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**Montreal Protocol  
on Substances that  
Deplete the Ozone Layer**

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**Open-ended Working Group of the Parties  
to the Montreal Protocol on Substances  
that Deplete the Ozone Layer**  
**Forty-fifth meeting**  
Bangkok, 3–7 July 2023  
Items 3–10 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-fifth meeting**

**Note by the Secretariat**

**I. Introduction**

1. The present note provides an overview of the issues on the provisional agenda of the forty-fifth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. Section II contains a summary of issues for discussion by the Open-ended Working Group. Section III contains information that will not be addressed by the Open-ended Working Group at its forty-fifth meeting but that is relevant to the Thirty-Fifth Meeting of the Parties to the Montreal Protocol, to be held in October 2023, regarding decision XXXIV/7 on strengthening institutional processes with respect to information on HFC-23 by-product emissions, as well as information on the dates and venue of the Thirty-Fifth Meeting of the Parties and associated meetings.

2. Further information on a number of items on the provisional agenda will be provided in addenda to the present note (UNEP/OzL.Pro.WG.1/45/2/Add.1 and Add.2) once the expected 2022 quadrennial assessment and the 2023 reports of the Technology and Economic Assessment Panel (see paras. 46–49 of the present note) have been finalized. Reports of the Panel are anticipated under item 4 of the provisional agenda, on the replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol; item 6, on energy-efficient and low- or zero-global-warming-potential technologies; item 7, on identification of gaps in the global coverage of atmospheric monitoring of controlled substances and options for enhancing such monitoring; item 8, on the Panel's 2023 progress report; and sub-item 8 (a), on nominations for critical-use exemptions for methyl bromide for 2024. The addenda will contain summaries of the reports of the Panel on the relevant issues as well as updates to the information provided by the Secretariat.

3. Issues not directly related to the implementation of the Montreal Protocol or decisions of the parties, but still of possible interest to the parties, will be addressed in an information note on issues that the Secretariat would like to bring to the attention of the parties (UNEP/OzL.Pro.WG.1/45/INF/2). That note will contain information on, among other matters, activities undertaken by the Secretariat, its cooperation with and contributions to the work of the United Nations Environment Programme (UNEP) and other bodies, and the Secretariat's participation in relevant meetings since the Thirty-Fourth Meeting of the Parties, held from 31 October to 4 November 2022.

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\* UNEP/OzL.Pro.WG.1/45/1/Rev.2.

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

### Agenda item 3

#### 2022 quadrennial assessment of the Montreal Protocol (decision XXXI/2)

4. Article 6 of the Montreal Protocol calls for a review, at least once every four years, of the control measures provided for in Article 2 and Articles 2A–2J of the Protocol on the basis of available scientific, environmental, technical and economic information. Pursuant to Article 6 and in accordance with decision XXXI/2,<sup>1</sup> the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the five technical options committees<sup>2</sup> of the Technology and Economic Assessment Panel have completed their 2022 quadrennial assessment reports. The report of the Technology and Economic Assessment Panel itself is expected to be ready by the end of March 2023.

5. At the time of preparation of the present note, the full reports of the Scientific Assessment Panel,<sup>3</sup> the Environmental Effects Assessment Panel<sup>4</sup> and the technical options committees of the Technology and Economic Assessment Panel<sup>5</sup> had been posted on the Secretariat website. Highlights extracted from the reports of the Scientific Assessment Panel and the Environmental Effects Assessment Panel are set out in annexes I and II to the present note, respectively. The key messages of the Technology and Economic Assessment Panel report will be included in the addendum to the present note (UNEP/OzL.Pro.WG.1/45/2/Add.1).

6. Pursuant to paragraph 1 of decision XXXIV/2, the panels are jointly preparing the synthesis report that brings together the main components of each of the individual reports and draws key conclusions. The synthesis report will be available in document UNEP/OzL.Pro.WG.1/45/3.

(a) **Presentations and discussion on issues arising from the 2022 quadrennial assessment and synthesis report of the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the Technology and Economic Assessment Panel**

7. The panels will present the key findings of their assessments to the Open-ended Working Group. Parties may wish to refer to those findings and to the synthesis report to discuss the sub-items under item 3 of the provisional agenda.

(b) **Information on the consumption and production of hydrofluorocarbons not listed in Annex F (decision XXIX/12)**

8. In decision XXIX/12, the assessment panels were requested to provide in their quadrennial reports to be presented in 2023, and every four years thereafter, information on the consumption and production of hydrofluorocarbons (HFCs) not listed in Annex F of the Protocol which have a global warming potential no lower than the lowest global warming potential of the HFCs listed in Annex F to the Protocol, noting that this was for information purposes only, given that the substances referred to in the decision were not included in Annex F.

9. The response to decision XXIX/2 is included in the 2022 quadrennial assessment reports of the Scientific Assessment Panel (in section 2.11, on a summary of findings from previous assessments)<sup>6</sup> and the Medical and Chemicals Technical Options Committee (in section 2.11, on the response to decision XXIX/12, on the consideration of HFCs not listed as controlled substances in Annex F to the Protocol).<sup>7</sup> A summary of the responses will be provided in the addendum to the present note, taking into consideration the relevant messages in the expected report of the Technology and Economic Assessment Panel.

<sup>1</sup> Available at <https://ozone.unep.org/treaties/montreal-protocol/meetings/thirty-first-meeting-parties/decisions/decision-xxxi2-potential>.

<sup>2</sup> Flexible and Rigid Foams Technical Options Committee; Fire Suppression Technical Options Committee; Medical and Chemicals Technical Options Committee; Methyl Bromide Technical Options Committee; Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee.

<sup>3</sup> Available at <https://ozone.unep.org/science/assessment/sap>.

<sup>4</sup> Available at <https://ozone.unep.org/science/assessment/eeap>.

<sup>5</sup> Available at <https://ozone.unep.org/science/assessment/teap>.

<sup>6</sup> Available at <https://ozone.unep.org/system/files/documents/Scientific-Assessment-of-Ozone-Depletion-2022.pdf>.

<sup>7</sup> Available at <https://ozone.unep.org/system/files/documents/MCTOC-Assessment-Report-2022.pdf>.

**(c) Information on the availability of hydrochlorofluorocarbons (decision XXX/2, para. 4)**

10. In paragraph 4 of decision XXX/2, parties requested the Technology and Economic Assessment Panel to provide in its quadrennial reports to be presented in 2023 and 2027 information on the availability of Annex C, Group I substances, including amounts available from recovery, recycling and reclamation, and best-available information on country-level and total known stocks, as well as availability of alternative options for the applications described in Article 2F, paragraphs 6 (a) and 6 (b).

11. A summary of the response of the Technology and Economic Assessment Panel to decision XXX/2 will be provided in the addendum to the present note.

12. In paragraph 5 of decision XXVIII/2 parties requested the Technology and Economic Assessment Panel to conduct a technology review four or five years before 2028 to consider a compliance deferral of two years from the freeze date of 2028 for Article 5 group 2 parties to address growth above a certain threshold in relevant sectors. Parties may wish to consider requesting the Panel to conduct the review next year (i.e., four years prior to 2028), after the consideration of the quadrennial assessment in the current year (2023).

**(d) Update to the report of the working group of the Technology and Economic Assessment Panel on information on alternatives to hydrofluorocarbons (decision XXVIII/2)**

13. At the Twenty-Eighth Meeting of the Parties, held from 10 to 15 October 2016, the parties adopted decision XXVIII/2, related to the amendment on phasing down HFCs (the Kigali Amendment). In paragraph 4 of that decision, the Technology and Economic Assessment Panel was requested to conduct periodic reviews of alternatives in 2022 and every five years thereafter, using the criteria set out in paragraph 1 (a) of decision XXVI/9, on the response to the report by the Panel on information on alternatives to ozone-depleting substances, and to provide technological and economic assessments of the latest available and emerging alternatives to HFCs.

14. According to paragraph 1 (a) of decision XXVI/9, the Panel was to provide updated information on alternatives<sup>8</sup> in various sectors and subsectors, differentiating between parties operating under paragraph 1 of Article 5 (Article 5 parties) and parties not so operating (non-Article 5 parties), considering energy efficiency, regional differences and high-ambient-temperature conditions in particular, and assessing whether those alternatives were (a) commercially available; (b) technically proven; (c) environmentally sound; (d) economically viable and cost effective; (e) safe to use in areas with high urban densities, considering flammability and toxicity issues, including, where possible, risk characterization; and (f) easy to service and maintain. Furthermore, the updated report was to describe the potential limitations of use of identified alternatives and the implications of such limitations for the different sectors, in terms of, but not limited to, servicing and maintenance requirements, and international design and safety standards.

15. In 2022, the Panel had expressed the view that parties had also made a similar request for a review on alternatives to HFCs in paragraph 6 of decision XXXI/2, which set out the terms of reference for the Panel's 2022 quadrennial assessment report, and that the timing of the requested review in 2022 under decision XXVIII/2 was unclear. However, in order to enable parties to consider the matter in 2022, the Panel formed a working group and prepared a report in time for consideration by the Thirty-Fourth Meeting of the Parties, providing an extract of relevant information on alternatives to HFCs as a preview of the 2022 quadrennial assessment reports of the technical options committees in preparation at the time.

16. The quadrennial assessment reports of the technical options committees that have been completed contain more detailed, updated information and analysis on alternatives to HFCs in all relevant sectors.<sup>9</sup>

<sup>8</sup> Para. 1 (a) of decision XXVI/9 referred to alternatives to ozone-depleting substances. In the context of decision XXVIII/2, such a reference applies to alternatives to HFCs.

<sup>9</sup> See chap. 9 of the assessment report of Dec. 2022 of the Fire Suppression Technical Options Committee, available at <https://ozone.unep.org/system/files/documents/FSTOC-2022-Assessment.pdf>; vol. 1 of the assessment report of Jan. 2023 of the Technology and Economic Assessment Panel Flexible and Rigid Foams Technical Options Committee, available at <https://ozone.unep.org/system/files/documents/FTOC-Assessment-Report-2022.pdf>; the assessment report of Dec. 2022 of the Medical and Chemical Technical Options Committee, available at <https://ozone.unep.org/system/files/documents/MCTOC-Assessment-Report-2022.pdf> (chaps. 4, 5, 6, 9 and 10); and the 2022 assessment report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee, available at <https://ozone.unep.org/system/files/documents/RTOC-assessment%20-report-2022.pdf>.

17. During the Thirty-Fourth Meeting of the Parties, parties discussed the issue of aligning the periodic review of alternatives to HFCs with the preparation of the quadrennial assessment reports. Parties expressed the view that if the timing of the two types of reports were to be aligned and the report is presented at the Open-ended Working Group meeting, parties would benefit from a longer period to consider the report before taking it up at the Meeting of the Parties in the same year. It was also mentioned that, in order not to dilute the initial intent of decision XXVIII/2, the issue of the periodic review of alternatives to HFCs should remain a stand-alone item or sub-item on meeting agendas. The parties agreed to defer to 2023 consideration of the possible alignment of future periodic reviews with the quadrennial assessment reports.

18. The Working Group may wish to consider the updated information on alternatives to HFCs provided in the quadrennial assessment reports of the technical options committees, as well as the issue of possibly aligning future periodic reviews and quadrennial assessment reports and recommend a way forward.

**(e) Potential areas of focus for the 2026 quadrennial assessment**

19. Taking into consideration the findings of the 2022 quadrennial assessment, the Open-ended Working Group may wish to discuss the potential areas of focus for the next assessment, with a view to adopting the terms of reference for the next quadrennial assessment at the Thirty-Fifth Meeting of the Parties, in October 2023.

**(f) Future availability of halons and their alternatives (UNEP/OzL.Pro.WG.1/44/4, para. 140)**

20. A summary of the issue of the availability of halons and their alternatives will be provided in an addendum to the present note.

**(g) Any other issues**

21. From the wealth of information provided by the assessment panels in their quadrennial assessment reports, parties may wish to take up other issues not included specifically on the agenda of the forty-fifth meeting of the Open-ended Working Group. Any party wishing to raise any other issues related to the quadrennial assessment reports for discussion at the upcoming meeting is requested raise them at the time of adoption of the agenda at the meeting itself, and to ask for the inclusion of those issues on the agenda, as appropriate.

#### **Agenda item 4**

#### **Report of the Technology and Economic Assessment Panel on the replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol for the period 2024–2026 (decision XXXIV/2)**

22. At the Thirty-Fourth Meeting of the Parties, parties adopted decision XXXIV/2 on the terms of reference for the study on the 2024–2026 replenishment of the Multilateral Fund. In that decision, the Technology and Economic Assessment Panel was requested to prepare a report on the appropriate level of the 2024–2026 replenishment for submission to the Thirty-Fifth Meeting of the Parties through the Open-ended Working Group at its forty-fifth meeting. In preparing the report, the Panel was requested to take into account all control measures and relevant decisions of the parties and the Executive Committee of the Multilateral Fund, including paragraphs 9–25 of decision XXVIII/2 and the decisions of the Thirty-Fourth Meeting of the Parties and the Executive Committee at its meetings up to and including its ninety-second meeting, as relevant.

23. In preparing the report, the Panel was also requested to take into account the special needs of low-volume-consuming and very-low-volume-consuming countries; the need to allocate resources to enable Article 5 parties to comply with all control measures and their commitments under approved hydrochlorofluorocarbon (HCFC) phase-out management plans and the Kigali HFC implementation plans; relevant decisions, rules and guidelines agreed by the Executive Committee at all its meetings, up to and including its ninety-second meeting; the need to allocate resources for activities to maintain and/or enhance energy efficiency while phasing down HFCs, for supporting activities related to gender mainstreaming, and for supporting end-of-life management and disposal of controlled substances; and a scenario to increase funding for institutional strengthening and the compliance assistance programme.

24. The parties also requested the Panel to estimate the funding requirements for HCFC phase-out management plans and Kigali HFC implementation plans independently of the business plans of the

Multilateral Fund and include indicative funding to enable coordinated implementation by Article 5 parties. The Panel was also requested to provide indicative figures for replenishment for the periods 2027–2029 and 2030–2032 to support a stable and sufficient level of funding, on the understanding that those figures would be updated in subsequent replenishment studies.

25. In response to decision XXXIV/2 the Panel established a task force. The report of the task force will be issued as volume 3 of the Panel's 2023 report. A summary of the task force report will be included in the addendum to the present note.

## Agenda item 5

### Strengthening Montreal Protocol institutions, including for combating illegal trade (decision XXXIV/8)

26. At the forty-fourth meeting of the Open-ended Working Group, held in 2022, parties discussed possible ways of dealing with illegal trade and production of controlled substances, based on the information prepared by the Secretariat for the Implementation Committee under the Non-Compliance Procedure for the Montreal Protocol in 2019 and contained in annexes II and III to the report of the sixty-third meeting of the Committee.<sup>10</sup> At that meeting, the Open-ended Working Group discussed the issues in plenary sessions and informal group sessions. A list of ideas for areas of improvement was developed and forwarded to the Thirty-Fourth Meeting of the Parties.<sup>11</sup> At the Thirty-Fourth Meeting of the Parties, parties discussed and adopted two decisions: (a) decision XXXIV/8 on strengthening Montreal Protocol institutions, including for combating illegal trade; and (b) decision XXXIV/7 on strengthening institutional processes with respect to information on HFC-23 by-product emissions (see paras. 81 and 82 of the present note).

27. In decision XXXIV/8, the Thirty-Fourth Meeting of the Parties set out several measures to combat illegal trade, including urging parties to introduce in their national customs classification system separate subdivisions for HFCs and blends; and encouraging parties to facilitate the exchange of information and strengthen joint efforts to improve means of identification and prevention of illegal trade and to report to the Secretariat fully proven cases of illegal trade.

28. In paragraph 4 of the same decision, the Secretariat was requested to:

- (a) Compile and regularly summarize the practices of illegal trade reported under paragraph 3 of the same decision, as well as the approaches taken by national authorities to identify and address such cases;
- (b) Identify common features of licensing systems to assist parties wishing to improve their national licensing systems for controlled substances;
- (c) Organize a one-day workshop on further strengthening effective implementation and enforcement of the Montreal Protocol, back-to-back with the forty-fifth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol;
- (d) Prepare a background information paper outlining issues to be discussed at the workshop and reflecting discussions at the forty-fourth meeting of the Open-ended Working Group and the Thirty-Fourth Meeting of the Parties for consideration at the forty-fifth meeting of the Open-ended Working Group.

29. In accordance with paragraph 4 (c) of decision XXXIV/8, the Secretariat is preparing for the workshop on strengthening effective implementation and enforcement of the Montreal Protocol, to be convened on 2 July 2023. The concept note<sup>12</sup> containing the provisional programme will be posted on the meeting portal for the workshop<sup>13</sup> by early April.

30. As requested in paragraph 4 (d) of the same decision, the Secretariat is preparing a background information paper on issues to be discussed at the workshop as a note by the Secretariat<sup>14</sup> for the

<sup>10</sup> Annexes II and III to the report of the sixty-third meeting of the Implementation Committee (UNEP/OzL.Pro/ImpCom/63/6) were reproduced for the forty-fourth meeting of the Open-ended Working Group, in document UNEP/OzL.Pro.WG.1/44/3, and for the Thirty-Fourth Meeting of the Parties, in document UNEP/OzL.Pro/34/8.

<sup>11</sup> UNEP/OzL.Pro.WG.1/44/4, annex II, sect. B.

<sup>12</sup> UNEP/OzL.Pro/Workshop.11/1.

<sup>13</sup> <https://ozone.unep.org/meetings/workshop-strengthening-effective-implementation-and-enforcement-montreal-protocol>.

<sup>14</sup> UNEP/OzL.Pro/Workshop.11/2–UNEP/OzL.Pro.WG.1/45/5.

workshop as well as for the forty-fifth meeting of the Open-ended Working Group. The Secretariat is also preparing information on illegal trade and licensing systems pursuant to sub-paragraphs 4 (a) and 4 (b) of the decision, respectively, with a view to making this information available for the workshop as addenda to the note by the Secretariat. For this purpose, the Secretariat has requested parties to submit relevant information to help with the required analyses.

**(a) Outcomes of the workshop on strengthening the effective implementation and enforcement of the Montreal Protocol (UNEP/OzL.Pro/Workshop.11/3–UNEP/OzL.Pro.WG.1/45/6)**

31. The key outcomes of the workshop will be summarized and issued as a meeting document<sup>15</sup> for the forty-fifth meeting of the Open-ended Working Group. The Working Group may wish to discuss the outcomes and develop a way forward as appropriate.

**(b) Background documents prepared by the Secretariat in accordance with decision XXXIV/8 (UNEP/OzL.Pro/Workshop.11/2–UNEP/OzL.Pro.WG.1/45/5, UNEP/OzL.Pro/Workshop.11/2/Add.1–UNEP/OzL.Pro.WG.1/45/5/Add.1 and UNEP/OzL.Pro/Workshop.11/2/Add.2–UNEP/OzL.Pro.WG.1/45/5/Add.2)**

32. During the one-day workshop, not all the relevant issues may be adequately covered. Under this sub-item, the Open-ended Working Group may wish to discuss further and in more detail any issues covered in the background documents prepared by the Secretariat for the workshop and the Open-ended Working Group, with a view to developing appropriate recommendations on the matters in question.

## **Agenda item 6**

### **Energy-efficient and low- or zero-global-warming-potential technologies**

**(a) Report by the Technology and Economic Assessment Panel (decision XXXIV/3)**

33. At the Thirty-Fourth Meeting of the Parties, the parties discussed in plenary and contact group sessions two draft decisions on issues related to energy efficiency that took into account the report prepared by the energy efficiency task force of the Technology and Economic Assessment Panel in response to decision XXXIII/5 on the continued provision of information on energy-efficient and low-global-warming-potential technologies,<sup>16</sup> as well as the list of feedback and ideas for further work arising from the Panel's report as developed by the contact group at the forty-fourth meeting of the Open-ended Working Group. The discussions resulted in the adoption of decision XXXIV/3 on enabling enhanced access and facilitating the transition to energy-efficient and low- or zero-global-warming-potential technologies.

34. In decision XXXIV/3, the Technology and Economic Assessment Panel was requested to include in its 2023 progress report information on:

- (a) Enhancements in energy efficiency associated with improvements in appliance foams;
- (b) Updates relating to the availability, accessibility, electrical compatibility and cost of energy-efficient products and equipment containing low- or zero-global-warming-potential refrigerants;
- (c) Testing equipment and procedures for validation of energy efficiency claims to enforce minimum energy efficiency standards and labels, and voluntary labelling programmes;
- (d) Barriers to consumer and business acceptance of the adoption of more energy-efficient products and equipment containing low- or zero-global-warming-potential refrigerants;
- (e) Analysis of the potential benefits of introducing more energy-efficient refrigeration, air-conditioning and heat pump equipment, including costs and related climate benefits;
- (f) The range of, and trends in, the global warming potential and energy efficiency of refrigeration, air-conditioning and heat pump equipment for which there are available data.

35. A summary of the report by the Panel will be included in the addendum to the present note.

<sup>15</sup> UNEP/OzL.Pro/Workshop.11/3–UNEP/OzL.Pro.WG.1/45/6.

<sup>16</sup> Vol. 3 of the 2022 report of the Technology and Economic Assessment Panel (May 2022), available at <https://ozone.unep.org/system/files/documents/TEAP-EETF-report-may-2022.pdf>.

**(b) Illegal import of certain refrigeration, air-conditioning and heat pump products and equipment (decision XXXIV/4)**

36. At the Thirty-Third Meeting of the Parties, held in 2021, and subsequently at the forty-fourth meeting of the Open-ended Working Group and the Thirty-Fourth Meeting of the Parties, a proposal by a group of African States on the issue of dumping of obsolete, new and used cooling appliances in African and other developing countries through exports by parties that had transitioned to more efficient, lower-global-warming-potential refrigerants was discussed. After extensive discussion in plenary and contact group sessions in 2022, parties adopted decision XXXIV/4 on the illegal import of certain refrigeration, air-conditioning and heat pump products and equipment.

37. Decision XXXIV/4 invited parties that had restricted the manufacture and/or import of certain refrigeration, air-conditioning and heat pump products and equipment containing or relying on controlled substances, including with respect to energy efficiency, and that did not want to receive such products and equipment from other parties against payment or free of charge, to submit to the Secretariat by 1 May 2023 the following information:

(a) The types of products and equipment concerned, including their codes in the Harmonized Commodity Description and Coding System, where applicable;

(b) The specific domestic restrictions on the controlled substances (i.e., maximum global warming potential of HFCs permitted to be used) for each category of product and equipment;

(c) The minimum energy efficiency performance standard permitted under domestic legislation for each category of product and equipment;

(d) Any attempted illegal imports of such restricted products and equipment to their countries.

38. In the same decision, the parties decided to consider this issue at the Thirty-Fifth Meeting of the Parties and to include the item on the agenda of the forty-fifth meeting of the Open-ended Working Group, taking into account the information submitted to the Secretariat.

39. At the time of preparation of the present note, the Secretariat had not yet received any submissions. Any update on the matter will be provided in the addendum to the present note.

**Agenda item 7****Identification of gaps in the global coverage of atmospheric monitoring of controlled substances and options for enhancing such monitoring**

40. At the Thirty-Third Meeting of the Parties, parties adopted decision XXXIII/4 on enhancing the global and regional atmospheric monitoring of substances controlled by the Montreal Protocol, in which the parties requested the Ozone Secretariat, in consultation with relevant experts from the Scientific Assessment Panel, the Technology and Economic Assessment Panel and the Ozone Research Managers, to provide the following information to the parties at the forty-fifth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol, to be held in 2023, and to report on the progress of work at the forty-fourth meeting of the Open-ended Working Group:

(a) Options for the regional monitoring of atmospheric concentrations of substances controlled by the Montreal Protocol, based on the existing information provided by the Scientific Assessment Panel and the Ozone Research Managers, and the challenges for operationalizing relevant recommendations;

(b) The identification of suitable locations for possible high-frequency measurements and flask sampling for regions not, or not sufficiently, covered by existing atmospheric monitoring, with a view to strengthening monitoring capacity and networks;

(c) Options for possible means of establishing new monitoring capacity and related costs, taking into account existing monitoring infrastructure.

41. At the forty-fourth meeting of the Open-ended Working Group, the Secretariat presented a progress report<sup>17</sup> in response to decision XXXIII/4. The Secretariat's report included information on the implementation of the pilot project developed by the Secretariat in 2021 and funded by the European Union on the regional quantification of emissions of controlled substances. As requested by the Open-ended Working Group at its forty-fourth meeting, the Secretariat provided an update to its

<sup>17</sup> UNEP/OzL.Pro.WG.1/44/2/Add.1, paras. 5–10.

progress report in an addendum to a note by the Secretariat<sup>18</sup> for the Thirty-Fourth Meeting of the Parties.

42. At the forty-fourth meeting of the Open-ended Working Group, the European Union introduced a proposal on identifying sources of emissions originating from industrial processes. The proposal was subsequently discussed at the Thirty-Fourth Meeting of the Parties, which adopted decision XXXIV/5, in which it requested the Technology and Economic Assessment Panel to prepare a report for the forty-fifth meeting of the Open-ended Working Group (see paras. 44 and 45, below).

**(a) Report by the Secretariat (decision XXXIII/4)**

43. As requested by the parties in decision XXXIII/4, the Secretariat will include the final report on the issues specified in the same decision in the addendum to the present note. In addition, a presentation will be delivered at the forty-fifth meeting of the Open-ended Working Group.

44. The Working Group may wish to discuss the issues and recommend a way forward, as appropriate.

**(b) Report by the Technology and Economic Assessment Panel (decision XXXIV/5)**

45. At their Thirty-Fourth Meeting of the Parties, the parties adopted decision XXXIV/5, in which it requested the Technology and Economic Assessment Panel to prepare a report for the forty-fifth meeting of the Open-ended Working Group on:

- (a) Chemical pathways in which substantial emissions of controlled substances are likely to occur;
- (b) Best practices available to control these emissions;
- (c) Gaps in understanding the sources of emissions referred to in point (a), above.

46. That report of the Technology and Economic Assessment Panel is expected to be included in the Panel's 2023 progress report. A summary of the report will be included in the addendum to the present note.

## **Agenda item 8**

### **Technology and Economic Assessment Panel 2023 progress report**

47. The following volumes of the Technology and Economic Assessment Panel 2023 report are expected to be issued in May 2023:

- (a) Volume 1: Technology and Economic Assessment Panel 2023 progress report;
- (b) Volume 2: Evaluation of 2023 critical-use nominations for methyl bromide – interim report;
- (c) Volume 3: Decision XXXIV/2 task force report on the terms of reference for the study on the 2024–2026 replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol.

48. When the reports become available, they will be posted on the portal of the forty-fifth meeting of the Open-ended Working Group.

49. Under item 8 of the provisional agenda, the Panel will present volumes 1 and 2 of its 2022 report, in relation to sub-items (a), (b), (c), (d), (e) and (f):

- (a) Nomination for critical-use exemption for methyl bromide for 2024;
- (b) Ongoing emissions of carbon tetrachloride (decision XXXIV/6);
- (c) Quarantine and pre-shipment uses of methyl bromide for which alternatives are available (decision XXXIV/10, para. 4);
- (d) Existing challenges and potential options for the future configuration and function of Panel technical options committees (XXXIV/11, paragraph 1);
- (e) Panel membership changes;

<sup>18</sup> UNEP/OzL.Pro.34/2/Add.1.



(f) Any other issues.

50. The information and recommendations of the Panel relevant to the above-mentioned sub-items, as well as key findings and messages relating to other issues that the Panel brings to the attention of the parties, will be summarized in the addendum to the present note.

**(a) Nomination for critical-use exemptions for methyl bromide for 2024**

51. In 2023, one non-Article 5 party (Canada) submitted one nomination for a critical-use exemption for 2024.

52. During its meeting to be held from 13 to 17 March 2023 in Philadelphia, United States of America, the Methyl Bromide Technical Options Committee will review, among other things, the critical-use nomination and any additional information submitted by the nominating party. The interim recommendation on the quantity of methyl bromide eligible for exemption will be included in the report of the Committee, to be made available in volume 2 of the 2023 report of the Technology and Economic Assessment Panel. The recommendation, which is expected to be finalized in mid-May 2023, will be summarized in the addendum to the present note (UNEP/OzL.Pro.WG.1/45/2/Add.1) for consideration by the Open-ended Working Group.

**(b) Ongoing emissions of carbon tetrachloride (decision XXXIV/6)**

53. At the Thirty-Fourth Meeting of the Parties, parties adopted decision XXXIV/6 on ongoing emissions of carbon tetrachloride after extensive discussions in 2019 and 2022 as well as intersessional efforts led by Switzerland, the proponent of the proposal.

54. In decision XXXIV/6, the Thirty-Fourth Meeting of the Parties invited parties that have production of carbon tetrachloride, as well as by-production, or use of carbon tetrachloride as a feedstock for other substances or as a process agent, to provide to the Ozone Secretariat on a voluntary basis, by 1 February 2023, information on the national procedures and frameworks in place for the management of such activities in their respective countries. In the decision, the Secretariat was also requested to share with the Technology and Economic Assessment Panel the information received from the parties, and the Technology and Economic Assessment Panel was requested to review the information received and to present that information in its 2023 progress report for consideration by the Open-ended Working Group at its forty-fifth meeting.

55. The Secretariat sent a letter requesting the relevant information to 15 parties that have reported carbon tetrachloride production in the last 10 years. The Secretariat received responses from four parties, namely China, the European Union, the United Kingdom of Great Britain and Northern Ireland and the United States of America. Some of the producer parties from the European Union explicitly wrote to confirm that the submission by the European Union was to be considered to include their input. The submissions were all forwarded to the Technology and Economic Assessment for its review and presentation in the 2023 progress report.

56. A summary of the report by the Panel on its review of the submissions by the parties, prepared as part of its progress report, will be included in the addendum to the present note.

**(c) Quarantine and pre-shipment uses of methyl bromide for which alternatives are available (decision XXXIV/10, para. 4)**

57. At the forty-fourth meeting of the Open-ended Working Group and the Thirty-Fourth Meeting of the Parties, a proposed draft decision on the issue of stocks and quarantine and pre-shipment uses of methyl bromide was discussed. After discussions in plenary sessions and informal and contact group sessions at both meetings, decision XXXIV/10 was adopted.

58. In paragraph 1 of decision XXXIV/10 on stocks and quarantine and pre-shipment uses of methyl bromide, parties were invited to submit to the Ozone Secretariat, on a voluntary basis, by 1 June 2023, a list of the pest and commodity combinations in which methyl bromide is needed or used in their respective countries. At the time of drafting of the present note, the Secretariat had not received any submissions. An update on the matter will be provided in the addendum to the present note.

59. In paragraph 4 of the same decision, parties requested the Technology and Economic Assessment Panel and its Methyl Bromide Technical Options Committee, in consultation with the secretariat of the International Plant Protection Convention, to provide updated information, as part of its progress report to the Open-ended Working Group at its forty-fifth meeting, on current quarantine and pre-shipment uses for which alternatives are available.

60. Furthermore, in paragraph 5 of the decision, parties were invited to take into account the standards and guidelines under the International Plant Protection Convention in their national processes and to consider the potential for uptake of practices to minimize the use of methyl bromide.

61. A summary of the updated information requested in paragraph 4 of decision XXXIV/10, as contained in the progress report of the Panel, will be included in the addendum to the present note.

**(d) Existing challenges and potential options for the future configuration and function of Panel technical options committees (decision XXXIV/11, para. 1)**

62. The parties discussed the issue of the restructuring of the Technology and Economic Assessment Panel and its technical options committees at the Thirty-Fourth Meeting of the Parties, on the basis of a proposed draft decision by Morocco, which was first submitted in 2020 and resubmitted for discussion at the forty-fourth meeting of the Open-ended Working Group, on recommendations and explanations provided by the Technology and Economic Assessment Panel, and on the basis of other ideas that parties had put forward during the forty-fourth meeting.

63. At the Thirty-Fourth Meeting of the Parties, the parties addressed the matter, taking into account whether there were any alternative solutions to the challenges and means of ensuring the availability of sufficient expertise on new issues such as energy efficiency and with a view to ensuring that the work of the Technology and Economic Assessment Panel and its technical options committees remained in line with the needs of parties.

64. The Thirty-Fourth Meeting of the Parties adopted decision XXXIV/11, in which the parties requested the Technology and Economic Assessment Panel, including through consultation by the co-chairs of the technical options committees with their members, to provide more information on existing challenges and potential options for the future configuration and function of its technical options committees, for consideration by the Open-ended Working Group of the Parties to the Montreal Protocol at its forty-fifth meeting, taking into account:

(a) Discussions and questions raised by parties at the forty-fourth meeting of the Open-ended Working Group and the Thirty-Fourth Meeting of the Parties concerning the Panel's recommendations in its 2022 progress report;<sup>19</sup>

(b) The fact that the vast majority of HFC uses are in the refrigeration, air-conditioning and heat-pump sector;

(c) Expertise required to provide technical and cost-related information to the parties, including in the context of implementation of the Kigali Amendment;

(d) Guidance provided in its terms of reference;

(e) The need to ensure continued collaboration and coordination across the technical options committees.

65. In paragraph 2 of the same decision, the Halons Technical Options Committee was renamed the Fire Suppression Technical Options Committee.

66. A summary of the Panel's report on the matter will be included in the addendum to the present note.

**(e) Panel membership changes**

67. Volume 1 of the 2023 report of the Technology and Economic Assessment Panel (the progress report) is expected to contain information on the membership of the Technology and Economic Assessment Panel and its technical options committees, including the term of appointment of each member; the expertise available in each committee; and the matrix of needed expertise of the Panel and its technical options committees. As requested in decision XXXI/8, entitled "Terms of reference of the Technology and Economic Assessment Panel and its technical options committees and temporary subsidiary bodies – procedures relevant to nominations", the Panel is expected to provide,

<sup>19</sup> Discussions under agenda item 11 of the Thirty-Fourth Meeting of the Parties, on strengthening the Technology and Economic Assessment Panel and its technical options committees for the phase-down of hydrofluorocarbons and other future challenges related to the Montreal Protocol and the climate, are covered in the report of the Thirty-Fourth Meeting of the Parties (UNEP/OzL.Pro.34/9, sect. IX). Questions raised by parties at the forty-fourth meeting of the Open-ended Working Group and the Thirty-Fourth Meeting of the Parties concerning the Panel's recommendations in its 2022 progress report are available on the portal for the contact group on restructuring the Panel, at <https://ozone.unep.org/meetings/thirty-fourth-meeting-parties/contact-groups/restructuring-teaptocs>.

in its 2023 report, a summary outlining the procedures that the Panel and its technical options committees have undertaken to ensure adherence to the Panel's terms of reference through clear and transparent procedures.

68. Information about changes in membership of the Technology and Economic Assessment Panel will be summarized in the addendum to the present note for consideration by the Open-ended Working Group.

**(f) Any other issues**

69. Volume 1 of the 2022 report of the Technology and Economic Assessment Panel (the progress report) is expected to contain information and key messages on various other issues, including organizational and administrative matters related to the Panel and its technical options committees. The Secretariat will summarize important issues raised by the Panel that may require the attention of the parties in the addendum to the present note.

70. Any party wishing to raise any other issues related to the Panel's progress report for discussion at the forty-fifth meeting of the Open-ended Working Group is requested to raise them at the time of adoption of the agenda at the meeting itself, and to ask for the inclusion of those issues on the agenda, as appropriate.

**Agenda item 9**

**Stocks of methyl bromide (decision XXXIV/10, para. 3)**

71. Parties adopted decision XXXIV/10, on stocks and quarantine and pre-shipment uses of methyl bromide, at the Thirty-Fourth Meeting of the Parties, after extensive discussions in plenary sessions and informal group and contact group sessions during 2022 at both the forty-fourth meeting of the Open-ended Working Group and the Thirty-Fourth Meeting of the Parties.

72. In paragraph 2 of decision XXXIV/10, parties were invited to submit, on a voluntary basis, accessible data on the volumes of pre-phase-out methyl bromide stocks at the country level to the Ozone Secretariat by 1 June 2023. At the time of drafting of the present note, the Secretariat had received a submission from one party, Australia. An update on the matter will be provided in the addendum to the present note.

73. In paragraph 3 of decision XXXIV/10, parties decided to include the issue of methyl bromide stocks in the agenda of the forty-fifth meeting of the Open-ended Working Group.

74. The Open-ended Working Group may wish to discuss the issue and recommend a way forward as appropriate.

**Agenda item 10**

**Potential impacts of the coronavirus disease (COVID-19) pandemic on hydrofluorocarbon consumption for Group 1 parties operating under paragraph 1 of Article 5 (decision XXXIV/13)**

75. During the closing session of the forty-fourth meeting of the Open-ended Working Group, the representative of Cuba spoke about the impact of the COVID-19 pandemic on HFC baselines for Article 5 parties and proposed that the issue be placed on the agenda of the Thirty-Fourth Meeting of the Parties. At the Thirty-Fourth Meeting of the Parties, a draft decision introduced by Cuba was discussed extensively in both plenary and informal group sessions, after which parties adopted decision XXXIV/13, on collecting data to understand potential impacts of the COVID-19 pandemic on HFC consumption for Group 1 parties operating under paragraph 1 of Article 5.

76. Decision XXXIV/13 encouraged Article 5 parties that believed that their reduced consumption of HFCs during the baseline years of 2020–2022, stemming from the effects of the COVID-19 pandemic, could hinder their ability to comply with the freeze in the consumption of HFCs in 2024 under the Kigali Amendment, to submit to the Ozone Secretariat as soon as possible, and no later than 1 May 2023, their HFC consumption data for 2022, in time for consideration at the forty-fifth meeting of the Open-ended Working Group.

77. Based on the data received by 1 May 2023, the Ozone Secretariat was requested to prepare for consideration at the forty-fifth meeting of the Open-ended Working Group:

- (a) Information on the HFC consumption for the years 2020, 2021 and 2022 and the calculated baselines of Group 1 Article 5 parties that have reported relevant data;
  - (b) Information on the HFC consumption for the years 2018 and 2019 of Group 1 Article 5 parties where information is available.
78. At the time of drafting of the present note, the Secretariat had received Article 7 data for 2022 from 15 Article 5 parties.
79. In decision XXXIV/13, the Executive Committee was requested to consider requesting the secretariat of the Multilateral Fund to provide to the Ozone Secretariat any HFC consumption data it had available that could assist in the preparation of the above-mentioned information. The Ozone Secretariat received the relevant HFC data from the Fund secretariat on 22 December 2022 and will seek an updated report in May 2023.
80. The Secretariat will issue its information on the HFC consumption of relevant Group 1 Article 5 parties in document UNEP/OzL.Pro.WG.1/45/4 for discussion by the Open-ended Working Group.
81. Any updates on the matter will be provided in the addendum to the present note.

### **III. Issues relevant to the Thirty-Fifth Meeting of the Parties, including updates on the implementation of previous decisions**

#### **A. Strengthening institutional processes with respect to information on HFC-23 by-product emissions (decision XXXIV/7)**

82. At the Thirty-Fourth Meeting of the Parties, the parties adopted decision XXXIV/7, in which they requested the Technology and Economic Assessment Panel to prepare a report for the Thirty-Fifth Meeting of the Parties, including:
- (a) Information on the possible chemical pathways that could be used in the production of Annex C, Group I, or Annex F substances that might generate HFC-23 as a by-product;
  - (b) Compilation of information on the amount of HFC-23 generation and emissions from facilities that manufacture Annex C, Group I, or Annex F substances, the reporting of which is required under Article 7 of the Montreal Protocol;
  - (c) Best practices available to control these emissions.
83. The issue will be included on the agenda of the Thirty-Fifth Meeting of the Parties. The report by the Panel is expected to be available around mid-September 2023, and a summary of the report will be included in the note by the Secretariat for the Thirty-Fifth Meeting of the Parties.

#### **B. Thirty-Fifth Meeting of the Parties to the Montreal Protocol**

84. As was announced in an email disseminated by the Secretariat on 16 January 2023, the Thirty-Fifth Meeting of the Parties will be held in Nairobi from 23 to 27 October 2023, as decided by the parties in decision XXXIV/23. Associated meetings that will take place in Nairobi in conjunction with the Thirty-Fifth Meeting of the Parties are:
- (a) The seventy-first meeting of the Implementation Committee, to be held on 21 October 2023;
  - (b) The workshop on issues related to energy efficiency, called for by the parties in decision XXXIV/3, to be held on 22 October 2023.

## Annex I\*

## HIGHLIGHTS

### Scientific Assessment of Ozone Depletion: 2022

*Science has been one of the foundations of the Montreal Protocol's success. This document highlights advances and updates in the scientific understanding of ozone depletion since the 2018 Scientific Assessment of Ozone Depletion and provides policy-relevant scientific information on current challenges and future policy choices.*

#### I. Major achievements of the Montreal Protocol

- Actions taken under the Montreal Protocol continued to decrease atmospheric abundances of controlled ozone-depleting substances (ODSs) and advance the recovery of the stratospheric ozone layer. The atmospheric abundances of both total tropospheric chlorine and total tropospheric bromine from long-lived ODSs have continued to decline since the 2018 Assessment. New studies support previous Assessments in that the decline in ODS emissions due to compliance with the Montreal Protocol avoids global warming of approximately 0.5–1 °C by mid-century compared to an extreme scenario with an uncontrolled increase in ODSs of 3–3.5% per year.
- Actions taken under the Montreal Protocol continue to contribute to ozone recovery. Recovery of ozone in the upper stratosphere is progressing. Total column ozone (TCO) in the Antarctic continues to recover, notwithstanding substantial interannual variability in the size, strength, and longevity of the ozone hole. Outside of the Antarctic region (from 90°N to 60°S), the limited evidence of TCO recovery since 1996 has low confidence. TCO is expected to return to 1980 values around 2066 in the Antarctic, around 2045 in the Arctic, and around 2040 for the near-global average (60°N–60°S). The assessment of the depletion of TCO in regions around the globe from 1980–1996 remains essentially unchanged since the 2018 Assessment.
- Compliance with the 2016 Kigali Amendment to the Montreal Protocol, which requires phase down of production and consumption of some hydrofluorocarbons (HFCs), is estimated to avoid 0.3–0.5°C of warming by 2100. This estimate does not include contributions from HFC-23 emissions.

#### II. Current scientific and policy challenges

- The recent identification of unexpected CFC-11 emissions led to scientific investigations and policy responses. Observations and analyses revealed the source region for at least half of these emissions and substantial emissions reductions followed. Regional data suggest some CFC-12 emissions may have been associated with the unreported CFC-11 production. Uncertainties in emissions from banks and gaps in the observing network are too large to determine whether all unexpected emissions have ceased.
- Unexplained emissions have been identified for other ODSs (CFCs-13, 112a, 113a, 114a, 115, and CC14), as well as HFC-23. Some of these unexplained emissions are likely occurring as leaks of feedstocks or by-products, and the remainder is not understood.
- Outside of the polar regions, observations and models are in agreement that ozone in the upper stratosphere continues to recover. In contrast, ozone in the lower stratosphere has not shown signs of recovery. Models simulate a small recovery in mid-latitude lower-stratospheric ozone in both hemispheres that is not seen in observations. Reconciling this discrepancy is key to ensuring a full understanding of ozone recovery.
- The existing network of atmospheric monitoring stations provides measurements of global surface concentrations of long-lived ODSs and HFCs resulting from anthropogenic emissions. However, gaps in regional atmospheric monitoring limit the scientific community's ability to identify and quantify emissions of controlled substances from many source regions.

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\* The annex has not been formally edited.

- Several space-borne instruments providing vertically resolved, global measurements of ozone-related atmospheric constituents (e.g., reactive chlorine, water vapor, and long-lived transport tracers) are due to be retired within a few years. Without replacements of these instruments, the ability to monitor and explain changes in the stratospheric ozone layer in the future will be impeded.
- The impact on the ozone layer of stratospheric aerosol injection (SAI), which has been proposed as a possible option to offset global warming, has been assessed following the terms of reference for the 2022 SAP Assessment Report. Important potential consequences, such as deepening of the Antarctic ozone hole and delay in ozone recovery, were identified. Many knowledge gaps and uncertainties prevent a more robust evaluation at this time.
- Heightened concerns about influences on 21st century ozone include impacts of: further increases in nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>), and CO<sub>2</sub> concentrations; rapidly expanding ODS and HFC feedstock use and emissions; climate change on TCO in the tropics; extraordinary wildfires and volcanic eruptions; increased frequency of civilian rocket launches and the emissions of a proposed new fleet of supersonic commercial aircraft.

### III. Future policy considerations

- If ODS feedstock emissions as currently estimated were to be eliminated in future years, the return of mid-latitude Equivalent Effective Stratospheric Chlorine (EESC) to 1980 abundances could be advanced by almost 4 years, largely due to reductions in CCl<sub>4</sub>, and thereby reduce total climate forcing from ODSs.
- Eliminating future emissions of methyl bromide (CH<sub>3</sub>Br) from quarantine and pre-shipment applications currently allowed by the Montreal Protocol would accelerate the return of mid-latitude EESC to 1980 abundances by two years (as noted in previous Assessments).
- Emissions of anthropogenic very short-lived chlorine substances, dominated by dichloromethane (CH<sub>2</sub>Cl<sub>2</sub>), continue to grow and contribute to ozone depletion. If CH<sub>2</sub>Cl<sub>2</sub> emissions continue at their current level, they will continue to deplete approximately 1 DU of annually averaged global TCO. Elimination of these emissions would rapidly reverse this depletion.
- A 3% reduction in anthropogenic N<sub>2</sub>O emissions, averaged over 2023–2070, would lead to an increase in annually averaged global TCO of about 0.5 DU over the same period, and a decrease of about 0.04 Wm<sup>-2</sup> in radiative forcing, averaged over 2023–2100.
- Global emissions of long-lived HFC-23, which are largely a by-product of HCFC-22 production, are as much as eight times larger than expected and are likely to grow unless abatement increases during HCFC-22 production or feedstock use of HCFC-22 decreases.
- The current combined GWP-weighted emissions of CFCs plus HCFCs are comparable to those of HFCs. Reductions in the future emissions of CFCs and HCFCs requires addressing releases from banks and continuing production and use in allowed manufacturing of feedstocks, in by-products, or in unknown uses, depending upon the compound.

## Annex II\*\*

## HIGHLIGHTS

## Environmental Effects Assessment Panel 2022 Quadrennial Assessment

### Environmental effects of stratospheric ozone depletion, ultraviolet radiation, and interactions with climate change

*The highlights of the 2022 Quadrennial Assessment focus on major findings since the last assessment, acknowledging the contribution of the Montreal Protocol to several of the United Nations Sustainable Development Goals and the alignment of the Panel with these Goals. The strong interconnected effects of stratospheric ozone depletion, ultraviolet (UV) radiation, and climate change are increasingly evident and complex, with consequences for life on Earth and a sustainable future. Within this context, current and projected consequences for human health including the COVID-19 pandemic, terrestrial and aquatic ecosystems, air quality, natural and synthetic materials, and microplastics identified in this assessment are summarised below.*

## I. Ultraviolet radiation, stratospheric ozone depletion, and climate change

- Concentrations of stratospheric ozone in the future will depend on the decrease in ozone-depleting substances (ODSs) controlled by the Montreal Protocol, other substances currently not controlled, and on emissions of greenhouse gases, such as carbon dioxide, methane and nitrous oxide. The trajectory of these emissions depends greatly on policy decisions.
- Large variability of UV radiation was observed during the 2020 Antarctic and Arctic springs, when the UV Index increased to 80% and 70%, respectively, above the historical means.
- These anomalously high amounts of UV radiation in the Antarctic, which extended over spring and the start of summer, may have had negative consequences for migrating animals returning to breed, and which may not be adapted to the unusually high UV irradiation.
- Increasing warming will lead to more ice melt and increased exposure of ecosystems to UV radiation on land and in water bodies especially in polar and high elevation regions.
- Thawing of permafrosts will result in the release of UV-absorbing organic carbon into aquatic ecosystems and enhanced emissions of carbon dioxide and methane to the atmosphere.
- The concurrence of heat waves with drought and high UV-B irradiance (280-315 nm) may negatively affect food security and biodiversity of crops and animals. These climatic conditions can disrupt formerly favourable habitats and may shift habitats to locations with different conditions, to which plants and animals may not be adapted. Tropical coral reefs under naturally high UV irradiance are of particular concern, since an increase in sea surface temperatures of 1 °C to 2 °C can cause bleaching of corals, enhanced by high amounts of UV radiation.

## II. Human health

- Exposure to UV radiation has multiple harms and benefits. Harms include skin cancer, inflammatory skin disorders, sunburn, and eye disorders such as cataract. Benefits include production of vitamin D, reduced autoimmune disease and, possibly, lowered blood pressure and decreased risk of metabolic disorders.
- The Montreal Protocol has resulted in significant reductions in UV-related diseases. The United States Environmental Protection Agency has estimated that, due to the Montreal Protocol, 11 million cases of melanoma, 432 million cases of keratinocyte skin cancers, and 63 million cases of cataract will have been avoided for those born between 1890 and 2100 in the United States.

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\*\* The annex has not been formally edited.

- The Montreal Protocol may have benefits for UV-induced inflammatory skin disorders. In some people these lead to large decreases in quality of life. Many diuretic and anti-inflammatory drugs can cause photosensitivity when skin is exposed to UV radiation, although the global incidence of drug-induced photosensitivity is unclear. Some drugs such as hydrochlorothiazide (HCTZ, used for decreasing blood pressure) may increase the risk of keratinocyte skin cancer through UV-induced DNA damage.
- By avoiding large increases in the UV Index, the Montreal Protocol may have enabled people, especially those with light skin, to spend time outdoors without incurring sunburn, thereby gaining the benefits of sun exposure. These include those arising from the generation of vitamin D in the skin. Vitamin D is important for musculoskeletal health, and there are increasing indications of benefits for diseases related to immune function, including autoimmune diseases (e.g., multiple sclerosis), infection, and for cardiovascular disease, cancer mortality, and all-cause mortality.
- Decreases in UV radiation under the Montreal Protocol may have resulted in a lower rate at which pathogens are inactivated, including the SARS-CoV-2 virus responsible for COVID-19. However, the positive outcomes of the Montreal Protocol outweigh any potential advantage for disinfection by higher amounts of solar UV radiation.

### **III. Role of UV radiation in the troposphere**

- Outdoor air pollution (e.g., from sulfate, nitrate, ozone, and particulate matter) results in ca 4 million premature deaths per year, and also damages vegetation and crops.
- Increasing concentrations of greenhouse gases are partly responsible for enhanced atmospheric circulation resulting in a downward transport of additional ozone ('good' UV-B-absorbing ozone) from the stratosphere to the troposphere ('bad' ozone, part of smog).
- In the troposphere (the layer of the atmosphere extending from the Earth's surface to a height of 8-15 km), UV-B radiation generates the cleaning agent of the atmosphere, the hydroxyl radical (OH). This radical removes many compounds released by human activity and natural sources, such as carbon monoxide, methane, and HFOs, HFCs and HCFCs<sup>1</sup> (widely used as refrigerants). HFCs and HCFCs have high global warming potential contributing to climate change. When broken down by hydroxyl radicals, these compounds can form halogenated chemicals, including trifluoroacetic acid (TFA). TFA has a long environmental lifetime, accumulates in surface and ground waters, and has been found in blood, drinking water, beverages, dust, plants, and agricultural soils. However, it does not interact with biological molecules and, due to its high solubility in water, it does not bioaccumulate. It is unlikely to cause adverse effects in terrestrial and aquatic organisms. Continued monitoring and assessment are nevertheless advised due to uncertainties in the deposition of TFA and its potential effects on marine organisms.
- UV radiation also plays a key role in creating harmful photochemical smog by reacting with pollutants such as nitrogen oxides, and volatile organic compounds (e.g., fuel, solvent vapours) mostly from industry and transport. Even low concentrations of pollutants are detrimental to human health, prompting the World Health Organization to recommend average annual decreases in key air pollutants, including halving the maximum current level (10 µg/m<sup>3</sup>) of emissions of particulate matter to 5 µg/m<sup>3</sup>, and that of nitrous oxide from 40 to 10 µg/m<sup>3</sup>

### **IV. Global challenges of increasing plastic debris in the environment**

- Many materials, including plastics, are susceptible to solar UV radiation, high temperature, and moisture, resulting in degradation, loss in strength, discolouration, decreased service life and environmental pollution due to the release of potentially environmentally harmful by-products. UV-stabilisers and other additives are being used to counteract photodegradation and release of toxic by-products. However, this can result in the persistence of plastics in the environment.
- UV-degradation of plastics leads to generation of micro- (<5 mm) and nanoplastics (<0.001 mm), which have been found in ecosystems, bottled drinking water, table salt, seafood, and wastewater. Microfibres, including textile fibre fragments, are common contaminants of the environment. However, the biological effects of micro- and nanoplastics remain uncertain.



- New UV-stabilisation technologies that block UV radiation through treatment of textiles with certain oxide nanoparticles (e.g., zinc oxide, titanium oxide), are being developed for next-generation synthetic (e.g., polyester fabric) and natural textiles (e.g. cotton fabric).

A sustainable future requires continued adherence to the Montreal Protocol, with particular attention paid to mitigation of climate change, since recovery of stratospheric ozone is highly dependent on changes in greenhouse gas emissions and lifetimes of the ozone-depleting substances, which will also determine future UV radiation at the Earth's surface.

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