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Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer
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Bangkok, 1–5 July 2019
Items 3, 5, 6, 7 and 13 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-first 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-first meeting (UNEP/OzL.Pro.WG.1/41/2) contains information that has become available since the preparation of that note. Section II sets out new information provided by the Technology and Economic Assessment Panel in its 2018 quadrennial assessment report and its May 2019 report[1] in relation to agenda items 3, 5, 6 and 7. It also presents the issue of the risk of non-compliance by the Democratic People's Republic of Korea with its hydrochlorofluorocarbon (HCFC) production and consumption reduction targets, to be addressed under agenda item 13 at the party's request.

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

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

* UNEP/OzL.Pro.WG.1/41/1/Rev.1.

[1] Available at http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/SitePages/Home.aspx. The May 2019 report of the Technology and Economic Assessment Panel consists of four volumes: Volume 1: Progress report; Volume 2: Evaluation of critical-use nominations for methyl bromide – Interim report; Volume 3: Decision XXX/3 TEAP task force report on unexpected emissions of trichlorofluoromethane (CFC-11); and Volume 4: Decision XXX/5 task force report on cost and availability of low-GWP technologies/equipment that maintain/enhance energy efficiency.

Agenda item 3

Unexpected emissions of trichlorofluoromethane (CFC-11) (decision XXX/3)

3. The note by the Secretariat presents an overview of the issue of unexpected emissions of CFC-11 (UNEP/OzL.Pro.WG.1/41/2, paras. 5–11), including the provisions of decision XXX/3 on the matter, adopted by the Thirtieth Meeting of the Parties in November 2018.

4. In response to that decision, the Scientific Assessment Panel submitted a brief preliminary report that included information on the International Symposium on the Unexpected Increase in Emissions of Ozone-Depleting CFC-11, held in Vienna from 25 to 27 March 2019, and on current action being undertaken by the Panel in that regard.

5. In its report, the Scientific Assessment Panel noted that the symposium had been attended by more than 70 experts from the scientific and technical community from 22 different countries, including representatives of all assessment panels. Participants made over 35 presentations,[2] a number of which focused on preliminary studies of the increase in CFC-11 emissions. Among the presentations, one summarized the findings of the report *Scientific Assessment of Ozone Depletion: 2018*;[3] another provided an update on the findings in the 2018 paper by Montzka and others;[4] a third outlined the findings of a 2019 paper by Rigby and others regarding recent emissions from eastern China;[5] and a fourth dealt with updated observations and model simulations of the impact of CFC-11 emissions on the ozone layer.

6. The Scientific Assessment Panel is currently forming a small working group of research scientists from around the world to develop a 10 to 20-page report, which will cover the following three areas:

(a) Current CFC-11 observations, along with updated estimates of global emissions;

(b) CFC-11 regional emissions, including information on techniques used to derive those emissions;

(c) Current ozone and radiative impacts of the increase in CFC-11 emissions and projections of future impacts.

7. According to the Scientific Assessment Panel, the material for the report will be derived from the peer-reviewed scientific literature, along with updated information on the findings set out in those publications. The Vienna symposium on CFC-11 emissions has stimulated new results that should begin to appear in the literature over the next two years. The report will be compiled under the auspices of the United Nations Environment Programme and the World Meteorological Organization. The formation of the author team will be completed in July 2019, and updates in that regard will be provided at the forty-first meeting of the Open-ended Working Group and the Thirty-First Meeting of the Parties. A final report will be delivered to the Thirty-Second Meeting of the Parties, in November 2020.

8. As also requested in decision XXX/3, the Technology and Economic Assessment Panel provided its preliminary report on the unexpected emissions of CFC-11, prepared by the task force established for that purpose. The full preliminary report is set out in volume 3 of the May 2019 report of the Technology and Economic Assessment Panel,[6] with the executive summary reproduced in annex I to the present addendum, as received by the Secretariat, without formal editing. A summary of the information provided in the preliminary report is provided in the following paragraphs.

9. In response to the request of the parties in decision XXX/3, the task force analysed the likelihood of potential sources of CFC-11 emissions and identified additional areas for consideration, as well as additional information needed to further determine the likelihood of potential sources. The task force also considered and incorporated into its assessment relevant information submitted by one

[2] Available at: https://www.sparc-climate.org/meetings/meetingscfc-11-workshop-march-2019-in-vienna/#Schedule.

[3] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Background-Documents/SAP-2018-Assessment-report.pdf.

[4] https://www.nature.com/articles/s41586-018-0106-2.pdf.

[5] https://www.nature.com/articles/s41586-019-1193-4.pdf.

[6] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Background-Documents/TEAP_Task_Force_Dec_XXX-3_on_Unexpected_CFC-11_Emissions_May_2019.pdf.

party, China, in response to decision XXX/3. The submission by China is reproduced in annex 1 to the task force report.

10. The report noted that CFC-11 was used primarily as a foam-blowing agent for flexible and polyurethane (closed cell) insulating foams, as an aerosol propellant, as a refrigerant for centrifugal chillers in large commercial buildings and in a range of other, smaller uses, including asthma inhalers and tobacco expansion. There are alternative chemicals or products available as replacements for CFC-11. A bank of CFC-11 remains in closed-cell foams and centrifugal chillers, from which CFC-11 is released slowly into the atmosphere over time.

11. The task force considered several production plant options involving primarily the use of carbon tetrachloride (CTC) and the co-production of CFC-11 and CFC-12. Given the relevance of CTC and CFC-12, their production and availability were also examined. Furthermore, potential sources of CFC-11 from its use in the foam, refrigeration and air-conditioning sectors, as well as in aerosols, solvents and other applications, were explored.

12. Based on updated modelling and analysis of CFC-11 emissions and banks, the task force found it unlikely that past production, historical usage and the resulting banks could account for the unexpected increase in CFC-11 emissions observed in the atmosphere, unless there had been a significant change in the treatment of large quantities of banked CFC-11 that was unknown of at the time of completion of the preliminary report.

13. The task force also noted that none of the analyses of the available data eliminated the possibility that newly produced CFC-11 might be involved in resumed use of CFC-11 in closed-cell foams. Scenarios modelling the potential use of CFC-11 in closed-cell foams align with the derived emissions of CFC-11. Based on the overall evaluation, the task force recommended that the potential use of CFC-11 in closed-cell foams as an explanation for the unexpected increased emissions of CFC-11 continue to be explored.

14. The task force identified areas for further work, with a view to determining the likelihood of potential sources of CFC-11 emissions and associated controlled substances. Those areas are: the use of CFC-11 for polyurethane foams and polyol systems for polyurethane rigid foams; the use of CFC-11 in flexible foams to reduce volatile organic compound emissions and toxicity concerns related to dichloromethane; the further validation of CFC-11 emission rates from installed foams and landfills; the further analysis of CFC-11 banks by geographic location and market sector; and compiling information on recent enforcement action and/or prosecutions undertaken relating to CFC-11 production and/or associated usage to further determine the scope of the issue and the extent of the banks resulting from such production. The task force is therefore interested in receiving further information about:

(a) CTC production quantities and the uses to which CTC was put, by quantity, including export amounts and locations;

(b) CTC and HCFC-22 plant capacities;

(c) Validation of ozone-depleting substance plant shutdowns and dismantling;

(d) Quantities of CFC-11 inventory in stockpiles at the cessation of production and the fate of inventory thereafter;

(e) Any evidence of illegal CFC-11 or CTC shipments;

(f) The capacities and production quantities for CFC-11/12 and CTC plants in parties where less is known about historic production of ozone-depleting substances;

(g) CFC-11 emission sources related to equipment and foams recycling and destruction;

(h) Rates of foam-blowing-agent emissions from foams that may be used for any purpose (i.e., to determine insulating capability or exposure from a public health perspective);

(i) Specific end-of-life practices, especially for foams;

(j) Regulations impacting the use of dichloromethane.

15. The Open-ended Working Group may wish to consider the task force report and discuss a way forward.

Agenda item 5

Quadrennial assessment of the Montreal Protocol for 2018 and potential areas of focus for the 2022 assessment

16. The full reports of the 2018 quadrennial assessments prepared by the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the Technology and Economic Assessment Panel and its technical options committees are available on the Ozone Secretariat website under the corresponding panel tabs[7] and as background documents for the forty-first meeting of the Open-ended Working Group.[8]

17. The highlights of the Scientific Assessment Panel report and a summary of the key findings and highlights in the executive summary of the Environmental Effects Assessment Panel report are set out in annexes II and III, respectively, to the note by the Secretariat (UNEP/OzL.Pro.WG.1/41/2). The overall key findings of the assessment of the Technology and Economic Assessment Panel, along with the progress and challenges by sector, are reproduced in annex II to the present addendum, as received by the Secretariat, without formal editing, and are summarized below.

2018 quadrennial assessment of the Technology and Economic Assessment Panel

18. The Panel's 2018 assessment essentially highlights the following:

(a) The Montreal Protocol continues to be effective because: control measures have created incentives for new technology; enterprises and organizations have worked diligently to implement new technology; and the Multilateral Fund for the Implementation of the Montreal Protocol has financed the agreed incremental costs of the transition for parties operating under paragraph 1 of Article 5 (Article 5 parties).

(b) Since the Panel's 2014 assessment, significant technical progress has been achieved in phasing out ozone-depleting substances from many applications. In particular, metered-dose inhalers containing chlorofluorocarbons (CFCs) have been successfully phased out worldwide and replaced by a range of CFC-free inhalers; the phase-out of ozone-depleting refrigerants in new chillers is nearly complete, with only limited production continuing in Article 5 parties; the phase-out of HCFC-22 is essentially complete in parties not operating under paragraph 1 of Article 5 (non-Article 5 parties) and is progressing in Article 5 parties; and global production and consumption of methyl bromide for controlled uses was phased out in 2015, since which time a decreasing number of critical uses have been sought by a few parties.

(c) The planned phase-down of hydrofluorocarbons (HFCs) under the Kigali Amendment, as well as national and regional regulations, are driving industry towards lower-global-warming-potential (GWP) HFC alternatives or not-in-kind solutions, in particular in refrigeration, air-conditioning and foam applications. Around 90 per cent of the potential improvement in energy efficiency of refrigeration and air-conditioning equipment comes from technological innovation of equipment, rather than the refrigerant itself. At the same time, the overall drive to reduce energy demand will also lead to increasing energy efficiency of such equipment.

(d) Challenges relate to: the phasing out of remaining uses of controlled ozone-depleting substances in specific sectors; specific uncontrolled and growing uses of such substances; and emerging options for the use of more climate-friendly alternatives (see sub-paragraphs (e) to (i) below). In terms of new options, given the range of new, lower-GWP products, it is challenging to identify the best solution for each application, considering factors such as flammability, toxicity, availability and operating conditions (e.g., high ambient temperatures).

(e) Issues related to halon uses have not all been resolved. Increasing demand for ongoing, enduring fire-fighting uses, such as in civil aviation, oil and gas facilities, nuclear facilities and military-installed base/reserves, will soon exceed supply from stockpiles. Atmospheric abundances suggest higher emissions than previously predicted, meaning that the stockpile of halon-1301 may be less than previously estimated. This will be exacerbated by regional imbalances in stocks. For users without access to significant stockpiles, halon-1301 supplies may run out well before the previously estimated 2032–2054 time frame. The growing civil aviation demand for halon-1301 will require action under the Montreal Protocol, with likely submission of essential-use nominations for the production of new halon-1301 in the foreseeable future.

[7] https://ozone.unep.org/science/assessment/sap; https://ozone.unep.org/science/assessment/eeap; https://ozone.unep.org/science/assessment/teap.

[8] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/SitePages/Home.aspx.

(f) Atmospheric concentrations of methyl bromide have stopped declining, which may indicate that methyl bromide continues to be used for quarantine and pre-shipment uses (QPS) in quantities that are greater than are being reported. Alternatives to methyl bromide are available for about 40 per cent of QPS uses, in particular for pre-shipment. Furthermore, around 70 per cent of current methyl bromide emissions from reported QPS uses could be avoided through the use of barrier films for any remaining pre-plant soil fumigation or recapture and destruction technologies. The resulting reductions in atmospheric concentrations of methyl bromide would provide near-term benefits for the ozone layer.

(g) Continued vigilance through atmospheric monitoring and regular assessments of ozone depletion, including ozone-depleting substance banks, is needed to monitor progress and achievements under the Montreal Protocol. This has been reinforced by the recent scientific findings on the unexpected emissions of phased-out CFC-11.

(h) Not-in-kind technologies are expected to provide savings in operating costs in the refrigeration and air-conditioning sector. The unique ability of such technologies to use waste and renewable energy sources makes their application potentially highly energy efficient;

(i) Research conducted in high-ambient-temperature conditions has identified viable low-GWP refrigerant alternatives. There is more awareness of the challenges such conditions present for the design, implementation and servicing of equipment using low-GWP refrigerants that are capable of delivering a high level of energy efficiency.

19. In accordance with its mandate, set out in decision XXVII/6, the Panel also addressed the impact of the phase-out of ozone-depleting substances on sustainable development in its assessment. To do this, the Panel considered how sector transitions relate to the relevant Sustainable Development Goals.[9] The Panel has concluded that the near elimination of ozone-depleting substances under the Montreal Protocol has made a major and effective contribution to sustainable development, and that vigilance should be maintained to ensure full compliance with the phase-out of ozone-depleting substances. When ozone-depleting-substance replacements such as HFCs have been phased down and replaced by environmentally neutral, safe and sustainable alternatives, the Montreal Protocol will have made its full contribution to sustainable development.

Agenda item 6

Technology and Economic Assessment Panel 2019 report

20. The Technology and Economic Assessment Panel will present its findings and recommendations as contained in volumes 1 and 2 of its May 2019 report under item 6 of the provisional agenda. Volume 1 contains the Panel's annual progress report, comprising the progress reports of the Panel's five technical options committees as at December 2018 and focusing on progress and developments identified after the submission of their respective assessment reports, and other Panel matters, including organizational matters, mainly membership-related, and continued challenges.[10] Volume 2 contains the interim report of the Methyl Bromide Technical Options Committee on the evaluation of 2019 critical-use nominations for methyl bromide and matters related to stocks.[11]

[9] Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture; Goal 3: Ensure healthy lives and promote well-being for all at all ages; Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all; Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation; Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable; Goal 12: Ensure sustainable consumption and production patterns; Goal 13: Take urgent action to combat climate change and its impacts; Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development; and Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

[10] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Background-Documents/TEAP_Progress_Report_May-2019.pdf.

[11] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Background-Documents/MBTOC-CUN-interim-report-may2019.pdf.

(a) Nominations for critical-use exemptions for methyl bromide for 2020 and 2021

21. As indicated in the note by the Secretariat (UNEP/OzL.Pro.WG.1/41/2, paras. 32 and 33), the Methyl Bromide Technical Options Committee evaluated a total of six nominations for critical-use exemptions that were submitted in 2019. Two Article 5 parties (Argentina and South Africa) submitted two nominations each for 2020, and two non-Article 5 parties (Australia and Canada) submitted one nomination each, for 2021 and 2020, respectively. Table 1 summarizes the nominations of the parties and the interim recommendations of the Committee, with brief comments in the footnotes to the table when the recommendations differ from the amounts nominated.

22. The Methyl Bromide Technical Options Committee noted in its report that it had not taken stocks held by nominating parties into consideration in its recommendations for critical-use exemptions; it has instead relied on parties to take this into consideration when approving the amounts recommended by the Technology and Economic Assessment Panel for each nomination.

Table 1

Summary of the nominations for 2020 and 2021 critical-use exemptions for methyl bromide submitted in 2019 and the interim recommendations of the Methyl Bromide Technical Options Committee

(Metric tons)

Party	*Nomination for 2020*	*Interim recommendation for 2020*	*Nomination for 2021*	*Interim recommendation for 2021*
Non-Article 5 parties and sectors				
1. Australia				[14.49][a]
Strawberry runners			28.98	
2. Canada	5.261	[5.017][b]		
Strawberry runners				
Subtotal	**5.261**	**[5.017]**	**28.98**	**[14.49]**
Article 5 parties and sectors				
3. Argentina				
Tomato	22.20	[12.79][c]		
Strawberry fruit	13.50	[7.83][d]		
4. South Africa				
Mills	1.5	[0.30][e]		
Structures	40.0	[34.0][f]		
Subtotal	**77.2**	**[54.92]**		
Total	**82.461**	**[59.937]**	**28.98**	**[14.49]**

[a] The nominated amount has been reduced by 50 per cent in accordance with the transition plan for phasing out methyl bromide proposed by Australia and the party's statement that the licensed amount would be reduced to 14.49 metric tons in 2021 if methyl iodide were registered and accessible for the treatments that year. Should circumstances prevent the envisioned partial adoption of methyl iodide in the 2021 season, the party would have the opportunity to re-apply for the balance of the nomination (the additional 14.49 metric tons) prior to the Thirty-First Meeting of the Parties (when the Methyl Bromide Technical Options Committee's recommendation becomes final) or during the next round of critical-use nominations, in early 2020.

[b] The nominated amount has been reduced by 4.6 per cent overall to account for a 10 per cent reduction for generation 2A production of runner tips (a step-wise system producing propagation material that increases at each step). The reduction is based on the findings of a research programme that achieved positive results with soilless production methods for two of three varieties for runner tip production.

[c] The nominated amount has been reduced by 42 per cent, based on a lower dosage rate (reduced from 26.0 to 15.0 g/m^2) for the adoption of barrier films (e.g., totally impermeable film for the treated area, which is 58 per cent of the 147 ha nominated (147 ha x 58 per cent x 15 g/m^2), in accordance with the Methyl Bromide Technical Options Committee's standard presumptions.

[d] The recommended amount, which represents a 42 per cent reduction from the amount nominated, includes 2.61 t for Mar del Plata (30 ha x 58 per cent x 15 g/m^2) and 5.22 t for Lules (60 ha x 58 per cent x 15 g/m^2). The dosage rate of 15 g/m^2 is based on the Methyl Bromide Technical Options Committee's standard presumptions for the dosage rate needed for methyl bromide with virtually impermeable films or totally impermeable film and row treatments that make up 58 per cent of the field area.

[e] The recommendation represents a reduction of 66 per cent from the approved amount of the critical-use exemption for 2019 and is for pest control in the three specific nominated mills. The reduction is based on a lower number of treatments for each mill with an amount of methyl bromide for only one fumigation per year at approximately 20 g/m^3 (the Methyl Bromide Technical Options Committee's standard presumption) considered sufficient. This is only a transitional measure to allow time for the adoption and optimization of alternatives in an integrated pest management system, with phase-in of an alternative whole-site fumigant, sulfuryl fluoride, if desired.

[f] The nominated amount has been reduced by 15 per cent to account for the uptake of heat, especially in attics or roof spaces, and commercial treatments with sulfuryl fluoride following its registration in January 2018.

23. The nominating parties and the Methyl Bromide Technical Options Committee are expected to hold further bilateral discussions, including during the forty-first meeting of the Open-ended Working Group, on the interim recommendations and additional information that may be provided to the Committee for its final evaluation and recommendations. The final report of the Committee will be available prior to the Thirty-First Meeting of the Parties, to be held in November 2019.

24. The Open-ended Working Group may wish to consider the report and interim recommendations of the Methyl Bromide Technical Options Committee and propose a way forward.

(b) Stocks of methyl bromide (UNEP/OzL.Pro.30/11, paras. 73 and 77)

25. As mentioned in the note by the Secretariat ((UNEP/OzL.Pro.WG.1/41/2, paras. 34–37), the criteria for permitting critical-use exemptions of methyl bromide are set out in decision IX/6, adopted in 1997 by the Ninth Meeting of the Parties. According to one of the criteria, exemptions can be authorized if "methyl bromide is not available in sufficient quantity and quality from existing stocks of banked or recycled methyl bromide, also bearing in mind the developing countries' need for methyl bromide" (para. 1 (b) (ii)).

26. The Meeting of the Parties has requested parties that have been granted critical-use exemptions to report quantities of methyl bromide produced, imported and exported under the terms of critical-use exemptions, using an agreed format called the accounting framework.[12,13] Although such reporting is not mandatory, nominating parties have largely been submitting the information requested. Some parties that have ceased putting forward nominations have also submitted accounting framework reports for the last year of their authorized nominations.

27. The Methyl Bromide Technical Options Committee, which has been evaluating the submitted accounting framework reports on amounts used for critical uses and stocks over the years, addresses the issue of stocks in its report. The Committee acknowledges that the efficient functioning of commerce requires a certain level of available stocks and additional stocks to respond to emergencies; that stocks may be held on behalf of other parties or for exempted uses (feedstock and QPS uses); that stocks may be privately owned and therefore not readily available for critical uses; and that there may be national regulations preventing the transfer of stocks. Despite these restrictions, the Committee notes that parties may wish to ensure that stocks are used wherever possible to minimize the quantity of methyl bromide that needs to be produced each year for critical uses.

28. The report includes summary tables with data on stocks as reported by seven non-Article 5 parties for 2005 in 2006, the first year of accounting, amounting to a total of 618.7 metric tons, and on stocks reported for 2017 and 2018 by five parties (both Article 5 and non-Article 5), amounting to a total of 23.98 metric tons and 0.742 metric tons, respectively. The Committee notes, however, that the accounting information in its report does not accurately show the stocks of methyl bromide held globally for controlled uses by Article 5 parties, as there is no requirement for these parties to report pre-2015 stocks under the Montreal Protocol. According to the Committee, such stocks may be substantial (greater than 1,500 metric tons).

29. Furthermore, the Committee is concerned that existing stocks may not be reported by Article 5 parties that are applying for critical-use exemptions, or by parties not applying for such exemptions. It suggests that parties consider revising the accounting framework submission requirements to ensure complete and accurate reporting on stocks, by requiring parties that hold stocks of methyl bromide for controlled uses and parties that have been granted critical-use exemptions for methyl bromide and still hold stocks to report such stocks.

30. The Open-ended Working Group may wish to consider the additional information provided by the Committee in discussing issues pertaining to agenda item 6.

[12] See decision Ex.I/4, para. 9 (f) and decision XVI/6.

[13] The accounting framework was adopted pursuant to decision XVI/6 of the Sixteenth Meeting of the Parties, in 2004, as set out in annex II to the report of that meeting, and has been included in the Handbook on Critical Use Nominations of Methyl Bromide, available on the Secretariat's website at: https://ozone.unep.org/sites/default/files/data-reporting-tools/MBTOC_Handbook_ver_6_Dec_07_final.pdf. A number of other decisions include provisions that request parties to submit, in their accounting framework reports, by 1 February each year, information on how the criteria set out in decision IX/6 are met when licensing, permitting or authorizing critical-use exemptions.

(c) Development and availability of laboratory and analytical procedures that can be performed without using controlled substances under the Protocol (UNEP/OzL.Pro.30/11, paras. 83 and 127)

31. As set out in the note by the Secretariat (UNEP/OzL.Pro.WG.1/41/2, paras. 38–41), the Thirtieth Meeting of the Parties considered the report by the Technology and Economic Assessment Panel prepared in response to decision XXVI/5 on the global laboratory and analytical-use exemption for ozone-depleting substances. After assessing the development and availability of laboratory and analytical procedures that could be performed without using controlled substances, the Committee recommended nine procedures currently using methyl bromide, carbon tetrachloride and 1,1,1-trichloroethane for removal from the global essential-use exemption.

32. In its 2019 progress report, the Medical and Chemicals Technical Options Committee provides updated information on the total global production of ozone-depleting substances reported by the parties for laboratory and analytical uses, which was 162 metric tons in 2017, showing a slight increase compared to the 151 metric tons reported in 2016. Only three ozone-depleting substances (CTC, CFC-113 and methyl bromide) were produced for such uses in 2017, with CTC remaining the dominant component. Reported production of ozone-depleting substances for laboratory and analytical uses shows a continuous decline for non-Article 5 parties (12 metric tons in 2017) and a slight increase in the three years prior to 2017 for Article 5 parties (150 metric tons in 2017). Small quantities of a wide range of such substances continue to be used for laboratory and analytical uses.

33. The Committee also notes that since the publication of its 2018 assessment report, it has identified two new ASTM standard methods (D7678 and D8193) and one new draft standard in China that use cyclohexane or tetrachloroethylene as alternatives to ozone-depleting substances for oil analysis.

34. The Open-ended Working Group may wish to consider the additional information provided by the Committee in discussing issues pertaining to agenda item 6.

(d) Process agents (decision XXIX/7 and UNEP/OzL.Pro.30/11, para. 86)

35. The list of uses of controlled substances as process agents was first set out in table A of decision X/14, adopted in 1998 by the Tenth Meeting of the Parties. Subsequent recommendations by the Panel led to the table being revised over the years. The latest version of table A, in the annex to decision XXIX/7, lists 11 process-agent uses.

36. To further update the list of process-agent uses, in decision XXIX/7 parties were urged to update their information on such uses and to provide the Secretariat, by 31 December 2017, with information on the implementation and development of emission-reduction techniques. In addition, the Technology and Economic Assessment Panel was requested to report to the Open-ended Working Group at its forty-first meeting on the industrial application of any alternative technology employed by parties in the processes listed in table A.

37. By 31 December 2017, three of the four parties using ozone-depleting substances as process agents (China, the European Union and the United States of America) had submitted information in response to decision XXIX/7. The Medical and Chemicals Technical Options Committee reviewed the information provided, along with other available information, and summarized it in table 5.1 of its progress report. For each use, the table indicates the parties that no longer require ozone-depleting substances for a given process agent application, the reason for the process agent application using ozone-depleting substances and the status of process-agent use. The information in the table supports the Committee's recommendation to update the latest version of table A by removing two uses, as mentioned in the note by the Secretariat (UNEP/OzL.Pro.WG.1/41/2, para. 42).

38. Limits for process-agent uses and reported make-up or consumption and emissions were set out in table B of decision X/14 and subsequently revised, with the latest version of table B appearing in decision XXIII/7. After reviewing the process-agent uses and emissions submitted by parties for 2016, the Medical and Chemicals Technical Options Committee recommended, in the Technology and Economic Assessment Panel's 2018 progress report, that table B of decision XXIII/7 be revised accordingly.

39. For ease of parties' reference, the proposed changes to table A of decision XXIX/7 are indicated in table 2 below, while table 3 reproduces table B as it appears in decision XXIII/7, along with the make-up or consumption and emissions reported by parties for 2016.[14] In considering

[14] Tables 2 and 3 are reproduced from the addendum to the note by the Secretariat for the fortieth meeting of the Open-ended Working Group, held in 2018 (UNEP/OzL.Pro.WG.1/40/2/Add.1).

revisions to table B, however, the Open-ended Working Group may wish to take into account data on the make-up or consumption and emissions reported by parties for 2017, which have become available since the Medical and Chemicals Technical Options Committee made its recommendations in its May 2018 progress report. Those data are presented in table 4 below.

Table 2

Changes to table A of decision XXIX/7 proposed by the Medical and Chemicals Technical Options Committee

List of uses of controlled substances as process agents

No.	*Process agent application*	*Substance*	*Permitted parties*
1	Elimination of NCl_3 in chlor-alkali production	CTC	European Union, Israel, United States
2	Recovery of chlorine by tail gas absorption from chlor-alkali production	CTC	~~European Union,~~ United States
3	Production of chlorinated rubber	CTC	European Union
4	Production of chlorosulfonated polyolefin	CTC	China
5	Production of aramid polymer	CTC	European Union
6	Production of synthetic fibre sheet	CFC-11	United States
7	Photochemical synthesis of perfluoropolyetherpolyperoxide precursors of Z-perfluoropolyethers and difunctional derivatives	CFC-12	European Union
~~8~~	~~Preparation of perfluoropolyether diols with high functionality~~	~~CFC-113~~	~~European Union~~
9	Production of cyclodime	CTC	European Union
10	Bromination of a styrenic polymer	BCM	United States
11	Production of high modulus polyethylene fibre	CFC-113	United States

Abbreviations: BCM – bromochloromethane; CFC – chlorofluorocarbon; CTC – carbon tetrachloride.

Table 3

Limits for process-agent uses (table B of decision XXIII/7) and reported make-up or consumption and emissions for 2016

(Metric tons[a] per year)

Party	*Make-up or consumption (decision XXIII/7)*	*Maximum emissions (decision XXIII/7)*	*Reported make-up or consumption for 2016*	*Reported emissions for 2016*
China	1 103	313	177.42	105.05
European Union	1 083	17	365.28	3.808
Israel	3.5	0	0	0.0143
United States	2 300	181	Not reported	[31.2 ODP-tons]
Total	**4 489.5**	**511**	**[542.70][b]**	**[108.8723][b]**

[a] Except for the amount reported by the United States, which is given in ODP-weighted metric tons.

[b] Nominal totals for 2016, which exclude data not reported or data reported in ODP-weighted metric tons.

Table 4
Reported process agent make-up or consumption and emissions for 2017
(Metric tons[a] per year)

Party	*Reported make-up or consumption for 2017*	*Reported emissions for 2017*
China	175.96	104.19
European Union	324.301	4.143
Israel	0	0
United States	Not reported	[24.65 ODP-tonnes]
Total	**[500.261][b]**	**[108.833][b]**

[a] Except for the amount reported by the United States, which is given in ODP-weighted metric tons.
[b] Nominal totals for 2017, which exclude data not reported or data reported in ODP-weighted metric tons.

40. The Open-ended Working Group may wish to consider the recommendations of the Medical and Chemicals Technical Options Committee and take appropriate action.

(e) Any other issues

1. Emergency use reported by Israel

41. In correspondence dated 28 March 2019, the Government of Israel notified the Ozone Secretariat that it had given permission for the use of 100 kg (0.1 metric ton) of methyl bromide, under the emergency methyl bromide use provision in decision IX/7, to control an infestation in the library of the Greek Orthodox Patriarchate in Jerusalem by the common furniture beetle (*Anobium punctatum*). In accordance with decision IX/7, the Secretariat and the Technology and Economic Assessment Panel have evaluated that use. In the Panel's May 2019 progress report, the Methyl Bromide Technical Options Committee recognized the difficulties presented by the specific circumstances and suggested that the party approach a named national expert and consider relevant studies conducted in Israel should that issue arise in the future. The Committee also reaffirms the readiness of its experts to provide further information to the party if required.

2. Organizational matters

42. In its May 2019 progress report, the Technology and Economic Assessment Panel elaborated on organizational issues related to each of its technical options committees, including the specific expertise needed, with a view to bringing those issues to the attention of the parties. Information on the status of the membership of the Technology and Economic Assessment Panel and its technical options committees as at May 2019 is included in annex 1 to the progress report.

43. Table 5 lists the co-chairs and members of the Technology and Economic Assessment Panel whose membership expires at the end of 2019 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 2019 and whose reappointment does not require a decision by the Meeting of the Parties are listed in annex III to the present addendum.

44. Nominations or renominations to technical options committees and temporary subsidiary bodies and appointments or reappointments can be made at any time. The Panel has clarified that new appointments to technical options committees are to start from the date of appointment by the committee's co-chairs and are to end on 31 December of the fourth year of membership.

Table 5
Members of the Technology and Economic Assessment Panel whose membership expires at the end of 2019 and whose reappointment requires a decision by the Meeting of the Parties

Name	*Position*	*Country*
Keiichi Ohnishi	MCTOC co-chair	Japan
Jianjun Zhang	MCTOC co-chair	China
Suely Machado Carvallo	TEAP senior expert	Brazil
Sidi Menad Si-Ahmed	TEAP senior expert	Algeria

Abbreviations: MCTOC – Medical and Chemicals Technical Options Committee; TEAP – Technology and Economic Assessment Panel.

45. The parties may wish to consider nominating or renominating and appointing or reappointing co-chairs and members, as appropriate, taking into account the Panel's terms of reference as set out in the annex to decision XXIV/8.[15] In doing so, the parties may wish to consider the expertise currently needed by the Panel and its technical options committees, as set out in the "matrix of needed expertise", contained in annex 2 to the Panel's May 2019 progress report, reproduced in annex IV to the present addendum and posted on the Ozone Secretariat website.[16]

46. With regard to nominations to the Technology and Economic Assessment Panel, to date the Secretariat has received a submission from Algeria nominating Mr. Sidi Menad Si-Ahmed, currently a senior expert on the Panel, to continue serving on the Panel in that role for a period of four years; and a submission from Japan nominating Mr. Keiichi Ohnishi, currently a co-chair of the Medical and Chemicals Technical Options Committee, to continue serving on the Panel in that role for an additional period of four years. The parties may wish to consider these nominations, along with the curriculum vitae of the nominees, which are available on the meeting portal. [17,18]

3. Continuing challenges

47. The May 2019 progress report notes a number of continuing challenges faced by the Technical and Economic Assessment Panel and its technical options committees. One of those is the identification of candidates with adequate experience, technical expertise and time. The main approach taken by the Panel and its technical options committees is to appoint experts in the required technical areas to contribute to task forces and/or the technical options committees, where new appointees can share their experience, knowledge, ability to communicate and write and capacity to contribute in a timely manner. Another major concern is the substantially increased workload in recent years which, if unaddressed, will increasingly affect the delivery and timeline of the Panel's outputs.

48. The Panel once again suggests that there may be a need to consider, at the time of making decisions requesting specific work, the overall annual workload, the deadlines for delivery and the support provided to the Panel. Welcoming the opportunity to further engage with parties to address its challenges, the Panel reaffirms its commitment to continue serving the needs of the parties.

Agenda item 7

Access of parties operating under paragraph 1 of Article 5 of the Montreal Protocol to energy-efficient technologies in the refrigeration, air-conditioning and heat-pump sectors (decision XXX/5)

49. As mentioned in the note by the Secretariat (UNEP/OzL.Pro.WG.1/41/2, paras. 47–49), in decision XXX/5, the Thirtieth Meeting of the Parties requested the Technology and Economic Assessment Panel to prepare a report on the cost and availability of low-GWP technologies and equipment that maintain or enhance energy efficiency, inter alia, covering various refrigeration, air-conditioning and heat-pump sectors, in particular domestic air-conditioning and commercial refrigeration, taking into account geographical regions, including countries with high-ambient-temperature conditions. In response to the request, the Panel established a task force to produce the requested report for the consideration of the Open-ended Working Group at its forty-first meeting. The full task force report is available on the meeting portal,[19] with the executive summary of the report summarizing the key findings reproduced in annex V to the present addendum, as received by the Secretariat, without formal editing.

50. The task force report focuses on the air-conditioning and commercial refrigeration sectors during the phase-down of HFCs and assesses the availability and cost of low-GWP technologies and equipment that maintain or enhance energy efficiency, as well as the role of markets in the transition to energy efficient refrigeration and air-conditioning equipment and low-GWP refrigerants. Overall, the task force finds that:

[15] https://ozone.unep.org/sites/default/files/Handbooks/MP_Handbook_2019_W.pdf.

[16] See https://ozone.unep.org/teap-expertise-required.

[17] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Shared%20Documents/Algeria_SI_MENAD.pdf.

[18] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Shared%20Documents/Curriculum_Vitae_for_Ohnishi_K.pdf.

[19] http://conf.montreal-protocol.org/meeting/oewg/oewg-41/presession/Background-Documents/TEAP_May-2019_Task_Force_Report_on_Energy_Efficiency.pdf.

(a) The technology to enhance energy efficiency using different types of refrigerants is available to varying degrees in the different regions of the world.

(b) Research and development is ongoing, both for refrigerants and for the new technologies that use those refrigerants in an efficient way.

(c) Costs and market incentives are important factors in the availability of energy efficient technologies. Countries that use market incentives to increase energy efficiency in air conditioning and commercial refrigeration in parallel with the HFC phase-down will benefit economically and environmentally.

(d) Part of the transition to lower-GWP technologies and equipment has already happened, as some markets have been transitioning to more energy efficient technologies and/or equipment.

51. The Open-ended Working Group may wish to consider the task force report and discuss a way forward.

Agenda item 13

Risk of non-compliance with hydrochlorofluorocarbon production and consumption reduction targets by the Democratic People's Republic of Korea

52. On 10 April 2019, the Government of the Democratic People's Republic of Korea addressed a letter to the Secretariat in which it expressed its concern that the country would be unable to maintain compliance with its obligations under the Montreal Protocol starting in 2019, set out the reasons for its concern and requested that the issue be placed as a separate item on the agendas of the forty-first meeting of the Open-ended Working Group and the Thirty-First Meeting of the Parties, to be duly considered in accordance with paragraph 6 of Article 5 of the Montreal Protocol.[20] The issue has also been included on the provisional agenda of the sixty-second meeting of the Implementation Committee, in accordance with paragraph 4 of the non-compliance procedure for the Montreal Protocol.

53. In the letter, the Government informed the Secretariat of the following:

(a) The Democratic People's Republic of Korea "may not be able to honour its obligations under the Montreal Protocol with regard to the HCFCs reduction from 2019".

(b) With the HCFC phase-out management plan approved by the Executive Committee of the Multilateral Fund in November 2014, and with the assistance of the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP), the Government was able to meet its targets to reduce consumption and production starting in 2015 and 2016.

(c) The Government continues to operate its national ozone unit, enforce its licensing and quota system and conduct awareness-raising activities, notwithstanding the lack of direct financial support.

(d) In the light of the restrictions arising from Security Council sanctions, most of the investment and non-investment activities under the HCFC phase-out management plan, including the delivery of alternative polyurethane foam equipment and the organization of national workshops and training sessions for stakeholders and technicians, could not be completed until 2018, which was the final year of the project, thereby placing the country in a difficult position.

[20] Paragraph 5 of Article 5 of the Protocol, and paragraph 6 of Article 5 referenced in the letter by the Government of Democratic People's Republic of Korea, provide as follows:

> "5. Developing the capacity to fulfil the obligations of the parties operating under paragraph 1 of this Article to comply with the control measures set out in Articles 2A to 2E and Articles 2I and 2J, and with any control measures in Articles 2F to 2H that are decided pursuant to paragraph 1 *bis* of this Article, and their implementation by those same parties will depend upon the effective implementation of the financial co-operation as provided by Article 10 and the transfer of technology as provided by Article 10A.
>
> "6. Any party operating under paragraph 1 of this Article may, at any time, notify the Secretariat in writing that, having taken all practicable steps it is unable to implement any or all of the obligations laid down in Articles 2A to 2E and Articles 2I and 2J, or any or all obligations in Articles 2F to 2H that are decided pursuant to paragraph 1 *bis* of this Article, due to inadequate implementation of Articles 10 and 10A. The Secretariat shall forthwith transmit a copy of the notification to the Parties, which shall consider the matter at their next Meeting, giving due recognition to paragraph 5 of this Article and shall decide upon appropriate action to be taken."

(e) In 2017, at its seventy-ninth meeting, the Executive Committee decided to defer consideration of the request for preparation of a stage II of the HCFC phase-out management plan for the country, in the light of the sanctions imposed by the Security Council. In addition, the country's proposal for enabling activities for the phase-down of HFCs was not accepted for consideration at the eighty-second meeting of the Executive Committee, in 2018.

(f) Failure to complete stage I of the HCFC phase-out management plan and to secure approval for further projects has had consequences, in particular for the production of HCFC-22. In March 2019, in response to repeated requests to increase production of HCFC-22, the national coordinating committee for the environment decided to temporarily accept the increase in production of HCFCs "to a certain level until adequate financial and technical assistance is in place".

(g) The party was facing the situation of being unable to meet its reduction obligation for the production of HCFCs starting in 2019, with the risk of exceeding the baseline level for HCFC consumption. It was also unlikely to be able to comply with the 35 per cent reduction target starting in 1 January 2020 if the situation continued.

(h) Finally, the Government of Democratic People's Republic of Korea formally requested that the matter be included on the agenda of the forty-first meeting of the Open-ended Working Group, in accordance with paragraph 6 of Article 5 of the Protocol, in order for a decision to be adopted as follows:

> "Recognising the main cause that restrained DPRK to fulfil its obligations under the Montreal Protocol fully rests with the unfair and excessive implementation of the UNSC sanctions resolutions by some countries of the Executive Committee of the Multilateral Fund and its irresponsible decisions, with a correct understanding that such sanctions are not at all relevant to the environment protection and such unfair and uncivilized decisions and barriers should be removed with no repetition in the future;
>
> "Acknowledging that the DPRK cannot be a subject of penalty and flexibility should be given with regard to the HCFCs production and consumption in the DPRK; and
>
> "Urging to render adequate financial and technical assistance to the DPRK and other member states to enable them to meet their obligations in the implementation of multilateral environmental agreements."

54. In response to the party's request, the Secretariat has placed the matter on the provisional agenda of the forty-first meeting of the Open-ended Working Group.

55. The Secretariat had also contacted the secretariat of the Multilateral Fund for information on progress in the implementation of the approved activities in the country and on the status of submissions regarding future activities for consideration by the Executive Committee. On 17 May 2019, the Secretariat received a communication from the secretariat of the Multilateral Fund, indicating that the secretariat had contacted the implementing agencies working with the party (UNEP and UNIDO) to request an update on progress in the implementation of those activities. The information provided by the secretariat can be summarized as follows:

(a) As a general principle, any project to be funded and implemented through United Nations agencies should not contravene Security Council resolutions. In the particular case of projects under the Multilateral Fund for the Democratic People's Republic of Korea, in addition to being in conformity with the Multilateral Fund policies and guidelines, implementing agencies should also ensure that they would not contravene Security Council resolution 1718 (2006) or subsequent resolutions on the matter (i.e., resolutions 1874 (2009), 2087 (2013), 2094 (2013), 2270 (2016), 2321 (2016), 2371 (2017), 2375 (2017) and 2397 (2017)).

(b) Over the years, the two implementing agencies that are assisting the Government of the Democratic People's Republic of Korea have submitted project proposals for consideration by the Executive Committee, and, in consultation with the Security Council Committee established pursuant to resolution 1718 (2006), they have been able to provide confirmation that those projects do not contravene that resolution or the subsequent resolutions mentioned in subparagraph (a) above. In some instances, pieces of equipment required for the conversion of manufacturing enterprises had been excluded from approved project proposals since they were potentially prohibited under relevant Security Council resolutions. The proposals submitted also included mechanisms to ensure that all items would be utilized for the purpose of the project, along with descriptions of the methodologies for disbursement, the organizational structure and the monitoring procedures to be used in implementing the approved activities. Implementing agencies have followed that approach in a careful manner to

ensure that no project under the Multilateral Fund would be in violation of any Security Council resolution.

(c) Following those procedures, assistance had been provided to the Democratic People's Republic of Korea to comply with its consumption targets up to 2018, including funding for the operation of the national ozone unit (to support institutional strengthening) and implementation of stage I of the HCFC phase-out management plan. With the promulgation by the Security Council of additional resolutions on the Democratic People's Republic of Korea in 2016 and 2017, the implementing agencies reported that it had become increasingly difficult to deliver the previously approved assistance and to confirm that new activities that were being proposed for funding would also be in conformity with all relevant resolutions.

(d) On that basis, at its seventy-ninth meeting, the Executive Committee gave due consideration to the funding request submitted by the implementing agencies for the preparation of stage II of the HCFC phase-out management plan for the Democratic People's Republic of Korea. During the discussions, concerns were expressed by the Executive Committee regarding scientific and technical cooperation with the country, in the context of Security Council resolution 2321 (2016), in which the Council called for such cooperation to be suspended. Previous approvals of proposals for activities in the country had been subject to review by the Security Council Committee established pursuant to resolution 1718 (2006) at a time when the circumstances in the country had been different. Accordingly, the Executive Committee decided to defer consideration of the request until it could be confirmed that such projects did not conflict with resolution 2321 (2016) or any other resolutions that the Security Council might adopt on the matter. At the same meeting, the sub-group on the production sector reported to the Executive Committee that it had agreed to defer consideration of the request submitted by UNIDO to carry out a technical audit of the HCFC production sector in the Democratic People's Republic of Korea until it could be confirmed that the project did not conflict with resolution 2321 (2016) or any other resolutions that the Security Council might adopt in relation to the Democratic People's Republic of Korea. At its eightieth meeting, the Executive Committee decided to remove project activities related to the Democratic People's Republic of Korea from the consolidated business plan of the Multilateral Fund for the period 2018–2020.

(e) On 5 September 2018, the Government of the Democratic People's Republic of Korea sent a letter to the Executive Committee notifying the Committee of the country's risk of non-compliance with its agreement regarding the reduction of HCFC consumption in 2018. Accordingly, at its eighty-second meeting, the Executive Committee agreed to consider the letter, under agenda item 14 ("other matters"). During the discussion, one member said that, on the basis of the information provided to the Committee, there did not appear to be an issue of compliance or non-compliance meriting further consideration at the eighty-second meeting. Subsequently, the Executive Committee took note of the letter from the Government of the Democratic People's Republic of Korea.

56. The communication from the secretariat of the Multilateral Fund included a summary of the projects for the Democratic People's Republic of Korea that have been considered by the Executive Committee since 2012 and the current status of implementation of ongoing projects, based on the information received from the implementing agencies. That summary has been made available as an information document for the forty-first meeting of the Open-ended Working Group (OzL.Pro.WG.1/41/INF/8).

57. The Open-ended Working Group may wish to discuss the issue as appropriate.

Annex I

Report by the Technology and Economic Assessment Panel (May 2019) Volume 3

Technology and Economic Decision XXX/3 Task Force report on unexpected emissions of trichlorofluoromethane (CFC-11)

Executive Summary

The Montreal Protocol was established to protect the stratospheric ozone layer by reducing ozone-depleting substances (ODS), such as chlorofluorocarbons (CFCs), in the atmosphere. Successful measures were taken, with the abundance of ODS peaking in the late 1990s and continuously decreasing thereafter. CFC-11 (trichlorofluoromethane, $CFCl_3$) was used primarily as a foam-blowing agent (for flexible and polyurethane (closed cell) insulating foams), as an aerosol propellant, as a refrigerant (for centrifugal chillers used in large buildings and industrial plants), and in a range of other smaller uses, including asthma inhalers, and tobacco expansion. There are alternative chemicals or products available as replacements for CFC-11. A bank of CFC-11 remains in closed-cell foams and centrifugal chillers, from which CFC-11 is released slowly into the atmosphere over time.

CFC-11 production peaked between 350,000 and 400,000 tonnes per year, and peak emissions were about 350 gigagrams (or 350,000 tonnes) per year, in the late 1980s[1]. Under the Montreal Protocol, production of CFC-11 in non-Article 5 parties was phased out in 1996; production of CFC-11 in Article 5 parties was phased out in 2010, with some limited exceptions authorised by parties.

In a recent letter to Nature, Montzka et al. reported an unexpected, global increase in CFC-11 emissions of 13,000±5,000 tonnes per year after 2012. The study strongly suggests a concurrent increase in CFC-11 emissions from eastern Asia although the contribution of this region to the global increase was not quantified. The study also suggests that the CFC-11 emissions increase arises from new production that has not been reported to the Ozone Secretariat, which is inconsistent with the agreed phase-out of CFC production by 2010.

In response to these scientific findings of an unexpected increase in global emissions of CFC-11 after 2012, at their 30th Meeting, parties requested the Technology and Economic Assessment Panel (TEAP) to provide them with relevant information on potential sources of emissions of CFC-11 and related controlled substances, as given in decision XXX/3. In response, TEAP formed a temporary subsidiary body, in the form of a Task Force, which combines expertise from TEAP and its Technical Options Committees (TOCs), and also outside expertise, to address the requirements of this decision.

Decision XXX/3 requests TEAP to prepare a preliminary report, to be provided in time for the Open-ended Working Group at its forty-first meeting and a final report, to be provided in time for the Thirty-First Meeting of the Parties. This report is the preliminary report. A submission in response to decision XXX/3, paragraph 3, was received from China, which the Task Force has considered in its assessment.

The preliminary report is structured to address the different elements in responding to the decision: production of CFC-11 and related controlled substances; foams uses; refrigerant uses; aerosols, solvents and miscellaneous uses; emissions modelling and analysis. It analyses the likelihood of potential sources of emissions and also identifies additional areas for consideration, as well as additional information needed to further determine the likelihood of some potential sources.

Production options for CFC-11 and related controlled substances

The possible production plant options for the manufacture of CFC-11 have been considered. The main process routes to CFC-11 production use carbon tetrachloride (CTC) as feedstock; the possible availability of CTC has been considered to meet a range of potential CFC-11 production quantities annually from small-scale (≤ 10,000 tonnes per year) to large-scale (≥ 50,000 tonnes per year).

[1] Montzka, S. *et al.*, An unexpected and persistent increase in global emissions of ozone-depleting CFC-11, *Nature*, 2018, **557**, 413–417. https://doi.org/10.1038/s41586-018-0106-2.

The Task Force considered 20 potential alternative CFC-11 production routes. The most likely production routes are CTC to CFC-11 on micro-scale plants using minimal equipment (to make low grade CFC-11 for foam blowing use); and CTC to CFC-11/12 on a large-scale in an existing liquid phase plant (HCFC-22 plant). Less likely but possible is CTC to CFC-11/12 on a large-scale in an existing vapour phase plant (dedicated CFC plant). If new CFC-11 production is occurring, emissions related solely to the production stage may occur but at relatively low rates, which are dependent on the production process used.

If larger scale CFC-11 production (≥ 50,000 tonnes per year) were required to account for the increased emissions, then it seems less likely that a large number of micro-scale plants would be solely responsible, although this does not preclude some micro-scale plants from contributing to the production.

The production of CFC-11 (and CFC-12) is possible in HCFC-22 plants. Spare annual capacity to produce CFC-11 in a HCFC-22 plant is estimated to be available in: Argentina, Mexico, Russia, and Venezuela for small-scale CFC-11 production (≤ 10,000 tonnes); the European Union and the United States for medium-scale CFC-11 production (between 10,000 and 50,000 tonnes); and China, for large-scale CFC-11 production (≥50,000 tonnes).

CTC is produced in chloromethanes plants as an unavoidable part of the production of dichloromethane and chloroform. China, the European Union, and the United States have the largest chloromethanes capacities, and therefore also the largest potential availability of CTC. In 2016, the global maximum amount of potential CTC available from chloromethanes production, after existing local supply commitments had been met, was 305,000 tonnes. A number of regions have the spare annual capacity that might allow CTC production in the amounts required for small-scale CFC-11 production. Only China has the spare annual capacity that might allow CTC production to supply the larger amounts of CTC required for large-scale CFC-11 production.

CTC is also produced in perchloroethylene/CTC (PCE/CTC) plants, which have the flexibility to produce either substance according to demand. Five PCE/CTC plants are operative in Europe and the United States. Spare global capacity to produce CTC by this process is estimated to be between 50,000-100,000 tonnes per year, existing mainly in the European Union.

There does not appear to be evidence through customs or other agency activities, including seizures or interceptions, that illicit international trade in significant quantities of CFC-11 or CTC has occurred in recent years. However, there have been indications of recent marketing of CFC-11 for use in foams.

Foams

Based on its current assessment, the Task Force finds that the production of certain foam products using CFC-11 may be a potential source of the sudden and increased emissions of CFC-11.

It seems unlikely that the unexpected emissions have resulted from the traditional handling of foams at end-of-life alone unless there has been a significant change in those processes from appliances and construction for a very large volume of foams.

There are indications of CFC-11 marketing into foams use. The Foams Technical Options Committee was provided with a copy of an offer for sale of CFC-11 for 2200 USD/tonne through distribution, has seen offers for sale on internet websites, and has learned more through industry discussions.

Although technically feasible, the Task Force questions the economic incentive for open-cell flexible foams of broadly replacing methylene chloride, given its very low cost, with CFC-11. Nevertheless, the Task Force continues to explore the possibility of use of CFC-11 to reduce volatile organic compound emissions from flexible foams as limited in some parties or limitations in the use of methylene chloride due to toxicity concerns.

Further investigation is warranted into the use of CFC-11 for polyurethane (PU) foams and polyol systems for PU rigid foams as it is technically feasible and more economically advantageous than reverting to use CFC-11 in flexible foams. However, it seems unlikely that multi-national or other large system houses would risk their reputations by knowingly using CFC-11. The increased CFC-11 emissions imply volumes of CFC-11 usage that seem to go beyond that of smaller or local system houses.

The conversion of enterprises in the spray foam sector and small and medium enterprises (SMEs) has created technical and economic challenges that might drive the use of CFC-11. Whether or not this has resulted in the actual usage of CFC-11 blowing agents, or to any significant degree, has not been confirmed.

There is a difference between the projected estimated CFC-11 emissions from foams in banks (including landfills), based on emission rates found in the literature, and the derived atmospheric emissions, including in regions where CFC-11 has not likely been used in foams in decades (< 1.5% and 3-4%, respectively). It is possible that further processing of foams before disposal, through shredding and crushing of foams, accounts for at least some of that difference. Further investigation into emission rates from foams banks is warranted.

Any scenario where significant CFC-11 is used in rigid or closed cell polyurethane foams would require significant CFC-11 production and would also result in an increase of the foam banks (e.g., emissions of 1,000 tonnes of CFC-11 from the manufacture of closed-cell foams would imply an increase in the foam bank of 3,000 tonnes or more). Further analysis of the potential use of CFC-11 in rigid or closed-cell polyurethane foams is warranted.

Refrigeration and air conditioning

Centrifugal chillers using CFC-11 (some used CFC-12) have always been a relatively small part of the total CFC refrigerant inventory and emissions of all R/AC sub-sectors. While CFC-12 centrifugal chillers have been virtually phased out, a small number of CFC-11 chillers are still in operation and expected to reach their end of life in the next 1 to 5 years, at the latest. Based on estimates of CFC-11 banks and emissions, emissions from CFC-11 chillers do not constitute a major portion of the global CFC-11 emissions calculated from atmospheric observations in 2002-2012, and similarly emissions from chillers cannot be a cause for the sudden increase of global CFC-11 emissions since 2013, as derived from atmospheric calculations. It is unlikely that CFC-11 production would be employed to maintain a very small number of centrifugal CFC-11 chillers in operation.

It is also unlikely that there is a significant resumption of CFC-12 usage in any R/AC sub-sector in both non-Article 5 and Article 5 parties. This implies that no significant new CFC-12 production would be needed for all R/AC sub-sector uses, and that this would not be the reason for possible CFC-11 co-production. There might be a continuing small CFC-12 demand for a limited number of CFC-12 mobile ACs in certain vehicles, namely some luxury or special vehicles built before 2002 in Article 5 parties. However, this small demand is likely to be supplied from the recycling of refrigerant from aged CFC-12 equipment.

Aerosols, solvents, and other applications

The main use of CFCs was as a pressurized liquid in aerosols, which is an emissive use. While CFC-11 worked very well in combination with CFC-12 to obtain variations in propellant pressure, CFC-11 could not be used alone as a propellant. It is technically feasible to use mixtures of hydrocarbon propellants and CFC-11 in aerosols. If CFC-11 were readily available, it would be technically feasible to use it in aerosol products. However, it seems unlikely that CFC-11 would be produced or used nowadays for aerosols; the main reason is that hydrocarbons are much cheaper than CFCs. While it would be technically possible to make an MDI mixing CFC-11 and HFC-134a or HFC-227a, it seems highly unlikely that any MDI producer would choose this route.

Production of synthetic fibre sheet with CFC-11 is listed in decision XXIX/7 Table A as a process agent and is permitted for use only in the United States, for which emissions are very low. It is extremely unlikely that CFC-11 would be used in a newly established (illicit) plant to manufacture synthetic fibre sheet and that this would be highly emissive. Similarly, it seems extremely unlikely that CFC-11 might be used as a solvent. With the alternatives available, there are also no technical or economic reasons to believe that the recent increase in CFC-11 emissions would be due to tobacco expansion or the processing of uranium.

Emissions and banks modelling

Based on updated modelling and analysis of CFC-11 emissions and banks, it is unlikely that past production, historic usage, and the resulting bank can account for the unexpected CFC-11 emissions unless there has been a significant change in the treatment of large quantities of banked CFC-11, which is unknown at the time of completion of this preliminary report.

Atmospheric-measurement derived emissions from banks in Western Europe, where CFC-11 has not been used for several decades, continue to generally decline (2-4% per year). If it is assumed that CFC-11 emissions from banks in other regions generally decline in a similar fashion, it appears that the unexpected increases in global CFC-11 emissions cannot be explained by bank emissions. Unless banks are treated very differently in other regions where CFC-11 has been used more recently, or

where there is no atmospheric data collected, it seems unlikely that the source of the increased CFC-11 emissions is from CFC-11 banks.

None of the analyses of the available data eliminates the possibility that newly produced CFC-11 might have resumed use in closed-cell foams. There are scenarios modelling the potential use of CFC-11 in closed-cell foams that align with the derived emissions of CFC-11. Based on this overall evaluation, the Task Force recommends continued exploration into the potential use of CFC-11 in closed-cell foams to explain the unexpected increased emissions of CFC-11.

Annex II

2018 Assessment Report of the Technology and Economic Assessment Panel

Overall key findings

The Montreal Protocol continues to be effective because control measures have created incentives for new technology, because enterprises and organizations have worked diligently to implement new technology and because the Multilateral Fund (MLF) has financed the agreed incremental costs of the transition for Article 5 parties. As each production and consumption phase-out milestone have been achieved, the implementation of new phases of technology have further ratcheted down the production, use, and emissions of ODSs most of which are also potent greenhouse gases. Through these efforts, the world has avoided the substantial economic, environmental and health consequences of increases in both ultraviolet radiation and global warming.

Since the 2014 TEAP Assessment Report, important technical developments have taken place as the parties to the Montreal Protocol continue working toward key ODS production and consumption phase-out milestones. The Kigali Amendment, which was adopted in 2016 and entered into force in 2019, creates new challenges and additional milestones for parties to achieve the phase-down of certain hydrofluorocarbons (HFCs). Regular assessments by TEAP highlight the challenges and provide the necessary information to transition to alternatives and technologies across the various sectors of use. The sector and technology-specific challenges include phase out of remaining uses of ODS in specific sectors, some specific uncontrolled and growing ODS uses, and emerging options for the use of more climate-friendly alternatives.

A key message of the Assessment Panels from their 2014 assessment remains relevant today: *"The sustained success of the Protocol hinges on continued vigilance by the parties to fulfil their commitments and prevent any future actions that threaten to nullify the ozone and climate benefits achieved under the agreement. Success also depends on continuing the lessons of collaboration, leadership, innovation, and shared investment in our global environment that was the promise made to future generations under the Protocol."*

HFC phase down under the Kigali Amendment

The Kigali Amendment established a strong link between ozone protection and climate and set a clear path in protecting our planet's environment through the control of HFCs. The measures taken to phase-down production and consumption of HFCs is expected to avoid up to 0.4 °C of warming by the end of the century. Improvements in the energy efficiency in the refrigeration and air conditioning sector in parallel with HFC phase-down could double that climate benefit.

The TEAP and TOC expertise is evolving to meet the new challenges dictated by the Kigali Amendment. The planned HFC phase-down under the Kigali Amendment, as well as national and regional regulations, are driving industry towards lower-GWP HFC alternatives or not in kind, particularly in refrigeration, air conditioning, and foam applications. However, the range of new, lower GWP products creates challenges in finding the best solution for each application, considering factors such as flammability, toxicity, availability and operating conditions (e.g., high ambient temperatures, HAT).

Around 90% of the potential improvement in energy efficiency of refrigeration and air-conditioning (RAC) equipment comes from technological innovation of equipment, rather than the refrigerant itself. On the other hand, the overall drive to reduce energy demand will lead to increasing energy efficiency of RAC equipment. These twin drivers create an enhanced synergy for HFC phase-down.

Significant technical progress

Progress continues in every consumer, commercial, industrial, agricultural, medical, and military sector, with ODS no longer used in many applications worldwide. CFC-containing MDIs have been successfully phased out worldwide and replaced by a range of CFC-free inhalers.

The phase-out of HCFC-22 in non-Article 5 parties is essentially complete and is progressing in Article 5 parties.

The phase-out of ozone-depleting refrigerants in new chillers is nearly complete. HCFC-22 in new, small chillers has been phased out in non-Article 5 parties, but limited production continues in Article 5 parties.

The year 2015 marked the final production and consumption phase-out date for controlled uses of methyl bromide (MB) in Article 5 parties, and there only a small number of critical uses still being sought by these parties in 2019. This milestone for A5 parties was reached showing steady progress under the Protocol, the successful conclusion of many investment projects, and clear demonstration of how far key sectors, previously dependent on MB, had come in their transition to alternative options and technologies.

Continuing uses of ODS

Continued vigilance through atmospheric monitoring and regular assessments of ODS consumption and use and inventories (banks) is needed to monitor the progress and achievements under the Montreal Protocol. Continuing use of already phased out ODS and recent reporting of unexpected emissions of CFC-11 reinforce this importance.

CFC-11 remains a major source of ozone-destroying chlorine to the stratosphere. Its concentration in the atmosphere has been declining over several decades because of the Montreal Protocol, but recent measurements indicate that this decline has recently become slower than expected under the Montreal Protocol. CFC-11 was used primarily as a foam-blowing agent, as a refrigerant, and in a range of other smaller uses, including asthma medical inhalers and in tobacco expansion. However, alternative chemicals or products are available as replacements for all applications, and have been from the mid-1980s onwards. Production of CFC-11 in non-Article 5 parties was phased out in 1996; production of CFC-11 in Article 5 parties was phased out in 2010. Production of CFC-11 to supply essential uses was less than 400 tonnes each year after 2010 and ceased altogether after 2014. No feedstock uses of CFC-11 have been reported from parties.

Despite these controls, an increase in global CFC-11 emissions after 2012, at least part of which is strongly suggested to originate from eastern Asia, was derived from measurements by two independent networks. In response to Decision XXX/3 (November 2018), SAP and TEAP have coordinated efforts to provide additional information regarding atmospheric monitoring and modelling, with respect to the unexpected emissions, and on potential sources of emissions of CFC-11 and related controlled substances, respectively.

Contrary to the general perception that the halon sector issues are all resolved, in fact the demand from on-going, enduring uses (e.g., civil aviation, oil & gas facilities, nuclear facilities, and military installed base/reserves, etc.), and the growing civil aviation demand of halon-1301 resulting from the lack of replacements for new designs for engine and cargo compartment applications, will likely soon exceed the supply from stockpiles. Emission estimates derived from atmospheric abundances suggest that there were more emissions than previously estimated and therefore there is significantly less stockpiled halon 1301 available to support ongoing needs. It was previously projected that available halon 1301 supplies will run out by the years 2032 to 2054. However, there are regional imbalances, which could mean that for those without dedicated, long-term stockpiles, the run-out date will occur much earlier. Therefore, TEAP anticipates that this will require action under the Montreal Protocol with the strong likelihood that essential use nominations for the production of new halon-1301 will be submitted in the foreseeable future to supply these important fire-fighting uses, and especially for civil aviation.

However, atmospheric concentrations of MB have stopped declining, indicating possible continued use of MB larger than is currently reported for QPS (exempted) uses. An estimated 40% of reported QPS uses have immediately available alternatives, but are not being adopted because QPS uses are exempted under the Protocol. Further, around 70% of current MB emissions derived from reported QPS uses could be avoided, by using re-capture or destruction for QPS commodity uses and barrier films for the QPS pre-plant soil fumigation uses. The resulting reductions in atmospheric concentrations of MB would provide near-term benefits for the ozone layer.

Progress and challenges by sector

Foams

- There have been significant improvements in the development and availability of additives, co-blowing agents, equipment and formulations enabling the successful commercialisation of foams and foam systems containing low GWP blowing agents.

- Growth in the construction sector and the cold chain in Article 5 parties, coupled with the adoption of enhanced energy efficiency criteria for buildings has led to a growth in demand for thermal insulation materials.
    - Total global production of polymeric foams continues to grow (3.9% per year) at a slightly lower rate than noted last year (4.0%), from an estimated 24 million tonnes in 2017 to 29 million tonnes by 2023. Production of foams used for insulation is expected to grow in line with global construction and continued development of refrigerated food processing, transportation and storage (cold chain).
    - Based on average blowing agent percentages of 5.5% w/w (weight by weight or mass fraction) for polyurethane and 6%[22] w/w for XPS, this leads to an estimated demand of greater than 400,000 tonnes with a further 10,000 tonnes being consumed by other foam types. Further, it is estimated that blowing agent demand would grow to above 500,000 tonnes by 2023 based on the growth rates presented below.
- Article 5 parties (A5 parties) face common challenges in phasing out production and consumption of hydrochlorofluorocarbons (HCFCs) and phasing down high global warming potential (GWP) HFC blowing agents.
- The conversion from HCFC-141b in insulation foam applications has been largely successful within larger and some medium enterprises where the critical mass of the operation is sufficient to justify investment in hydrocarbon technologies.
- Managing foams transition for the multitude of SMEs in both Article 5 and non-Article 5 parties remains a challenge. The low GWP alternatives are mostly flammable, and SMEs may find the necessary fire precautions unaffordable. Unless there is industrial rationalisation, this leaves high GWP solutions as the only option, often with considerable emissions.
- The unexpected emissions of CFC-11 requires revisiting previous assessments of this transition in the foams sector and the many factors that may influence selection of foam blowing agent including foam blowing agent cost, safety (flammability, toxicity), ease of use, compatibility with equipment and other raw materials (etc.).

Halons

- There is great concern regarding the general perception that the halon sector issues are all resolved. Increasing demand for on-going and enduring uses (e.g., civil aviation, oil & gas facilities, nuclear facilities, and military installed base/reserves, etc.) will soon exceed supply from stockpiles. The stockpile of halon 1301 may be less than previously estimated, because atmospheric abundances suggest higher emissions than previously estimated, and this will be exacerbated by regional imbalances in stocks. Taken together these factors suggest that for users without access to significant stockpiles, halon 1301 supplies will run out well before the previously estimated 2032 to 2054 timeframe. The growing civil aviation demand for halon-1301 will require action under the Montreal Protocol, with likely submission of essential use nominations for the production of new halon 1301 in the foreseeable future.
- Implementation of 2-BTP as a halon-1211 replacement in hand-held portable extinguishers on board civil aviation aircraft is currently on-going. (This represents approximately 10% of the halon installed in aircraft.) In contrast, the fact that civil aviation has only implemented a replacement for halon- 1301 in lavatory fire extinguishing systems, its smallest use by far, is a remarkably disappointing result, given the level of research and testing efforts performed by governments and fire protection companies for the past 25+ years.
- Since the 2014 Assessment Report, little further progress on additional low-GWP alternatives for total flooding systems (to replace halon-1301, HFC-227ea and/or HFC-125) has been reported. Although research to identify potential new fire protection agents continues, it could be five to ten years before a viable agent could have significant impact on the fire protection sector.

[1] Compound Annual Growth Rate

Methyl Bromide

- MBTOC considers that technical alternatives exist for almost all remaining controlled uses of methyl bromide. Ninety-nine per cent of the reported controlled consumption has been phased out, with only 141 t being presently approved for critical use exemptions. Concern exists that a much greater amount of MB used for controlled purposes is presently unreported.
- In recent years some countries have reported steep increases in QPS consumption, whilst others have significantly declined. Owing to this, there has been no overall sustained reduction in QPS use over the last twenty years. MBTOC estimates that alternatives to MB are immediately available for about 40% of QPS uses, particularly pre-shipment.
- Methyl bromide used for QPS purposes is almost entirely emitted to the atmosphere. Control of these emissions by use of barrier films (for any remaining pre-plant soil fumigation) or recapture and destruction technologies would eliminate more than 70% of these emissions, providing a significant near-term gain to the reduction of ODS substances in the stratosphere.

Medical and Chemical

- CFC-containing metered dose inhalers (MDIs) have been successfully phased out worldwide. A range of alternative treatment methods is available. The choice of the most suitable treatment method is a complex decision and may be enhanced with an increase in publicly available information about the environmental impact, including carbon footprint, of different inhaler products.
- Based on a recent study, an increase in CFC-11 emissions of 13,000 ± 5,000 tonnes per year is suggested for the period 2013 to 2016. The increase in emissions of CFC-11 appears unrelated to past production. Losses of 13,000 tonnes per year of CFC-11 are not economical from a chemical production process. At the upper end of possible emission levels (5 percent losses) for an economically run process, this would equate to production of 260,000 tonnes CFC-11 per year. The fate of any CFC-12 produced as a by-product of CFC-11 production is not yet clear.

Refrigeration and Air Conditioning

- The phase-out of HCFC-22 in non-Article 5 parties is essentially complete and is progressing in Article 5 parties.
- There is no single “ideal” refrigerant. Refrigerant selection results from balancing several factors which include: suitability for the targeted use, availability and cost of the refrigerant, the availability and cost of the RAC equipment, the cost and effectiveness of servicing, energy efficiency, safety, ease of use, and environmental issues. Since the publication of the RTOC 2014 Assessment Report, 35 new refrigerants have received a standard designation and safety classification of which five are single-compound refrigerants, and 30 are blends.
- The HFC phase-down under the Kigali Amendment, as well as regional and national regulations, are driving the industry towards the use of low GWP refrigerants. Alternatives to high GWP refrigerants exist and new lower GWP refrigerants have been proposed. Finding the best refrigerant for each application is a continuing challenge. Refrigerants with low direct impact on climate change are often flammable and may have higher toxicity. In order to maintain the current safety levels new technologies are being developed and an increased level of training will be needed.
- In domestic refrigeration, HC-600a (predominantly) or HFC-134a continue to be the refrigerant options for new production and currently, more than 1 billion domestic refrigerators use HC-600a. In commercial refrigeration, lower GWP HFC/HFO blends and non-halocarbon options like R-744, HC-290, HC-600a and R-717 are growing in use, especially as research and development improves system performance; this trend will further increase with new safety standards and codes which will come into effect in the next few years. In larger industrial refrigeration plants, while R-717 has been extensively used, current technological advances include the use of low charge R-717 systems, as well as cascade systems using R-717 together with R-744. In transport refrigeration, some regions have experienced a significant migration from R-404A to lower GWP alternatives. R-404A has been completely replaced by R-452A in new truck and trailer equipment in Europe. R-744 and R-513A have been introduced in intermodal container applications. R-744 is being field tested on trucks and trailers.

- In air-to-air air conditioners and heat pumps, there is an almost continuous introduction of new refrigerants for use, but few match or exceed the performance of HCFC-22 regardless of the GWP. Nevertheless, market transformation for lower GWP refrigerants as replacement to R-22 has occurred; currently millions of R-32 AC are commercially available, especially in Asia. Despite the reported low risk for certain applications, safety standards remain restrictive to several low GWP flammable refrigerants in certain product types, but are under revision for all refrigerants. Water and space heating heat pumps are a dynamic market with a number of lower GWP options.
- The phase-out of ozone-depleting refrigerants in new chillers is nearly complete. HCFC-22 in new, small chillers has been phased out in non-Article 5 parties, but limited production continues in Article 5 parties.
- Due to the enforcement of regulations, HFO-1234yf is rapidly increasing its market share in US and Europe in new AC equipped passenger cars, while HFC-134a remains widely used in other regions. Although the transition away from CFC-12 has been successful, there are still some luxury or special types of vehicles (built before year 2002) in operation in A5 countries with MACs operated on CFC-12. The CFC-12 quantities used are minimal and are resulting from the recycling of CFC-12 contained in old products.
- Comprehensive sustainable selection criteria for refrigerants have been introduced and include: energy efficiency, impact on climate and hydrosphere, usage of renewable energy, and other options to reduce GHG emissions and consumption of natural resources, adaptability for thermal energy storage, costs, technological development level, safety, flammability and liability.
- Not-In-Kind (NIK) technologies do not primarily use mechanical vapour compression (MVC) technology to produce air conditioning or refrigeration. NIK technologies are expected to provide savings in operating costs. Their unique ability to use waste and renewable energy sources makes their application potentially highly energy efficient.
- Research done at HAT conditions has identified viable low-GWP refrigerant alternatives. There is more awareness of the challenges faced at HAT conditions in the design, implementation, and servicing of equipment using low-GWP refrigerants that are capable of delivering a high level of energy efficiency.

Annex III

Members of the Technology and Economic Assessment Panel technical options committees [a] whose membership expires at the end of 2019 and whose reappointment does not require a decision by the Meeting of the Parties

Name	*Position*	*Country*
Members of technical options committees		
Paul Ashford	FTOC member	United Kingdom
Angela Austin	FTOC member	United Kingdom
Kultida Charoensawad	FTOC member	Thailand
Lisa Norton	FTOC member	United States
Miguel Quintero	FTOC member	Colombia
Johan Åqvist	HTOC member	Sweden
Youri Auroque	HTOC member	France
Sait Erturk	MBTOC member	Turkey
Jordi Riudavets	MBTOC member	Spain
Jose Pons Pons	MCTOC member	Venezuela
Paula Rytilä	MCTOC member	Finland
Ashley Woodcock	MCTOC member	United Kingdom
Mohan Lal D.	RTOC member	India
Maher Mousa	RTOC member	Saudi Arabia
Samuel Yana Motta	RTOC member	Peru

[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).

Annex IV

Matrix of needed expertise by the Technology and Economic Assessment Panel

Body	Required Expertise	A5/ Non-A5
Foams TOC	XPS technology and conversion in Asia especially in India and China	A5
	PU System House technical experts	Southern Africa, Middle East, India. Mexico
	Additional foam chemistry experts	A5/ non-A5
	Building envelope/ energy efficiency	A5/ non-A5
Halons TOC	Fire suppression applications in civil aviation	A5, South East Asia
	Knowledge of halon alternatives and their market penetration	A5, Africa, South America, South Asia
	Knowledge of banking and supplies of halon and alternatives	A5 Africa, South America
	Knowledge of ship breaking activities	A5 or non-A5
Methyl Bromide TOC	Issues related to the validation of alternatives to MB for certification of nursery plant materials related to movement across state and international boundaries and related risk assessment	A5 or non-A5
	Expert in economic assessment of alternatives to MB	Non-A5
	Expert in QPS uses of MB and alternatives	A5
Medical and Chemical TOC	Destruction technologies (experts with knowledge on the range of different technologies) Laboratory and analytical uses (experts with knowledge of analytical procedures)	A5 or non-A5
Refrigeration TOC	Not seeking additional experts at this time	
Senior Experts	Extensive knowledge of the MLF operations and/or assessing financial needs of A5 parties relating to MLF replenishment	A5 or non-A5
	Extensive knowledge of global financing mechanisms and options relevant to ozone and climate protection	A5 or non-A5

Annex V

Report by the Technology and Economic Assessment Panel (May 2019) Volume 4

Technology and Economic Assessment Panel decision XXX/5 Task Force report on access of Article 5 parties to energy efficient technologies in the refrigeration, air-conditioning and heat pump sectors

Executive Summary

The Energy Efficiency Task Force has made an assessment of the availability and costs of technologies and equipment that enhance energy efficiency during HFC phase-down, focusing on air conditioners (AC) and commercial refrigeration (CR). The technology to enhance energy efficiency (EE) using different types of refrigerants is available to varying degrees in the different regions of the world. Research and development (R&D), is ongoing, both for refrigerants and for the new technologies that use these refrigerants in an efficient way. Costs and market incentives are important factors in the availability of energy efficient technologies. Countries which utilize market incentives to drive up the energy efficiency of AC and CR in parallel with HFC phasedown will benefit economically and environmentally. Part of the transition to lower-GWP technologies and equipment has already happened; some markets have been transitioning to higher EE technologies and/or equipment.

CHAPTER 2: AVAILABILITY OF LOW GWP TECHNOLOGY AND EQUIPMENT THAT MAINTAIN OR ENHANCE ENERGY EFFICIENCY

General Considerations

- Medium and low-GWP refrigerants are widely available and do not limit the demand for AC.
- AC and CR equipment meeting the minimum EE requirements in the respective countries are widely available for all refrigerant families including HCFCs; however, extremely limited development to achieve higher EE is taking place on HCFC equipment due to their phase-out schedules.
- Where markets and supporting policies provide clear signals towards alternative refrigerant choice, manufacturers invest in related R&D for those refrigerants while maintaining or enhancing energy efficiency. As a consequence, the R&D effort to develop energy efficient RAC (Refrigeration and Air Conditioning) equipment is being focused on lower GWP technologies. This is particularly visible in the HCFC-22 transition, where no manufacturers supply high-efficiency variable-speed air conditioners using HCFC-22. While the development of new efficient equipment with high GWP HFCs is still taking place in some regions, most effort is now being put into developing energy efficient equipment with medium- and low-GWP refrigerants that exceed the minimum EE ratings by 10% or more.
- Some components to enhance EE in use in AC and CR equipment with lower GWP refrigerants are not widely available. Components for medium-GWP refrigerants are more widely available with some countries transforming the majority of their consumption to these refrigerants.
- Intellectual Property (IP): Most of the widely available new technologies contributing to higher EE equipment are not directly impacted by IP considerations. However, for technologies available from a limited number of suppliers, emerging technologies, or R&D technologies, the IP impact has to be determined on a case-by-case basis.

Air Conditioning equipment:

- HCFC-based AC generally has a lower EE, with no on-going R&D to improve EE.
- High GWP refrigerant-based ACs are available around the world across all tiers of EE.
- Medium and lower GWP refrigerant-based AC is “available” in many parts of the world, but in some important markets (e.g. US, HAT countries) it remains a “new technology”.

Air Conditioning components:

The most important factor in developing any new product is the availability of components, such as compressors and heat exchangers.

- Higher efficiency and inverter driven compressors are available and presently used (mostly used for rotary). There is very limited availability for two-stage compression
- China produces 60% of rotary compressors worldwide (200 million/year). Its production of variable speed compressors (inverter) has doubled in 5 years to 70 million/year. This has been driven by the introduction of Minimum Energy Performance Standards (MEPS) in many important markets.
- Heat exchangers are still mainly “fin and tube” type; there is a move to smaller tube diameters and to micro-channel exchangers.
- These higher EE components reduce the refrigerant charge and are valuable in enabling medium and lower GWP flammable refrigerant AC units to comply with safety standards. They are widely available and presently in use.

Commercial Refrigeration equipment:

- Self-Contained Commercial Refrigeration Equipment (SCCRE) units are diverse in design, construction and function. They are made on a small to medium scale (100’s to few thousand). They must have high reliability since they often contain perishable foods. The equipment design (vertical vs horizontal, doors) impacts the heat load.
- The refrigerants used in CR were previously limited to HCFC-22, R-404A, and HFC-134a, but this is now changing with CO2, hydrocarbon units using HFC-600a and HC-290, and with HFO blends (based on HFO-1234yf) being introduced in many countries.

Commercial Refrigeration components:

- The combination of variable speed compressor with modern control technology, cabinet design and inclusion of doors or curtains makes the most significant contribution to improvement of energy efficiency in SCCRE.
- The majority of technical options for reducing energy consumption listed in this report indicate that they are available today and presently in use.

HAT considerations for Air conditioning and Commercial refrigeration

- Large-scale testing projects of AC prototypes using low- and medium-GWP refrigerants have identified several refrigerants, which provide comparable efficiencies in HAT conditions. The MLF-funded PRAHA-II is re-testing optimized units, using efficient compressors and heat exchangers, which were rebuilt from the original prototypes used in PRAHA-I. The results should be available in late 2019.
- HAT conditions are not generally an issue for commercial refrigerators (SCCRE), which are often placed inside air-conditioned stores and shops. However, in Article 5 parties, SCCRE are sometimes placed outdoors to prevent additional heat load inside the building and this will impact performance due to HAT.

CHAPTER 3: COST OF LOW-GWP TECHNOLOGIES AND EQUIPMENT THAT MAINTAIN OR ENHANCE ENERGY EFFICIENCY IN AC AND CR

- Local industries in A5 parties with AC manufacturing or assembly plants may need financial assistance to convert facilities for safe use of flammable refrigerants, and to in-license technological advances for EE.
- A transition from manufacturing RAC equipment from low to high flammability refrigerants (high to low GWP), requires additional capital and operating costs.
- There are capital and operating costs for the conversion of RAC equipment manufacturing to flammable refrigerants. There are additional capital and operating costs to incorporate technologies to improve energy efficiency at the same time. The Task Force has provided detailed estimates of these costs.

- Refrigerant cost accounts for ~1% of the overall RAC equipment cost. It is predicted that HFC costs will rise as phasedown progresses and this will make low GWP refrigerants increasingly cost-competitive.
- Compressors account for ~20% of the cost of RAC equipment. Efficiency can be improved by up to 20% by technical advances, but cost increases proportionately.
- Heat exchangers of the "fin and tube" type have improved their efficiency with the introduction of small diameter tubes. Most recently the switch to micro-channel heat exchangers has been accelerating – they have similar or marginally lower cost (~5%) and up to 5% higher efficiency. They reduce the refrigerant charge by ~40%
- Optimising airflow improves EE. The power and cost of fans increase in a stepwise fashion, leading to a complex relationship between increasing cost and EE. The cost effectiveness for optimal EE is determined on a case-by-case basis.
- Other technologies including self-cleaning to reduce dust deposition are a marginal cost.
- At any given time, Life Cycle Cost analysis indicates for both AC and CR, that there is a ceiling of efficiency, above which the energy savings will not payback the higher capital cost within the lifetime of the equipment. As the cost for efficient components and designs decrease over time due to increases in scale of production or learning, the cost of higher efficiency equipment decreases. As this occurs, higher levels of efficiency pay back over shorter periods.

CHAPTER 4: ROLE OF MARKETS IN THE TRANSITION TO ENERGY EFFICIENT RAC EQUIPMENT AND LOW GWP REFRIGERANTS

- Price to consumers is only loosely correlated with EE. Enterprise pricing strategies, and especially the inclusion of features that are irrelevant for EE, influence the price to a greater degree.
- EE measures deliver significant positive environmental impacts and reduces the amount of electricity that needs to be generated to deliver the same level of cooling service. National policies (MEPS, labels, pull-policies) have a significant impact on technology/product availability and price. Individual countries setting long-term targets for energy efficiency alongside the Montreal Protocol/ Kigali Amendment transition, would give their markets a clear trajectory and increase investor confidence that there will be a market for higher-efficiency products
- In addition to focusing on availability or costs, the transition towards energy efficient AC and CR can be accelerated by improving national regulations such as MEPS, market incentivisation, improving servicing capacity and training, as well as promoting financial support for local industry in A5 parties for access to IP and know-how, and capital cost conversion of manufacturing lines.
- Many A5 parties do not have local AC manufacturing and import AC equipment. They may need assistance to develop MEPS and labelling programmes to avoid importing low energy-efficiency AC equipment. For example, of African countries, currently 23 of 54 do not have MEPS. A strategy of early switching towards energy efficient low-GWP AC equipment would bring long-term economic and environmental benefits.
- The transition to lower-GWP and higher efficiency AC equipment can happen together at lower overall cost than otherwise and can be further accelerated by encouraging R&D for new solutions and approaches and through regional and international cooperation and partnerships
- Article 5 parties using HCFC technologies and with low EE or no MEPS regulations have the greatest scope to improve the EE of equipment, compared to countries with high EE MEPS regulations and already using HFCs technologies. They have the opportunity to transition directly to high efficiency/lower GWP equipment while avoiding high-GWP HFCs.
- The adoption of common standards for testing and qualification methods between markets would enable manufacturers to capitalize on scale and accelerate technology readiness. Governments setting testing and performance requirements that are not comparable with main trading partners or suppliers may disadvantage that country economically by delaying the adoption of new energy efficient technologies in that country.
- Awareness influences market and consumer choice. A good consumer communication strategy is critical to increase market penetration of more efficient products.

- International cooperation as well as regional partnerships and the development of similar metrics enable monitoring of the market, which allows an easy comparison of products on the market in different geographic regions.
- The transition can be further accelerated through regional and international cooperation and by encouraging R&D for new solutions and approaches towards low GWP and energy efficient equipment.