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Synthesis report of the 2010 assessments of the Montreal Protocol assessment panels

Synthesis report

Note by the Secretariat

1. The annex to the present note contains a synthesis of the following three reports prepared pursuant to Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer by the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the Technology and Economic Assessment Panel, respectively: Scientific Assessment of Ozone Depletion: 2010; Environmental Effects of Ozone Depletion and its Interactions with Climate Change: 2010 Assessment; and 2010 Report of the Technology and Economic Assessment Panel.

2. The synthesis is presented as submitted by the co-chairs of the three assessment panels and is issued without formal editing.

3. The findings contained in the synthesis report are supported in the three 2010 assessment panel reports, which can be found on the Ozone Secretariat website at the following addresses:

> Scientific Assessment of Ozone Depletion: 2010
> http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2010/index.shtml
>
> Environmental Effects of Ozone Depletion and its Interactions with Climate Change: 2010 Assessment"
> http://ozone.unep.org/Assessment_Panels/EEAP/eeap-report2010.pdf
>
> 2010 Report of the Technology and Economic Assessment Panel
> http://ozone.unep.org/Assessment_Panels/TEAP/Reports/TEAP_Reports/teap-toc-assessment-reports-2010.shtml

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Annex

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SYNTHESIS REPORT

Major findings of the 2010 assessments of the Scientific Assessment Panel (SAP), Environmental Effects Assessment Panel (EEAP), and Technology and Economic Assessment Panel (TEAP)

Ayité-Lô Ajavon, Stephen O. Andersen, Janet F. Bornman, Lambert J. M. Kuijpers, Paul A. Newman, Nigel D. Paul, Marta Pizano, John A. Pyle, and A. R. Ravishankara

The Montreal Protocol is working to protect the ozone layer; this finding has strengthened since the 2006 assessments. There is further evidence that the total abundance of ozone-depleting substances (ODSs) in the atmosphere continues to decline, even though concentrations of hydrochlorofluorocarbons (HCFCs), the chlorine-containing replacement compounds for chlorofluorocarbons (CFCs), are rising. Observed global, mid-latitude, and polar ozone column amounts are lower than the 1980 levels, but have neither decreased nor increased during the last decade. The lack of ozone changes during this period, when ODSs decreased only slightly, is consistent with our understanding of the atmosphere.

If the Montreal Protocol had not been successful and ODS emissions had continued to increase, there would have been very large ozone depletion and consequent substantial increases of ultraviolet (UV) radiation. These changes in UV radiation would have had serious impacts on human health and the environment.

The decline of ODSs has brought benefits not just to the ozone layer but also to Earth's climate. The amount of ODS emissions (CO_2-equivalent) avoided in the year 2010 by the controls under the Montreal Protocol is about five times larger than the emission reduction target for the Kyoto basket of gases in the first commitment period. If ozone-depleting greenhouse gases had continued to increase, the contribution of ODSs to the total climate forcing could have reached by now a significant fraction of that due to CO_2.

The major findings of the 2010 assessments from the Scientific Assessment Panel (SAP), Environmental Effects Assessment Panel (EEAP), and Technology and Economic Assessment Panel (TEAP) are included herein. In addition, three issues of particular interest to the Parties are highlighted below. First is the strong linkage between stratospheric ozone and climate. Second is the climate consequences of the continued use of high-GWP HFCs as replacements for ODSs in some applications. Third is the rapidly growing use and emissions of methyl bromide in quarantine and pre-shipment uses not controlled by the Montreal Protocol.

Stratospheric Ozone and Climate

Stratospheric ozone depletion and climate change are intricately coupled. Ozone absorbs UV radiation and is a greenhouse gas (GHG). Stratospheric ozone influences surface climate and GHGs influence stratospheric ozone. For example, carbon dioxide cools the stratosphere, while some other GHGs (e.g., methane and nitrous oxide) directly impact stratospheric ozone levels. ODSs not only destroy stratospheric ozone but also can be potent GHGs. Furthermore, some HFCs currently used as chemical substitutes for some ODSs, are potent GHGs as well. Hence, ozone layer and climate protection should be considered together when deciding to control anthropogenic chemical emissions.

The increase of ODSs has caused major ozone depletion over Antarctica during spring. This depletion has prolonged the Southern Hemisphere stratospheric winter, modified wind patterns in the Southern Hemisphere troposphere, and caused an increase of surface temperature on the Antarctic Peninsula while cooling the Antarctic plateau.

The phase-out of ODSs as a result of the controls established by the Montreal Protocol will increase stratospheric ozone levels and decrease anthropogenic climate forcing by these potent GHGs. The increased GHG levels cool the stratosphere and modify the stratospheric circulation; both of these impact ozone levels.

The intricate coupling of climate change and stratospheric ozone depletion lies not only in their phenomena but also in their environmental effects. Stratospheric ozone depletion increases surface UV radiation, while climate change increases surface temperature and modifies cloud formation and precipitation. Response to changing UV radiation is altered by these climate effects, while the response to climate change is modified by UV radiation. For example, recent studies have shown that for the same level of UV radiation, temperature increases can result in an increased risk of non-melanoma skin cancer and that terrestrial and aquatic ecosystems will be affected by interactions between exposure to UV radiation and climate change. The magnitudes of the consequences of climate-ozone interactions for health, biodiversity, ecosystem function and feedbacks are currently uncertain.

It is technically and economically feasible to accelerate the phase-out of most ODSs, to reduce their emissions in many applications, and to collect and destroy a large amount of the ODS contained in foam, refrigeration, and air conditioning equipment. With economic incentives, adequate financing, and access to new technology, it is technically and economically feasible to leapfrog the use of high global warming potential (GWP) HFCs when phasing out most HCFC applications. It is also technically and economically feasible to phase down the use of high-GWP HFCs in mobile air conditioning (MAC) and other applications where ODSs already have been phased out. New technology will emerge rapidly as additional controls are implemented to protect the global atmosphere.

Hydrofluorocarbons (HFCs)

HFCs are replacement compounds for CFCs and HCFCs because their ozone depletion potentials are essentially zero. HFCs have found increasing utility and their atmospheric abundances are increasing rapidly. Because many HFCs are very potent GHGs, unabated global utilization and emission of HFCs could lead to emissions projected to be as much as 20% of the total GHG emissions (weighted by the GWP) by 2050.

The concentrations of atmospheric breakdown products in the environment, including trifluoroacetic acid (TFA), from projected future HFC and HCFC uses are currently predicted to remain relatively low, and are therefore not expected to be a significant risk to human health or detrimental to the environment.

The Montreal Protocol protected the ozone layer by providing the framework for phasing out ODSs. This phase-out has greatly benefited climate, but also incurred partially offsetting consequences because of the use of high-GWP HFCs. Until recently, there were few economic incentives to avoid and eliminate uses and emissions of the HFCs for applications where environmentally superior alternatives and substitutes are emerging or already available. Now, however, low-GWP alternatives to high-GWP HFCs are being introduced rapidly in large-scale manufacturing operations such as for insulating foams, while longer time is required for other sectors because of the lifetime of the existing products and further economic and technical considerations (e.g., flammability, toxicity, and energy efficiency). Choosing the substance with the lowest GWP may not always be the environmentally optimum approach because the GHG emissions from product manufacturing and product energy use often dominate the life-cycle carbon footprint. Now, new technology is emerging because low-GWP technology with high energy efficiency is being increasingly commercialized.

The above considerations highlight that there are further options for addressing the climate consequences associated with the ODS phase-out. Three examples include: 1) the European Commission MAC Directive and the United States Environmental Protection Agency decisions to phase out HFC-134a in motor vehicle AC. 2) The Multilateral Fund (MLF) currently offers 25% higher financing for projects to leapfrog high-GWP HFCs. 3) Some Parties to the Montreal Protocol have proposed an amendment that would phase down HFCs through controls typical of the Montreal Protocol. Proposals to amend the Montreal Protocol to phase down HFCs encourage investment in alternatives and substitutes.

Methyl Bromide

The Montreal Protocol has led to the successful control of the vast majority of ODSs. Hence, further action to accelerate the recovery of the ozone layer by adjustment is limited. Existing efforts have reduced the observed tropospheric abundance of methyl bromide (a key ODS) by 1.9 parts per trillion (ppt) (about 20%) from the peak values found during 1996–1998. Methyl bromide is a major contributor to stratospheric bromine loading and, by 2008; nearly 50% of total methyl bromide consumption was for uses not controlled by the Montreal Protocol (quarantine and pre-shipment, QPS). QPS consumption has increased significantly in some Parties since 2007, as a consequence of expanding international trade.

However, further control of methyl bromide is still possible. Approximately 20–35% of present global consumption of methyl bromide for QPS uses could be replaced with available alternatives. Complete QPS phase-out would have an immediate benefit, and is estimated to bring forward ozone layer recovery by roughly 1.5 years. Since QPS uses are presently exempted under the Protocol, there is no obligation or incentive to limit uses. Nevertheless, some Parties have entirely phased out QPS uses and others have announced their intention to do so in the near future.

The highlights of the three assessment panel reports follow.

Highlights of the Three Assessment Panel Reports

Highlights of the Scientific Assessment

Ayité-Lô Ajavon, Christine A. Ennis, Paul A. Newman, John A. Pyle, and A. R. Ravishankara

I. The Success of the Montreal Protocol

The Montreal Protocol continues to be successful in reducing the overall abundance of ozone-depleting substances (ODSs) in the atmosphere.

- Atmospheric total chlorine from ODSs is continuing to decline from its 1990s peak values in both the troposphere and the stratosphere. In the troposphere, total chlorine has declined by 8% from its peak value of 3.7 parts per billion (ppb).
- Atmospheric removal of chlorofluorocarbons (CFCs) is now making the largest contribution to the total chlorine decline since the short-lived methyl chloroform has largely been removed from the atmosphere. Carbon tetrachloride abundances have declined less rapidly than expected, with reasons for the discrepancies not fully understood at present.
- Total brominated ODSs including halons are declining in the lower atmosphere and are no longer increasing in the stratosphere. The halon-1211 abundance also is decreasing.
- Tropospheric abundances of most hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) are increasing rapidly as a result of replacement of CFCs and economic growth.
- Chlorine in the lower atmosphere declined more slowly than would have been anticipated from reduced emissions and atmospheric removal because of increasing emissions of HCFCs, along with leakage of CFCs from “banks” in existing equipment and foams.

The Montreal Protocol has protected the ozone layer.

- Ozone depletion at midlatitudes and globally has stabilized. Midlatitude annual mean total column ozone amounts in Southern and Northern Hemispheres over the period 2006–2009 have remained at the same level as observed during 1996–2005, at about 6% and 3.5%, respectively, below the 1964–1980 average.
- The springtime Antarctic ozone hole continues to occur each year, with year-to-year variations as expected from year-to-year changes in meteorology. October mean ozone within the vortex has been about 40% below 1980 values for the past 15 years. Although ODSs in the vortex have shown small decreases, the Antarctic springtime ozone column does not yet show a statistically significant increase.
- Ozone loss in the Arctic winter and spring between 2007 and 2010 has been variable but in a range comparable to values since the 1990s. Because of natural meteorological variations, Arctic springtime ozone will be expected to exhibit large year-to-year variability. Natural meteorological variability combined with the high levels of total effective chlorine from anthropogenic emissions leads to occasional large ozone depletions.

The Montreal Protocol has also benefited climate, because many ODSs are also greenhouse gases.

- In terms of relevance to climate, the decrease of 100-year GWP-weighted ODS emissions achieved under the Montreal Protocol is equivalent to a reduction of carbon dioxide (CO_2) emissions that is five times larger than the target of the first commitment period of the Kyoto Protocol.

The impact of the Antarctic ozone hole on surface climate is becoming evident.

- The Antarctic ozone hole, which is the largest ozone depletion observed today, has caused tropospheric wind patterns to shift southward in the Southern Hemisphere.
- As a consequence of polar ozone depletion, the surface climate has warmed over the Antarctic Peninsula and cooled over the high plateau.

The ozone layer and surface ultraviolet (UV) radiation are responding as expected to the ODS reductions achieved under the Montreal Protocol.

- Over the last decade, global ozone as well as ozone in the Antarctic and Arctic regions are no longer declining (i.e., they are no longer decreasing, but are not yet increasing). Now, ozone amounts continue to exhibit year-to-year variability.
- At midlatitudes, surface UV radiation has been about constant over the last decade, whereas in Antarctica large UV increases are seen when the springtime ozone hole is large.

II. The Future of the ODSs, their Chemical Substitutes, and the Ozone Layer

HCFC- and HFC- atmospheric abundances are increasing in the lower atmosphere and are expected to continue to do so in the immediate future.

- Atmospheric abundances of HFCs continue to increase; for example, HFC-134a has been increasing at about 10% per year in recent years.
- Atmospheric abundances of HCFCs are projected to begin to decline during the coming decade due to additional control measures agreed to in 2007 under the Montreal Protocol.

By successfully controlling the emissions of ODSs, the Montreal Protocol has protected the ozone layer from much higher levels of depletion.

- Globally, the ozone layer is projected to recover to its 1980 level before the middle of this century.
- The Antarctic ozone hole is expected to persist beyond the middle of this century.

III. Climate, Atmospheric Composition, and the Ozone Layer: Current and Future Issues

HFCs and HCFCs used as replacements for CFCs are adding to the atmospheric levels of greenhouse gases.

- The sum of HFCs currently contributes about 0.4 gigatonnes of CO_2-equivalents per year to total global CO_2-equivalent emissions, and is increasing at a rate of about 8% per year.
- Projections of HFC growth in scenarios that assume no controls suggest that by midcentury, the GWP-weighted emissions from HFCs could be comparable to the GWP-weighted emissions of CFCs at their peak in 1988.
- The HCFCs contribute about 0.7 gigatonnes of CO_2-equivalents per year, but this contribution is expected to start decreasing in the next decade because of the accelerated HCFC phase-out agreed to by the Parties in 2007.

The ozone layer and climate change are intricately coupled.

- For the next few decades, the decline in ODSs achieved under the Montreal Protocol will be the dominant influence on the recovery of the ozone layer. As ODSs decline, climate change and other factors are expected to become increasingly more important to the future ozone layer.
- Climate change is likely to be the dominant factor for the future ozone layer by the end of the century, assuming continued compliance with the Montreal Protocol.
- The cooling of the stratosphere caused by climate change will hasten the return of global ozone as well as Arctic springtime ozone to 1980 levels, with projections suggesting their returns will occur between about 2025 and 2040.
- Models suggest that increases in greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) will accelerate the stratospheric Brewer-Dobson circulation, which could have important consequences for column ozone amounts.
- The ozone levels globally, at midlatitudes, and in the Arctic may even become larger than those before 1980, when ozone depletion was very small.
- The Antarctic ozone hole is much less influenced by climate change than other areas of the globe; ozone-depleting substances primarily determine when the ozone hole will heal, currently projected to be after midcentury.
- Nitrous oxide (N_2O) is known to both deplete global ozone and warm the climate. Current anthropogenic ozone depletion potential (ODP)-weighted emissions of N_2O are larger than that of any ODS, and are expected to remain the dominant ozone-depleting emission throughout the 21st century.
- Deliberate injections of sulphur-containing compounds into the stratosphere, which have been suggested as a climate intervention approach (“geoengineering”), could have substantial unintended effects on the ozone layer.

IV. ODS Options Relevant to Policy

Further limiting the future emissions of ODSs would advance recovery dates by only a few years.

- Leakage of CFCs and halons from banks is currently the largest source of ODP-weighted emissions. A four-year delay (from 2011 to 2015) in capturing and destroying CFC and halon banks would result in about a 30% reduction in the ozone and climate benefits.

- If all ODS emissions were eliminated after 2010, the return of stratospheric chlorine and bromine to 1980 levels would be accelerated by about 13 years (from 2046 to 2033), and this would also have climate benefits. If methyl bromide emissions were eliminated from quarantine and pre-shipment applications, recovery of the ozone layer would be accelerated by roughly 1.5 years.

Highlights of the Environmental Effects Assessment

Janet F. Bornman, Nigel D. Paul, and Xiaoyan Tang

The success of the Montreal Protocol has prevented large-scale environmental impacts of ozone depletion, such as increases in UV radiation and consequent damage to human health and ecosystems. Increases in sun-burning (erythemal) UV-B radiation due to ozone depletion have been small outside regions affected by the Antarctic ozone hole. As a result of the Montreal Protocol, major increases in skin cancer rates that would have occurred with uncontrolled ozone depletion have been prevented. Large reductions in the growth and productivity of plants and aquatic organisms, and hence significant changes to the global carbon cycle, also have been avoided.

Current State-of-Knowledge

- UV-B radiation has well-defined effects on human health. These include increased skin cancer incidence, increased cataract and melanoma of the eye, and decreased immunity to certain diseases, but also Vitamin D synthesis in the skin. The balance of exposure to UV-B radiation required to allow for sufficient Vitamin D production, while ensuring minimal risks for skin cancer and UV-related eye diseases, is becoming clearer for a range of UV conditions. However, research-based information needs to be effectively communicated to the public.
- Based on current and expected future use of HFCs and HCFCs, the concentration of their breakdown product trifluoroacetic acid in the environment currently is predicted to remain low, and therefore not a significant risk to human health or the environment. Other substitutes, such as sulfuryl fluoride, a fumigant proposed to replace methyl bromide, and a range of breakdown products of substitutes are toxic, but the risks posed under normal conditions need to be considered in technical assessments of their future use.
- Despite the success of the Montreal Protocol, substantial increases in UV-B radiation have been observed at Southern high latitudes where ozone depletion has been large. In these areas, results from a wide range of field studies have shown that increased UV-B radiation has reduced the productivity of terrestrial plants by about 6% around 50°S. Detrimental effects of solar UV-B radiation also have been demonstrated for a large number of aquatic organisms.

Future Predictions and Interactions

- Analysis of skin cancer incidence has shown a predominant effect of UV radiation and a significant influence of temperature. For the same UV level, each degree Celsius increase can result in about 3–6% increase in non-melanoma skin cancer. Although evidence to date is sparse, increased solar UV-B radiation in combination with other environmental factors, such as increases in temperature and humidity, may enhance the incidence of certain infectious diseases.
- Ecosystems will be responding to new combinations of environmental factors resulting from the interaction of increasing atmospheric CO_2, climate change, and UV radiation, including reductions in the negative effects of UV radiation in some regions as total column ozone recovers. For example, in terrestrial ecosystems moderate drought may reduce sensitivity to UV radiation in plants, but the projected further decreases in precipitation and rising temperatures for some regions of the Earth will interact with the effects of UV radiation to reduce plant growth. Even with the predicted recovery of total column ozone, the exposure of organisms to UV radiation in many ecosystems will be increased by reduced cloud cover, and decreases in vegetation cover due to predicted increases in aridity and deforestation.
- The detrimental effects of solar UV-B radiation on many aquatic organisms are expected to be worsened by climate change. Increases in temperature will alter the exposure of aquatic organisms to solar UV radiation by decreasing their depth distribution. Accelerated input of dissolved organic matter into water bodies as well as the degradation of this organic matter by UV radiation will modify the transparency of the water. Acidification of marine waters from the increasing concentration of atmospheric carbon dioxide also may make some aquatic organisms more vulnerable to solar UV-B radiation.

- The consequences of interactions between the responses of organisms to climate change and future changes in UV radiation for biodiversity, ecosystem function, and feedbacks into climate change have not yet been fully quantified, and would be expected to show significant geographical variation. However, carbon cycling in terrestrial and aquatic ecosystems is expected to be affected. The balance of positive and negative effects on terrestrial carbon cycling remains uncertain, but the interactions between UV radiation and climate change are likely to contribute to reduced CO_2 fixation by many aquatic ecosystems. Interactions between solar UV radiation and climate change affecting element cycling, for example nitrogen and the halogens, will also influence the concentration of naturally-occurring greenhouse and ozone-depleting gases, and the environmental chemistry of many contaminants.
- UV radiation is one of the controlling factors for the formation of photochemical smog that includes tropospheric ozone and aerosols; it also initiates the formation of hydroxyl radicals, which control the amount of many climate- and ozone-relevant gases in the atmosphere. The net effects of future changes in UV radiation, meteorological conditions, and anthropogenic emissions (particularly nitrogen oxides and volatile organic compounds) on hydroxyl radicals, tropospheric ozone, and aerosols, will depend on local conditions, posing challenges for prediction and management of air quality.
- For construction materials, increased ambient temperature accelerates the UV-induced degradation of plastics and wood, thus shortening their useful outdoor lifetimes. However, presently available technologies for stabilizing polymers can partly mitigate the damage to some types of common plastics.

Highlights of the Technology and Economic Assessment

Stephen O. Andersen, Lambert J. M. Kuijpers, and Marta Pizano

The Montreal Protocol is working. There is progress in every consumer, commercial, industrial, and military sector, with ozone-depleting substances (ODSs) phased out in many applications worldwide. However,

1. Some metered-dose inhalers (MDIs), laboratory and analytical uses still depend on new production of ODSs authorized by essential use exemptions;
2. Some fire protection, refrigeration and air conditioning service, and minor other applications still depend on banked and recycled ODSs;
3. Uncontrolled ODSs continue to increase for feedstock, quarantine and pre-shipment (QPS) uses;
4. Banks of unwanted ODS are leaking away to the atmosphere where they deplete stratospheric ozone and force climate change; and
5. High-GWP HFC greenhouse gases have replaced ODSs, particularly in refrigeration, air conditioning, and thermal insulating foam applications, where low-GWP alternatives and substitute are not available.

It is technically and economically feasible in both Article 5 and non-Article 5 countries:

- To collect and destroy certain surplus ODSs not required for important uses;
- To reduce emissions of ODSs and HFCs substitutes for ODSs from refrigeration, air conditioning, and fire protection equipment;
- To phase out HCFCs faster and to largely avoid high-GWP substances in new refrigeration and air conditioning equipment.

If financing is made available, Article 5 Parties can go beyond compliance and can phase down high-GWP HFCs in applications like mobile air conditioning where the ODS phase-out is already complete in the manufacture of new vehicles and to increase the energy efficiency in refrigeration, air conditioning and foam applications with the co-benefit of sustainable prosperity due to lower ownership costs.

Technology is available to leapfrog high-GWP HFCs in some applications, which would avoid a second transition out of HFCs and complications of an increasingly large inventory of HFC equipment requiring servicing with HFCs that may be expensive or not easily available. Adequate financing will be needed for Article 5 Parties and regulatory incentives will be required for non-Article 5 Parties.

The opportunity to destroy unwanted ODS refrigerants is leaking away as equipment reaches end-of-life and ODSs are discharged. Economic incentives and infrastructure are not available in most developing and developed countries. The co-benefits of ozone and climate protection from collecting and destroying ODSs exceed the costs:

- Collection and destruction is not profitable without payment for environmental benefit;

- Collection and destruction would be highly profitable if enterprises were paid for the contribution to ozone and climate protection, but neither economic incentive is available in most countries; and
- It is counter-productive to compel collection and destruction without incentives, because owners may discharge ODS that would otherwise be available for paid destruction.

Foam Applications

Unsaturated HFCs (HFOs) are likely to be available commercially earlier than originally expected (2013–2015) and in preliminary evaluations are showing better thermal performance than saturated HFCs. However, widespread uptake will require substantial further validation of both performance and cost. Not-in-kind thermal insulation is available in all markets. Voluntary green building initiatives, building energy use disclosure, and regulatory incentives are relentlessly forcing innovation in building design, thermal insulation, and technology to replace foam made with or containing ODSs and GHGs.

Halons

There appear to be sufficient halon 1211 and 1301 stocks to meet known needs for the foreseeable future, although regionally stocks are not evenly distributed. The United Nations International Civil Aviation Organization (UN ICAO) has endorsed a schedule to replace halons on board new aircraft in the lavatory trash receptacles, hand-held extinguishers, engine nacelles, and auxiliary power units. The protection of cargo compartments remains a challenge for which there is no acceptable solution at this time, but for which research continues.

Medical Applications

There has been significant global progress in the transition of CFC MDIs to CFC-free inhalers, in the phase-out of ODSs in other medical aerosol products, and in the transition to ODS-free sterilization.

Technically satisfactory alternatives to CFC MDIs are now available in almost all countries worldwide to cover all of the key classes of drugs used in the treatment of asthma and chronic obstructive pulmonary disease.

A cautious approach to CFC production for MDI manufacture is advisable, since transition is moving quickly. It could be possible to complete the phase-out of CFC MDIs with careful management of existing CFC stockpiles, provided that manufacture of pharmaceutical-grade CFCs is also carefully managed.

Methyl Bromide

88% of global methyl bromide (MB) controlled uses have been phased out. Increased use of MB for QPS uses not controlled by the Montreal Protocol is offsetting gains made by reductions in controlled uses for soils, structures and commodities. Some of this increase is due to preplant soil use in propagation nursery sectors.

TEAP estimates that currently available alternatives and substitutes could replace approximately 22% to 33% of global QPS consumption.

Some Parties have stopped all uses of MB, including QPS, and other Parties have announced their intention to stop exempted QPS uses in the near future.

Article 5 Parties have reduced MB consumption by nearly 80% of the baseline, which is well ahead of phase-out schedules, but further efforts are still necessary to ensure the full phase-out deadline of 2015 can be met.

Technical alternatives exist for almost all controlled uses of MB, but phase-out for the remaining MB uses will be greatly influenced by the registration and the regulatory controls on several key chemical alternatives (including 1,3-dichloropropene, chloropicrin, methyl iodide and sulfuryl fluoride) and by the incentives for non-chemical alternatives and Integrated Pest Management.

Refrigeration and Air Conditioning and Heat Pumps

The technical options to phase out ODSs and avoid high-GWP HFC refrigerants are universal, but local laws, regulations, standards, economics, competitive situations and other factors influence regional and local choices.

Since the 2006 Assessment, more than 60 new refrigerants and refrigerant blends were introduced for use either in new equipment or as service fluids (to maintain or convert existing equipment), and the overarching concern of climate change will continue to advance equipment innovations. Both HFCs and non-fluorochemical options are increasingly used in most sectors, with emphasis on optimising system energy efficiency and reducing emissions of high-GWP refrigerants.

Alternatives for HCFC-22 include lower GWP HFC refrigerants (HFC-32, HFC-152a, HFC-161, HFC-1234yf and other unsaturated fluorochemicals, as well as their blends), hydrocarbons (HC-290) and carbon dioxide (R-744). Flammable hydrocarbon and HFC refrigerants will need to be applied in accordance with appropriate safety standards.

In Europe and Japan, hydrocarbons (HCs) and R-744 are gaining market shares in commercial refrigeration stand-alone equipment as a replacement for HFC-134a, which is the dominant choice in most other countries. In many developed countries, R-404A and R-507A have been the main replacements for HCFC-22 in supermarkets, however, because of their high GWP, a number of other options are now being introduced. In two-stage systems in Europe, R-744 is used at the low-temperature level and HFC-134a, R-744 and HCs at the medium-temperature level.

In air-to-air air conditioning, HFC blends, primarily R-410A is still the dominant near-term replacement for HCFC-22 in air-cooled systems. HC-290 is also being used to replace HCFC-22 in low charge split systems, window and portable air conditioners in some countries.

Motor vehicle manufacturers and suppliers have evaluated low-GWP refrigerant options for new car (and truck) air conditioning systems including R-744 (GWP=1), HFC-152a (GWP=133) and HFC-1234yf (GWP=4). Associations of automobile manufacturers in Europe, Japan and the United States have endorsed HFC-1234yf as has the only company to announce a refrigerant choice (General Motors). HFC-152a and HFC-1234yf are listed under the US EPA SNAP program as environmentally acceptable replacements.

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