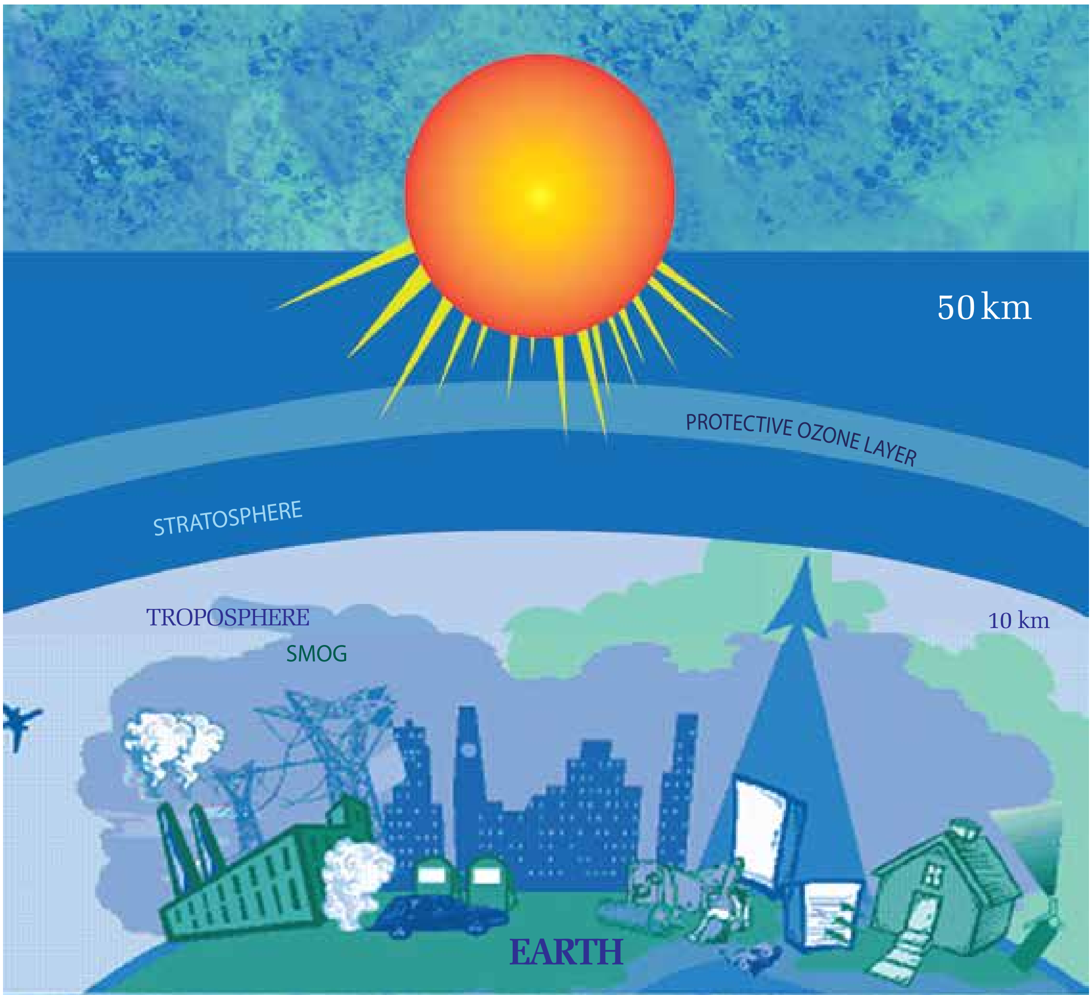

Protection of the Ozone Layer
Global and National Response

UNDP
Empowered lives. Resilient nations.
UN environment
Multilateral Fund for the Implementation of the Montreal Protocol
Department of Environment

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ACRONYMS AND ABBREVIATIONS

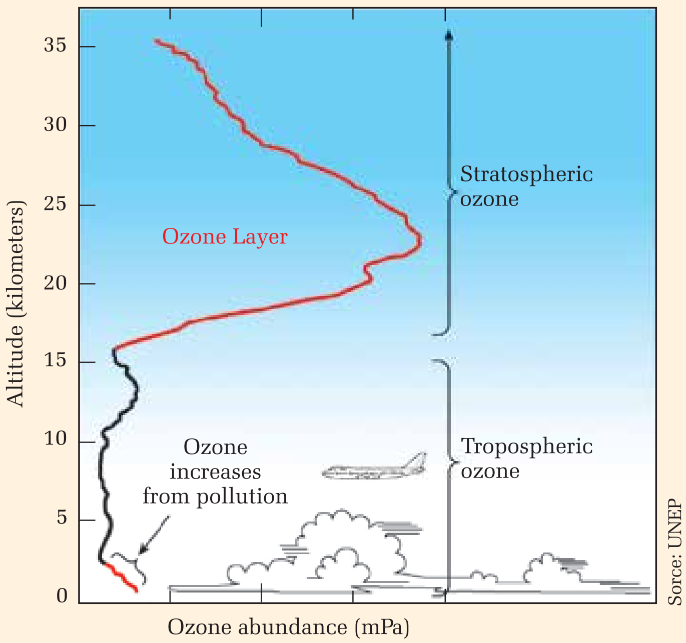
CCAC	Climate & Clean Air Coalition
CFC	Chlorofluorocarbon
CTC	Carbon tetrachloride
DOE	Department of Environment
DU	Dobson Unit
EUN	Essential Use Exemption
ExCom	Executive Committee of MLF
GHGs	Greenhouse gases
GT	Gegi Ton
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFA	Hydrofluoroalkane
HFC	Hydrofluorocarbon
HPMP	HCFC Phase-out Management Plan
HBFCs	Hydrobromofluorocarbons
MBr	Methylbromide
MCF	Methylchloroform
MDI	Metered dose inhaler
MOEF	Ministry of Environment & Forests
MOP	Meeting of the Parties
MP	Montreal Protocol
MLF	Montreal Protocol Multilateral Fund
MT	Metric Ton
NOPP	National ODS Phase-out Plan
ODS	Ozone Depleting Substance
ODP	Ozone Depleting Potential
PVC	Polyvenylchloride
RAC	Refrigeration and Air-conditioning
RMP	Refrigerant Management Plan
SAP	Scientific Assessment Panel
TEAP	Technical & Economic Assessment Panel
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
UV-B	Ultraviolet B rays
VC	Vienna Convention for the Protection of the Ozone Layer

OZONE: THE PRECIOUS LAYER TO PROTECT

The Ozone Layer

Ozone is a gas that is naturally present in our atmosphere. Each ozone molecule contains three atoms of oxygen and is denoted chemically as O_3. 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 kilometres). The remaining ozone (about 90%) resides in the stratosphere between the top of the troposphere and about 50 kilometres altitude. The large amount of ozone in the stratosphere is often referred to as the “ozone layer.” Total ozone is generally lowest at the equator and highest in polar regions.

Ozone in the Atmosphere

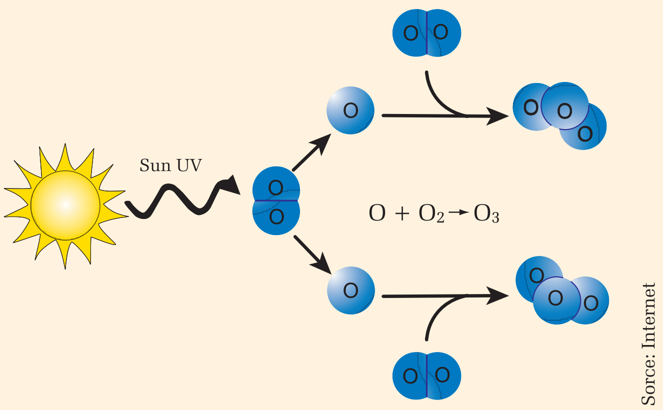


Ozone is formed throughout the atmosphere in multistep chemical processes that require sunlight. In the stratosphere, the process begins with an oxygen molecule (O_2) being broken apart by ultraviolet radiation from the Sun. Ozone is created when ultraviolet radiation of sunlight strikes the stratosphere, dissociating oxygen molecules into atomic oxygen. The atomic oxygen quickly combines with oxygen molecules to form ozone. The amount of ozone above a point on the earth surface is measured in Dobson Unit (DU). It is typically around 260 DU near the tropics and higher elsewhere, though there are large seasonal fluctuations.

Stratospheric O_3 Production

Step 1:	O_2 + UV Sunlight $\rightarrow$ O + O
Siep 2:	$2O + 2O_2 \rightarrow 2O_3$
Overall Reaction:	$3O_2$ (In the presence of sunlight) $\rightarrow 2O_3$

Ozone Formation in the Stratosphere

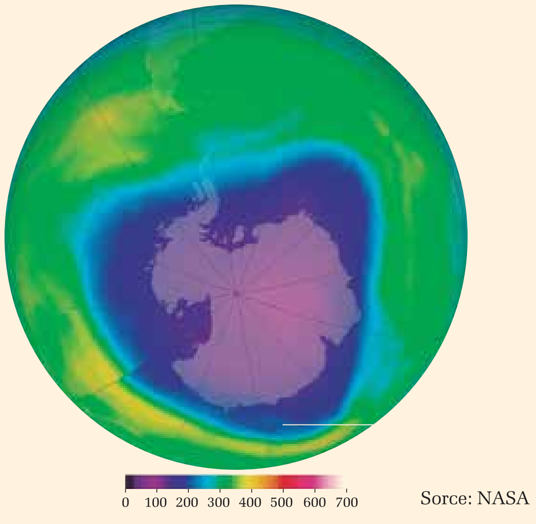


Ozone in the stratosphere absorbs a large part of the sun's biologically harmful ultraviolet radiation. Stratospheric ozone is considered "good" ozone because of this beneficial role. In contrast, ozone formed at Earth's surface in excess of natural amounts is considered"bad" ozone because it is harmful to humans, plants, and animals.

The Ozone Hole

Ozone forms a layer in the stratosphere, thinnest in the tropics and denser towards the poles. The ozone hole is defined as the surface of the earth covered by the area in which the ozone concentration is less than 220 DU. The first clear sign of damage to the ozone layer in the stratosphere was reported in 1985 by the British Antarctic Survey team which had been measuring ozone leels over the Antarctic since 1957. The team observed that in every southern spring ozone was almost completely destroyed over the Antarctic, covering a region as big as the United States and as deep as Mount

Ozone Hole in the Blue Region

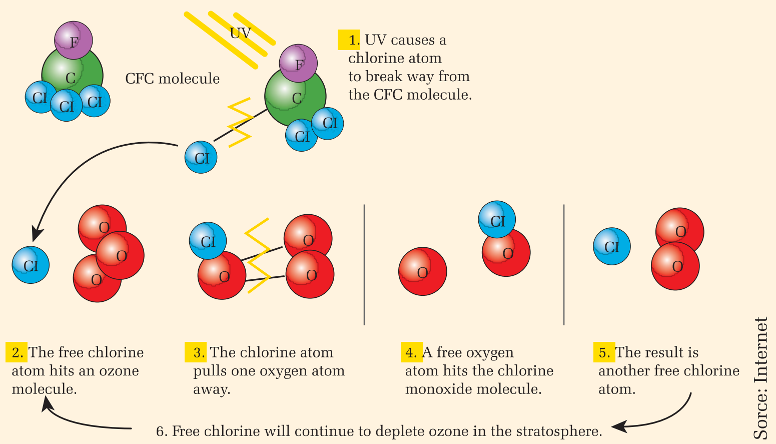


Everest. Research also shows that since 1979 total ozone had declined by some 50% over Antarcticddfdffa throughout the year as a whole.

Ozone Layer Depletion

A scientific research led by Prof. F. S. Rowland and M. Molina (1974) suggests that the continued emission of chlorofluorocarbons (CFCs) depletes the stratospheric ozone layer. Because of their stability, CFCs do not break down in the lower atmosphere but are transported into the stratosphere where they are eventually broken down by ultraviolet radiation, realeasing free chlorine radicals. These chlorine radicals act as catalysts in the destruction of ozone. The net result is that two molecules of ozone are replaced by three of molecular oxygen leaving the chlorine free to repeat the process. For a single stable CFC molecule, this can continue for over a century.

Ozone Depletion in the Stratosphere



Ozone Destruction

Cycle 1	$Cl + O_3 \rightarrow ClO + O_2$
	$ClO + O \rightarrow Cl + O_2$
Overall reaction:	$O_3 + O \rightarrow 2O_2$

Ozone Destruction Cycles in Polar Region

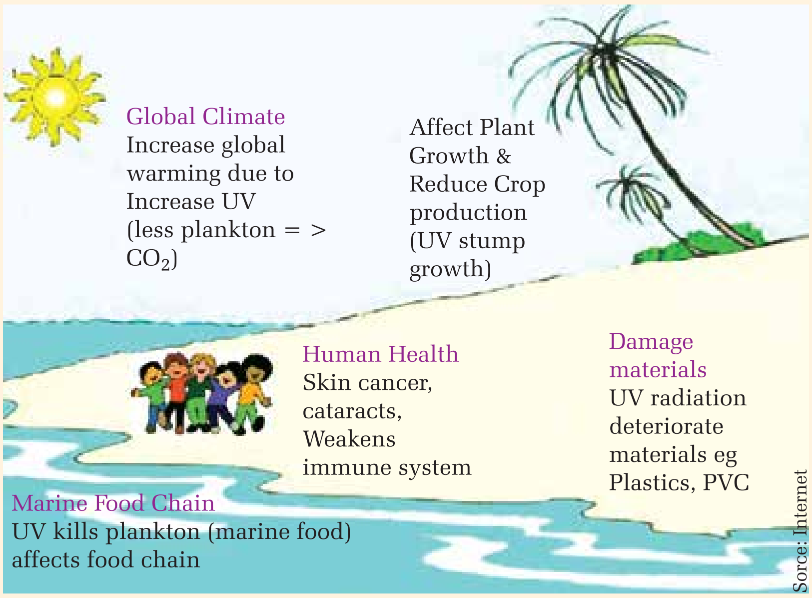
Cycle 2	$ClO + ClO \rightarrow (ClO)_2$
	$(ClO)_2 + \text{Sunlight} \rightarrow ClOO + Cl$
	$ClOO \rightarrow Cl + O_2$
	$2(Cl + O_3 \rightarrow ClO + O_2)$
Overall reaction:	$2O_3 \rightarrow 3O_2$
Cycle 3	$ClO + BrO \rightarrow Cl + Br + O_2$
	$ClO + BrO \rightarrow BrCl + O_2$
	$BrCl + \text{Sunlight} \rightarrow Br + Cl$
	$Cl + O_3 \rightarrow ClO + O_2$
	$Br + O_3 \rightarrow BrO + O_2$
Overall reaction:	$2O_3 \rightarrow 3O_2$

Harmful Consequences of Ozone Layer Depletion

Any rise in the amount of UV-B reaching the Earth's surface has potential harmful effects on human health, animals, plants, micro-organisms, materials and air quality. In humans, long-term exposure to UV-B is associated with the risk of eye damage, suppression of immune systems, etc. In light-skinned populations, high exposure of UV-B is the key risk factor in development of skin cancer. The risk of the more serious melanoma skin cancer also may increase with prolonged UV-B exposure, particularly during childhood. Melanoma is now one of the most commmon cancers among white-skinned people. Animals are subject to similar effects of increased UV-B. Marine life is particularly vulnerable to UV-B as more than 30% of the world's animal protein for human consumption comes from the sea. UV-B damages the early developmental stages of fish, shrimp, crab and other aquatic lives and reduces the productivity of phytoplankton.

Plant-growth may also be directly reduced by UV-B radiation, harming crop yields and quality, and damaging forests. Reduction in the productivity of marine and terrestrial ecosystems could, in turn, reduce the uptake of carbon dioxide (CO_2) thus contributing to global warming.

Consequences of Ozone Depletion



Finally, reductions in stratospheric ozone and the accompanying increases in UV-B radiation have important effects on the troposphere. The change in chemical reactivity increases both production and destruction of ozone. Ozone at lower atmosphere is a pollutant, causing irritation to eye, lung and damage crops and structures.

Common Ozone Depleting Substances (Chemical) and Their Application Sectors

Chlorofluorocarbons (CFCs) are the most commonly used ozone depleting substances (ODSs). CFCs were mainly used in refrigeration and air-conditioning appliance, foam production, cleaning solvents, process agents, propellant etc. Halons, methyl bromide (MBr), carbon tetrachloride (CTC), methylchloroform (MCF), hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs) etc. are also ozone depleting substances. However, CFCs, MBr, CTC, MCF, halons are already phased-out under Montreal Protocol. HCFCs are under phasing-out process.

Applications of Common ODSs

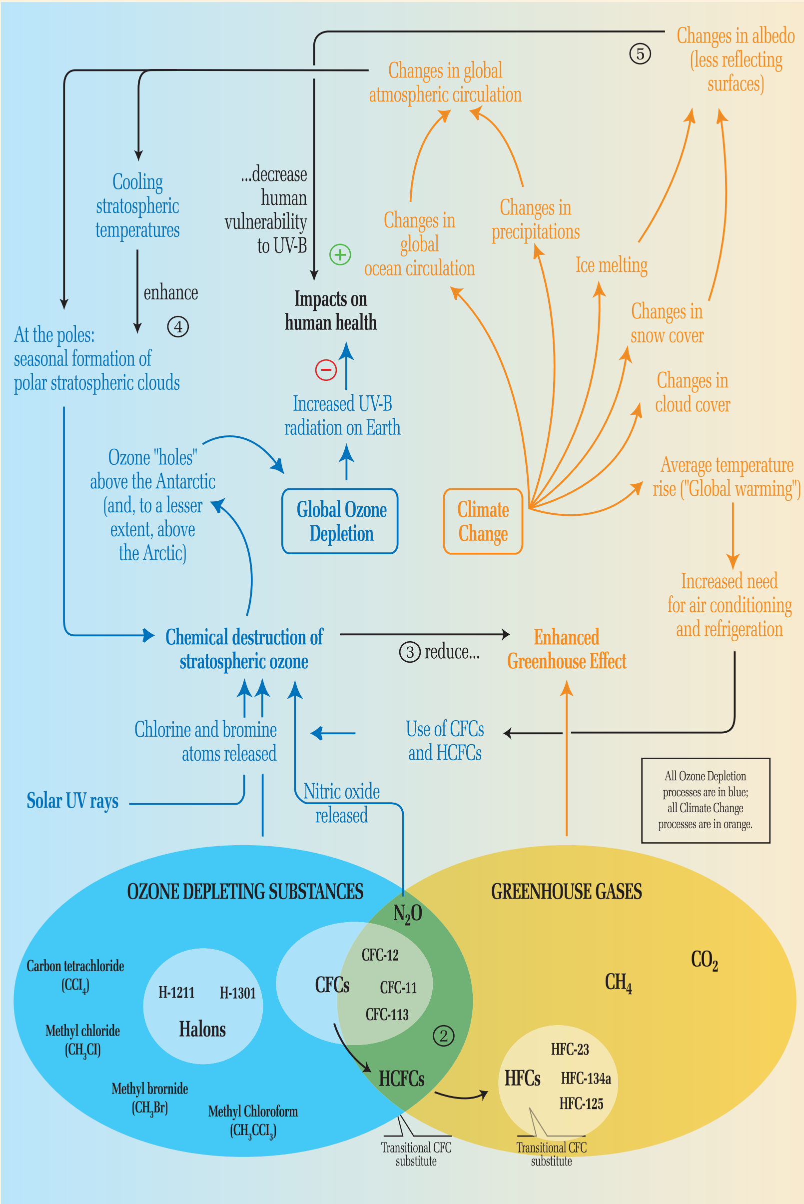
Ozone and Climate Change

Many of the manmade ozone depleting chemicals (viz., CFCs) and their replacements (viz., HCFCs and HFCs) are potent greenhouse gases (GHGs). The build-up of GHGs, including ODSs and their replacements, is known to enhance warming of the troposphere (where weather systems occur). And to balance the warming at troposphere, cooling of the stratosphere is also expected.

Stratospheric cooling creates a more favourable environment for the formation of polar stratospheric clouds, which are a key factor in the development of polar ozone holes. Thus cooling of the stratosphere due to the build-up of GHGs and associated climate change are likely to exacerbate destruction of the ozone layer.

The troposphere and stratosphere are not independent of each other. Changes in the circulation and chemistry of one, can affect the other. Thus changes in the troposphere associated with climate change can affect functions in the stratosphere. In the same way, changes in the stratosphere due to ozone depletion can affect functions in the troposphere.

Ozone and Climate Relation



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National Activities for the Protection of the Ozone Layer

National Activities for the Protection of the Ozone Layer

RESPONSE TO THE THREAT

The Global Response

The international approach to combat ozone layer depletion was led by the United Nations Environment Programme (UNEP). The "Vienna Convention for the Protection of the Ozone Layer (VC)" was adopted in 1985. It contained pledges to cooperate in research and monitoring, to share information on CFC production and emission etc., but no commitment on control or restrictions. The Parties to the VC subsequently agreed to take appropriate measures to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer. And later the Montreal Protocol (MP) was adopted in 1987.

The Montreal Protocol initially controlled only 8 ODSs, and established modest reductions in production and consumption. However, the Protocol provided for adjustments and amendments based on periodic assessments of ODS and on its available alternatives by panels of experts and Parties. The Protocol thereafter has been adjusted six times during the period of 1990-2007. There have also been five amendments, namely 1990 London Amendment, 1992 Copenhagen Amendment, 1997 Montreal Amendment, 1999 Beijing Amendment and 2016 Kigali Amendent had taken place. These revisions increased the number of controlled ODS to 96 substances (which have Ozone Depletion Potential ranging from 0.001 to 10) and established timetables for phasing-out specific groups of ODS. For Kigali Amendment, Parties have agreed to phase down 18 high global warming potential hydrofluorocarbons (HFCs). The MP was initially signed by 24 countries. Now MP have been ratified by all 197 countries of the world, making the MP the first environmental treaty ratified universally. All Parties to the Protocol have ratified all its amendment except newly adopted Kigali Amendment. As of september 2019, 81 Parties have ratified the Kigali Amendment.

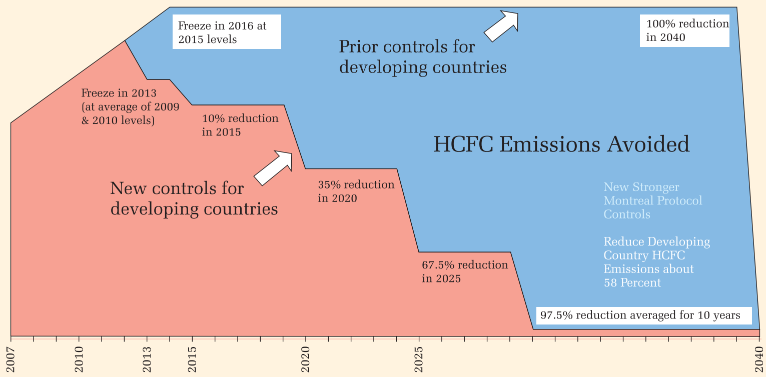
Phase-out Schedule

ODS	Phase-out date in non-A5 Parties	Phase-out date in A5 Parties
CFCs	By 1996	By 2010
Halons	By 1994	By 2010
Carbon tetrachloride (CTC)	By 1996	By 2010
Methylchloroform (MCF)	By 1996	By 2015
HCFCs	By 2020	By 2030
HBFCs	By 1996	By 1996
Bromochloromethane	By 2002	By 2002
Methyl bromide (MBr)	By 2005	By 2015

As the industrialized nations are mainly responsible for the ozone depletion, it has, hence, been agreed that these industrialized countries should first reduce their production and consumption of these substances. For special needs of developing countries operating under paragraph 1 of Article 5 with an annual consumption of less than 0.3 kg per capita, Montreal Protocol allowed them a ten-year grace period for the control measure.

When the Montreal Protocol was revised in June 1990, the Parties (who have signed the Protocol) agreed to establish a mechanism to provide financial and technical cooperation, including the transfer of technology to the developing countries and accordingly established a Multilateral Fund. Industrialized country contribute to the Fund according to the standard UN scale of assessment. The Multilateral Fund has its secretariat in Montreal and is overseen by its Executive Committee, comprising representatives of seven developed and seven developing countries selected during the annual meeting of the Parties to the Protocol. Multilateral Fund now operates through UNEP, UNDP, UNIDO and the World Bank.

Phase-out Schedule for HCFCs for Article 5 Parties



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Developing countries started controlled use of CFCs, Halons and CTCs from 1st July 1999 and 100% phase- out target by 1 January 2010. By 2010 virtually all Parties had reported compliance with their phase out obligations in respect of CFCs, halons, CTC, methyl chloroform and chlorobromomethane. As a consequence, the Protocol has now led to the phase-out of 98% (about. 1.8 million ODP tonnes or 2.5 million metric tonnes) of the record levels of production and consumption of ozone-depleting substances. The remaining 2% is mainly HCFCs to be phased out (about 32,000 ODP tonnes or 500,000 metric tonnes). The HCFCs that need to be phased out seem small in terms of ODP weighted amount but it is still an enormous challenge in terms of actual quantities in metric tons and also because the phase out schedule was accelerated in 2007.

The Montreal Protocol (MP) controls 40 different HCFCs, with ODPs ranging from 0.001 to 0.52. HCFCs are always considered as interim substitutes for CFC/halon because HCFCs have only 5-10% of the ozone impact of CFCs. In 2007, the MOP accelerated the phase-out schedule as the use of HCFCs grew far more than expected.

While implementing the monteal Protacil alternative technology, HFCs had been introduced. In 2016, Parties have adopted Kigali Amendment at Kigali, the capital city of Rwanda at the 28th Meeting of the Parties to the Montral Protocol (MOP). Under this amendment, Parties have agreed to phase-down 18 HFCs which have high global warming potentials but zero ozone depleting potentials. If the Kigali Amendment been successfully implemented, the earth would avoid about global average 0.5ºC of rise in temperature by the end of this century.

Under Kigali Amendment, 18 HFCs will be phased-down. As of today alternatives of all HFC usages are not viable. So phase-down rather phase-out of HFCs, has been introduced. Kigali Amentment entered into force from 1st January 2019. To avoid the implementation complexities, Parties have divided into four groups. Two groups from Article 5 countries and another two groups from Non-Article 5 countries. All Article 5 countries belong to Group-1 cxecpt Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Saudi Arabia and United Arab Emirates - which belong to Group-II. For Non-Article 5 Parties - Belarus, Russia, Kazakhstan, Tajikistan and Uzbekistan are in one group and rest developed Parties are in another group.

HCFCs are greenhouse gases with GWPs ranging from 77 (HCFC-123) to 2310 (HCFC-142b). So, HCFC emissions also contribute directly to climate change. Equipment using HCFCs consumes energy from fossil fuels, contributing indirectly to climate change. Unfortunately some major alternatives mainly hydrofluorocarbons (HFCs), are greenhouse gases.

Depending on the type of alternative selected, the phase- out of HCFCs could either significantly contribute to climate mitigation or nullify a country’s efforts to reduce its climate impact. This makes the process of selecting appropriate alternatives for HCFCs more complex than for other ODS.

By phasing out CFCs, HCFCs and other chemicals under the Montreal Protocol, more than 5 giga tons equivalent of CO_2 have already been eliminated - representing more than 25% of the world’s greenhouse gas emission compared to 1990. This surpasses the Kyoto Protocol’s target of reducing GHGs by 5 times.

Nevertheless, the HCFC phase-out presents an opportunity to adopt ozone-free and climate-friendly technologies, to improve energy efficiency, enhance employment, and thereby contribute to the Green Economy. Aligning HCFC phase-out policies to maximize climate benefits will be helpful for our industry and consumers in the longer term.

Bangladesh Response and its Accomplishment

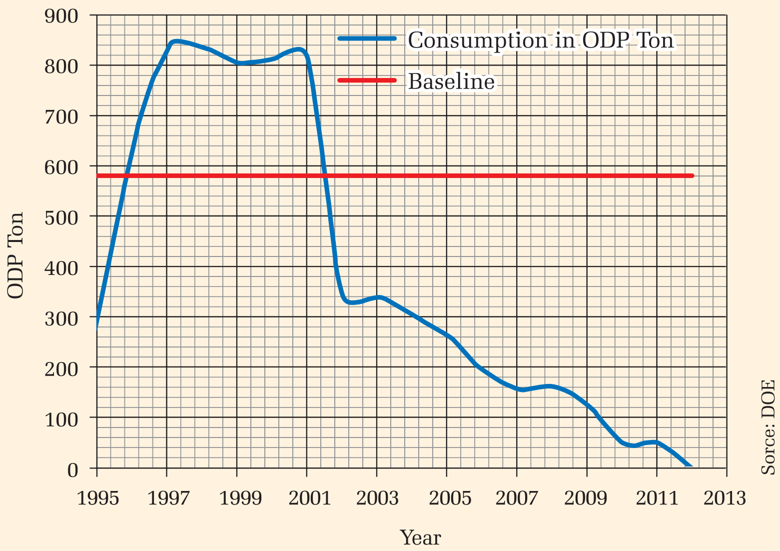
Bangladesh accessed the Montreal Protocol on 2nd August 1990 and ratified London, Copenhagen, Montreal and Beijing amendments in 1994, 2000, 2001 and 2010 respectively. As a signatory to the protocol, control measures have to be imposed on the import and consumption of ODSs in Bangladesh from 1st July 1999. The first step toward achieving the objectives of the Montreal Protocol, a preliminary survey on ODS use and import in Bangladesh was carried out in 1993 followed by a Country Programme undertaken in 1994 towards phasing-out the use of ODS. The government also set up Ozone Cell in 1995 within the Department of Environment which undertook various activities towards achieving target under Montreal Protocol.

The baseline data for controlling the ODSs was the average ODS consumption of the year 1995, 1996 and 1997. The baseline for the CFCs, CTC and Halon needs to be determined because control measure had to start from 1999 as per Montreal Protocol obligation. According to the survey in Bangladesh, the baseline consumption was 581.6 ODP tons which means Bangladesh cannot consume ODS more than 581.6 ODP tons in 1999 and gradually it had to decrease the consumption by 2010 to zero. But from the consumption data, it was apparent that Bangladesh was in the category of non-compliance during 1999 to 2001 as the consumption was higher than the Montreal Protocol target. However, Bangladesh returned to state of compliance by phasing-out CFCs from aerosol sector by taking a project on "Conversion to CFC-free Technology for the production of Aerosol products at ACI Ltd" which was completed in 2002. This single project phased-out over 50% of ODS-consumption in Bangladesh. The remaining CFCs were phased out through Refrigerant Management Plan (RMP) during 2001 to 2004.

Under RMP, Department of Environment took various projects like Recovery and Recycling Project, Customs Training, and Technician Training Programme. RMP, by its investment project in Aerosol sector and non-investment component, phased-out about 380 metric tons of ODS from the country successfully.

In 2004 Bangladesh's response to ODS control measures was further reinforced when the government enacted Ozone Depleting Substances (Control) Rules, 2004. This rule empowered the government with a legal instrument to control ODS in the country and phase-out ODS as per Montreal Protocol schedule. After RMP, remaining ODS was phased-out by National ODS Phase-out Plan (NOPP). The NOPP again had investment and non-investment components. Under NOPP about 3000 refrigeration and air-conditioning (RAC) technicians were trained under "Good Service Practices in RAC". About 2000 technicians were trained on Refrigerator Retrofit and 800 RAC service shop- owners were provided with the retrofit kits and essential tools for retrofitting refrigerators. To build capacity of the policy-makers and decision-makers on ODS

Consumption of CFCs in Bangladesh



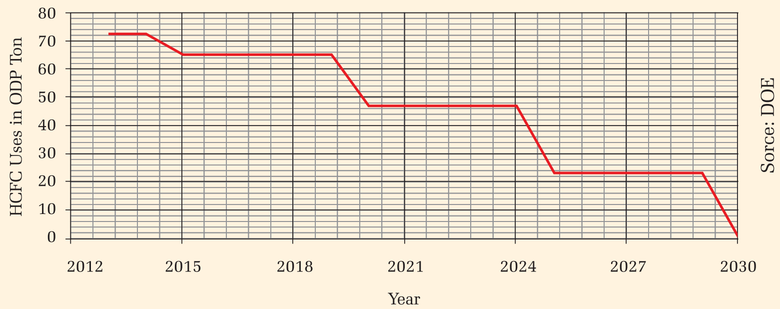
issues, 300 officers were trained under training programmes on 'Promotion of Ozone Layer Protection in Bangladesh'. Besides, solvent sector was also phased-out under NOPP. Bangladesh successfully phased-out CFCs, CTC and MCF from commercial sector use in January 2010.

While the government was updating the Country Programme in 2004, it was revealed that, Bangladesh has increasing demand of CFCs in the manufacturing of metered dose inhalers (MDIs) which was not included in the base-line survey earlier. Bangladesh then proposed essential use nomination (EUN) for medical use and received funding from MLF for phasing-out CFCs in the manufacturing of metered dose inhalers. For its implementation Bangladesh took investment project activities for retrofitting the manufacturing facilities at the MDI producing companies while non-investment activities were taken up to sensitize doctors and users. The transition was seamless to retrofit CFC based inhalers to HFA based inhalers. Bangladesh successfully phased out CFCs in the medical application in the year 2012. This was a great challenge to overcome.

The main challenges faced during the CFC phase-out in the country were from the bulk users like aerosol sector and medical sector. The single aerosol producing sector was consuming over 50% of CFCs in the country. The second largest industrial consumption was Metered Dose Inhalers. Undertaking investment projects for aerosol producing factory or MDI producing pharmaceuticals under public-private partnership was also a challenge. But government has so far successfully overcome all the barriers faced. Bangladesh received appreciation from UNEP in 2012 for her achievement in Montreal Protocol compliance.

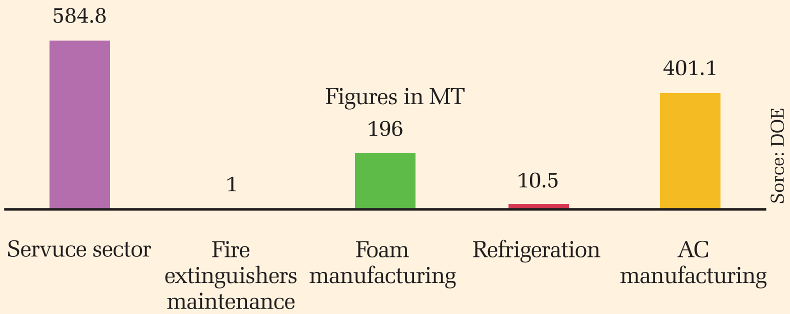
After CFC phase-out it was considered that major activities were done. But while phasing out CFCs, it was substituted globally by another ODS called hydrochlorofluorocarbon (HCFC). HCFCs are low potent ODS but still it is controlled under Montreal Protocol and it has also global warming potential. In view of the new development, Montreal Protocol Meeting of the Parties in 2007 shifted the phase-out date for HCFCs to 2030 from 2040. To keep pace with the Montreal adjustment, government has amended the Ozone Depleting Substance (Control) Rules, 2004 in September 2014.

HCFC Phase-out Shcedule in Bangladesh



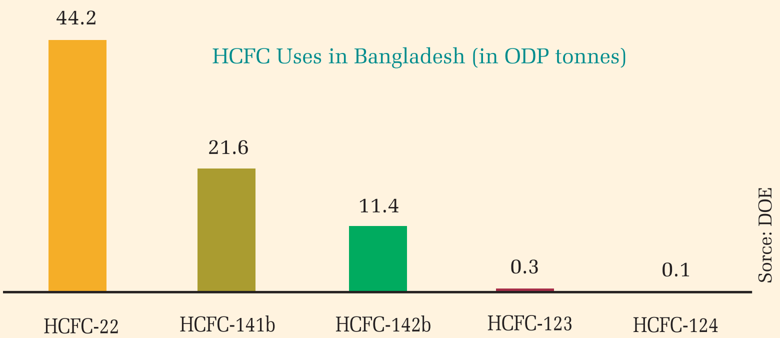
A baseline survey was undertaken for HCFC uses in Bangladesh in 2011 for the year 2009 and 2010. According to HCFC survey it was found that HCFCs are not produced in the country. Bangladesh only imports HCFCs. The consumption of HCFCs was found in RAC servicing, fire fighting, foam manufacturing, and RAC manufacturing sectors. In 2012 the use of HCFC-22 was 1278.60 metric tons while HCFC-141b was 170.00 metric tons. The baseline was estimated 72.6 ODP ton of HCFC consumption in the country.

Sectoral Application of HCFCs in Bangladesh in 2012



Following the survey, HCFC Phase-out Management Plan (HPMP)-Stage-I was prepared which was approved by the 65th Executive Committee Meeting of Montreal Protocol Multilateral Fund. Under HPMP an investment project to phase-out HCFC-141b use in the insulation foam blowing sector was undertaken. Bangladesh is the pioneer among the developing countries of the world to phase-out HCFC-141b in the manufacturing of foam as blowing agent in January 2013. Now cyclopentane is being used as alternatives of HCFC-141b in the country for insulation foam production for refrigerators.

Molecular HCFC Consumption in Bangladesh in 2012



Besides investment project, under HPMP (Stage-I), non-investment project was also being implemented. Bangladesh implemented HPMP (Stage-I) to acheive 30% reduetion torget by 2018. Under the non-investment activities, about 4,000 RAC service technicians were trained on 'Good Practices in RAC'; 100 teachers/ instructors were trained from polytechnic and technical institutions under "ToT on Good Service Practices in RAC'; about 300 customs and law enforcing officers were trained to combat illegal trade of ODSs under 'Green Trade for the Protection of Ozone Layer'. Besides, four ODS identifiers were distributed to customs entry point in the country to detect ODS. A set of five books was prepared and printed on refrigeration and air-conditioning servicing.

Government has received fund to prepare HPMP (Stage-II) by MLF to acheive 2025 reduction target. Under HPMP (Stage-II) investment project has been taken to convert R-22 bascd air conditioners to R-290 or R-32 based energy efficient and environment friendly air-conditioners in 5 manufacturing companies and one chiller manufacturing company. Under non-investment component policies adoption rclated to low GWP alternatives along with training and capacity building will be undertaken. Being a compliant country to the Montreal Protocol, Bangladesh hopes to phase-out remaining ODSs before the stipulated schedule of the Protocol. Being a compliant country to the Montreal Protocol, Bangladesh hopes to phase-out remaining ODSs before the stipulated schedule of the Protocol.

Bangladesh is now experiencing increased use of HFCs in the country. This has been driven mainly by economic growth and affordability of the population coupled with industries moving to HFC based technologies in Refrigeration and Air Conditioning (RAC) applications. Besides, Bangladesh is one of the few countries in the Asia Pacific region that makes Metered Dose Inhalers (MDIs) using HFCs. These HFCs use have, by and large, grown in the country rapidly as a result of CFC phase-out activities undertaken under Montreal Protocol. To monitor the consumption pattern and consumption trends of HFCs in the country, the Government of Bangladesh conducted HFC survey in 2014 for the year 2011-13 funded by CCAC Secretariat administered by UNDP.

After that HFC Survey Bangladesh took intiatives to address HFC isaues in the country. US State Department funded a demonstration project to convert HFC-134a refrigerator to R-600a based refrigerator in one manufacturing line in one of the major refrigerator manufacturing industries. This project was successfully implemented. Following this project, Bangladesh has accessed a project to Kigali Cooling Efficiency Program (K-CEP) fund to convert remaning lines of that industry along with conversion of compressor for R-600a. This project has also a component of energy boosting. Hopefully with support form UNDP this project will be completed by the and of 2019. Bangladesh also undertook Kigali enabling activies including ODS alternative survey, review of existing rules, development of National Cooling Plan. Bangladesh will soon ratify Kigali Amendment

Bangladesh has adopted policy of low GWP, zero ODP and energy efficient technology in choosing the HCFC alternatives in the country during implementation of HCFC Phase-out Management Plan.

Government has successfully implemented 21 ODS related projects to protect the ozone layer. International Ozone Day is observed on |6 September every year to create mass awareness about the importance of ozone layer protection. In January 2010, CFCs from the commercial and servicing sector, carbon tetrachloride and methyl chloroform from solvent sector etc. were phased out. CFCs use in the manufacturing of MDIs in the country and HCFC-141b in the production of insulation foam in refrigerator sector were phased-out in January 2013. Besides, methyl bromide was phased-out earlier in 1995. Bangladesh has been appreciated by UN Environment for her succcss in implementing Montreal Protocol in 2012 an 2017. For combating illegal trade Department of Environment has been appreciated by WCO, Ozone Secretariat and UN Environment in 2019.

Challenges to Protect the Ozone Layer

While the Montreal Protocol has made great efforts for the protection of the ozone layer, the task is far from over. All scientific analysis predicting the healing of the ozone layer around the middle of this century is premised on full compliance with the phase-out required by the Protocol. Over the next several years, the parties must therefore facilitate the complete elimination of the remaining substances listed under the Protocol. While support for related activities is being provided, the final phase-out of these remaining uses, which include the use of HCFCs in air conditioning and refrigeration equipment, will not be easy and will require a long-term commitment from developed and developing countries alike.

HCFCs and some related by-products are global warming gasses and their continued production and consumption contributes to climate change as well as to ozone layer depletion. Furthermore, some alternatives to HCFCs, such as HFCs, do not harm the ozone layer but are potent global warming gasses. The parties to the Montreal Protocol have recently been considering four proposed amendments to the Protocol that would lead to the control of HFCs under the Montreal Protocol, but to date no agreement has been reached. The essential transition away from ozone-depleting substance in the refrigeration and air conditioning sectors presents an opportunity to achieve substantial global warming benefits through enhancements in energy efficiency. Although not required by the Montreal Protocol, the parties have committed themselves to taking matters such as energy efficiency into account as they proceed with their HCFC phase-out programme.

As most of the phase-out activities are accomplished under Montreal Protocol, it become increasingly difficult to get the attention of policy-makers to deal with the remaining phase- out. To date, most eligible developing countries have relied heavily upon funding from the Multilateral Fund to support their phase-out efforts, and continued assistance from the Fund will be important to ensure that a high level of compliance in these countries is maintained and that environmental benefits from the phase-out are maximized. The completion of the phase-out in both developed and developing countries will require a commitment to both a continued high level of attention to the issue and continued funding.

As the continuing phase-out of ODSs further constrains their supply. The temptation to make money through illegal trade in such substances can be expected to increase. This makes imperative that the Parties must redouble their efforts to address this issue. Some businessmen and traders take the opportunity of obtaining low priced obsolete technology. Monitoring and restricting such trading and technology transfer will be a challenge.

The same creative spirit that inspired the development of alternatives to ODSs may spark the invention of new substances with ozone depleting or climate changing properties. This also requires for the parties to the Protocol to be vigilant with regard to the testing of new chemicals, lest new harmful chemicals gain a foothold in the marketplace.

Recent findings on the interaction between climate change and ozone depletion have led scientists to push back the date that they believe the ozone layer will be healed. The world community is left with the challenging task to continue to monitor the state of the ozone layer and the nexus between ozone depletion and climate change so that the related risks are understood and are adequately addressed.

Implementation of Kigali Amendment will be another challenge as there is no viable alternatives to HFCs for some technologies. Consequently, Article 5 Parties will face difficulties to adopt alternative sustainable technology. But the journey shout never be stopped.

Annex -I

GWP and ODP of Commonly Used Refrigerants and Blowing Agents

Refrigerant	Name	Structure	GWP	ODP
CFC-11	trichlorofluoromethane	CCI_3F	4,750	1
CFC-12	dichlorodifluoromethane	$CC1_2F_2$	10,900	1
CFC-502	chlorodifluoromethane chloropentafluoroethane	$CHCIF_2$ $CCIF_2CF_3$	4,657	0.33
HCFC-141b	1,1-dichloro-1-fluoroethane	CCI_2FCH_2	725	0.11
HCFC-22	chlorodifluoromethane	$CHCIF_2$	1,810	0.055
HFC-134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	1,430	0
HFC-404a	pentafluoroethane 1,1,1-trifluoroethane 1,1,1,2-tetrafluoroethane	CHF_2CF_3 CH_3CF_3 CH_2FCF_3	3,922	0
HFC-407a	difluoromethane pentafluoroethane 1,1,1,2-tetrafluoroethane	CG_2F_2 CHF_2CF_3 CH_2FCF_3	1,774	0
HFC-410a	difluoromethane pentafluoroethane	CH_2F_2 CHF_2CF_3	2,088	0
HFO-1234yf	2,3,3,3-tetrafluoropropene	$CF_3CF=CH_2$	4	0
HFO-1234ze	trans-1,3,3,3-tetrafluoropropene	$CF_3CH=CHF$	6	0
N/A	cyclopentane	C_5H_{10}	11	0
HC-290	propane	$CH_3CH_2CH_3$	11	0
HC-600s	isobutane	$CH(CH_3)_2CH_3$	3	0
R-717	ammonia	NH_3	0	0
R-744	carbon dioxide	CO_2	1	0

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Annex-II

Controlled Substances under Kigali Amendment

Substances	100-Year Global Warming Potential
HFC-134	1,100
HFC-134a	1,430
HFC-143	353
HFC-245fa	1,030
HFC-365mfc	794
HFC-227ea	1,220
HFC-236eb	1,340
HFC-236ea	1,370
HFC-236fa	9,810
HFC-245ca	693
HFC-43-10mee	1,640
HFC-32	675
HFC-125	3,500
HFC-143a	4,470
HFC-41	92
HFC-152	53
HFC-152a	124
HFC-23	14,800

Annex -III

Replacement that had taken place

Substance	Characteristics	Uses	Alternatives
Chlorofluorocarbons (CFCs)	Long lived, non- toxic, non-corrosive and non-flammable. They are also versatile. Depending on the type of CFC, they remain in the atmosphere from between 50 to 1700 years.	Refrigerants, cleaning solvents, manufacture of aerosol sprays, blowing agents for plastic foam.	HCFCs, HFCs (do not deplete stratospheric ozone, but they are potent greenhouse gases). Hydrocarbons (ozone and climate friendly substances, they are however toxic and flammable, which limits their applications).
Halons	Atmospheric lifetime of 65 years.	Mobile fire extinguishers, Fire suppression systems in places such as computer rooms and airplanes, explosion protection.	Halocarbon-based agents and inert gas agents (i.e., nitrogen, argon, carbon dioxide).
Methyl chloroform (CHC13)	Toxic, Takes about 5.4 years to break down.	Industrial solvent for cleaning, inks, correction fluid.	HCFC 225ca/cb, HCFC-141b, HCFC-123.

Substance	Characteristics	Uses	Alternatives
Carbon Tetrachloride	Colourless liquid, non flammable.	Industrial cleaning solvent, feedstock. As its use as a feedstock results in the chemical being destroyed and not emitted, this use is not controlled by the Montreal Protocol.	Acetone (followed by asequate drying), trichloroethylene, chloroform, white petrol, detergents etc.
Methyl bromide (CH3Br)	Takes about 0.7 years to break down.	Fumigant used to kill soil-borne pests and diseases in crops prior to planting and as disinfectants in commodities a awaiting export.	Soil solarisation. Soil-less cultures are another option as well as the breading of pest-resistant varieties.
Hydrochlorofluorocarbons (HCFCs)	Transitional CFC replacements HCFCs deplete stratospheric ozone, but to a much lesser extent than CFCs; they are greenhouse gases.	Refrigerants, solvents, blowing agents fro plastic foam manufacture, and fire extinguishers.	HFCs, HCs, CO_2, NH_3 not-in-kind technology etc.

Annex -IV

Chronology of Ozone Protection Milestones

1928	• The First ODS Halocarbons were invented and their production commercialized.
1970	• Scientists discovered that ODS depleted the ozone layer.
1974	• Scientists Sherry Rowland and Mario Molina in a scientific article published in the journal Nature warn that human-generated chlorofluorocarbons (CFCs) are harming the ozone layer.
1977	• The World Plan of Action on the Ozone Layer adopted by the UNEP Governing Council calls for intensive international research and monitoring of the ozone layer.
1985	• British Antarctic Survey scientists report on the recurring springtime ozone hole over Antarctica. • The Vienna Convention is signed on 22 March.
1987	• The Montreal Protocol was signed 16 September 1987 and strengthened progressively in 1990, 1992, 1995, 1997 and 1999 through amendments. The day is marked globally as the International Day for the Preservation of the Ozone Layer since 16 September 1995:
1988	• The Vienna Convention enters into force on 22 September.
1989	• The Montreal Protocol enters into force on 1 January. • The first set of control measures under the Montreal Protocol take effect for developed countries.

1990	• Parties to the Montreal Protocol decide to amend the Protocol to create a financial mechanism under the Protocol, including the Multilateral Fund. • The Interim Non-Compliance Procedure for the Montreal Protocol is adopted.
1991	• Adjustments to the Montreal Protocol agreed in 1990 in London at the Second Meeting of the Parties enter into force. • The Interim Multilateral Fund becomes operational. • Implementing agencies commence ozone phase-out activities, with funding from the Multilateral Fund.
1992	• The London Amendment to the Montreal Protocol agreed in 1990 in London at the Second Meeting of the Parties enters into force. • The Non-Compliance Procedure for the Montreal Protocol is adopted. The Implementation Committee is established.
1993	• Adjustments to the Montreal Protocol agreed in 1992 in Copenhagen at the Fourth Meeting of the Parties enter into force. • The Multilateral Fund is established on a permanent basis to replace the Interim Multilateral Fund.
1994	• The UN General Assembly proclaims 16 September as the International Day for the Preservation of the Ozone Layer, to be observed from 1995 on 16 September. • The Copenhagen Amendment to the Montreal Protocol agreed in 1992 in Copenhagen at the Fourth Meeting of the Parties enters into force. • Developed countries phase out halons used in products such as fire-fighting equipment, followed by developing countries by 2010.

1995	• The Nobel Prize for Chemistry is awarded to Sherwood Rowland, Mario Molina and Paul Crutzen for their pioneering work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.
1996	• Adjustments to the Montreal Protocol agreed in 1995 in Vienna at the Seventh Meeting of the Parties enter into force. • Developed countries phase out production and consumption of chlorofluorocarbons (CFCs), followed by developing countries by 2010.
1998	• Adjustments to the Montreal Protocol agreed in 1997 in Montreal at the Ninth Meeting of the Parties enter into force. • The Non-Compliance Procedure is reviewed and amended.
1999	• The Montreal Amendment to the Montreal Protocol agreed in 1997 in Montreal at the Ninth Meeting of the Parties enters into force. • The first set of control measures under the Montreal Protocol take effect for developing countries.
2000	• Adjustments to the Montreal Protocol agreed in 1999 in Beijing at the Eleventh Meeting of the Parties enter into force.
2002	• The Beijing Amendment to the Montreal Protocol agreed in 1999 in Beijing at the Eleventh Meeting of the Parties enters into force.
2003	• Former United Nations Secretary-General Kofi Annan terms the Montreal Protocol “perhaps the single most successful international environmental agreement to date.”

2005	• Developed countries phase out methyl bromide, followed by developing countries by 2015.
2006	• The largest Antarctic ozone hole, averaging 26.6 million square kilometres, is recorded.
2007	• The Montreal Protocol is adjusted to accelerate the phase-out of hydrochlorofluorocarbons (HCFCs) by developing countries.
2008	• Adjustments to the Montreal Protocol agreed in 2007 in Montreal at the Nineteenth Meeting of the Parties enter into force.
2009	• The Vienna Convention and the Montreal Protocol become the first multilateral environmental treaties to achieve universal ratification. • Ascientific article published in the PNAS journal notes that the Montreal Protocol has averted more than 135 billion tonnes of carbon dioxide equivalent emissions going to the atmosphere, thus significantly contributing to the mitigation of climate change.
2010	• All parties to the Montreal Protocol phase out the consumption and production of chlorofluorocarbons, halons, carbon tetrachloride and other fully hydrogenated ozone depleting substances. As a consequence, the cumulative phase-out of production and consumption of ozone-depleting substances achieves over 98 per cent of the historic levels of these substances.
2013	• Developing countries freeze the production and consumption of HCFCs. • A scientific article published in the Photochemistry and Photobiology journal notes that through ozone protection efforts, up to 2 million cases of skin cancer may be prevented each year by 2030.

2014	• All four Amendments to the Montreal Protocol achieve universal ratification by 197 Parties. • The scientific assessment of ozone depletion in 2014 confirms that the ozone layer is healing and will return to pre-1980 levels by mid-century, thanks to actions taken by Parties under the Montreal Protocol.
2015	• Developed countries phase out the production and consumption of HCFCs by 90 per cent. • Developing countries phase out methyl chloroform and reduce the production and consumption of HCFCs by 10 per cent. • Parties achieve a cumulative commitment of US$3.7 billion for contribution to the Multilateral Fund for the period 1991 - 2015 to assist developing countries make the transition to more environmentally friendly practices and products through industrial conversion, technical assistance, training and capacity-building.
2016	Parties adopted Kigali Amendment to the Montreal Protocol. It will achieve to reduce about 0.5ºC global temperature rise by the end of this century.
2019	Kigali Amendment entered into force from 1 January 2019.

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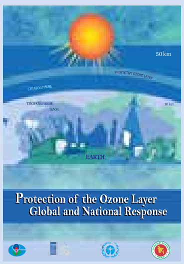

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