environmental investigation agency

CoP26 Climate Brief

Saving the Planet by Degrees

Past and future climate benefits of the Montreal Protocol

November 2021

Introduction

The Montreal Protocol was created in 1987 to regulate the chemicals responsible for ozone depletion. Widely hailed as the world's most successful international environmental treaty, it has phased out 99 per cent of all Ozone Depleting Substances (ODS), setting the ozone layer on the path to recovery.

It was also the first UN treaty to achieve universal ratification – truly, a global agreement and an outstanding model of international cooperation.

Spurred by the frightening discovery in the mid-1980s of a springtime 'hole' in the ozone layer, the Protocol has not only protected the ozone layer but has evolved to address the current climate emergency.

This briefing examines the impact of the Montreal Protocol on climate change and calls on the world´s governments to undertake new measures under the Protocol and invest, both politically and financially, to secure even more significant greenhouse gas (GHG) reductions.

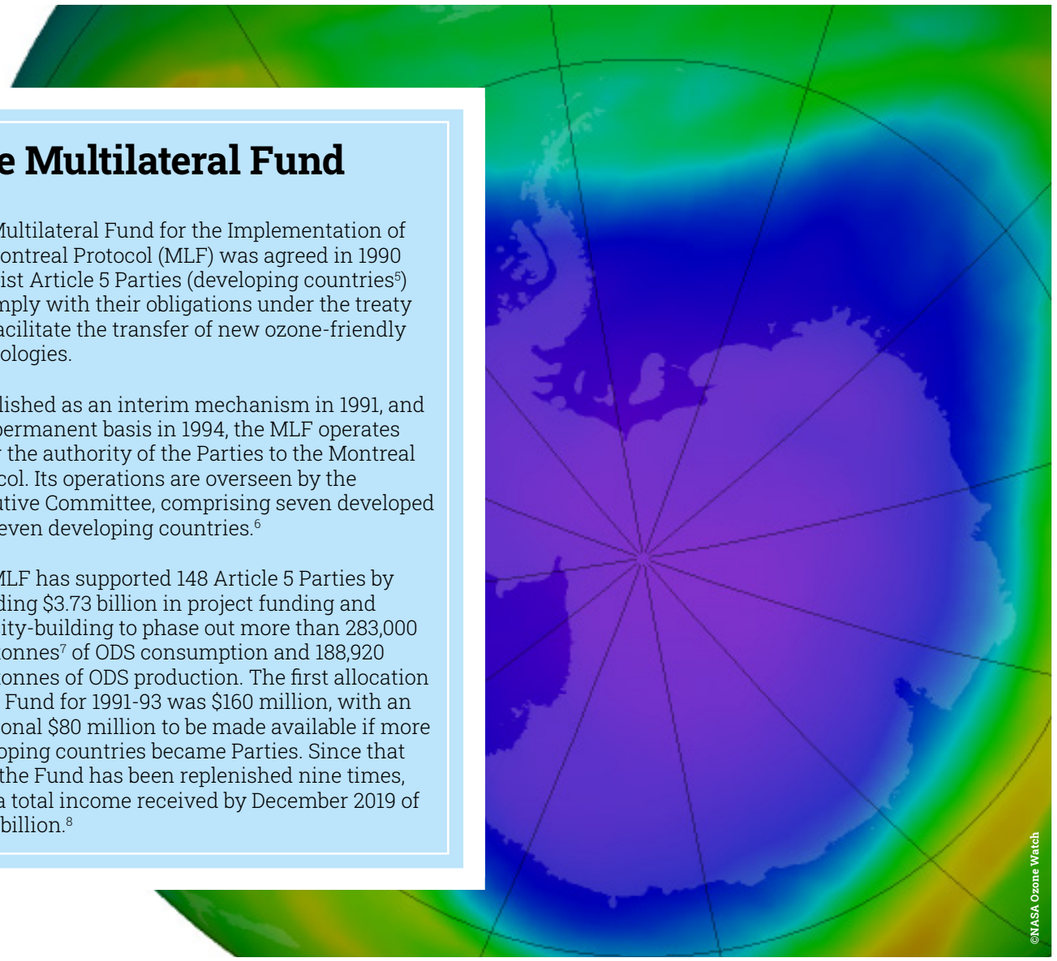
Ozone depletion and the Montreal Protocol

All life on Earth is dependent on the ozone layer, a thin stratum of gas in the upper atmosphere which shields the planet's surface from about 99 per cent of harmful solar ultraviolet (UV) radiation.

In 1974, Mario Molina and F. Sherwood Rowland published groundbreaking scientific research showing that chlorofluorocarbons (CFCs) chemicals used widely in refrigeration, air-conditioning, foams and aerosols, could destroy ozone in the Earth's stratosphere.[1]

Initially, only a few countries took action to curtail CFC use, primarily through bans on CFC aerosols, and CFC emissions continued growing over the next decade. However, efforts at the international level to better understand and monitor the ozone layer in order to coordinate an effective response ultimately led to the adoption of the Vienna Convention for the Protection of the Ozone Layer in March 1985. The Vienna Convention was the first global instrument to address an environmental threat to the Earth's atmosphere. It was designed as an "umbrella treaty", to be supplemented by more specific agreements and protocols.[2]

The 1985 discovery of the ozone hole over the Antarctic by British researchers Joseph Farman, Brian Gardiner and Jonathan Shanklin sharply focused world attention on CFCs and stratospheric ozone depletion.[3] Two years later, the Montreal Protocol on Substances that Deplete the Ozone Layer was concluded at Montreal on 16 September, 1987 and came into force on 1 January 1989, initially signed by 46 countries.[4]



The Multilateral Fund

The Multilateral Fund for the Implementation of the Montreal Protocol (MLF) was agreed in 1990 to assist Article 5 Parties (developing countries[5]) to comply with their obligations under the treaty and facilitate the transfer of new ozone-friendly technologies.

Established as an interim mechanism in 1991, and on a permanent basis in 1994, the MLF operates under the authority of the Parties to the Montreal Protocol. Its operations are overseen by the Executive Committee, comprising seven developed and seven developing countries.[6]

The MLF has supported 148 Article 5 Parties by providing $3.73 billion in project funding and capacity-building to phase out more than 283,000 ODP-tonnes[7] of ODS consumption and 188,920 ODP-tonnes of ODS production. The first allocation of the Fund for 1991-93 was $160 million, with an additional $80 million to be made available if more developing countries became Parties. Since that time, the Fund has been replenished nine times, with a total income received by December 2019 of $4.07 billion.[8]

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The evolution of climate protection under the Montreal Protocol

The initial Montreal Protocol measures were a 50 per cent reduction in CFC production and a freeze on halon production. Since then, the agreement has been amended and adjusted multiple times, adding new ODS and strengthening existing consumption and production phase-out schedules.[9] To date, 99 per cent of controlled ODS have been phased out.[10]

Over the past 15 years, the climate impact of the Montreal Protocol's controls on ODS, which are often potent GHGs, has been increasingly recognised.[11] In 2007, the Parties accelerated the phase-out of hydrochlorofluorocarbons (HCFCs). HCFCs are ODS that were developed as more benign CFC substitutes and were later also subject to a phase-out. A key motivation for the 2007 agreement was the climate benefits such an accelerated HCFC phase-out would bring, as well as ozone layer benefits.[12]

The 2007 accelerated HCFC phase-out decision recognised that the ODS phase-out was leading to increased use and emissions of hydrofluorocarbons (HFCs), which were non-ozone-depleting but potent GHGs, some with higher Global Warming Potentials (GWP) than the ODS they were replacing.[13] It encouraged Parties to "promote the selection of alternatives to HCFCs that minimise environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations" and agreed that funding for the HCFC phase-out would give priority to "Substitutes and alternatives that minimise other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors."[14]

This was later implemented through a 2010 decision on HCFC phase-out funding guidelines under the MLF, which increased the level of funding available to Article 5 countries "up to a maximum of 25 per cent above the cost-effectiveness threshold for projects when needed for the introduction of low-GWP technologies."[15] This has enabled MLF-funded HCFC projects so far to largely avoid switching to HFC technologies, with the exception of the air-conditioning sector.[16]

At the same time, Parties began to discuss the possibility of adding HFCs to the list of controlled substances, even though HFCs were not ODS. An amendment proposal in 2009 submitted by the Federated States of Micronesia and Mauritius[17] kickstarted years of negotiations, which culminated in the adoption of the Kigali Amendment in 2016.[18] The Kigali Amendment will phase down HFC consumption and production based on the carbon dioxide equivalent (CO_2e) by 80-85 per cent by 2045[19] (See Table 1). According to the Montreal Protocol's Scientific Assessment Panel, this will avoid 2.8-4.1 billion tonnes of CO_2e ($GtCO_2$e) per year emissions by 2050 and 5.6-8.7 $GtCO_2$e per year by 2100, reducing the impact of HFCs on future global average warming in 2100 by up to 0.4°C.[20]

Page 2: Antarctic zone hole on 1 November 2021. The phase-out of ozone depleting substances will enable the ozone hole to close by the 2060s

Above: The MLF supports developing countries to phase out ODS and HFCs, including support for training to handle alternative climate-friendly refrigerants

Table 1: HFC phase-down schedule under the Kigali Amendment.

	Article 5 Parties	
	Group 1 A5 Parties not in Group 2	**Group 2** Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, United Arab Emirates
Baseline Years	2020-2022	2024-2026
Baseline Calculation	Average production/consumption of HFCs in 2020-2022 + 65% of HCFC baseline production/ consumption	Average production/consumption of HFCs in 2024-2026 + 65% of HCFC baseline production/ consumption
Reduction steps		
Freeze	**2024**	**2028**
1st step	2029 – 10%	2032 – 10%
2nd step	2035 – 30%	2037 – 20%
3rd step	2040 – 50%	2042 – 30%
4th step	2045 – 80%	2047 – 85%
	Non-Article 5 Parties	
	Non-Article 5 countries except Belarus, the Russian Federation, Kazakhstan, Tajikistan, Uzbekistan	Belarus, the Russian Federation, Kazakhstan, Tajikistan, Uzbekistan
Baseline Years	**2011-2013**	**2011-2013**
Baseline Calculation	Average production/consumption of HFCs in 2011-2013 + 15% of HCFC baseline production/ consumption	Average production/consumption of HFCs in 2011-2013 + 25% of HCFC baseline production/ consumption
Reduction steps		
1st step	2019 – 10%	2020 – 5%
2nd step	2024 – 40%	2025 – 35%
3rd step	2029 – 70%	2029 – 70%
4th step	2034 – 80%	2034 – 80%
5th Step	2036 – 85%	2036 – 85%

Impact of the Montreal Protocol

Although commonly known as the ozone treaty, the impacts of the Montreal Protocol are far-reaching, contributing to 13 out of 17 Sustainable Development Goals (SDGs).[21]

As a result of the phase-out of ODS consumption and production, the Antarctic ozone hole is no longer growing and the ozone layer is healing.[22] Substantial recovery from the depletion of the global and polar ozone layer is expected around the middle of this century, with the recovery time varying between the tropics, mid-latitudes and polar regions due to the influence of climate change.[23]

Without the Montreal Protocol, ozone depletion would have trebled peak values of UV radiation[24] and the Antarctic ozone hole would have been about 40 per cent larger by 2013,[25] with disastrous effects on humans, ecosystems and planetary health. The global phase-out of CFCs has resulted in an estimated $1.8 trillion in health benefits through the avoidance of skin cancer and cataracts and $460 billion in avoided damages to agriculture, fisheries and materials between 1987 and 2060.[26]

Montreal Protocol and vaccines

The COVID-19 pandemic has brought to the fore the lifesaving importance of an effective cold chain that does not rely on climate damaging CFC, HCFC and HFC refrigerants. Eradicating this disease, and many others, relies on a safe and efficient vaccine distribution system. This system involves cold rooms, freezers, fridges, cold boxes, trucks and carriers, all of which require cooling to maintain temperature during the journey.

Up to a quarter of the total eight billion vaccines used annually pre-COVID are damaged and wasted due to transportation storage issues, costing an estimated $34.1 billion each year.[33] This problem will be accentuated as the number of vaccines triples to 25 billion to combat COVID. An estimated 70,000 refrigerators will be needed to provide two COVID-19 vaccine doses to the 7.9 billion people in the world, requiring one of the most significant cold chain build outs in the developing world.[34]

The Montreal Protocol and climate change mitigation

The swift response to the impact of CFCs on the ozone layer by the Parties to the Montreal Protocol has avoided as much as 2.5°C global average temperature rise by the end of the century.[27]

CFCs and other chlorine or bromine compounds controlled by the Montreal Protocol are potent greenhouse gases (eg, CFC-12, the most widely produced CFC, has a GWP of 10,900[28]). Actions to cut the use of CFCs and other ODS under the Montreal Protocol have therefore avoided significant GHG emissions and a substantial amount of warming.

A landmark 2007 paper compared the estimated contribution of ODS to radiative forcing in scenarios where the link to stratospheric ozone depletion was not discovered and the Montreal Protocol was not subsequently agreed.[29] Without the Montreal Protocol, ODS emissions would have reached 15-18 $GtCO_2e$ per year in 2010, equivalent to about half of global annual CO_2 emissions at that time. From 1990-2010 the reduction in GWP-weighted ODS emissions expected due to Montreal Protocol controls was estimated to be 8 $GtCO_2e$ per year, leading the authors to note that the "climate protection already achieved by the Montreal Protocol alone is far larger than the reduction target of the first commitment period of the Kyoto Protocol".

Another study of the "world avoided" by the Montreal Protocol looking at regional impacts found that by 2019, regional warming of 0.5°C-1.0°C has been avoided over some land areas and over much of the Arctic.[30]

A recent study looked not just at the impact of unmitigated CFC emissions, but also at the damaging effect of UV radiation on the terrestrial biosphere and its capacity as a carbon sink.[31] The authors estimated that, without the Montreal Protocol, between 325-690 billion tonnes less carbon would have been held in plants and soils by the end of this century due to the damaging impact of high UV-B levels on plant biomass. This would

have led to an additional 0.85°C warming by the end of the century on top of an estimated 1.7°C warming caused by unmitigated CFC emissions – a total of 2.5°C avoided by the Montreal Protocol. The damaging impact of UV radiation on marine primary productivity would have had additional impacts on temperature rise,[32] but is not so far quantified.

Although the Montreal Protocol has already avoided as much as 2.5°C of temperature rise by the end of the century through the CFC phase-out, the real impact of the Montreal Protocol is yet to be determined. This will depend on how quickly alternatives to CFCs – in particular HCFCs and HFCs – are phased out, and the extent to which full compliance with the controls is sustained in the long term.

Unexpected emissions and unfinished business

Alongside the clear success of the ozone treaties lie several challenges which signal the need for increased investment in the Vienna Convention and Montreal Protocol.

Ozone and climate scientists have drawn attention to the "unfinished business" of the Protocol, which includes understanding and mitigating unexpected emissions of controlled substances, tackling emissions of ODS from leaking banks of equipment and products and from feedstocks, which are not subject to any Montreal Protocol phase-out controls.[35]

Accelerating the transition to climate-friendly alternatives to ODS and HFCs

The climate emergency warrants a faster global phase-down of HFCs than is currently envisaged under the Kigali Amendment.[36]

According to studies using the International Institute for Applied Systems Analysis GAINS model framework, full compliance with the Kigali Amendment is estimated to achieve a 56 per cent reduction in HFC emissions by 2050 over 2010 levels, compared to the 70-80 per cent envisaged in a 1.5°C consistent scenario under the Paris Agreement.

A faster phase-down of HFCs, where maximum technically feasible reductions are implemented, could achieve more than 99 per cent reductions in 2050, a decade earlier than the current Kigali schedule.[37]

Currently, Article 5 Parties have two different phase-down schedules: Group 1 countries, which include the majority of developing countries including China, plan to freeze HFC consumption and production in 2024, take the first 10 per cent phase-down step in 2029, phasing down HFCs by 80 per cent by 2045; Group 2 countries, which includes India, a major HFC producer and consumer, are not required to freeze HFC production and consumption until 2028, with the first phase-down step of 10 per cent in 2032 and an 85 per cent reduction by 2047 (see Table 1 on page 4).

At the same time, Article 5 countries are still phasing out HCFCs under the accelerated phase-out schedule agreed in 2007. This envisages a 67.5 per cent reduction in HCFC consumption and production by 2025 and a phase-out by 2030 (with a 2.5 per cent consumption allowance for servicing requirements until 2040).[38] If adequate financial and technical support is provided through the MLF to ensure the transition to climate-friendly HFC-free alternatives, a large amount of the predicted short-term growth in HFC emissions can be avoided.

Finally, given much of the current and predicted future growth of HFCs relates to their use in the cooling sector, avoided GHG emissions could as much as double if the phase-down is coupled with energy efficiency gains in cooling equipment.

Implementation of the Kigali Amendment alongside improving the energy efficiency of cooling equipment can avoid an estimated 441-631 $GtCO_2e$ of greenhouse gas emissions between 2018 and 2100.[39]

Sustaining the success of the Montreal Protocol through strengthened monitoring, reporting, verification and enforcement

In 2018, scientists reported a huge, inexplicable increase in the emissions of banned CFC-11 in the atmosphere in 2018.[40]

EIA investigations traced the source of CFC-11 to illegal production and use in the polyurethane foam sector in China.[41] A nationwide enforcement effort by China in response to the findings appears to have successfully tackled the problem, with latest atmospheric data indicating that CFC-11 emissions significantly decreased in 2019[42] and the change in emissions trajectory has continued through 2020 and the early part of 2021.[43]

However, emissions of CFC-12, CFC-113 and several other CFCs are also unexpectedly high, raising the possibility of illegal production or other sources, 10 years after the CFC phase-out should be complete.[44] ODS used as feedstocks, chemical building blocks for the manufacture of other chemicals, are exempt from Montreal Protocol controls, due to the assumption that feedstock chemicals are entirely converted to other chemicals and therefore not emitted to the atmosphere. Higher-than-expected emissions of carbon tetrachloride and CFC-113, both GHGs as well as ODS, suggest that this assumption is incorrect and should be re-examined.[45] The reported feedstock use of controlled ODS is increasing year on year, reaching almost 1.5 million tonnes in 2019.[46]

At the same time, emissions of HFC-23, a highly potent GHG emitted as an unwanted by-product of HCFC-22 production, are at an all-time high despite numerous and repeated pledges from companies and producer countries to ensure incineration of the unwanted climate pollutant.[47] The Kigali Amendment requires the destruction of HFC-23 by-product emissions.

After the illegal production and use of CFC-11 was identified in 2018, Parties to the Montreal Protocol were quick to respond, initiating a variety of studies to examine the Protocol's institutions and mechanisms to better understand how to avoid similar situations in the future.

This has highlighted a broad set of shortcomings which must be addressed and new challenges that will arise as the Protocol takes on additional HFC controls.[48] The Parties are now taking the first steps to address these, most recently at the 33rd Meeting of the Parties in October 2021 where a decision was taken on "Enhancing the global and regional atmospheric monitoring of substances controlled by the Montreal Protocol".[49]

More remains to be done to ensure a robust early warning system, strengthened monitoring, reporting, verification and enforcement (MRV&E) and to tackle illegal trade of ODS and HFCs and the drivers of non-compliance.

Tackling emissions from banks of products and equipment and exempt uses

Emissions of ODS and HFCs from 'banks' found in products and equipment at end of life have never been squarely addressed by the Montreal Protocol.

The potential mitigation from preventing emissions of ODS and HFC banks has been estimated by Project Drawdown at 57.7 $GtCO_2e$ between 2020-50.[50] This is likely an underestimate. For example, the recently identified illegal production and use of CFC-11 may have contributed an additional 266,000 – 333,000 tonnes to the existing CFC-11 bank of foam products during 2007-19, equivalent to 1.4 $GtCO_2$.[51]

Addressing ODS and HFC banks represents a massive but time-limited climate mitigation opportunity. A global framework to recover and destroy banks is therefore required, which should be led by the Montreal Protocol in coordination with other stakeholders and global climate institutions.[52]

The absence of comprehensive global data regarding the size and emissions of refrigerant and foam banks is a key issue that needs to be addressed. A global inventory where banks and amounts available for recovery can be reported would help facilitate increased end-of-life recovery and destruction.[53]

Below: Vincent Biruta, MOP 28 President, gavels the adoption of the Kigali Amendment to the Montreal Protocol

Next steps for the Montreal Protocol to help prevent climate breakdown

Just five years ago, the Montreal Protocol officially became a climate treaty when the Parties adopted the Kigali Amendment to phase down HFCs.

But it has played a critical role in addressing the climate emergency for almost 35 years, through the successful phase-out of ODS greenhouse gases and restoration of the ozone layer, protecting the world's biosphere from harmful UV radiation.

As action to tackle the climate emergency becomes ever more urgent, it is clearly time to extract every degree of mitigation available from the world's most successful environmental treaty. Both the Vienna Convention and the Montreal Protocol have achieved universal ratification. Every government in the world is on board, making it a powerful weapon of global governance in the fight against climate change.

Avoidance of more than 2.5°C warming by the end of the century is a significant achievement, but political and financial investment is needed to ensure that the Montreal Protocol can meet new challenges, maximise the climate impact of current ODS and HFC controls and undertake new measures and actions to secure additional climate change mitigation.

Recommendations

EIA urges the world's governments to:

- Ratify the Kigali Amendment without delay – as of 2 November 2021, 128 Parties to the Montreal Protocol have ratified the Kigali Amendment[54]
- Commit significant funding to the next replenishment of the Multilateral Fund in order to secure maximum climate benefits from the HCFC phase-out and accelerate actions to phase down HFCs
- Undertake measures to avoid the near-term growth in HFC consumption, including consideration by Article 5 countries currently in Group 2 to move to Group 1
- Initiate discussions to accelerate the Kigali Amendment in line with a 1.5°C consistent scenario
- Initiate a comprehensive fitness check of the Protocol's MRV and enforcement processes and institutions at the 2022 Meeting of the Parties, with clear timetables for consideration and adoption of needed improvements
- Undertake a review of ODS and HFC feedstock uses and emissions and consider measures to reduce the production of controlled substances for feedstock purposes
- Set up a comprehensive framework for recovering and destroying ODS and HFC banks under the Protocol
- Support developing countries to ensure an adequate, efficient, HFC-free vaccine cold chain is in place.

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