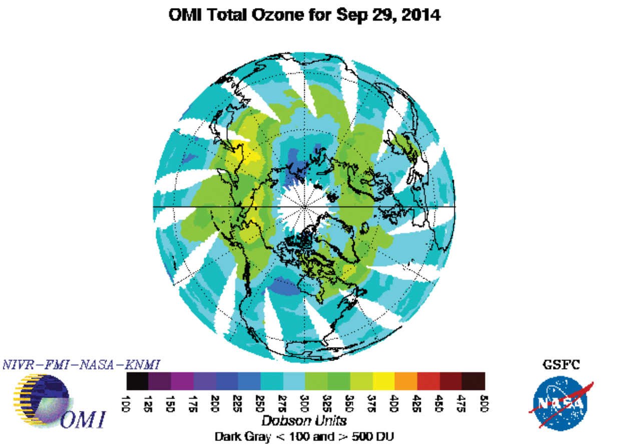
**Stratospheric Ozone in Southern Hemisphere : September, 2014**



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.

**Stratospheric Ozone in Northern Hemisphere : September, 2014**




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 stratospheric 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 flowering. 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.

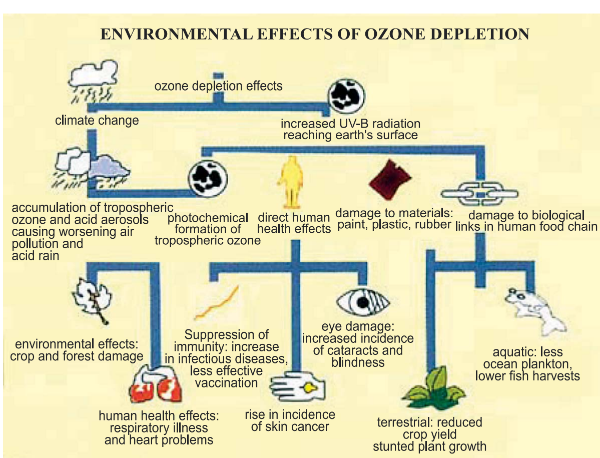
- A few commercially important trees have been tested for UV-B radiation sensitivity. Results indicate that plant growth, especially in seedlings, is more vulnerable to intense UV radiation.

## 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 countries 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.

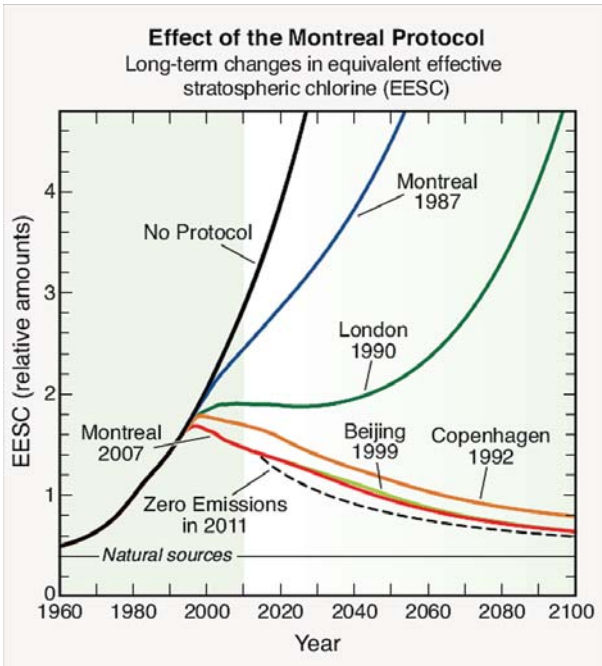
## Evolution of the Montreal Protocol

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 | 197 |
| 2 | Montreal Protocol, 1987 | 01.01.1989 | 197 |
| 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 |

## 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<br><br>Foam: CFC-11 HCFC-141b | Refrigerant: HFC-134a, Isobutane, HC blend, HFO-1234yf<br>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<br><br>Foam: CFC-11 HCFC-141b | Refrigerant: HFC-134a, HC-600a HC-blend, $CO_2$<br>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<br><br>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 ($CO_2$) 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<br>CTC<br><br>Methyl chloroform | DI Water<br>Aqueous cleaning process<br>Semi-acqueous cleaning process, organic non-halogenated, solvents, perfluorocarbons |
| Coatings | CFC-113<br>Methyl chloroform | Aqueous solvents<br>Trichloro ethylene |
| Manufacture of pesticides and pharmaceuticals | CTC | Ethylene-dichloride<br>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 (base line), 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 nine 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 minimisation of economic dislocation as a result of conversion to non-ODS technologies, maximisation of indigenous production, preference to one time replacement, emphasis on decentralized management and minimisation 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 program 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 Pulmonary Diseases (COPD) patients). India has also phased-out production and consumption of Methyl Chloroform and Methyl Bromide. A total of 304 projects have been approved and funded by the Ex-Com of the MLF for Implementation of the Montreal Protocol. A total amount of US $279,342,203 has been approved by the Ex-Com of the MLF to phase-out 58,980 ODP tonne of ODSs.

### Sector-wise Approved Projects as on 31.8.2015

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:

| Sl. No. | Sector | No. of Projects | Grant Amount (US $) | Phase out of ODP (in Tonne) |
|---|---|---|---|---|
| 1. | Industrial Aerosol | 27 | 3,227,739 | 689 |
| 2. | Medical Aerosol (MDIs) | 1 | 10,202,267 | 704 |
| 3. | Foam | 159 | 34,785,641 | 4373 |
| 4. | Halon | 18 | 2,639,389 | 2162 |
| 5. | RAC | 49 | 32,254,823 | 3203 |
| 6. | Solvent | 41 | 71,007,980 | 12,966 |
| 7. | Production Sector | 3 | 100,546,874 | 34,541 |
| 8. | Accelerated phase-out of CFCs | 1 | 2,113,000 | -- |
| 9. | HCFC Phase-out Management Plan (HPMP) Stage-I Preparation | 1 | 570,000 | -- |
| 10. | HPMP Stage-I | 1 | 21,294,490 | 342 |
| 11. | HPMP Stage-II Preparation | 1 | 490,000 | -- |
| 12. | Demonstration Project in Foam Sector | 1 | 30,000 | -- |
| 13. | Proposal for survey on ODS alternatives | 1 | 180,000 | -- |
| | **Total** | **304** | **279,342,203** | **58,980** |

## 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 Ex-Com of the MLF meeting 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 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, $CO_2$-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 financial 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 technological 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 Meeting of the Parties (MOP) held in September, 2007, would require conversion of foam manufacturing facilities from HCFCs to non-ODS technologies viz. hydrocarbons, HFCs, low-GWP HFCs, 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 covering 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 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 44 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 has been carrying out technical assistance activities, including awareness for sustaining the phase-out of CTC in different applications, except in feedstock use.

## 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.

## Accelerated Phase-out of HCFCs

India ratified all the amendments to the Montreal Protocol including Copenhagen and Beijing Amendments and need to phase-out HCFCs as per the reduction schedule specified in the Protocol. 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

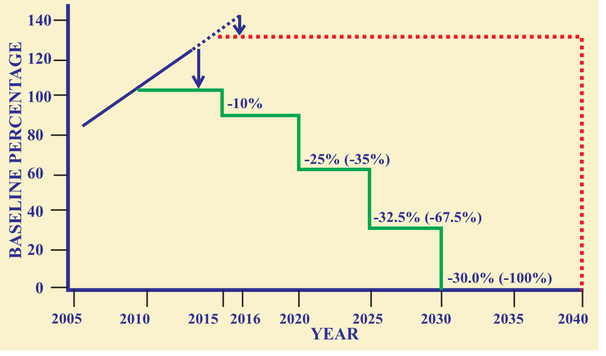
### Production

- 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 initiated discussions on guidelines for preparing HCFC Phase-out Management Plan (HPMP) Stage-I and policy guidelines for determining the costs for phasing out of HCFCs in different applications. The 54th Ex-Com 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.

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 ESC of the MoEF&CC at its 33rd meeting held on 21st November, 2007 decided to involve the World Bank, UNDP, UNEP, UNIDO, bilateral agencies like Government of Germany and France etc. as implementing agencies for the implementation of accelerated phase-out production and consumption of HCFCs in the country. UNDP has been designated as Lead Implementing Agency for HCFC phase-out in consumption sector. Accordingly, all the agencies have included activities to phase-out HCFCs in their respective business plans for triennium 2009-2011, 2012-2014 as well as for the triennium 2015-2017.

## 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 with UNDP as the lead implementing agency in association with UNEP and GIZ, Government of Germany.

The Sectoral Working Groups meeting was organized as early as in September, 2009 which was very well attended by the stakeholders from Industry, Industry Associations, Research Organizations, Non-Governmental Organizations (NGOs) and concerned line Ministries. The major Sectoral Groups represented were RAC manufacturing, foam manufacturing and servicing of RAC equipment. The Sectoral Groups deliberated for 2 days and made recommendations for future action plan. The Sectoral Working Groups meeting also served the objective of creating awareness among the stakeholders and take them on board.

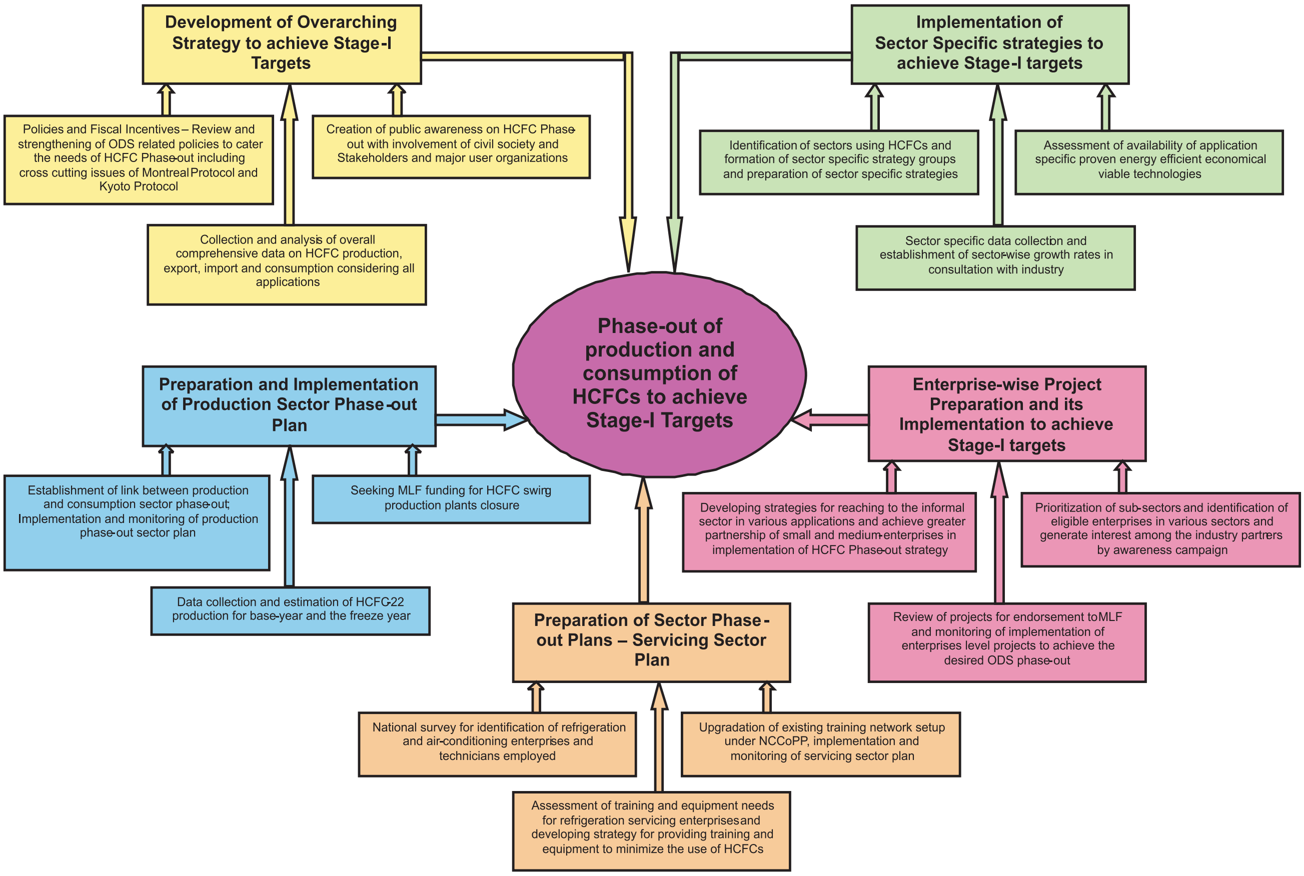
Based on the outcome, the Ozone Cell, MoEF&CC developed and launched a **"Roadmap for Phase-out of HCFCs in India"** describing the long term vision and action plan including the policy instruments for phase-out of production and consumption of HCFCs in India in accordance with the decision of the 19th MOP.

The Sectoral meeting identified 3 major HCFC consuming sectors namely the RAC Manufacturing Sector, Polyurethane Foam Manufacturing Sector and RAC Servicing Sector.

Considering Refrigeration and Air-Conditioning Manufacturers Association (RAMA) and Indian Polyurethane Association (IPUA) are the technical professional associations of the industry which have subject expertise and close networking with the industry, UNDP in consultation with the Ozone Cell, MoEF&CC decided to entrust the preparation of sectoral strategies for RAC manufacturing and polyurethane foam manufacturing to these associations.

The Memorandum of Agreements (MOAs) were signed between the Ozone Cell, MoEF&CC and RAMA and IPUA for preparation of RAC manufacturing and Foam manufacturing Sectoral Strategies.

RAMA and IPUA organized awareness workshops in close cooperation with the Ozone Cell, MoEF&CC, one in each major industrial hub, Chennai, Delhi and Mumbai, in June/July 2010. These workshops were well attended by stakeholders, especially from Foam and RAC




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

Sectors. RAMA and IPUA made extraordinary efforts to involve MSMEs in these workshops to create awareness among MSMEs. Overall, these workshops proved to be very effective in reaching out to large enterprises as well as MSMEs who are involved in manufacturing of RAC equipment and Polyurethane Foam.

RAMA and IPUA also carried out detailed surveys involving market research consulting agencies for collection of data of number of enterprises using HCFCs, the date of establishment and annual consumption of HCFCs for the past three years. The information was collated and analyzed by RAMA and IPUA through their sub-sectoral committees. Sectoral strategies were developed and submitted to the Ozone Cell. The sectoral strategies were further updated by including enterprises wise data on consumption of HCFCs and details of base-line equipment used by the enterprises.

The RAC Servicing strategy was prepared by the Servicing Sector Group of the industry under the guidance of GIZ, Govt. of Germany as implementing agency in close cooperation with the Ozone Cell, MoEF&CC.

A two-day stakeholder workshop was organized in October, 2011 for finalization of sectoral strategies and overarching HPMP Stage-I. A large number of stakeholders, especially from industry, industry associations, defence forces, NGOs, R&D organizations, and implementing agencies actively participated in the deliberation and provided their inputs for the preparation of HPMP.

The HPMP Stage-I was finalized by UNDP, the lead implementing agency in association with other implementing agencies, UNEP, UNIDO and GIZ and in close cooperation with Ozone Cell, MoEF&CC, based on the inputs provided by the stakeholders during the workshop held in October, 2011.

The HPMP Stage-I is to phase-out the HCFCs enabling India to meet 2013 freeze and 10% reduction in 2015.

The phase-out will address the conversions in foam manufacturing sector from HCFCs to non-ODS technologies in the enterprises with large consumption of HCFC-141b, technical assistance to the systems houses for developing HCFC-free low-GWP pre-blended polyols and activities in the RAC servicing sector. In order to ensure that the phase-out actions are carried out on time and phase-out of HCFCs remain sustainable, targeted policy and regulatory actions and awareness programs are also being implemented during the HPMP Stage-I.

The Ex-Com of the MLF in its 66th meeting held in April 2012 approved the HPMP Stage-I for India for the period from 2012 to 2015 for phase-out HCFCs in the consumption sector to meet the 2013 and 2015 targets at the total cost of US $23,011,537 including the implementing agency support cost to reduce 341.77 ODP tonne of HCFCs from the starting point of 1691.25 ODP tonne. The 66th Ex-Com also approved the first tranche of US $12,265,080 including the implementing agency support costs for Stage-I of HPMP and corresponding implementation plan.

Since the approval of the HPMP Stage-I, a number of activities have been conducted by the Ozone Cell, MoEF&CC in close cooperation with the implementing agencies and stakeholders. The interagency meeting was held as early as in September, 2012 to discuss the implementation modalities of HPMP Stage-I. Subsequently, Stakeholders Consultative meeting on Amendment of ODS Rules was organized in October, 2012 to seek inputs from the stakeholders on the proposed amendment to the Ozone Depleting Substances (Regulation and Control) Rules, 2000. A Stakeholders Workshop was organized in February, 2013. The Workshop was well attended by the stakeholders especially the industry representatives from foam manufacturing, RAC manufacturing and RAC servicing sectors. On this occasion, the HPMP Stage-I was also launched.

The HPMP Stage-I is being implemented successfully by UNDP in association with UNEP and GIZ and in close cooperation with the participating enterprises. India has achieved the freeze as on 1.1.2013 and 10% reduction of production and consumption of HCFCs in 2015.

### HPMP Stage-II

The 72nd meeting of the Ex-Com 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, Proklima, Government of Germany as cooperating agencies. The HPMP Stage-II would address phase-out of HCFCs in various sector of foam manufacturing including XPS, various sub-sectors of 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 Stage-II of HPMP will be addressing a large number of MSMEs especially in foam manufacturing sectors as large HCFC consuming enterprises have already been addressed under HPMP-I.

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.

Subsequently, Industry associations, namely, RAMA and IPUA, were involved in the HPMP Stage -II preparation process. IPUA and RAMA were responsible for providing sector inputs for achieving HPMP Stage-II targets. They were also responsible for carrying out survey of enterprises across the country in the Foam and RAC sectors, respectively. IPUA and RAMA engaged professional survey agencies for data collection at enterprise-level.

In order to inform the stakeholders of the challenges and opportunities in complying with the phase-out of HCFCs, 3 workshops each in foam and RAC sectors were held in Delhi, Mumbai and Chennai during October 2015, by the IPUA and RAMA, respectively. Inputs were provided by technical experts on industry trends and status of alternatives for various applications.

HPMP Stage-II proposal of India has been prepared for assisting the country in achieving compliance with the Montreal Protocol 2020 phase out targets for consumption of Annex C Group 1 substances (HCFCs). The HPMP II proposal inter alia focusses on complete phase out of HCFC 141 b in foam manufacturing sector and phase out of HCFC-22 in the air conditioning manufacturing sector for enterprises that have volunteered to participate in the HPMP Stage-II. In addition, phase-out of HCFC-22 in the RAC servicing sector and project activities and policy and regulations, enforcement training have also been addressed. The plan also includes activities that build on already implemented HPMP Stage-I activities.

## 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 benefit 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 participants. The draft 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.

## 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.

The 30th Anniversary of the Vienna Convention for the Protection of the Ozone Layer and the 21st International Day for the Preservation of the Ozone Layer was organized on 16th September, 2015 at New Delhi with the theme: **"30 Years of Healing the Ozone Together"**. The theme is supported by the slogan **"Ozone: All there is between you and UV"**. The then Hon'ble Minister of State for Environment, Forest and Climate Change (Independent Charge) Mr. Prakash Javadekar was the Chief Guest for the function. A large number of stakeholders and school children participated in the event.

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.

A bimonthly newsletter Value Added Technical Information Service (VATIS) Update for Ozone Layer Protection was published and distributed to about 2000 individuals and institutions in collaboration with United Nations Asia and Pacific Centre for Technology Transfer. This newsletter covers the latest technologies and developments relating to ozone layer protection.

## Meetings

The following meetings were organized:

- A presentation on India's Amendment

Proposal for Phase-down of HFCs was made to Secretary, MoEF&CC on 27th October, 2015. During the meeting, India's approach-cum-brief for the 27th MOP was also discussed.

- A meeting was held with UNDP India officials on 20th January, 2016 on mid-term review of UNDP's India Country Program Action Plan 2013-2017.
- A meeting to review the progress on HPMP Stage-I implementation and preparation of HPMP Stage-II was held on 27th January, 2016 under the Chairmanship of Mr. Susheel Kumar, the then Special Secretary, MoEF&CC.
- A Digital Video Conference (DVC), as part of the India-US Task Force on HFCs under the Co-Chairmanship of Mr. Susheel Kumar, Special Secretary, MoEF&CC and Mr. Daniel A. Reifsnyder, Deputy Assistant Secretary for Environment & Sustainable Development, Bureau of Oceans, Environment and Science, Department of State, USA with representatives of officials from India and USA was held on 25th February, 2016.
- A meeting to review the progress of implementation was held on 17th February 2016 with the participating enterprises of HPMP Stage-I.
- Editorial Board meeting for "Newsletter" forming part of the enabling component of India's HPMP Stage-I was held on 17th February, 2016.
- The then Hon'ble Minister (EF&CC) Mr. Prakash Javadekar and senior officials of the MoEF&CC participated in the Roundtable discussion on phase down of HFCs in the context of India's proposal on Amendment to the Montreal Protocol, organized by Natural Resources Defence Council (NRDC) and CEEW on 17th March, 2016 at New Delhi.
- A DVC, as part of the India-US Task Force on HFCs under the Co-Chairmanship of Mr. R. R. Rashmi, Additional Secretary, MoEF&CC and Ms. Jennifer Haverkamp, Special Representative for Environment and Water Resources, Department of State, USA with representatives of officials from India and USA was held on 15th June, 2016.
- Stakeholders Consultative meeting on India's Amendment proposal on phase-down of HFCs under the Monteral Protocol was held on 23rd June, 2015 under the Chairmanship of the then Hon'ble Minister (EF&CC) Mr. Prakash Javadekar.
- Meeting of the India-US Task Force on HFCs under the Co-Chairmanship of Mr. R. R. Rashmi, Additional Secretary, MoEF&CC and Ms. Jennifer Haverkamp, Special Representative for Environment and Water Resources, Department of State, USA was held from 30th June, 2016 to 1st July, 2016 at New Delhi. Besides officials from India and USA, industry representatives from both India and USA participated in the meeting.
- A presentation on Ozone Cell and its activities was made to the Hon'ble Minister (EF&CC) on 12th July, 2016.
- A meeting was held to discuss modalities for undertaking research for development of low-GWP alternatives was held on 10th August, 2016 under the Chairmanship of Secretary (EF&CC). Representatives from research institutions, industry and civil society participated in the meeting.
- A meeting to review the progress of implementation was held on 22nd August, 2016 with the participating enterprises of HPMP Stage-I under the Chairmanship of Mr. Manoj Kumar Singh, Joint Secretary, MoEF&CC.

## Workshops

The following workshops were conducted:

- RAMA and IPUA organized 3 awareness workshops each for RAC and Foam Manufacturing Sectors at Chennai, New Delhi & Mumbai during October, 2015 as part of HPMP Stage-II preparation. All the workshops were well attended and resulted in creation of awareness on HPMP.

- Refrigeration and Air-Conditioning Servicing Sector Society (RASSS) organized one day awareness' workshop on 17th October, 2015 at Pune as part of the enabling component of India's HPMP Stage-I. A large number of service enterprises and technicians attended the workshop.

- Two regional Awareness Workshops on HCFC Phase out Management Plan for Refrigeration and Air Conditioning (RAC) and Refrigerant dealers" on 15th February, 2016 at Lucknow, and 15th March, 2016 at Bangalore, as part of the enabling component of India's HPMP-I. The workshop was well attended.

- Director, Ozone Cell participated and delivered Key-note address at the International Conference - ACRECONF India 2016, organized by the Delhi Chapter of Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) along with American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) India Chapter from 18th to 19th March, 2016 at New Delhi.

- Director Ozone Cell participated and gave address at the Round table discussion on energy efficient and environment friendly refrigeration for super markets and office buildings in India - Testing of $CO_2$ in commercial refrigeration, organized by the Council on Energy, Environment and Water (CEEW).

- Stakeholder's workshop on HPMP Stage-II was organized on 5th August, 2016 at New Delhi.

- Training, workshops were organized across the country for RAC servicing technicians by GIZ, Proklima, Government of Germany as part of the Servicing Sector strategy of HPMP Stage-I. These include training to service technicians on good servicing practices of HCFC based appliances/ equipment.

In addition, several consultative meetings with the stakeholders were organized on a regular basis for interaction with industry, Government departments etc.

## INDIA-US TASK FORCE ON HYDROFLUOROCARBONS (HFCS)

HFCs being non-ODS chemicals are not controlled under the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer. However, HFCs have high-GWP. The emissions of HFCs are controlled along with other six Green House Gases (GHGs), Carbon Dioxide ($CO_2$), Methane, Nitrous Oxide, Perfluorocarbons (PFCs), Hexasulfurfluoride ($SF_6$) and Nitrogen Trifluoride ($NF_3$) under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol.

Recognizing the growing use of HFCs, North American Countries (Canada, United States of America and Mexico) and Federated States of Micronesia have been submitting proposals for amendment to the Montreal Protocol for phase-down of HFCs under the Montreal Protocol since 2009.

The India-US Task Force on HFCs was constituted in 2011 to work together by India and the USA on effective approaches and facilitate to enhance the understanding of stakeholders on various technical, policy, cost and legal issues related to HFCs.

The Task Force met a number of times and had detailed deliberations on the issues relating to HFCs. The meetings provided a unique opportunity for the industry, experts and the concerned officials, from the two countries to have in-depth discussions on various aspects related to HFCs and to develop better understanding on the issues of concern.

During the bi-lateral meeting held in September, 2014 between the Hon'ble Prime Minister of India, Mr. Narendra Modi and the Hon'ble President of the United States of America, Mr. Barack Obama, the two leaders recalled previous bilateral and multilateral statements on the phase-down of HFCs. They recognized the need to use the institutions and expertise of the Montreal Protocol to reduce consumption and production of HFCs, while continuing to report and account for the quantities reduced under the UNFCCC.

In line with the above said joint statement, the India-US Task Force was reconstituted. Since then, 4 meetings of the India-US Task Force on HFCs were held on 13th-14th October, 2014 in Delhi, 15th-16th January, 2015 in San Antonio, USA, 7th-8th July, 2015 in Delhi and 30th June-1st July, 2016 at New Delhi. During these meetings, progress was made on enhancing the understanding of the stakeholders and clarification on key issues relating to phase-down of HFCs.

## Indian Amendment Proposal for Phase-down of HFCs

Considering the likely adverse impact of increased use of HFCs on climate, India prepared and submitted an amendment proposal for phase-down of production and consumption of HFCs using expertise and institutions of the Montreal Protocol and continue to include HFCs within the scope of UNFCCC and its Kyoto Protocol for accounting and reporting of emissions.

## Salient Features of the Indian Amendment Proposal

Indian amendment proposal for phase-down of HFCs is a visionary pathway to address HFCs under the Montreal Protocol taking into account challenges of ongoing phase-out of HCFCs in Article 5 Parties by incorporating flexibilities in terms of choice of alternative technologies and timeframe for transitioning from HFCs to low-GWP/zero-GWP technologies.

A flexible step-down function has been proposed for the developing countries. The steps for reduction of production and consumption to be decided by the countries depending on their national circumstances every five years for a period of next five years. This would not only enable the developing countries to meet the challenging compliance with HCFC phase-out obligations of the Montreal Protocol but would also provide flexibility to industry in these countries to move with their doable pace.

The salient features of the Indian Proposal are:

1. There are 19 HFCs with varying GWP from 4 to 12400.

2. Baseline year (Production and consumption):

   - developed countries -
     - Average of 2013, 2014, 2015

   - for developing countries
     - 2028, 2029, 2030

3. Freeze : 2015 (developed countries)
   : 2031 (developing countries)

4. Phase down completion -
   : 2035 (developed countries)
   : 2050 (developing counties)

5. Control Period: 19 years (both for developed and developing countries).

6. Nationally determined phase down steps for developing countries to be decided

each five years in advance for next five years.

7. Continue to use HCFC/HFC and blends of HFCs in transition of phasing out HCFC wherever low GWP/Zero-GWP alternatives are not available.

8. Strengthening of financial mechanism under Montreal Protocol by addressing the following:
   (i) Compensation for lost profit streams for gradual closure of production facilities of HFCs.
   (ii) Full conversion cost.

9. Full Conversion Cost:
   (i) Total cost of converting a chemical production plant from HFCs to low GWP/Zero GWP alternatives.
   (ii) Cost for manufacturing unit of equipment from HFC to low GWP/ Zero GWP alternatives and operating cost for 5 years.
   (iii) Adequate funding for servicing sector including training of technician, awareness, equipment support to technicians, compensation for obsolescence/immature retirement of equipment etc.
   (iv) Full second conversion cost wherever transitional technologies shall be deployed
   (v) Cost of Intellectual Property Rights (IPR)/patents/technology-transfer/ Research and Development (R&D)/ in-house development.
   (vi) Lost profit due to shut down/closure of plant and manufacturing unit.
   (vii) Change in structure design, layout of plant and machinery, civil, electrical and mechanical works.

10. Grace period of 15 years for Article 5 Parties.

11. Date of freeze shall be the date of eligibility of enterprises for financial assistance in case of developing countries.

12. Categorization of HFCs in Groups:

    ANNEX F
    Group I: HFC-134, HFC-134a, HFC-143, HFC-245fa, HFC-365mfc.
    Group II: HFC-227ea, HFC-236cb, HFC-236ea, HFC-236fa, HFC-245ca, HFC-43-10mee.
    Group III: HFC-32, HFC-125, HFC-143a
    Group IV: HFC-41, HFC-152, HFC-152a, HFC-161

    ANNEX G
    Comprehensive R&D to be undertaken to make use of HFC-23 for converting it to a useful product.

13. Use of GWP weightage for HFCs in Montreal Protocol.

14. Exemption for production and consumption of HFCs for manufacturing of MDIs and other medical appliances.

15. Provisions of EUN for both developed and developing countries.

16. No control on feedstock applications of HFCs.

17. Requirement of licensing of HFC imports and exports and ban of imports and exports to non-Parties.

18. Requirement of reporting of production, imports and exports of HFCs.

19. Phase-down of production and consumption of HFCs shall be eligible for funding under the Montreal Protocol.

20. Relationship with UNFCCC:

    The Amendment is not intended to have the effect of excepting HFCs from the scope of the commitments contained in Articles 4 and 12 of the UNFCCC and in

Articles 2, 5, 7 and 10 of its Kyoto Protocol that apply to "Green House Gases (GHGs) not controlled by the Montreal Protocol." Each Party to this Amendment shall continue to apply the principles and provisions of the UNFCCC and its Kyoto Protocol identified above to HFCs as long as those principles and provisions, respectively remain in force with respect to such Party.

Accordingly, the UNFCCC and the Kyoto Protocol need to be amended.

## PARTICIPATION IN MONTREAL PROTOCOL MEETINGS

Officials of the MoEF&CC participated in the following Montreal Protocol meeting:

- Resumed 36th meeting of the OEWG of the Parties to the Montreal Protocol and 27th MOP to the Montreal Protocol held from 29th October, 2015 to 5th November, 2015 at Dubai, United Arab Emirates (UAE).
- Seventy fifth meeting of the Ex-Com of the MLF held from 16th to 20 November, 2015 at Montreal, Canada.
- Thirty Seventh meeting of the OEWG held from 4th to 8th April, 2016 at Geneva, Switzerland.
- Seventy Sixth meeting of the Ex-Com of the MLF held from 9th to 13th May, 2016 at Montreal, Canada.
- Resumed thirty seventh meeting of the OEWG and 38th meeting of the OEWG and 3rd Extraordinary MOP held from 15th to 23rd July, 2016 at Vienna, Austria.
- Ministerial Roundtable at 3rd Extraordinary Meeting of Parties (MoP)

### Significant Outcomes of the meetings

- The 27th MOP elected India as a Member of the Ex-Com of the MLF for the 2016.
- The 27th MOP established a Contact Group to discuss the ways of managing HFCs, including generating solutions to the 19 challenges identified by the parties to Montreal Protocol and then discuss the 4 amendment proposals submitted by the Parties. As mentioned above, India also is the proponent of one of the amendment proposals.
- The 75th meeting of the Ex-Com of the MLF approved the completion of remaining activities of the accelerated CFC production phase-out project and the remaining technical assistance activities of the National CTC phase-out Plan through the UNDP as lead agency in close cooperation with the Ozone Cell, MoEF&CC.
- The 76th meeting of the Ex-Com of the MLF approved the continuation of the Institutional Strengthening (IS) project with UNDP as lead implementing agency for a period of 2 years from April, 2016 to March, 2018. During the meeting, the template of agreement for HPMP Stage-II for the consumption sector was also approved.
- The 37th meeting of OEWG and the resumed 37th meeting of the OEWG generated solutions to the challenges identified by the parties to the Montreal Protocol on ways to manage HFCs.
- The 38th meeting of the OEWG and the 3rd Ex-MOP took up the discussions on the baseline and freeze years as stated under the 4 different amendment proposals. Discussion on baseline years was initiated in the 38th OEWG and 3rd Ex-MOP, could not be concluded and are still continuing.
- During the 3rd Ex-MOP, a Ministerial Round table was organised, during which participants considered how the parties to the Montreal Protocol could move forward in 2016 to deliver on the mandate

of the "Dubai pathway on HFCs. The discussion was moderated by Mr. John Barkat, United Nations Ombudsman. The Shri R. R. Rashmi, Special Secretary, MoEF&CC participated in the Round Table on behalf of India.

## Technology Policy and Awareness Workshops

Workshops on technology policy and awareness among stakeholders have been organised from time to time across the country for successful implementation of the phase-out of HCFCs as per the Montreal Protocol schedule.

## Refrigeration and Air-Conditioning Servicing Sector Society

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 Refrigeration and Air-Conditioning Servicing Sector Society (RASSS). The RASSS was formally launched in the workshop organized on 6th of August, 2015 at Ludhiana.

A large number of service enterprises and technicians attended the workshop.

## 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 uploaded on the web in public domain for viewing and retrieving information.

## 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, Central Pollution Control Board (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, Directorate General of Commercial Intelligence and Statistics (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.

## 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 Stratospheric 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 manufacturing, 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.

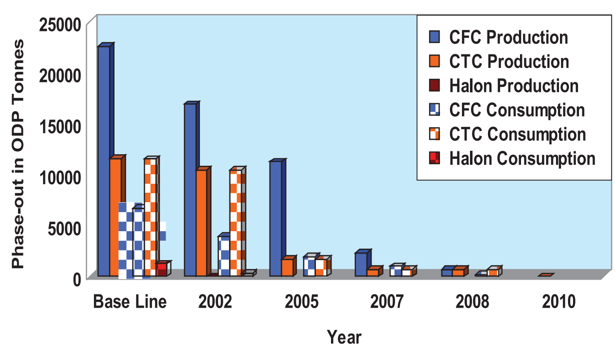
The phase-out of use of CFCs in RAC Servicing Sector was an extremely challenging task because it involved the informal sector comprising of a large number of very tiny enterprises. These enterprises were located throughout the country, including in small towns and rural areas. NCCoPP and its forerunning 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.

The chart below depicts the phase-out of production and consumption of ODSs in India achieved earlier than the Montreal Protocol schedule through proactive initiatives, approaches and active participation of the industries.

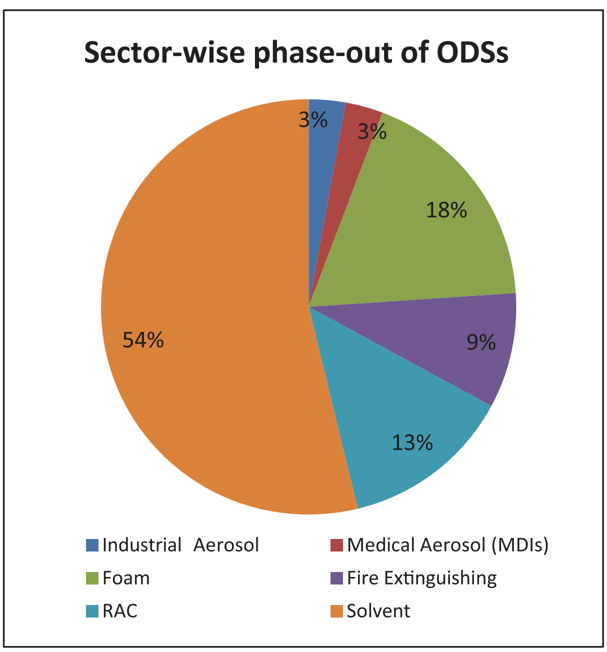
**Phase-out of Production and Consumption of ODSs**




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.

The pie chart presents the sector-wise phase-out of consumption of ODSs in terms of ODP tonne. It may be noted that the solvent was the largest ODS consuming sector followed by Foam and RAC sectors.




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.

The HPMP Stage-I is being implemented successfully in close cooperation with the participating enterprises on time for the period 2012 to 2015. India has already achieved the freeze as on 1.1.2013 and 10% reduction of production and consumption of HCFCs.

The HPMP Stage-I is being successfully implemented, resulting in 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 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.

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.

## Challenges Ahead

India has already phased-out 94% of the ozone depletion weighted level (in terms of ODP tonne) of production and consumption of all the chemicals controlled by the Montreal protocol which is quite similar to the global phase-out scenario. However, in terms of MT it is still long way to go as 55% of the production and consumption of the ODSs is yet to be phased out by 2030. This is similar to the global scenario in terms of MT yet to be addressed by the Montreal Protocol mainly under the accelerated phase-out of HCFCs.

In recent years, it has been recognized by the global community that there is a need to adopt low-GWP alternatives while phasing out HCFCs. This approach is being promoted to draw maximum climate benefits from HCFCs phase-out regime. This approach has made the process of phase-out of HCFCs complex and challenging as there are no safe, technically proven, economically viable, low-GWP alternatives especially for RAC sector.

Indian Industry has been evaluating the low-GWP technical options to HCFCs for various applications and it is making all efforts for the successful implementation of accelerated phase-out of HCFCs.

The HPMP Stage-II which would be addressing the 2020 phase-out target as per the accelerated phase-out schedule of the Montreal Protocol is also challenging with regard to availability of low-GWP alternatives.

## HFCs and Proposed Amendment for Phase-down of HFCs

Considering the growing use of HFCs as alternatives to most of the ODSs and their likely impact on climate, India has been making all round efforts to understand the issues relating to HFCs since the beginning of the discussion on phase-down of HFCs in the meetings of the Montreal Protocol.

An Indo-US Workshop on HFCs was organized in 2011. As a follow up, an India-US Task Force on HFCs was constituted with the objective to work together on effective approaches and facilitate to enhance the understanding of stakeholders on various technical, policy, cost and legal issues related to HFCs.

Since then, 4 meetings of the India-US Task Force on HFCs were held on 13th-14th October, 2014 in Delhi, 15th-16th January, 2015 in San Antonio, USA, 7th-8th July, 2015 in Delhi and 30th June-1st July, 2016 at New Delhi. During these meetings, progress was made on enhancing the understanding of the stakeholders and clarification on key issues relating to phase-down of HFCs.

The joint statements issued by Hon'ble Prime Minister of India and Hon'ble President of United States of America recognize the need for working towards an HFC amendment in the Montreal Protocol with increased financial support for the developing countries.

Recognizing the likely impact of HFCs on the climate, India had submitted an amendment proposal for phase-down of production and consumption of HFCs in the Montreal Protocol in 2015.

There are 4 amendment proposals under consideration of the parties to the Montreal

Protocol viz. North American proposal, European Union Proposal, Micronesia and Island States proposal and Indian proposal.

While generating solutions for challenges identified parties on ways for managing HFCs, India was able to successfully negotiate (i) the inclusion of costs of patents, designs and incremental cost of royalties as eligible cost element for support by Multilateral Fund, and (ii) continuation of Critical Use exemptions and Essential use exemptions available under the Protocol for the HFC amendment.

The parties are now discussing the baseline and freeze years stated in the various amendment proposals. These discussions would be carried forward in the Montreal protocol meetings in 2016.

# 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.


***Release of "Poster" during "21st International Day for the Preservation of the Ozone Layer" function held on 16th September, 2015 at New Delhi, India***


***Release of "The Montreal Protocol: India's Success Story" during "21st International Day for the Preservation of the Ozone Layer" function held on 16th September, 2015 at New Delhi, India***

*Shri Prakash Javadekar, the then Hon'ble Minister of State for Environment, Forest and Climate Change (Independent Charge) with school students during the "21st International Day for the Preservation of the Ozone Layer" function held on 16th September, 2015 at New Delhi, India*

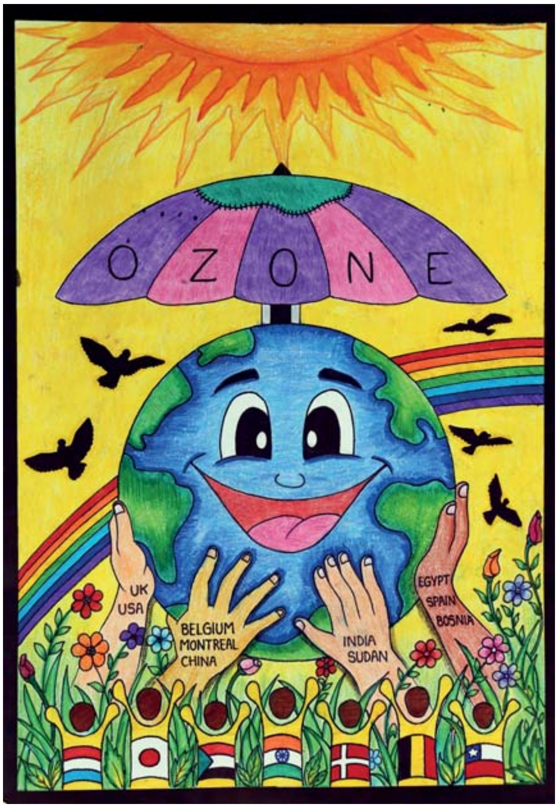

*Shri Prakash Javadekar, the then Hon'ble Minister of State for Environment, Forest and Climate Change (Independent Charge) addressing the participants during "21st International Day for the Preservation of the Ozone Layer" function held on 16th September, 2015 at New Delhi, India*


*"Stakeholders workshop on HCFC Phase-out Management Plan Stage-II" held on 5th August, 2016 at New Delhi*

*Participants in the "Stakeholders workshop on HCFC Phase-out Management Plan Stage-II" held on 5th August, 2016 at New Delhi*

***Painting competition First Prize winning entry of Mr. Divyanshu, Vikas Bharati Public School, Rohini, New Delhi organized on the occasion of 22nd International Day for the Preservation of the Ozone Layer, 2016 at New Delhi***

***Painting competition Second Prize winning entry of Ms. Kumkum, Government Sarvodaya Kanya Vidyalaya, Hastsal, New Delhi organized on the occasion of 22nd International Day for the Preservation of the Ozone Layer, 2016 at New Delhi***

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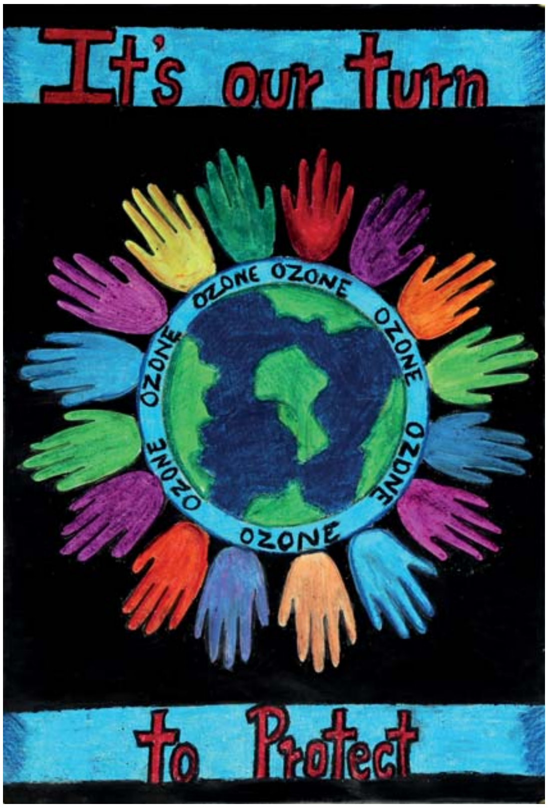


***Poster competition Second Prize winning entry of Ms. Soni, Sarvodaya Kanya Vidyalaya, Pandara Road, New Delhi organized on the occasion of 22nd International Day for the Preservation of the Ozone Layer, 2016 at New Delhi***


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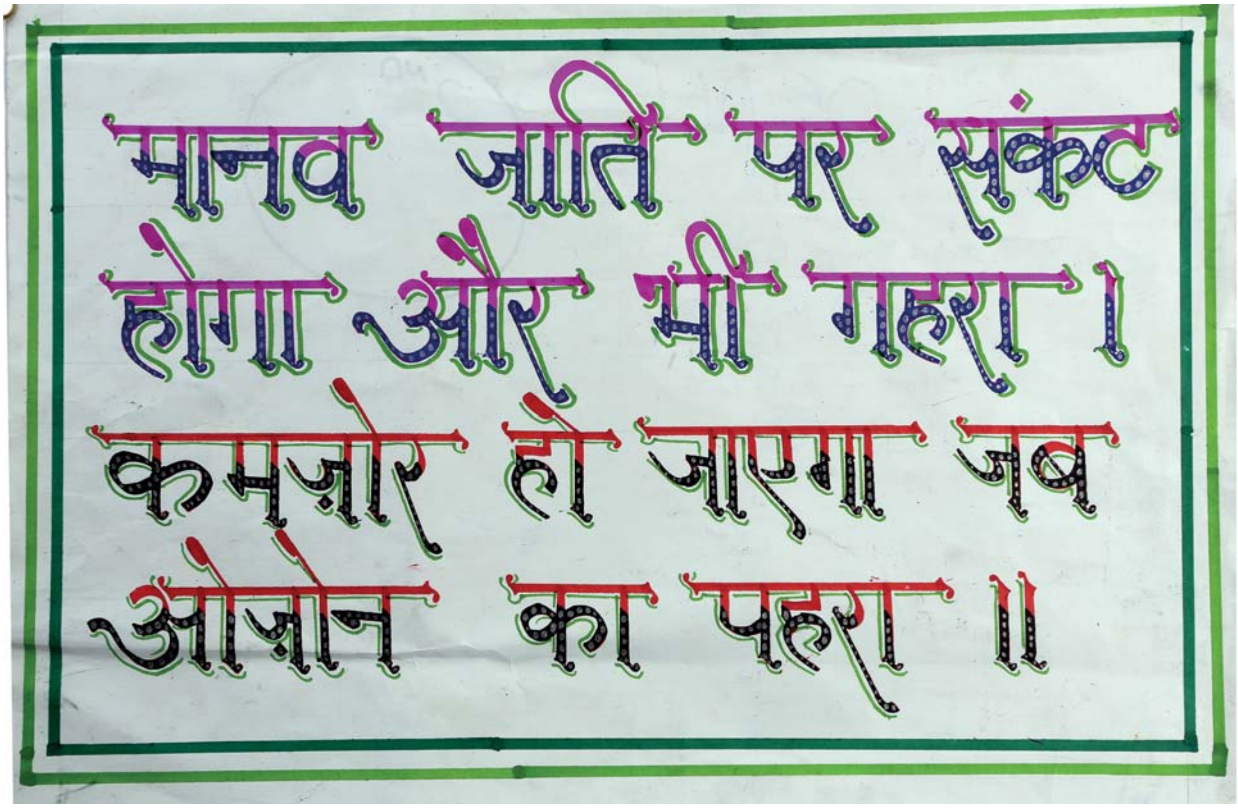


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# POSTER COMPETITION


**1ST PRIZE**
Mr. Anshul Goswami
Delhi Police Public School


**2ND PRIZE**
Ms. Soni
Sarvodaya Kanya Vidyalaya


**3RD PRIZE**
Ms. Kiran
Govt. Sarvodaya Kanya Vidyalaya

## WHOM TO CONTACT TO LEARN MORE ABOUT OZONE

**Ozone Cell**
**Ministry of Environment,**
**Forest and Climate Change**
Government of India
Core 4B, 2nd Floor, India Habitat Centre
Lodhi Road, New Delhi – 110 003
Tel. : 011-2464 2176
Fax: 011-24642175
E-mail: ozone-mef@nic.in
Website: www.ozonecell.com

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