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Montreal Protocol on Substances that Deplete the Ozone Layer

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Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer
Forty-fourth meeting
Bangkok, 11–16 July 2022
Items 8 (b), 8 (c), 8 (d) and 9 of the provisional agenda*

Issues for discussion by and information for the attention of the Open-ended Working Group of the Parties to the Montreal Protocol at its forty-fourth meeting

Note by the Secretariat

Addendum

I. Introduction

1. The present addendum to the note by the Secretariat on issues for discussion by and information for the attention of the Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer at its forty-fourth meeting (UNEP/OzL.Pro.WG.1/44/2)[1] contains information that has become available since the preparation of the first addendum to that note (UNEP/ OzL.Pro.WG.1/44/2/Add.1).[2] That addendum provided updates by the Secretariat in relation to items 4, 6 (a) and 8 (a) of the provisional agenda of the forty-fourth meeting of the Open-ended Working Group.

2. Section II of the present addendum sets out new and updated information on the future availability of halons and their alternatives, in relation to item 8 (b) of the provisional agenda; on membership changes in the Technology and Economic Assessment Panel; on other issues, in relation to items 8 (c) and 8 (d) of the provisional agenda; and on strengthening the Technology and Economic Assessment Panel and its technical options committees for the phase-down of hydrofluorocarbons (HFCs) and other future challenges related to the Montreal Protocol and the climate, in relation to item 9 of the provisional agenda. The above information is included in volume 1 of the Panel's 2022 report,[3] which was made available on the Ozone Secretariat meeting portal on 26 May 2022. Section III provides further information on issues of relevance to the Thirty-Fourth Meeting of the Parties to the Montreal Protocol, in particular pertaining to the periodic review of alternatives to HFCs.

* UNEP/OzL.Pro.WG.1/44/1.

[1] https://ozone.unep.org/system/files/documents/OEWG-44-2E.pdf.

[2] https://ozone.unep.org/system/files/documents/OEWG-44-2-Add-1E.pdf.

[3] https://ozone.unep.org/system/files/documents/TEAP-Progress-report-may2022.pdf.

II. Summary of issues for discussion by the Open-ended Working Group at its forty-fourth meeting

3. The issues covered in the present addendum are provided below in the order of the respective agenda items in the provisional agenda of the meeting.

Agenda item 8

Technology and Economic Assessment Panel 2022 report and related issues

4. The 2022 progress report of the Technology and Economic Assessment Panel includes progress reports by its technical options committees, updates on the Panel's response to two decisions of the Meeting of the Parties (XXX/7 and XXXI/8), and information on its modelling work and on other matters, including membership and organizational matters.

5. Key messages in the progress reports by the technical options committees are reproduced in annex I to the present addendum, as set out in the Panel's progress report, without formal editing by the Secretariat. Issues related to sub-items 8 (b), 8 (c) and 8 (d) of the provisional agenda are summarized in the following sections.

(a) Future availability of halons and their alternatives (decision XXX/7)

6. In decision XXX/7, as outlined in document UNEP/OzL.Pro.WG.1/44/2 (paras. 36 and 37), the Technology and Economic Assessment Panel, through its Halons Technical Options Committee (HTOC), was requested to prepare a report on halon availability, based on the assessment and identification activities provided in the decision, and submit it to the parties in advance of the forty-second meeting of the Open-ended Working Group. The Panel's response to that decision was included in its 2020 progress report[4] and a summary of that response was provided in document UNEP/OzL.Pro.WG.1/42/2/Add.1.[5]

7. As parties were not able to discuss this matter in 2020 and 2021 due to disruptions caused by the coronavirus disease (COVID-19) pandemic, the issue is to be considered at the forty-fourth meeting of the Open-ended Working Group under item 8 (b) of the provisional agenda. In the 2022 progress report of the Technology and Economic Assessment Panel, HTOC provided updated information on its earlier response to decision XXX/7. The key conclusions are summarized in the following paragraphs.

8. HTOC reiterates the concern it raised previously that the economic downturn caused by the global response to the pandemic would have a lasting impact on the halon-1301 sector. Airframe manufacturers have lowered their production rates and their forecasts for aircraft sales for the next several years. Their internal predictions are that growth rates will not return to pre-pandemic levels for at least five years. Additionally, airlines have accelerated decommissioning of their older, less efficient aircraft and are replacing them with new, smaller aircraft that use less halon.

9. While civil aviation flight hours dropped by 60 per cent during the pandemic, data for 2020 indicate that total global halon emissions did not do so, suggesting that a different part of the aviation lifecycle, such as fire-extinguisher maintenance, might be responsible for a large proportion of those emissions. While awaiting the 2021 data on global emission estimates derived from atmospheric abundances, the Committee is working with the International Civil Aviation Organization, relevant companies, non-governmental organizations and working groups on civil aviation to better understand not only the magnitude of the emissions but also potentially where in the aviation life cycle those emissions occur.

10. Additionally, the Committee continues to cooperate with the International Maritime Organization, maritime and merchant shipping non-governmental organizations, and other experts in the halon-1301 sector to understand the implications of relevant data and to update the modelling work and estimates for the current and projected halon-1301 market in terms of uses, installed base and annual emissions. As this remains a significant task, the Committee will provide updated information on this work in its upcoming 2022 quadrennial assessment report.

11. The 2022 progress report also presents results from the comparison of estimates of halon-1301 emissions in a HTOC model and estimates derived from measured atmospheric abundances from the 1960s to 2020. Those results indicate two periods (2010–2016 and 2018–2020) during which

[4] https://ozone.unep.org/system/files/documents/TEAP-Progress-report-and-response-decXXXI-8-may2020.pdf.

[5] https://ozone.unep.org/system/files/documents/OEWG-42-2-Add-1E.pdf.

measurement-based estimates were markedly higher than HTOC model estimates. HTOC continues to work with atmospheric scientists from the Advanced Global Atmospheric Gases Experiment network to determine whether additional data analysis can provide any insight into these differences.

12. The Open-ended Working Group may wish to discuss the issue and make any appropriate recommendations on the way forward.

(b) Panel membership changes

13. In its 2022 progress report, the Technology and Economic Assessment Panel elaborates on organizational issues related to each of its technical options committees. Information on the status of the membership of the Technology and Economic Assessment Panel and its technical options committees as at May 2022 is included in annex 1 to the progress report.

14. The table below lists the members of the Technology and Economic Assessment Panel whose membership expires at the end of 2022 and whose reappointment requires a decision by the Meeting of the Parties. The members of the technical options committees whose membership expires at the end of 2022 and whose reappointment does not require a decision by the Meeting of the Parties are listed in annex II to the present addendum.

Members of the Technology and Economic Assessment Panel whose membership expires at the end of 2022 and whose reappointment requires a decision by the Meeting of the Parties

Name	*Position*	*Country*
Marta Pizano	TEAP co-chair	Colombia
Ashley Woodcock	TEAP co-chair	United Kingdom of Great Britain and Northern Ireland
Fabio Polonara	RTOC co-chair	Italy
Shiqiu Zhang	TEAP senior expert	China
Marco Gonzalez	TEAP senior expert	Costa Rica
Rajendra Shende	TEAP senior expert	India
Ray Gluckman	TEAP senior expert	United Kingdom of Great Britain and Northern Ireland

Abbreviations: TEAP – Technology and Economic Assessment Panel; RTOC – Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee.

15. Parties may wish to submit nominations, as necessary, in accordance with paragraph 3 of decision XXXI/8, whereby they are requested, "when nominating experts to the Panel, its technical options committees or its temporary subsidiary bodies, to use the Panel's nomination form and associated guidelines so as to facilitate the submission of appropriate nominations, taking into account the matrix of needed expertise, and geographical and gender balance, in addition to the expertise needed to address new issues related to the Kigali Amendment, such as energy efficiency, safety standards and climate benefits". In paragraph 5 of the same decision, the parties are urged "to follow the terms of reference of the Panel, consult the Panel's co-chairs and refer to the matrix of needed expertise prior to making nominations for appointments to the Panel". Owing to the Panel's proposed adjustments to its current structure, the matrix of needed expertise for 2022 is not included in the progress report, but the Panel states that it will provide the matrix well ahead of the Thirty-Fourth Meeting of the Parties later in 2022 for its consideration (see also paras. 25–31 below).

16. In accordance with paragraph 4 of decision XXXI/8, the Secretariat will make available on the meeting portal for the forty-fourth meeting of the Open-ended Working Group any forms submitted by parties nominating members to the Panel, as well as on the meeting portal for the Thirty-Fourth Meeting of the Parties later in 2022, to facilitate the review of and consultations on the proposed nominations by parties. Panel membership changes are included under item 8 (c) of the provisional agenda.

17. Nominations to the technical options committees other than for co-chair positions, as well as nominations to temporary subsidiary bodies, can be made at any time. Appointments are made by the co-chairs of the relevant committees in consultation with the Panel.

(c) Any other issues

18. The present section summarizes some key issues raised by the Technology and Economic Assessment Panel in its progress report for the information of the parties. These issues fall under item 8 (d) of the provisional agenda.

1. *Modelling work update*

19. The Technology and Economic Assessment Panel provides an update on the ongoing work of an internal small working group, established to build a database model for estimating annual regional emissions and banks based on historic, current, and projected use of controlled substances. The purpose of this initiative is to respond better to parties' requests and to support both the Panel's work and that of the other assessment panels under the Montreal Protocol. The Panel underscores the importance of a consistent, transparent and published methodology to ensure that the best available assumptions and methods are incorporated in the modelling work. Model estimates for each chemical substance can be integrated to calculate total ozone depletion potential (in ozone-depleting-potential units) or climate impact (in carbon dioxide equivalent units). Any additional data that parties may wish to convey to the Panel could be used to further refine the modelling work.

20. An example of the results of this modelling work is the estimated expected emissions and banks of trichlorofluoromethane (CFC-11) set out in the Panel's task force report on unexpected emissions of CFC-11.[6] A more recent example, outlined in the progress report, pertains to estimates of expected emissions and banks of HCFC-141b. According to the Panel, more information on its modelling work will be provided in its 2022 quadrennial assessment report.

2. *Response to decision XXXI/8 entitled "Terms of reference of the Technology and Economic Assessment Panel and its technical options committees and temporary subsidiary bodies – procedures relevant to nominations"*

21. In decision XXXI/8, the Technology and Economic Panel was requested to provide, as part of its annual progress report, a summary outlining the procedures that the Panel and its technical options committees have undertaken to ensure adherence to the Panel's terms of reference through clear and transparent procedures, including full consultations with the focal points, in line with the terms of reference, regarding: (a) nomination processes, taking into account the matrix of needed expertise and already available expertise; (b) proposed nominations and appointment decisions; (c) termination of appointments; and (d) replacements. The Panel's response, including references to the relevant provisions of its terms of reference, is set out in section 8.1 of its progress report and is summarized in the following paragraphs.

22. In addressing the nomination and appointments processes, the Panel notes its continued efforts to identify appropriate expertise and qualified candidates who are interested and available to serve. In doing so, it considers its current pool of experts, the potential loss of expertise, through attrition or lack of support, and the need for specific and cross-cutting expertise within the Panel and its technical options committees.

23. Identified needs are communicated to the parties through the Panel's annual progress reports, which include updated information on the membership of the Panel and its technical options committees[7] and the annual matrix of needed expertise, which is also posted on the website of the Ozone Secretariat. A standard form for nominations of experts to the Panel, technical options committees or temporary subsidiary bodies has been finalized and is also available on the website.[8]

24. Nominations for appointment or reappointment of experts to technical options committees can be made at any time throughout the year and are considered by the co-chairs of the relevant committee in consultation with the co-chairs of the Panel and the relevant national focal points. In determining whether to accept or decline a nomination submitted by a party, consideration is given to the expertise of the nominee, the expertise needed by the relevant committee, the balance between experts from Article 5 and non-Article 5 parties on the committee, as well as geographical and gender balance. The needed expertise may, however, outweigh the other considerations. The need to maintain a reasonable size and balance, to avoid duplication of expertise and to ensure that expertise gaps are filled means that nominations may sometimes be declined or that their consideration may be deferred.

[6] https://ozone.unep.org/system/files/documents/Final_TEAP-DecisionXXXI-3-TF-Unexpected-Emissions-of-CFC-11-may2021.pdf.

[7] See annex 1 to the Panel's May 2022 progress report.

[8] https://ozone.unep.org/sites/default/files/assessment_panels/teap-nomination-form.docx.

Agenda item 9

Strengthening the Technology and Economic Assessment Panel and its technical options committees for the phase-down of hydrofluorocarbons and other future challenges related to the Montreal Protocol and the climate (proposal by Morocco) (UNEP/OzL.Conv.12(I)/6–UNEP/OzL.Pro.32/8, para. 15)

25. As is indicated in document UNEP/OzL.Pro.WG.1/44/2 (paras. 43–45), the Technology and Economic Assessment Panel included in its progress report information on organizational matters. In particular, in chapter 8.4 of its 2022 progress report, the Panel presents its thoughts and recommendations on adjustments that can be made to its current structure with a view to supporting more efficiently the parties' efforts to ensure the phase-out of ozone-depleting substances and meeting the challenges of HFC phase-down.

26. The Panel notes that during the discussions on its future structure and scope, it considered the increasing importance of food and vaccine cold chains and the performance of buildings, manifested especially during the COVID-19 pandemic, along with the associated issues of energy efficiency, safety, and availability of ozone- and climate-friendly alternatives. It also reflected on the importance of fire safety, and sustainable agriculture, food production and food safety. After thorough deliberation, the Panel decided to recommend to the parties, for their consideration, restructuring two of its five technical options committees and renaming two of the remaining committees, as follows:

(a) Establishment of two new technical options committees

27. The formation of two new technical options committees would be based on the existing Refrigeration, Air Conditioning and Heat Pump Technical Options Committee (RTOC) and the Foams Technical Options Committee (FTOC) and would cover all sectors currently dealt with by these committees, while integrating relevant issues such as energy efficiency. The new committees to replace RTOC and FTOC could be called the Cold Chain Technical Options Committee (CCTOC) and the Building and Indoor Climate Control Technical Options Committee (BICCTOC). The functional areas served by these Committees, as outlined by the Panel, are described below:

(a) **CCTOC**. Cold chains for food and other perishables including agriculture and fisheries, and medicines such as vaccines, with a focus on sustainability; refrigeration including foam insulation and other foams and refrigerants. Examples of equipment include factory-sealed appliances, food retail and food service, transport refrigeration and industrial refrigeration. Expected coordination on cross-cutting issues, e.g., on safety standards, with BICCTOC.

(b) **BICCTOC**. Stationary and mobile air conditioning, heat pumps, construction foam, and refrigerants. Examples of equipment include air-to-air air conditioning and heat pumps, commercial comfort air conditioning, mobile air conditioning, heating heat pumps and heat engines. Expected coordination on cross-cutting issues with CCTOC.

28. Regarding membership, the Panel recommends that the terms of current RTOC and FTOC members expire at the end of 2022, so that the new committee co-chairs can consider appointments of members based on a new matrix of needed expertise to be provided before the Thirty-Fourth Meeting of the Parties. New members would start their service in 2023 following the established nomination and appointment requirements.

29. Recognizing that the current RTOC and FTOC co-chairs hold significant institutional knowledge and excellent understanding of the expectations under the Montreal Protocol, the Panel recommends that they all be appointed as co-chairs to the new committees for a term of no longer than four years to provide continuity in this new structure.

(b) Proposed adjustments to the remaining technical options committees

30. Upon considering the future roles and scope of work for HTOC, the Methyl Bromide Technical Options Committee (MBTOC), and the Medical and Chemicals Technical Options Committee (MCTOC), the Panel proposes the following:

(a) Rename HTOC as the Fire Protection Technical Options Committee (FPTOC) to reflect its broad role in fire safety and the increasing range of fire suppressant options other than halons;

(b) Rename MBTOC as the Methyl Bromide, Agriculture and Sustainability Technical Options Committee (MBASTOC) to reflect the broad importance of sustainability in food production and food safety as well as sustainable agriculture, beyond methyl bromide. The Committee would still

address controlled and exempted uses of methyl bromide and its alternatives, but its scope of work would be much wider and relevant to sustainable production in agriculture (e.g., nitrogen management). Cross-cutting issues would also be addressed jointly with other technical options committees as appropriate (e.g., the impact of the cold chain on food security).

(c) Make no changes to the Medical and Chemicals Technical Options Committee (MCTOC) at present.

31. The Open-ended Working group may wish to consider the recommendations of the Technology and Economic Assessment Panel.

III. Issues that are relevant to the Thirty-Fourth Meeting of the Parties, including updates on the implementation of previous decisions

Periodic review of alternatives to hydrofluorocarbons (decision XXVIII/2, para. 4)

32. As is indicated in document UNEP/OzL.Pro.WG.1/44/2 (paras. 60–63), in paragraph 4 of decision XXVIII/2 related to the amendment on phasing down HFCs (the Kigali Amendment), the Technology and Economic Assessment Panel was requested to conduct, in 2022 and every five years thereafter, periodic reviews of alternatives to HFCs using the criteria set out in paragraph 1 (a) of decision XXVI/9, and to provide technological and economic assessments of the latest available and emerging alternatives to HFCs. In its 2022 progress report, the Panel indicates that similar requests were made to the Panel in paragraph 6 of decision XXXI/2, which set out the terms of reference for the Panel's 2022 quadrennial assessment report. The Panel's views and proposals are summarized below.

33. The exact timing of the requested review in 2022 is not specified in decision XXVIII/2, while the quadrennial reports of the Panel's technical options committees will, according to decision XXXI/2, be submitted to the Secretariat by the end of 2022. Given that the requests to the Panel to review alternatives to HFCs in 2022 overlap in the two decisions, in order to facilitate early consideration of this issue by the parties, the Panel indicates in its progress report that it is planning to convene a working group on decision XXVIII/2, including experts from all of its technical options committees. The working group will prepare a report to respond to this decision in time for consideration by the Thirty-Fourth Meeting of the Parties (to be held from 31 October to 4 November 2022), drawing information from the 2022 quadrennial assessment reports of the technical options committees.

34. Notwithstanding its decision to convene the above-mentioned working group on this occasion, the Panel notes that the parties' requests for subsequent periodic reviews of HFC alternatives every five years after 2022 do not coincide with the timing of submissions of the Panel's quadrennial assessments. To manage its workload and minimize duplicative efforts, the Panel suggests that parties may wish to consider aligning future periodic reviews, such as those requested in decision XXVIII/2, with the reviews to be undertaken in connection with its already-planned quadrennial assessment reports.

Annex I*

Technology and Economic Assessment Panel 2022 Progress Report (Volume 1)

Key messages from the Technical Options Committees

TEAP presents below the main findings of the 2022 Progress Report, as key messages from each of the TOCs.

Flexible and Rigid Foams Technical Options Committee (FTOC)

Low-global warming potential (GWP) blowing agent shortages continue in both Article 5 (A5) and non-Article 5 (on-A5) parties which may be due to pandemic-related supply chain issues, raw material and supply chain shortages, manufacturing issues, and severe weather. Undisclosed manufacturing issues from at least one supplier have led to *force majeure* declarations, according to a number of foam manufacturers. As a result, there has been a significant increase in the use of hydrofluorocarbon HFC-365mfc/ HFC-227ea or HFC-365mfc/ HFC-245fa blends in some A5 parties and a reversion to HFC-365mfc blends and HFC-245fa in some non-A5 parties. Prices of HFCs have also increased during the pandemic. There have also been reported shortages of hydrocarbons, such as cyclopentane.

The transition away from ODS foam blowing agents in some regions and market segments (e.g., spray foam and extruded polystyrene [XPS]) may be delayed because of cost, especially where local codes require higher thermal performance[9]. It should be noted that the price of HFC blowing agents is nearly as high as hydrofluoroolefin/hydrochlorofluoroolefin (HFO/HCFO) prices were prior to the pandemic in some A5 parties.

Hydrocarbon (HC), methylal, methyl formate, and methylene chloride are reportedly being used in blowing agent blends to reduce costs in some parties. FTOC is seeking additional details on the safety measures being taken to address exposure and safety risks.
For example, a number of spray foam (SPF) formulators use 1,2 dichloroethylene as a co-additive for ostensibly improving solubility of HFC and now HFO blowing agents as a means of extending their value. With a boiling range of 48 - 60 ºC for both isomers, it can support blowing and may be used further as HFO and HFC supplies are tight[10]. As the transition proceeds and there are continued challenges in supply and costs, foam manufacturers and chemical producers are introducing new options and potential challenges.

Halons Technical Options Committee (HTOC)

In the 2018 Assessment Report, the HTOC anticipated that the initial 10% reduction in HFC production within non-A5 parties would not have a significant impact on the availability of HFCs for fire protection. It was reasoned that the use of HFCs in fire protection is extremely small in comparison to other uses, the emissions are low, and sales of HFCs in most non-A 5 parties were either declining or flat. Instead, the experience in the EU and Japan has shown a movement away from the use of HFCs in new fire protection systems (although use of HFCs in Japan has never been widespread). HFCs have been replaced in large part by low-GWP and no-GWP alternatives such as FK-5-1-12 and inert gases. The US HFC phase-down began on January 1, 2022, and it has already had an impact on the cost and availability of newly produced HFCs for fire protection. The US allocation system is GWP-weighted and the HFCs used for fire protection have very high GWPs, so the impact has been greater than initially expected. It is the HTOC's experience that HFCs contained in fire protection equipment historically have been recycled and reused to a relatively high extent. As the supply of newly produced HFCs for fire protection decreases in response to phase-down regulations,

* The annex has not been formally edited.

[9] Although the cost of hydrochlorofluorocarbons (HCFCs) was approximately 20-30% of the cost of high-GWP HFCs, HCFC price is increasing as they are phased out globally. The low price of some high-GWP HFCs, particularly HFC-365mfc which is banned in some non-A5 parties, is leading to an increase in market share, which is slowing the conversion to low-GWP blowing agents

[10] Toxicity of 1,2 dichloroethylene is currently being reviewed by at least one party. Field studies related to Indoor Air Quality in SPF installations often shows some concentration of 1,2-dichloroethane up to months or years after installation due to its higher boiling point and high solubility in foam matrixes.

recycling becomes even more important as an alternative source of supply and is likely to increase in the future.

- Parties may wish to consider re-emphasizing the need to foster international trade of recycled/reclaimed high-GWP HFCs, i.e., HFC-227ea, HFC-125 and HFC-236fa used in legacy fire protection applications, which include those in civil aviation lavatory fire protection systems.

The HTOC has identified several issues affecting the availability and quality of recovered halons from all fire protection sectors, but especially from the civil aviation sector. The HTOC also believes that shipbreaking could represent a significant source of halon 1301 which could support on-going activities. It is therefore important to conserve this supply to the greatest extent possible. To address these issues parties may wish to consider:

- Requesting the Ozone Secretariat to disseminate the recently developed halon management guidance document available from the HTOC, to all National Ozone Units (NOUs) and sponsoring presentations during all upcoming Ozone Regional Officer Networks and other applicable meetings,
- Liaising with their civil aviation authorities to disseminate this halon management guidance document to all applicable entities within their country such as airlines, maintenance, repair, and overhaul (MRO) companies, and associated non-governmental organisations (NGOs),
- Requesting that the International Civil Aviation Organisation (ICAO) formally disseminate through a State letter, the halon management guidance document to all civil aviation authorities requesting that the halon management guidance document receive the widest possible dissemination within their State and/or region,
- Emphasising the importance of effective and complete recovery of halons to minimize halon losses by all parties, particularly those with shipbreaking activities, and
- Re-emphasising the need to allow for appropriate, open trade of recovered, recycled and/or reclaimed halons in bulk containers and in prefilled fire protection components to support enduring halons uses, including civil aviation components that are required to allow aircraft to operate under international airworthiness requirements.

The EU proposal to define perfluoroalkyl and polyfluoroalkyl substances (PFAS) as any substance that contains at least one fully fluorinated carbon CF_2 or CF_3 group (without any hydrogen, chlorine, bromine or iodine (H/Cl/Br/I) atom(s) attached) would include virtually all of the halogenated, clean, agent alternatives to halons, HCFCs and high-GWP HFC fire extinguishing agents except for HFC-23 and CF_3I. Thus, hydrochlorofluorocarbon (HCFC)-124, HCFC Blend A, HCFC Blend B, HFC Blend B, HFC-227ea, HFC-125, HFC-236fa, fluoroketone (FK-5-1-12), 2-bromo-3,3,3-trifluoroprop-1-ene (2-BTP), and Halocarbon Blend 55 could all be included in the proposed regulations. This could leave halons, or in some cases also HFC-23, as the only viable non-PFAS options in some applications.

R&D for civil aviation cargo compartment fire protection systems continues. However, the development and certification timescales remain long and can be uncertain. As such, it will still be at least several more years before any of the fire extinguishing agents being evaluated could be in service on aircraft. If these are not successful, the chances of finding an as-yet undiscovered alternative that is safe and effective are, after so many years of research, are extremely low.

While civil aviation flight hours dropped by 60% during the pandemic, global halon-1301 emissions did not decline. Therefore, emissions do not seem to be dependent on the number or duration of civil aviation flights (i.e., do not occur during flight operation). This does not necessarily mean that civil aviation is not the cause of some of or even a significant amount of the emissions but rather that a different part of the aviation lifecycle such as fire extinguisher maintenance could be responsible for much of these emissions.

- Parties may wish to consider requesting that ICAO continue to sponsor activities related to halon regulation and management, include the HTOC in these activities, and work with the HTOC to provide annual updates on changes to their halon regulations, the status of development and implementation of aviation alternatives, and other halon management issues important for the long-term use and management of halons.

The HTOC is concerned that many personnel who are now responsible for managing fire protection agents controlled by the Montreal Protocol do not have the necessary experience with the issues surrounding the use, recovery, recycling, reclamation, and banking of these agents. To address these issues, parties may wish to consider:

- Supporting programmes to mitigate the loss in institutional memory of fire protection agents controlled by the Montreal Protocol; and
- Supporting awareness programmes to address recovery, recycling, reclamation, and banking of halons as well as HCFC and HFC fire protection agents.

Methyl Bromide Technical Options Committee (MBTOC)

In 2020, reported methyl bromide (MB) consumption for controlled uses was only 69 tonnes, although stocks substantially higher than this may be used in some sectors in various countries. After 20 years of applications for MB critical use during which substantial R&D has taken place on alternatives, some non-A5 parties continue to make critical use nominations without adoption of alternatives.

Quarantine and pre-shipment (QPS) uses of MB (approximately 10,000 tonnes per year), which are exempted from the Montreal Protocol controls, far exceed the use of MB for controlled uses and continue to be the major anthropogenic contributor of MB to the stratosphere. Over the last decade, some parties have succeeded in completely phasing out QPS use of MB, however, the overall global consumption of MB for QPS has not changed markedly since some A5 parties have increased QPS consumption substantially. Despite this, research programs globally are continuing to find successful alternatives to replace MB. The successful application of alternatives to QPS would accelerate the decline in stratospheric MB levels with a near-term impact on ozone.

Since 1999, the reduction in MB production and use from controlled uses has led to a reduction greater than 30% in the concentration of MB in the atmosphere and this has been responsible for more than 35% of the present fall in Effective Equivalent Stratospheric Chlorine and a key driver for the recovery of the ozone layer. Recent data, however, shows that a decline in the atmospheric levels of MB has stalled as emissions of MB from QPS uses and from any unreported uses continue unabated. MBTOC notes that near-term reduction of atmospheric concentrations of MB in the future will overwhelmingly rely on reduction in emissions from QPS or any unknown/unreported uses.

A significant proportion of emissions of MB from QPS can be reduced by recapture, recycling and/or reuse. Recapture of MB from QPS uses has recently been reviewed in New Zealand (NZ), with stepwise increases in use of recapture required by regulations implemented to phase out methyl bromide emissions. In addition, fumigation of the holds of ships with MB will be banned from 2023.

Some specific bilateral agreements are reducing MB use. For instance, India and Canada have agreed to lift the MB fumigation requirement for Canadian pulses exported to India while a systems approach is being established. This measure will potentially reduce QPS MB treatments of pulses on arrival substantially.

It appears that some parties still have difficulties in identifying and reporting MB use for QPS purposes.

MBTOC considers Q and PS to have different priority for use of MB with PS uses having greater potential for adoption of alternatives. PS uses could potentially be phased out because there are technically alternatives which are widely available and suitable worldwide. MBTOC considers that these readily available alternatives for PS could result in replacing 30-40% (i.e., 3000-4000 tonnes) of the total QPS MB use by alternatives. Parties could consider requesting TEAP/MBTOC to update information on QPS uses and their alternatives, specifically allocating the uses under Q versus PS.

Sulfuryl fluoride (SF) is widely registered and adopted around the world as an alternative to MB for disinfestation of dried fruit, tree nuts, grain flour, and timber, and is a key alternative to MB for treatment of empty structures such as flour mills and food and feed processing premises. In recent years, however, there is growing concern about the high 20-year GWP value of SF currently set at 7510 and MBTOC considers it prudent to ensure that other alternatives are considered.

Medical and Chemical Technical Options Committee (MCTOC)

Medical and Chemicals Technical Options Committee provides information on the production and use of controlled substances, including for chemical feedstock, HFC-23 by-production and emissions, and new developments for metered dose inhalers (MDIs). It also includes background to, and an update on, TEAP's assessment of destruction technologies under decision XXX/6, to be included in MCTOC's 2022 Assessment Report. The status of aerosols (other than MDIs), laboratory and analytical uses, process agent uses, and n-propyl bromide were reviewed, however, no compelling new information is reported in this report.

Production issues

As reported by FTOC, there have been reported challenges relating to production and chemical supply in the transition to low-GWP HCFO and HFO foam blowing agents. These challenges relate to several factors, including production constraints, restrictive manufacturing and application patents, high prices of HCFO/HFOs relative to HCFC-141b and HFC blowing agents, and regional shortages of CTC used as starting raw material in the process to manufacture HCFO/HFOs. New production capacity for HCFO/HFOs is expected to become available in 2023.

Feedstock use of controlled substances

The proportions of the largest controlled ODS feedstocks in 2020 are HCFC-22 (48% of the total mass quantity), CTC (20%), and HCFC-142b (11%). HCFC-22 is mainly used to produce tetrafluoroethylene, which is then used to make fluoropolymers such as polytetrafluoroethylene. HCFC-142b is used to make polyvinylidene fluoride. The feedstock use of CTC has increased in recent years, due to growing demand for lower GWP HCFO/HFOs and perchloroethylene (PCE).

Accurate and consistent Article 7 reporting of production of controlled substances, including for feedstock uses, contributes to the better understanding and assessment of atmospheric burdens of controlled substances. Reported production can be correlated with related emissions of controlled substances. There are some products that are not reported because they are intermediates not isolated in a chemical manufacturing process. These intermediates may also be emitted in low quantities and detected by atmospheric monitoring. In chemical production, a non-isolated intermediate in a chemical process is not considered as a finished product while it remains within the chemical process. As such, a non-isolated intermediate is not commonly reported. However, a substance that is isolated, most likely purified to a specification, and then used in a distinct, separate process, would be considered as a finished product and subject to reporting as production for feedstock use.

Destruction technologies

Decision XXX/6 on destruction technologies for controlled substances requests TEAP to assess destruction technologies listed (in annex II to the MOP-30 report) as not approved or not determined, as well as any other technologies, and to report to the Open-ended Working Group prior to MOP-33. In consultation with the Ozone Secretariat, TEAP and its MCTOC reported in 2021 that an assessment in response to decision XXX/6 will be included in MCTOC's 2022 Assessment Report based on available information.

MCTOC outlined preparations for its assessment of destruction technologies under this decision in the 2020 and 2021 TEAP Progress Reports, including suggested guidance on the type of relevant information needed for assessment, which is included again in this report. The 2020 and 2021 TEAP Progress Reports invited parties to submit this type of information in response to decision XXX/6 paragraph 3. Information from parties was requested to be submitted no later than January 2022 to allow time for assessment. No information has been submitted. The opportunity has now passed for MCTOC to assess new data in time for its 2022 Assessment Report. MCTOC is not currently aware of new information, such as test data, relating to already approved destruction technologies or new technologies that would allow an assessment. MCTOC is aware of some developments in existing approved destruction technologies and emerging trends that are noteworthy to report in the Assessment Report.

In future, parties may wish to consider providing any new information for TEAP assessment of destruction technologies in January of the same year in which its assessment would be reported either as part of annual TEAP Progress Reports or future quadrennial assessments.

Metered dose inhalers

MDIs, dry powder inhalers (DPIs), aqueous soft mist inhalers (SMIs), and other delivery systems all play an important role in the treatment of asthma and COPD. New alternative propellant technologies to high-GWP HFC MDIs are under development. DPIs, soft mist inhalers and nebulisers are already available for most molecules and combinations as alternatives to high-GWP MDIs, offering a lower carbon footprint.

Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC)

Since the publication of the RTOC 2018 Assessment Report, one new single component refrigerant and eighteen refrigerant blends have received a designation/classification from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 34 and/or from the International Standards Organisation (ISO) 817. These eighteen refrigerants are listed in tables 6.1, 6.2

and 6.3. Their GWP and ODP values are calculated in the same way as the ones given in the RTOC 2018 Assessment Report.

The importance of reducing direct and indirect CO_2 emissions from the RACHP sector is gaining increasing attention, especially the sustainable design and operation of equipment taking into account the strong growth of the equipment base. Improving the equipment energy efficiency during the HFC phase-down is one major opportunity to reduce energy demand, alongside the phasing down of equipment containing high GWP HFCs. Training in the servicing and maintenance of RACHP equipment to reduce leaks will also reduce emissions of high GWP HFCs.

There has been significant progress with the development of safety standards to support the transition towards lower GWP alternative refrigerants, that are mostly flammable. IEC 60335-2-89 (applicable to commercial refrigeration) was revised to include larger charges of flammable refrigerants (up to 500 g – 1200 g given certain boundary conditions) and is currently being transferred to national standards.

The new edition of the standard IEC 60335-2-4011 was approved in April 2022 by the International Electrotechnical Commission. The approved revised version will allow HC-290 (propane), and other flammable refrigerants, to be used in many air conditioning systems and heat pumps that were previously prohibited by the previous version of the standard from using these refrigerants.

The revised safety standard allows for the use of a larger charge of flammable refrigerants (up to 988g of HC-290 in a standard split air conditioning system). This will be possible on new equipment that must have additional safety requirements to ensure the same high level of safety as equipment that does not use flammable refrigerants.

The use of flammable refrigerants in air conditioning equipment will lead to a reduction in direct climate emissions compared to systems using R-410A.

[11] Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers

Annex II*

Members of the Technology and Economic Assessment Panel technical options committees[a] whose membership expires at the end of 2022 and whose reappointment does not require a decision by the Meeting of the Parties

Name	*Position*	*Country*
Members of technical options committees		
Jamal Alfuzaie	HTOC member	Kuwait
Michelle M. Collins	HTOC member	United States
Carlos Grandi	HTOC member	Brazil
Emma Palumbo	HTOC member	Italy
Donald Thomson	HTOC member	Canada
Jonathan Banks	MBTOC member	Australia
Aocheng Cao	MBTOC member	China
Ayze Ozdem	MBTOC member	Turkey
Ken Glassey	MBTOC member	New Zealand
Eduardo Gonzalez	MBTOC member	Philippines
Takashi Misumi	MBTOC member	Japan
Christoph Reichmuth	MBTOC member	Germany
Jordi Riudavets	MBTOC member	Spain
Akio Tateya	MBTOC member	Japan
Alejandro Valeiro	MBTOC member	Argentina
Nick Vink	MBTOC member	South Africa
Emmanuel Addo-Yobo	MCTOC member	Ghana
Fatima Al-Shatti	MCTOC member	Kuwait
Paul Atkins	MCTOC member	United States
Olga Blinova	MCTOC member	Russian Federation
Nick Campbell	MCTOC member	France
Nee Sun (Robert) Choong Kwet Yive	MCTOC member	Mauritius
Jianxin Hu	MCTOC member	China
Javaid Khan	MCTOC member	Pakistan
Gerald McDonnell	MCTOC member	Ireland
Robert Meyer	MCTOC member	United States
Timothy J. Noakes	MCTOC member	United Kingdom
John Pritchard	MCTOC member	United Kingdom
Rabbur Reza	MCTOC member	Bangladesh
Kristine Whorlow	MCTOC member	Australia
Lifei Zhang	MCTOC member	China
Maria C. Britto Bacellar	RTOC member	Brazil
Bhambure, Jitendra	RTOC member	India
Calm, James M.	RTOC member	United States
Cermák, Radim	RTOC member	Czech Republic

* The annex has not been formally edited.

Name	*Position*	*Country*
Chen, Guangming	RTOC member	China
Colbourne, Daniel	RTOC member	United Kingdom
De Vos, Richard	RTOC member	United States
Devotta, Sukumar	RTOC member	India
Dieryckx, Martin	RTOC member	Belgium
Dorman, Dennis	RTOC member	United States
Elassaad, Bassam	RTOC member	Lebanon
Gluckman Ray	RTOC member	United Kingdom
Godwin, Dave	RTOC member	United States
Grozdek, Marino	RTOC member	Croatia
Hamed, Samir	RTOC member	Jordan
Herlianika Herlin	RTOC member	Indonesia
Janssen, Martien	RTOC member	Netherlands
König, Holger	RTOC member	Germany
Kauffeld, Michael	RTOC member	Germany
Koban, Mary E.	RTOC member	United States
Köhler, Jürgen	RTOC member	Germany
Kuijpers, Lambert	RTOC member	Netherlands
Lawton, Richard	RTOC member	United Kingdom
Li, Tingxun	RTOC member	China
Malvicino, Carloandrea	RTOC member	Italy
Mohan Lal D.	RTOC member	India
Mousa, Maher	RTOC member	Saudi Arabia
Nekså, Petter	RTOC member	Norway
Nelson, Horace	RTOC member	Jamaica
Okada, Tetsuji	RTOC member	Japan
Olama, Alaa M.	RTOC member	Egypt
Pachai, Alexander C.	RTOC member	Denmark
Pedersen, Per Henrik	RTOC member	Denmark
Rajendran, Rajan	RTOC member	United States
Rochat, Helene	RTOC member	Switzerland
Rusignuolo, Giorgio	RTOC member	United States
Vonsild, Asbjørn	RTOC member	Denmark
Yana Motta, Samuel	RTOC member	Peru
Yamaguchi, Hiroichi	RTOC member	Japan

[a] The five technical options committees are: Flexible and Rigid Foams Technical Options Committee (FTOC), Halons Technical Options Committee (HTOC), Methyl Bromide Technical Options Committee (MBTOC), Medical and Chemicals Technical Options Committee (MCTOC), and Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee (RTOC).