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Thirty-Fourth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer
Montreal, Canada, 31 October–4 November 2022
Items 6, 10 (a), 12, 14 (a) and 15 of the provisional agenda*

Issues for discussion by and information for the attention of the Thirty-Fourth Meeting of the Parties to the Montreal Protocol

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 Thirty-Fourth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer contains new and updated information that has become available since the preparation of that note. Section II of the addendum sets out some updates to the interim progress report provided by the Ozone Secretariat at the forty-fourth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol on the identification of gaps in the global coverage of atmospheric monitoring of controlled substances and options for enhancing such monitoring in relation to item 6 of the provisional agenda for the Thirty-Fourth Meeting of the Parties; new information provided by the Technology and Economic Assessment Panel in its 2022 report in relation to items 10 (a), 12 and 14 (a) of the provisional agenda; and an update on the status of safety standards for flammable low-global-warming-potential refrigerants in relation to item 15.

2. The information provided by the Technology and Economic Assessment Panel pertaining to the above-mentioned agenda items is set out in the following two volumes of the Panel's 2022 report:[1]

(a) *Report of the Technology and Economic Assessment Panel, September 2022, Volume 4: Evaluation of 2022 Critical-Use Nominations for Methyl Bromide and Related Issues – Final report*;

(b) *Report of the Technology and Economic Assessment Panel, September 2022, Volume 5: Decision XXVIII/2 TEAP Working Group Report – Information on Alternatives to HFCs*.

* UNEP/OzL.Pro.34/1.

[1] Available on the portal for the meeting at https://ozone.unep.org/meetings/thirty-fourth-meeting-parties/pre-session-documents.

II. Overview of items on the provisional agenda for the preparatory segment (31 October–2 November 2022)

3. The issues covered in the present addendum are provided below in the order in which the respective items are listed on the provisional agenda for the meeting.

A. Identification of gaps in the global coverage of atmospheric monitoring of controlled substances and options for enhancing such monitoring (decision XXXIII/4) (item 6 of the provisional agenda for the preparatory segment)

4. As mentioned in the note by the Secretariat on issues for discussion by and information for the attention of the Thirty-Fourth Meeting of the Parties to the Montreal Protocol (UNEP/OzL.Pro.34/2, paras. 40–43), in response to the request by the parties in decision XXXIII/4, on enhancing the global and regional atmospheric monitoring of substances controlled by the Montreal Protocol, the Secretariat presented a progress report at the forty-fourth meeting of the Open-ended Working Group. That report included information on the implementation of a pilot project developed by the Secretariat in 2021 and funded by the European Union, entitled "Regional quantification of emissions of substances controlled under the Montreal Protocol". The project was based on a white paper[2] prepared by the Scientific Assessment Panel, in cooperation with experts in atmospheric monitoring, and considered by the Ozone Research Managers at their eleventh meeting.

5. The progress report highlighted the importance of addressing the gaps in global coverage of atmospheric monitoring of controlled substances in order to measure more accurately the regional concentrations and trends of the controlled substances around the globe and to identify, quantify and attribute any unexpected emissions. Recognizing that currently there is almost no observational coverage in many parts of the world (i.e., Eastern Europe, Western, Southern and Central Asia, South America, portions of North America, large parts of Southeast Asia, Australia and New Zealand, and most of Africa), the long-term aim is to establish flask sampling and high-frequency in-situ measurements in countries within regions where observational coverage is largely absent and emissions are expected to be significant, in order to strengthen the regional identification and quantification of emissions of controlled substances.

6. Since the time of the forty-fourth meeting of the Open-ended Working Group, the following progress has been made under the pilot project funded by the EU:

(a) The identification of suitable locations for flask sampling measurements and high-frequency in-situ measurements was completed. A number of suitable locations were identified through observing system simulation experiments analysis, taking into account, inter alia, population distribution, locations of potential emissive industries and activities, regions of high economic activity or growth, site location, evaluation of sampling locations in terms of existence of infrastructure and a long-term financial and work commitment or access to appropriate logistical support.

(b) An institution with long-standing expertise and records of high-quality data generation and curation has been identified to assist in the implementation of flask sampling and analysis of data. The site for the flask sampling is yet to be determined.

7. Updated information on the implementation of the project will be included in the report of the Secretariat to the parties at the forty-fifth meeting of the Open-ended Working Group in 2023, as requested in decision XXXIII/4.

8. The parties may wish to take this information into consideration in the discussions under this agenda item.

B. Nominations for critical-use exemptions for methyl bromide for 2023 and 2024 (item 10 (a) of the provisional agenda for the preparatory segment)

9. As mentioned in the note by the Secretariat (UNEP/OzL.Pro.34/2, paras. 57–59), the Methyl Bromide Technical Options Committee of the Technology and Economic Assessment Panel evaluated a total of three nominations for critical-use exemptions for methyl bromide submitted in 2022. One party operating under paragraph 1 of Article 5 (Article 5 party), South Africa, submitted

[2] UNEP/OzL/Conv.ResMgr/11/4/Rev.2.

one nomination for 2023, and two parties not so operating (non-Article 5 parties), Australia and Canada, submitted one nomination each, for 2024 and 2023 respectively.[3]

10. According to the Committee, the general reasons for seeking critical-use exemptions cited by nominating parties were related to environmental conditions and regulatory restrictions that did not allow for partial or full use of alternatives; difficulties in the scaling-up of alternatives; and the fact that potential alternatives were considered uneconomical, insufficiently effective and/or unavailable.

11. In accordance with customary practice, the Committee evaluated the nominations and made interim recommendations, as set out in volume 2 of the 2022 report of the Technology and Economic Assessment Panel,[4] which were considered by the Open-ended Working Group at its forty-fourth meeting in July 2022. At that meeting, South Africa accepted the interim recommendation of the Committee for 2023 and it was therefore put forward as a final recommendation without further review. For Australia and Canada, the Committee was unable to assess the respective nominations in its interim report, but based on information provided by those parties after the meeting it was able to do so. As a result, the Committee did not recommend the nomination by Australia for 2024 and recommended a reduced amount for the nomination by Canada for 2023.

12. The report of the Committee, containing detailed information on the final recommendations, is available on the meeting portal for the Thirty-Fourth Meeting of the Parties. The final recommendations are outlined in the table below. The reasons given by the Committee for its final recommendations are summarized in the footnotes to the table.

Summary of the nominations for 2023 and 2024 critical-use exemptions for methyl bromide submitted in 2022 and the final recommendations of the Methyl Bromide Technical Options Committee
(Metric tons)

Party	*Nomination for 2023*	*Final recommendation for 2023*	*Nomination for 2024*	*Final recommendation for 2024*
Non-Article 5 parties and sectors				
1. Australia				
Strawberry runners			14.49	[0][a]
2. Canada				
Strawberry runners	5.017	[3.857][b]		
Subtotal	**5.017**	**[3.857]**	**14.49**	**[0]**
Article 5 parties and sectors				
3. South Africa				
Structures	20.000	[19.000][c]		
Subtotal	**20.000**	**[19.000]**		
Total	**25.017**	**[22.857]**	**14.49**	**[0]**

[a] The nominated amount has not been recommended. According to the Methyl Bromide Technical Options Committee, the party has indicated that methyl iodide will be registered in 2022, and a mixture of this fumigant with chloropicrin – that will enhance control to meet required efficacy levels – is expected to be considered for registration in 2023. Based on these timelines, methyl iodide and/or methyl iodide/chloropicrin will be available for use in 2024. If these timelines cannot be met, there is time for a new nomination to be submitted in 2023 to cover use in 2024.

[b] The nominated amount has been reduced by 23.1 per cent, based on the availability of alternatives (e.g., soilless production) for production of tips, which are a significant part of the nomination submitted. The Methyl Bromide Technical Options Committee has considered a two-year timeline suitable for full adoption of this technology. According to the updated national management strategy submitted by the party, chloropicrin is again being considered for use for outdoor production and a permit was submitted to local authorities at Prince Edward Island, Canada, to test the alternative on a small area (2 ha). The Committee notes that no timeline has been provided associated with possible methyl bromide reduction for outdoor production.

[c] The nominated amount covers the fumigation of residential houses and industrial premises for the control of wood-destroying insect pests. The recommended amount, to be used for the fumigation of houses being sold, represents a 5 per cent reduction from the nominated amount for 2023, as the Methyl Bromide Technical Options Committee considers that alternatives are available for 1 metric ton of the nomination, that is therefore not recommended.

[3] Another Article 5 party that nominated critical-use exemptions in recent years, Argentina, indicated that it would not put forward nominations in 2022.

[4] *Report of the Technology and Economic Assessment Panel, May 2022, Volume 2: Evaluation of 2022 Critical-Use Nominations for Methyl Bromide and Related Issues – Interim Report*. Available at https://ozone.unep.org/system/files/documents/TEAP-CUN-interim-report-may-2022.pdf.

13. In addition to the final recommendations on critical-use nominations, the report of the Methyl Bromide Technical Options Committee recalls the reporting requirements under relevant decisions and provides information on trends in methyl bromide critical-use nominations and exemptions for all nominating parties to date; the reported accounting frameworks for critical uses and stocks of methyl bromide; and the submission of national management strategies for the phase-out of critical uses of methyl bromide.

14. Based on the accounting framework information received from the nominating parties in 2022, at the end of 2021 Australia and Canada reported no available stocks, while South Africa reported the availability of 6.1 metric tons.

15. The Committee reiterates that the accounting information does not show accurately the total stocks of methyl bromide held globally for controlled uses by Article 5 parties, as some parties have no formal mechanism to account accurately either for such stocks or for stocks used in quarantine and pre-shipment applications, and there is no requirement for parties under the Montreal Protocol to report pre-2015 stocks. According to the Committee, such stocks may be substantial (approximately 1,200 metric tons).

16. Recent decisions[5] have reiterated that Article 5 parties requesting critical-use exemptions are required to submit their national management strategies for the phase-out of critical uses of methyl bromide in accordance with paragraph 3 of decision Ex.I/4. The Committee reports that in this round of nominations no detailed management plan was received from South Africa, but notes the continued progress made by the party in reducing its nominated amounts and its intention to phase out methyl bromide use by 2024.

17. The final report of the Methyl Bromide Technical Options Committee is also available on the online forum, to enable parties to submit comments and questions about the report prior to the Thirty-Fourth Meeting of the Parties. The Committee will take into consideration the questions raised and comments made in the forum in its presentation at the meeting.[6]

18. The parties may wish to consider the final report and recommendations of the Methyl Bromide Technical Options Committee and adopt decisions on critical-use exemptions as appropriate.

C. Consideration of nominations by parties of experts to the Technology and Economic Assessment Panel (item 12 of the provisional agenda for the preparatory segment)

19. Information about the status of membership of the Technology and Economic Assessment Panel and its technical options committees, including an outline of the nomination process, is set out in the note by the Secretariat (UNEP/OzL.Pro.34/2, paras. 72–79 and annex IX). Pursuant to decision XXXI/8, parties wishing to nominate experts to the Panel are urged to follow the terms of reference of the Panel, consult the co-chairs of the Panel and refer to the matrix of needed expertise prior to making nominations.

20. The matrix of needed expertise is customarily included in the annual progress report of the Panel. However, owing to the proposed adjustments to the current structure of the Panel, the matrix for 2023 was not included in the 2022 progress report. It was instead submitted by the Panel to the Secretariat on 5 October 2022 and was posted immediately on the Secretariat website and on the meeting portal. The matrix of needed expertise, valid as at September 2022, is set out in annex I to the present addendum.

21. The Panel notes that the required expertise in the matrix is based on the existing structure of the Technology and Economic Assessment Panel and its technical options committees. Any structural changes to the committees that may be agreed by the Thirty-Fourth Meeting of the Parties will require reconsideration of the needed expertise within those committees, for appointments by the committee co-chairs, in consultation with the Panel.

22. The Panel also reiterates that in setting up the matrix, ensuring relevant and sufficient technical expertise is a priority consideration. The need to maintain a reasonable size and balance, to avoid the duplication of expertise and to ensure that specific gaps in expertise are filled, means that experts nominated by parties may sometimes be declined or that consideration of their nominations may be deferred by the committee co-chairs in consultation with the Panel co-chairs. Although the committee

[5] Decisions XXXI/4, XXXII/3 and XXXIII/6.

[6] Any draft decision submitted by parties on the matter will also be posted on the online forum for the parties to review and comment on, as appropriate.

co-chairs take into account the balance between members from Article 5 and non-Article 5 parties, as well as gender and geographical balance, relevant technical expertise can outweigh such considerations.

23. In submitting any nominations to the Secretariat, parties are reminded to use the nomination form[7] and associated guidelines of the Panel. The Secretariat will then make the submitted forms available on the meeting portal for the Thirty-Fourth Meeting of the Parties, to facilitate the review of and consultations on the proposed nominations by parties, as requested in paragraph 4 of decision XXXI/8.

D. Periodic review on alternatives to hydrofluorocarbons (decision XXVIII/2, para. 4) (item 14 (a) of the provisional agenda for the preparatory segment)

24. In response to paragraph 4 of decision XXVIII/2 and as outlined in the note by the Secretariat (UNEP/OzL.Pro.34/2, paras. 82–87), the Technology and Economic Assessment Panel established a working group to prepare a report containing information on alternatives to hydrofluorocarbons (HFCs), using the criteria set out in paragraph 1 (a) of decision XXVI/9.[8] The working group, composed of experts from all of the technical options committees of the Panel, prepared its report, drawing on information from the 2022 quadrennial assessment reports of the technical options committees that are currently under preparation.

25. The report of the working group is set out in volume 5 of the 2022 Panel report and is available on the portal for the meeting.[9] The executive summary of the report is set out in annex II to the present addendum, as received from the Panel, without formal editing by the Secretariat. The report is also available in the online forum to afford parties the opportunity to submit comments and questions relating to it prior to the meeting.

26. Information on alternatives to HFCs is developed by the relevant four technical options committees of the Panel, namely, the Flexible and Rigid Foams Technical Options Committee, the Halons Technical Options Committee, the Medical and Chemicals Technical Options Committee, and the Refrigeration, Air Conditioning, and Heat Pumps Technical Options Committee. Each technical options committee presents its interpretation of the set criteria outlined in decision XXVI/9 that are of relevance to the sector it considers and disaggregates the requested information into the different application sectors under its purview.

27. The Panel notes that this information may be further updated in the assessment reports of the technical options committees to be completed by the end of 2022. Furthermore, the Panel reiterates its suggestion to align the preparation schedule of reports on HFC alternatives, as set out in decision XXVIII/2 (requesting a review in 2022 and every five years thereafter) with the timeline for the quadrennial assessment reports of the Panel. Such an alignment would take into consideration the workload of the Panel and avoid duplicative work, allowing it to respond to other decisions of the parties during the same periods.

28. Parties may wish to consider the report of the Panel and make recommendations on the way forward, as appropriate.

E. Safety standards (decision XXIX/11) (item 15 of the provisional agenda for the preparatory segment)

29. As mentioned in the note by the Secretariat (UNEP/OzL.Pro.34/2, paras. 93–95), in response to decision XXIX/11, on safety standards, in 2018 the Secretariat produced a tabular overview on safety standards systems for flammable low-global-warming-potential refrigerants, which in 2019 was further developed to an interactive online tool, available on the Secretariat website at https://ozone.unep.org/system-safety-standards. As requested in paragraph 4 of the decision, the Secretariat, in consultation with experts on such safety standards, has been updating the online tool regularly, ensuring that updated information is provided to the parties until the Thirty-Fourth Meeting of the Parties, when parties are expected to consider whether to renew that request to the Secretariat.

[7] Available at: https://ozone.unep.org/science/assessment/teap.

[8] The criteria set are that the alternatives to HFCs be commercially available, technically proven, environmentally sound, economically viable and cost-effective, safe to use, and easy to service and maintain.

[9] https://ozone.unep.org/system/files/documents/TEAP-Decision-XXVIII-2-HFC-%20Alternatives-report-sept2022.pdf.

30. While the information included in the online tool was initially limited to international and regional safety standards relevant to the use of low-global-warming-potential flammable refrigerants, it was subsequently expanded to include domestic safety standards submitted voluntarily in 2017 by 21 parties[10] in response to decision XXVIII/4, on the establishment of regular consultations on safety standards.[11]

31. The structure of the tabular overview on safety standards, emulated in the online tool on safety standards systems, has been described in past documents.[12] It includes concise information on the scope and content of the standards, the responsible standards bodies dealing with them and the status of their review, as requested in decision XXIX/11. For ease of reference, a short description of the tool, the rationale for including selected standards and its current content are provided in annex III to the present addendum.

32. The parties may wish to consider this issue and make recommendations on the way forward, as appropriate.

[10] Andorra, Armenia, Barbados, Brazil, Burkina Faso, Cabo Verde, European Union, Iran (Islamic Republic of), Iraq, Italy, Jamaica, Japan, Malaysia, Maldives, Montenegro, Nigeria, Panama, Serbia, Singapore, the United States of America and Zimbabwe.

[11] Extracts of the responses by 20 parties containing the substantive part of their submissions were compiled as received by the Secretariat in document UNEP/OzL.Pro.WG.1/39/INF/4. The submission by Montenegro, received at a later stage, was not included in that compilation but was shared with the Technology and Economic Panel upon receipt for its consideration.

[12] See UNEP/OzL.Pro.WG.1/41/INF/3/Rev.1 and UNEP/OzL.Pro.30/INF/3.

Annex I*

Matrix of expertise needed for the Technology and Economic Assessment Panel as at September 2022

Body	Required Expertise	A5/ Non-A5
Foams TOC	• Extruded polystyrene production in India and China • Polyurethane system house technical experts o Especially in southern Africa, and o Especially from small- and medium-sized enterprises • Foam chemistry experts globally and expertise in building science related to energy efficiency	A5 or non-A5
Halons TOC	• Fire protection applications in civil aviation, especially maintenance, repair and overhaul activities	A5 / non-A5
	• General civil aviation fire protection applications in A5 parties in particular in South-East Asia	A5
	• Knowledge of halons, HCFCs and high-GWP HFC agent use, their alternatives, and their market penetration in A5 parties in Central and South America, South-East Asia (including China), and Africa (particularly central and south Africa).	A5
	• Banking and supplies of halons, HCFCs and alternatives in A5 parties, particularly in Africa and South America	A5
	• Recycling of halons, HCFCs, high-GWP HFC agents and their alternatives in A5 parties	A5
Methyl Bromide TOC	• Nursery industries, especially issues affecting the strawberry runner industries globally	A5 or non-A5
	• QPS uses of MB and their alternatives particularly SE Asia	A5
	• Alternatives to QPS uses of MB in Europe	Non-A5
Medical and Chemical TOC	• Aerosols, including development of new propellants and new aerosol products and components.	A5 and/or non-A5
	• Destruction technologies, including knowledge of available technologies and their application, and end-of-life management of controlled substances and their products.	A5 and/or non-A5
	• Semiconductor and electronics manufacturing.	A5 and/or non-A5
	• Metered Dose Inhalers	A5 and/or non-A5
Refrigeration TOC	• Expert on issues related to cold chain technology, supply management and logistics for food and other perishables including agriculture and fisheries, and medicines, such as vaccines, with a focus on sustainability	A5 or non-A5
	• Expert on transport refrigeration and related challenges due to weather, road conditions, servicing, leakage, nature of transported goods, etc.	A5 or non-A5
	• Expert on applied building cooling systems, i.e., air conditioning systems that require engineering services to apply them in commercial building systems	A5 (Asia)

* The annex has not been formally edited.

Body	Required Expertise	A5/ Non-A5
	• Expert on Mobile Air Conditioning (MAC) systems and heat pumps in light- and heavy-duty vehicles and in buses; future transition into electric vehicles	A5 (China) or non-A5 (Japan)
	• Expert on industrial refrigeration with systems level experience and good understanding of the technology challenges	A5 or non-A5
	• Expert on economy-wide modelling of the impact of different strategies related to refrigerant transition	A5 or non-A5
	• Expert on economic assessment of refrigeration, air conditioning, and heat pump (RACHP) sector and technology transitions	A5 or non-A5
	• Expert on relevant policies, regulations, tools related to energy efficiency and related environmental benefits through RACHP sector transitions	A5 or non-A5
	• Expert in building and other RACHP load energy analysis and systems integration issues	A5 or non-A5
	• Expert on RACHP industry statistics, global supply chain and market trends analysis	A5 or non-A5
Senior Experts	• Experts with extensive experience on TEAP replenishment task force and thorough knowledge of Multilateral Fund (MLF) operations, technical and economic assessment of sector transitions, and related financial needs of A5 parties under MLF	A5 or non-A5
	• Expert in the analysis and assessment (including modeling) of factors, including energy efficiency and regional economics, for forecasting the market penetration and potential future disposition of HCFCs, HFCs, and alternatives	A5 or non-A5

Annex II*

2022 Report by the Technology and Economic Assessment Panel, Volume 5

Decision XXVIII/2 TEAP Working Group report – Information on alternatives to HFCs

Executive Summary

Overview

Decision XXVIII/2, "Decision related to the amendment to phasedown hydrofluorocarbons", included a request to the Technology and Economic Assessment Panel (TEAP) under paragraph 4 "to conduct periodic reviews of alternatives, using the criteria set out in paragraph 1 (a) of decision XXVI/9, in 2022 and every five years thereafter, and to provide technological and economic assessments of the latest available and emerging alternatives to hydrofluorocarbons."

To respond to paragraph 4 of Decision XXVIII/2, TEAP considered that the first year of the requested review of alternatives to hydrofluorocarbons in 2022 coincided with the preparation of 2022 quadrennial assessment report of the TEAP, based on the assessment reports prepared by its Technical Options Committees (TOCs). Decision XXXI/2, "Potential areas of focus for the 2022 quadrennial reports of the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the Technology and Economic Assessment Panel", included a request for the TEAP "to assess and evaluate…technical advancements in developing alternatives to HFCs." Information on alternatives to HFCs for this report is based on the current understanding and information available to the relevant TOCs (the Flexible and Rigid Foams TOC (FTOC), the Halons TOC (HTOC), the Medical and Chemicals TOC (MCTOC), and the Refrigeration, Air Conditioning, and Heat Pumps TOC (RTOC)) at the time of preparation of this report. Information contained in this report, which was requested ahead of the 34th Meeting of the Parties (MOP-34), may be further updated in the TOCs 2022 assessments, to be completed by the end of 2022, as part of the TEAP quadrennial assessment report.

Foams

HFC alternatives are already in use today with most providing necessary technical benefits to the foams end-product. Some characteristics are specific to the foam blowing agent (FBA), including commercial availability; environmental soundness, or economical viability and cost effectiveness, and safe for use in areas with high urban densities (considering flammability and toxicity issues, including risk evaluation). However, the technical performance of FBAs is specific to the end-use. Some specific concerns are identified with safety of FBAs in certain situations with specific foam types.

In flexible and rigid foam applications, for an alternative to be available, it must have passed all six Decision XXVI/9 criteria, i.e., it is commercially available, technically proven, environmentally sound, economically viable and cost effective, safe to use, and easy to service, according to the FTOC's evaluation of the requirements. It should be noted that foams are not generally maintained, and the category "easy to service" was considered not generally relevant for foams.

Manufacturers of a number of foam types had transitioned away from ozone-depleting chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC). However, it is possible that some manufacturers may choose to incorporate fluorocarbon (FCs) into foams to meet performance requirements (e.g., energy efficiency or structural requirements). Most flexible foams manufacturers no longer use FCs and are unlikely to be impacted by the hydrofluorocarbon (HFC) transition.

Historically, the transition from CFCs led to a significant fragmentation of the FBA market because no substitutes have the same technical properties and low cost of CFCs. Each sub-segment required a different FBA for optimal performance, with regional and national variations.

The heterogeneous nature of the FBA market has increased with each transition. No single FBA will likely be optimal for all sub-segments in the future. The divisions are more plentiful now than ever. For example, an overwhelming majority of the foam in appliances utilises hydrocarbon (HC) FBAs, but some companies are using HFCs or hydrofluoroolefins (HFOs) or hydrochlorofluoroolefins

* The annex has not been formally edited.

(HCFOs)[1] to meet mandated energy efficiency levels. A few companies are also considering blends of HFOs/HCFOs with HCs or methyl formate (MF) to optimise performance characteristics with cost. Finally, water[2] content in FBA blends has increased in many circumstances to reduce costs and enhance performance and is being used with at least one HFO/HCFO.

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[3]. However, the price of HFC blowing agents has risen substantively during the pandemic and are now becoming comparable to HFO/HCFO blowing agent prices prior to the pandemic in some A5 parties. In locations where HFCs are used HFO/HCFO costs will be higher but more comparable than when replacing HCFCs.

Small- and Medium-Sized Enterprises

It should be noted that small- and medium-sized enterprises (SMEs) and spray foam manufacturers may still be facing challenges related to the adoption of HFOs/HCFOs, due to their operating cost, and hydrocarbons, due to potentially cost-prohibitive capital investment or impractical safety requirements for field application. This continues to be an unresolved challenge for smaller companies and field applications for all parties.

Information provided for this report is based on information currently being developed for the "FTOC 2022 Assessment Report" and may be further updated as part of that report to be completed by the end of 2022.

Fire protection

The fire protection industry has worked on developing alternatives to halons, HCFCs and now HFCs for over four decades as environmental concerns have evolved. Extensive research was conducted initially to identify alternatives to halons, while simultaneously implementing improvements to maintenance, servicing and storage of halons, user awareness and training, replacement of halon systems where practical, as well as highly improved risk management. The evolution of alternatives has proceeded along the path of selection of chemicals with the most similar characteristics followed by research and development including testing, certification, toxicity and safety analyses, standards development, and commercialization. In that process, several HFCs were developed through to commercialisation (note: both the agent and hardware must successfully pass all testing and certifications). Following the commercialisation of HFCs, development of further alternatives continue and other chemicals were developed including FK-5-1-12, 2-BTP, CF3I, and some combinations with inert gases, water mist, or solid particulates. This evolution has been fairly linear, as makes sense, in that the most likely candidates would be the most commercially viable due to the extensive cost of research and development.

For fire protection applications, information where alternatives to HFCs are available are provided for applications in the following sectors of use: civil aviation; military ground vehicles, naval, and aviation applications; oil and gas; general industrial fire protection, and merchant shipping. For an alternative to be available, it must have passed all six Decision XXVI/9 criteria, i.e., it is commercially available, technically proven, environmentally sound, economically viable and cost effective, safe to use, and easy to service, according to HTOC's interpretation of these criteria. HTOC notes that some alternatives are actually halon alternatives rather than HFC alternatives. Furthermore, in some sectors or applications, HFCs were not used and there are no alternatives to the halons available, e.g., in aircraft cargo compartments. In these cases, it seems appropriate to state that, currently, alternatives to HFCs are not applicable (N/A). Information provided for this report is based on information currently being developed for the "HTOC 2022 Assessment Report" and may be further updated as part of that report to be completed by the end of 2022.

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[1] HFCs or hydrofluoroolefins (HFOs) or hydrochlorofluoroolefins (HCFOs) are chemically unsaturated HFCs and HCFCs respectively

[2] Water reacts with other chemicals allowing carbon dioxide to be released as a foam blowing agent. When FTOC refers to water, it is referring to this reaction and the carbon dioxide released. This is done to differentiate from the use of transcritical carbon dioxide which is a very high-pressure physical foam blowing agents still heavily studied but rarely used commercially.

[3] 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.

Medical and chemical uses

For medical and chemical uses, information on alternatives for HFCs are provided for the following: aerosols (consumer, technical, and medical), metered dose inhalers, solvents, semiconductor and other electronics manufacturing, and magnesium production. Information on the status of alternatives for HFCs in these uses is summarised in tables that address the relevant Decision XXVI/9, paragraph 1(a) criteria. Information provided in this report is based on information currently being developed for the "MCTOC 2022 Assessment Report" and may be further updated as part of that report to be completed by the end of 2022.

Aerosols incorporate propellants and solvents with the appropriate technical properties and characteristics in formulations designed to deliver a product for its intended purpose. Propellants include compressed gases (nitrogen, nitrous oxide, carbon dioxide) or liquefied gases, which are liquid inside the pressurized container. Liquefied gas propellants include HCFCs (e.g., HCFC-22), HFCs (e.g., HFC-134a, HFC-152a), HFOs (e.g., HFO-1234ze(E)), HCs, and DME. Some aerosol products contain solvents, including HCFCs, HFCs, hydrofluoroethers (HFEs), aliphatic and aromatic solvents, chlorinated solvents, esters, ethers, alcohols, ketones, and HCFOs (e.g., HCFO-1233zd(E)). HCFCs, including HCFC-141b, are still currently used and are being replaced by HFCs, HFEs and HCFOs. Aerosol production has developed differently in each country due to regulations for flammability and occupational safety, VOC controls, and the availability from suppliers of HCFCs, HFCs, or their alternatives for aerosol production. The availability and number of different aerosol products varies within parties and regions and is closely related to the development of the local aerosol industries. Hence, alternatives are not necessarily interchangeable because of regional or local differences. The aerosol product type can also determine the propellant used, which could be related to performance requirements for the end use or the higher market value of the product, e.g., allowing a more expensive propellant.

The more common types of inhalers for the delivery of respiratory drugs are the pressurised metered dose inhaler (pMDI) and the dry powder inhaler (DPI). Other methods of delivering drugs to the airways include soft mist inhalers (SMIs) and nebulisers. DPIs and SMIs are propellant-free inhalers. The choice of the most suitable treatment method is a complex decision taken between the health care provider and the patient. It is not uncommon for patients to be prescribed a mix of medications in a range of devices. There are HFC pMDIs available to cover all key classes of drugs in the treatment of asthma and COPD. Emerging in-kind propellant alternatives are in earlier stages of development or commercialization in pMDIs, such as isobutane, HFC-152a, and HFO-1234ze(E) propellants.

For solvents, many alternative solvents and technologies developed as alternatives to ODS are also the candidates for alternatives to HFCs. These include not-in-kind technologies, such as aqueous cleaning, semi-aqueous cleaning, hydrocarbon and oxygenated solvents, and in-kind solvents, such as chlorinated solvents and fluorinated solvents, including high GWP HFCs not listed in Annex F and low GWP HFOs, HCFOs, and HFEs, with various levels of acceptance. Alternatives to Annex F HFCs are being used for electronics defluxing/cleaning and precision cleaning in several industries, including automotive, aerospace, medical device, and optical components where high levels of cleanliness are required.

Semiconductors are fabricated by forming circuit patterns on silicon-based wafers by using chemicals to form the circuit pattern. More recently dry etching processes using reactive ion etching (RIE) are used for this process. Chemical vapour deposition chamber walls are also cleaned using fluorinated chemicals to remove the build-up of silicon materials. RIE and chamber cleaning use fluorinated gaseous chemicals, including perfluorocarbons (PFCs), HFCs, sulfur hexafluoride (SF6) and nitrogen trifluoride (NF3). The most commonly used HFCs are HFC-23 (CHF3), HFC-41 (CH3F) and HFC-32 (CH2F2). The usage of cyclic C4F8, HFC-41, HFC-32 and perfluoro butadiene is expected to increase due to their use in high aspect hole etching. HFCs are only minimally used for chamber cleaning. Heat transfer fluids control the wafer temperature during etching, which is an important factor for high aspect ratio hole etching. The most commonly used fluorinated chemicals used as heat transfer fluids are a saturated PFC (PFC and perfluoroalkyl amine), hydrofluoroethers, and perfluoropolyethers. HFCs (HFC-134a and HFC-23) are not commonly used as heat transfer fluids. Like semiconductor manufacturing, other electronics manufacturing, including flat panel display (FPD), photovoltaics (PV) and microelectromechanical systems (MEMS), use fluorinated chemicals for etching and chamber cleaning. These manufacturing processes primarily use PFCs, HFC-23, SF6, and NF3. In photovoltaic manufacturing, HFCs are not commonly used. Alternatives to HFC use in semiconductor and other electronics manufacturing are other fluorinated gases, such as PFCs, SF6 and NF3, many of which have higher GWPs and lower utilization rates than HFCs, such as HFC-32 and HFC-41.

Cover gases are used in magnesium production, casting processes and recycling to prevent oxidation and combustion of molten magnesium. The majority (80-90%) of primary magnesium production occurs in China, followed by the US, Israel, and Brazil. Without protection, molten magnesium will oxidize and ignite in the presence of air and form magnesium oxide (MgO) deposits that greatly reduce the quality and strength of the final product. An effective cover gas will modify and stabilise the MgO surface film to form a protective layer that prevents further oxidation. Sulfur hexafluoride (SF6) is the most widely used cover gas. However, SF6 has a GWP of 22,800. Several gases with lower GWPs have been identified as alternatives to SF6, including HFC-134a (GWP of 1,430) and a fluoroketone (GWP of 0.1), both of which are being used by the industry as a cover gas. HFC-134a has been shown to have adequate melt protection but careful selection of the diluent gas and concentration is required to prevent damaging corrosion. More recently, researchers have begun exploring the addition of small amounts of unique alloying elements (e.g., Be, Al, Ca) to enhance the oxidation resistance of the alloy and possible reduce the need for a cover gas.

Refrigeration and air conditioning

For the Refrigeration and Air Conditioning sectors, information on alternatives for HFCs are disaggregated into the different application sectors as per the RTOC 2022 Assessment Report, currently under development. Applications include: factory-sealed domestic and commercial appliances, food retail and service refrigeration, transport refrigeration, air-to-air conditioners and heat pumps, applied building cooling systems, mobile air conditioning/heat pumps, industrial refrigeration, and heating only heat pumps. Information on the status of alternatives to HFCs for these applications has been extracted from the forthcoming “RTOC 2022 Assessment Report” and is summarised in tables that address the relevant Decision XXVI/9, paragraph 1(a) criteria. Information may be further updated as part of the “RTOC 2022 Assessment Report” to be completed by the end of 2022.

Currently, the entire global production of domestic refrigeration appliances is based on non-ODS refrigerants, predominantly HC-600a (isobutane) and to some extent HFC-134a. Migration from HFC-134a to HC-600a is expected to continue, driven by the Kigali Amendment schedule or local regulations on HFCs. In the EU the transition to R-600a in new domestic refrigeration appliances was completed by 2015. In the USA, substantial progress has been made to convert from HFC-134a to HC-600a and is expected to be complete by 2023. Many A5 parties, including China, India and others are rapidly phasing out HFC-134a in domestic refrigerators using HC-600a. Energy efficiencies of refrigerators are constantly increasing, including in many A5 parties, mainly due to Minimum Energy Performance Standards (MEPS) and increasing awareness of consumers.

Stand-alone commercial refrigeration appliances, which are globally used, include a wide variety of appliances, including ice-cream freezers, ice machines, beverage vending machines, and display cases. Typical refrigerants used include HFC-134a, R-404A, and HCs. With the revision of safety standards, in low charge systems, migration is taking place to HC-290 with better energy efficiencies. This trend is spreading to some of the A5 parties. Multinational companies that supply food and drink retailers with refrigeration appliances usually have their own environmental policies that favour lower-GWP refrigerants and improved energy efficiency.

Domestic heat pump tumble dryers (HPTD) are significantly more efficient than conventional electrically heated dryers, using only about 40–50% of the electricity of conventional dryers. HPTDs continue to gain market share and concurrently costs have also reduced substantially. The most commonly used refrigerants in HPTDs are HFC-134a, R-407C, and R-410A. Some transition to HC-290 (propane) has happened, e.g., in EU parties.

For transport refrigeration, the majority of trucks and trailers today use R-404A. New equipment in Europe typically uses lower GWP A1 alternative, R-452A. Light commercial vehicles use mainly HFC-134a, while some new platforms will use HFO-1234yf. The majority of marine ISO-container refrigeration units operate on HFC-134a. The latest of these units are being offered as being retrofittable to R-513A. A marine container operating on R-744 is available with limited market penetration. The GWP of the refrigerants used is expected to come down consistently with present and future regulations; the pace at which the transition will occur is unclear as transport regulations make it hard to introduce flammable refrigerants (e.g., Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage (ATP) Regulation). Some experts predict that the long-term solution will be based on R-290 or R-744. However, challenges need to be overcome. The trend towards higher efficiency (lower fuel consumption) continues in all industry segments in parallel. Various refrigerants are used on board different types of ships; HFCs are today being replaced by alternative system which are finding their way from other market segments, such as R-744 for chilling water and for food storage systems, or HFO-1234ze(E) for chillers in cruise lines. R-717 today is experiencing revival in many ships and in particular fishing vessels.

Air-to-air conditioners, including reversible air heating heat pumps (generally defined as reversible air conditioners), sold within non-A5 parties use non-ODS refrigerants and around 90% of new systems in A5 parties do not use HCFCs, although a significant proportion of the installed population still use HCFC-22. In addition to the widespread use of R-410A, the extensive introduction of lower GWP HFC-32 in small split air conditioners continues in many parties around the world, accounting for nearly half of the total production of split room air conditioners in 2021. Enterprises within all regions continue to evaluate and develop products with various HFC/HFO blends, such as those comprising HFC-32, HFC-125, HFC-134a, HFC-1234yf and HFC-1234ze. Products are being introduced with lower GWP alternatives, R-454A, R- 454B, R-452B and R-463A. Further conversion of production lines to HC-290 in China, Southeast Asia and South America is underway but there is limited market introduction (except for small and portable units). Some enterprises within the Middle East still see R-407C and HFC-134a and in some applications R410A as favourable alternatives to HCFC-22.

Applied Building Cooling systems are used in medium and large sized buildings. They require engineering services to design and install air conditioning in larger buildings of all types. The dominant products used in these systems are water chillers although packaged commercial unitary product can also be used. There are now complete lines of all chiller types in all major markets that use refrigerants having lower GWP than their predecessors. Additionally non-fluorinated refrigerants, e.g., ammonia and HCs, are available in some chiller types, albeit in select sizes not complete product lines. Products using the existing refrigerants will continue to be sold and the installed base of these products will remain in service for years to come. Despite the new refrigerant choices that are now available for new and existing equipment, they may not be the final choices. There is continued pressure from regulators to move to yet another generation of zero ODP and near zero GWP, if technically possible and economically reasonable. New refrigerant choices, notably replacements for R-134a (medium pressure) and R-410A (high pressure), include flammable refrigerants, safety class A2L. Safety regulations that allow use of A2L refrigerants, supported by recent research, are being written, but are not uniform nor adopted in all regions. This is not a trivial matter, since health, safety and property issues are involved. Adoption and enforcement of revised codes and standards may slow the adoption new flammable refrigerants.

Currently, more than one refrigerant is used for car and light truck air conditioning: HFC-134a will remain largely adopted worldwide, while HFO-1234yf is currently the main option in Europe and North America. The deployment of highly electrified vehicles (plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV)) in Europe, China and North America will lead to the implementation of heat pump function and of a new generation of thermal systems. Manufacturers are working on the improvement of this feature by using cycle variations such as economiser coupled with vapor injected compressors. R-744 is increasingly applied in fully electrified vehicles due to its good performance when operating as a reversible heat pump. However, R-744 is less suitable in hot and humid climates where energy efficiency is somewhat lower than that of HFC-134a and HFO-1234yf systems. So, some European OEMs introduced reversible R-744 heat pumps for their high-volume BEV models, which they currently sell in the EU, North America (Canada), and China. It cannot be foreseen whether all these refrigerants will all remain in the market for a longer period of time (in parallel). It is also unclear whether the bus sector (where currently HCFC-22, HFC-134a, R407C, R-744, and R-449A are used and HFO-1234yf has been introduced) and the heavy-duty truck sector will follow these trends.

In industrial refrigeration applications, R-717 (ammonia) has been widely used for many years in large industrial systems. In small industrial systems there has historically been significant use of HCFC-22 and, more recently, HFCs such as R404A and HFC-134a. Looking forward, R-717 and R-744 are the dominant options for large industrial systems (e.g., in food and drink manufacturing and bulk cold storage), with HCs used in some large specialised applications (e.g., in the petrochemical industry). In smaller systems A2L blends such as R-454C and R-455A are starting to be used. In heat pumps above 100°C HCs will be dominating, partly because of their stability at high temperatures, partly due to the price of the fluids and finally due to their higher efficiency.

Heat pumps commercialised today make use of non-ODS refrigerants, including R-410A, HFC-32, HFC-134a, R-407C, HC-290, HC-600a, R-717 and R-744. The majority of new equipment currently uses R-410A. Safety constraints restrict the use of R-290 to monobloc units located outdoors. Recently HFC-32 and R-454B introduced as lower GWP alternatives for R-410A. The issue of high ambient temperature conditions is of importance for heating-only heat pumps. The main parameters to select the refrigerant are efficiency, cost effectiveness, economic impact, safe use and easiness of use. Replacements using lower GWP HFC blends have been developed and are under way to become commercially available. The temperature ranges in which HC-290 and HFC-32 can be operated are better than those for R-410A, moreover, their efficiencies are generally better. The application of R-410A, HFC-32 or HC-290 is most cost effective when used in small- to medium-sized systems.

Annex III

Information on the online safety standards system tool

A. Brief description of the tool

1. The interactive online safety standards system tool presents a non-exhaustive list of national, regional and international safety standards relevant to refrigeration, air-conditioning and heat pump equipment developed by relevant standards organizations.

2. The standards are broadly classified into two categories: main system safety standards, subdivided into vertical system safety standards and horizontal system safety standards; and supplementary safety standards.

3. The main system safety standards cover a complete system:

(a) The vertical system standards cover a narrow range of applications, for instance a household refrigerator or a domestic heat-pump tumble dryer;

(b) The horizontal system standards cover a broad range of applications, for instance all refrigerating, air-conditioning, heat-pump, and dehumidifier systems which are not covered by a vertical system standard.

4. The supplementary safety standards are relevant to the safety of refrigerating, air-conditioning, heat-pump and dehumidifier systems. The majority are related to a single aspect, such as a specific method for avoiding ignition sources in systems with flammable refrigerants.

B. Rationale for selecting standards for inclusion in the tool

5. The main reasons for the list being non-exhaustive are:

(a) International and regional safety standards are often published in national versions, with only editorial differences. For instance, EN 378 is not published as EN 378, but as DS EN 378 (Denmark), DIN EN 378 (Germany), NS EN 378 (Netherlands), GOST EN 378 (Russian Federation), BS EN 378 (United Kingdom of Great Britain and Northern Ireland). Officially these are all different standards, but referred to as EN 378 for brevity. Consequently, in cases where parties submitted national standards of this kind, these do not appear in the tool as they are already covered under regional or international standards;

(b) National standards are often only available in the national language of the country in question, and this makes it difficult for non-speakers of that language to access the information. Such standards have not been included in the tool;

(c) There is a very large number of supplementary safety standards. To maintain an overview, it is necessary to prioritize the most relevant. Specifically, component standards and standards for energy efficiency are not barriers for low-global-warming-potential refrigerants and are therefore not included in the list.

6. In creating the tool, priority was given to the inclusion of international and regional main system safety standards.[1] National safety standards, singled out by the parties in their submissions to the Secretariat,[2] have been included when sufficient information was available. In most cases, additional information was sought from publicly available websites.

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[1] See also the *Report of the Technology and Economic Assessment Panel, May 2017, Volume 3: Decision XXVIII/4 – Safety Standards for Flammable Low Global-Warming-Potential Refrigerants*.

[2] See the note by the Secretariat on submissions by parties on their domestic safety standards relevant to the safe use of low-global-warming-potential flammable refrigerants (UNEP/OzL.Pro.WG.1/39/INF/4).

C. Information included in the tool

7. For each standard that is currently included in the online tool, the information provided is outlined in the following table.

Data entry	*Comment*	*Rationale for including*
Standard code	The unique identifier of the standard, e.g., "EN 60335-2-40" or "ANSI/ASHRAE 15". Where available there is a web link to more information.	This is basic data identifying the standard and its scope.
Scope of the standard/title	The title of the standard, or if the title is very long, the first part of the standard.	
Technical aspects	Very brief description of what the standard covers. For standards with very long titles, this is often the second part of the title.	
Type	Standards are categorized into three types: vertical system safety standards, horizontal system safety standards and supplementary standards.	The type of the standard is provided to allow the reader to maintain an overview of the standards.
Specific committee	The standardization committee responsible for updating the standard. Where available this includes a web link to the committee homepage.	This identifies the organization to contact if more information is requested.
Status	The year that the standard was published, and if available the planned year of the publication of the next revision.	The timing of the updating of standards is important for the transition to low-global-warming-potential alternatives.
Further information	A more detailed description of the standard, including recent and coming developments, and charge limits where relevant.	This is information relevant to the safe use of low-global-warming-potential alternatives.
Market sectors	The type of systems for which the standard is relevant.	The relevant market sectors and life cycle stages are provided to allow the reader to maintain an overview of the standards.
Life cycle stages	The stages in the life cycle for which the standard is relevant.	