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Nairobi, 3–7 November 2025
Items 5, 6 and 11 (b) of the provisional agenda for the preparatory segment*

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

Note by the Secretariat

Addendum

I. Introduction

1. The present addendum to the note by the Secretariat on issues for discussion by and information for the attention of the Thirty-Seventh Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer presents new and updated information that has become available since the preparation of that note (UNEP/OzL.Pro.37/2), in particular regarding items 5, 6 and 11 (b) of the provisional agenda for the preparatory segment. Section II sets out the following: (a) brief summaries of additional information provided by the Scientific Assessment Panel and the Technology and Economic Assessment Panel on emissions of hydrofluorocarbon-23 (HFC-23); (b) issues related to enhancing regional atmospheric monitoring of substances controlled by the Montreal Protocol; and (c) information on nominations by parties of experts to the Technology and Economic Assessment Panel.

2. The additional information provided by the Scientific Assessment Panel and the Technology and Economic Assessment Panel is set out in the following reports:[1]

(a) Report of the Scientific Assessment Panel, September 2025, in response to decision XXXVI/3 on emissions of HFC-23;

(b) Report of the Technology and Economic Assessment Panel, September 2025, volume 2, in response to decision XXXVI/3 on emissions of HFC-23.

II. Overview of items on the provisional agenda for the preparatory segment (3–5 November 2025)

3. The issues covered in the present addendum are outlined below in the order in which the respective items are listed on the provisional agenda of the Thirty-Seventh Meeting of the Parties to the Montreal Protocol.

* UNEP/OzL.Pro.37/1.

[1] The reports are available on the portal of the Thirty-Seventh Meeting of the Parties, at https://ozone.unep.org/meetings/thirty-seventh-meeting-parties/pre-session-documents.

A. Emissions of hydrofluorocarbon-23 (HFC-23) (decision XXXVI/3) (item 5 of the provisional agenda for the preparatory segment)

4. As is mentioned in the note by the Secretariat (UNEP/OzL.Pro.37/2, paras. 33–36), in decision XXXVI/3 on emissions of HFC-23, the Scientific Assessment Panel and the Technology and Economic Assessment Panel were requested to update their reports submitted to the Thirty-Sixth Meeting of the Parties in response to decision XXXV/7 on the same subject[2] so as to reflect any additional or new information that had become available and to submit their updated reports on the matter to the Thirty-Seventh Meeting of the Parties.

5. In addition, in paragraph 6 of the same decision, the Technology and Economic Assessment Panel was requested to provide information on and a comparison of best practices and guidelines relating to measuring, estimating, reporting and verifying HFC-23 by-product emissions and their destruction.

6. In preparing their reports, the two panels took into consideration, as appropriate, information submitted by five parties (China, the European Union, India, Japan and the United States of America) on their current methodologies for estimating and reporting HFC-23 emissions from HCFC-22 production, and on best practice technologies to reduce HFC-23 emissions, in response to paragraphs 3 and 4, respectively, of decision XXXVI/3.

7. The executive summaries of the updated reports of the Scientific Assessment Panel and of the Technology and Economic Assessment Panel are set out in annexes I and II to the present addendum, respectively, reproduced as received from the panels, without formal editing by the Secretariat. A summary of some of the salient points is provided in the following paragraphs.

8. In the panels' 2025 reports, consistent with their 2024 reports, the term "generation" is defined as the total HFC-23 produced as a by-product, without taking into account abatement of emissions. The term "emissions" is defined as the total HFC-23 emitted from a facility that either uses HFC-23 as a feedstock or as a by-product, after any abatement, with the dominant emission pathway being direct emissions to the atmosphere.

9. In its 2025 report, the Scientific Assessment Panel has updated the information in and conclusions of its 2024 report on emissions of HFC-23 on the basis of new peer-reviewed studies, the 2025 report of the Technology and Economic Assessment Panel and 2023 data reported to the Secretariat on the production, generation and emission of halocarbons, including HFC-23. Global HFC-23 emissions have been estimated from atmospheric observations using established modelling methods, and trends have been presented from the 1990s up to and including 2023.

10. In 2023, global HFC-23 emissions derived from measured atmospheric abundances were found to be 14.2 ± 0.7 metric kilotons, similar to those of 2022 (14.4 ± 0.6 metric kilotons) but approximately 16 per cent lower than the estimated 2018–2019 peak emissions (16.9 ± 0.7 metric kilotons). Consideration has also been taken of new studies addressing HFC-23 production from the breakdown of some fluorinated gases in the atmosphere, with this source estimated at under 0.22 metric kilotons in 2023, smaller by a factor of 2 than the estimate provided in the 2024 report of the Scientific Assessment Panel.

11. The gap between HFC-23 emissions derived from global atmospheric abundances and available reported emissions in 2023 was found to be 11.4 ± 12.8 metric kilotons, similar to that of 2022 (10.5 ± 12.5 metric kilotons). According to the Scientific Assessment Panel, a clear understanding of the underlying causes for the observed gaps that emerged after 2014 remains elusive; suggested potential causes include smaller abatements than those reported and an increasing trend in HFC-23 emissions beginning in 2015, either from an unknown source or from a known source with underestimated emissions.

12. The Panel notes that, as the updated sum of all available observationally derived regional emission estimates was found to account for only 43 ± 10 per cent of global HFC-23 emissions in 2023, the understanding of such regional contributions to global HFC-23 emissions remains incomplete.

13. The 2025 report of the Technology and Economic Assessment Panel, prepared by its Medical and Chemicals Technical Options Committee, is based on HFC-23 generation up to and including 2023 as reported to the Secretariat by parties under Article 7 of the Montreal Protocol, and data submitted to the secretariat of the Multilateral Fund for the Implementation of the Montreal Protocol

[2] The reports are available on the portal of the Thirty-Sixth Meeting of the Parties, at https://ozone.unep.org/meetings/thirty-sixth-meeting-parties/pre-session-documents.

as part of project proposals to enable compliance with the HFC-23 by-product control obligations under the Kigali Amendment to the Montreal Protocol, as set out in paragraphs 6 and 7 of Article 2J of the Protocol.

14. In line with its 2024 report, the Technology and Economic Assessment Panel has estimated HFC-23 emissions from various industrial processes, including: (a) by-production associated with the production of HCFC-22; (b) pyrolysis of HCFC-22 to produce plastics (trifluoroethylene and hexafluoropropene); (c) the presence of HFC-23 as an impurity in other chemicals that are used in emissive uses; and (d) uses of HFC-23 as feedstock, fire suppressant, low-temperature refrigerant, and in semiconductor and electronics manufacturing.

15. The total HFC-23 emissions estimated by the Technology and Economic Assessment Panel from the above-mentioned sources were found to be in the range of 1.6–3.7 metric kilotons in 2023, similar to those reported in its 2024 report (1.5–3.5 metric kilotons in 2022). These amounts exclude the potential additional source of HFC-23 from atmospheric oxidation reported by the Scientific Assessment Panel.

16. The global HFC-23 emissions estimated by the Technology and Economic Assessment Panel are substantially lower than those estimated by the Scientific Assessment Panel for 2023, based on atmospheric observations (14.4 ± 0.7 metric kilotons). As in their 2024 reports, the two panels noted the uncertainties involved in their estimates while acknowledging that the large differences between their global HFC-23 emission estimates cannot currently be explained.

17. With regard to best practices available to measure, estimate, report and verify HFC-23 by-product emissions, as also requested in decision XXXVI/3, the Technology and Economic Assessment Panel noted that these are consistent with the best practices used to control other emissions associated with chemical manufacturing, including: (a) optimizing plant design, equipment, operation and maintenance; (b) instrumentation and monitoring of process and emissions; (c) training and instruction for plant operators; (d) periodic mass balancing; (e) technologies for destruction (i.e. thermal oxidation) or for separation and chemical transformation to treat unwanted co-products or by-products and abate their emissions; and (f) regulatory controls to provide the economic framework for ensuring that any or all of the aforementioned emission mitigation measures are implemented by operators, and to require emissions and other reporting. The relevant information previously provided by the Panel in response to decision XXXIV/7 is reproduced in annex 2 to the Panel's 2025 report.

18. In addition, the report provides a summary of relevant parts of the information on best practices submitted to the Secretariat by parties in response to decision XXXVI/3.

19. During the preparatory segment, parties may wish to consider the information provided and recommend a way forward.

B. Enhancing regional atmospheric monitoring of substances controlled by the Montreal Protocol (decision XXXVI/1) (item 6 of the provisional agenda for the preparatory segment)

20. As is mentioned in the note by the Secretariat (UNEP/OzL.Pro.37/2, paras. 37–43), in paragraph 1 of decision XXXVI/1, the Thirty-Sixth Meeting of the Parties requested the Secretariat, in consultation with the Advisory Committee of the General Trust Fund for Financing Activities on Research and Systematic Observations Relevant to the Vienna Convention for the Protection of the Ozone Layer, to organize activities for the specific purpose of evaluating the suitability of potential sites for monitoring regional emissions of controlled substances and to report on progress and any outcomes of those activities to the Open-ended Working Group of the Parties to the Montreal Protocol at its forty-seventh meeting and to the Thirty-Seventh Meeting of the Parties. In paragraph 5 of the same decision, the Secretariat was also requested to provide any updates with regard to its cost estimates and options for long-term financing associated with enhancing atmospheric monitoring, as provided for under decision XXXV/14, for consideration by the Thirty-Seventh Meeting of the Parties.

21. In terms of financial support for activities related to the atmospheric monitoring of controlled substances, in paragraph 1 of decision XXXVI/1, the parties allocated for 2025 a budget of $400,000 from the cash balance of the Trust Fund for the Montreal Protocol. In addition, in paragraph 4 of the same decision, the Executive Committee of the Multilateral Fund was requested to consider a funding modality to support a limited number of pilot projects to enhance regional atmospheric monitoring of substances controlled by the Montreal Protocol, guided by the scientific advice of the Advisory Committee of the General Trust Fund in relation to the location and establishment of new monitoring facilities, and to report to the Thirty-Seventh Meeting of the Parties on work carried out to develop such a funding modality for further consideration.

22. At the forty-seventh meeting of the Open-ended Working Group, the Secretariat and a Co-Chair of the Advisory Committee reported on progress in the implementation of decision XXXVI/1, as set out in documents UNEP/OzL.Pro.WG.1/47/2 and UNEP/OzL.Pro.WG.1/47/2/Add.1, as well as on progress made after the preparation of those documents. In addition, to facilitate the parties' discussions on these matters, the Secretariat prepared an information document containing decision 96/56 adopted by the Executive Committee at its ninety-sixth meeting, in May 2025 (UNEP/OzL.Pro.WG.1/47/INF/4, annex).

23. During the forty-seventh meeting of the Open-ended Working Group, a representative of the European Commission announced a contribution of €4.5 million (approximately $5.2 million) from the European Union to support the work of the General Trust Fund on the tasks called for in decision XXXVI/1. On 4 July 2025, the Secretariat received formal correspondence from the European Climate, Infrastructure and Environment Executive Agency informing it of the availability of a non-competitive grant in the field of atmospheric monitoring of emissions sources of ozone-depleting substances and F-gases, under the Horizon Europe programme, and inviting the Secretariat to submit a proposal thereto by mid-September 2025.

24. In the light of the known and emerging funding streams (i.e. the cash balance of the Trust Fund for the Montreal Protocol, the European Union grant and a potential funding modality under the Multilateral Fund), and following the discussions held in an informal group setting during the forty-seventh meeting of the Open-ended Working Group, the parties requested the preparation of a strategy detailing the use of funds and emphasized that the information therein should be streamlined, provide details of the activities conducted under the various funding windows and of how those activities complemented one another, and address the long-term sustainability of regional atmospheric monitoring.

25. A summary of the responses to the above-mentioned requests by parties is provided in the following paragraphs.

C. Progress report on the work of the Advisory Committee

26. Subsequent to the forty-seventh meeting of the Open-ended Working Group, and in preparation for the nineteenth meeting of the Advisory Committee, to be held in October 2025, a group of Committee members with expertise in atmospheric monitoring of controlled substances held several informal online meetings to discuss technical issues related to that subject area, including the following: (a) the status of and need for calibration and common scale (known as "calibration scale"); (b) the capacity and potential of current analytical facilities to analyse samples; (c) identification of potential partners in countries and locations where monitoring is needed; (d) knowledge of existing infrastructure at potential sites; (e) the height of sampling towers and alternatives to free-standing structures; (f) consideration of sites other than the 10 locations examined thus far; (g) additional Observing System Simulation Experiments that might be needed; and (h) the minimum number of inverse models required to quantify emissions and identify emission regions and locations with a high level of certainty.

27. In its informal discussions, the group of experts also took into consideration the outcomes of and lessons learned from the successful implementation of the European Union-funded pilot project on regional quantification of emissions of substances controlled under the Montreal Protocol, managed by the Secretariat and overseen by a small steering committee. The project, which started in 2022 and is due for completion in December 2025, has produced measurements of controlled substances and other gases though flask sampling on Bhola Island, Bangladesh, in cooperation with the University of Dhaka. Analysis of the samples was done at the University of Bristol from February 2023 to June 2025. The project also included two scientific studies: one on the impact of measurement frequency on estimating regional emissions; the other on the suitability of regional locations identified by the steering committee for the establishment of potential future sampling sites to monitor controlled substances.

28. The lessons learned from the monitoring project on Bhola Island were presented to the Open-ended Working Group at its forty-seventh meeting. In brief, those lessons highlighted the importance of the following: (a) the availability of a qualified and interested partner at the sampling station; (b) sufficient infrastructure, including a tower with a minimum height of 30 m, electricity, air conditioning, Internet connectivity, road access and security; (c) efficient logistical support to transport and receive sampling flasks through customs and in accordance with other regulations; (d) a capable analytical facility for chemical analyses of the collected samples; and (e) a calibration scale so that measurements can be placed on a common footing. The project also showed that consideration should be given to identification, diagnosis and resolution of problems during a measurement programme, given the time-consuming character of those processes.

29. Consistent with other related studies and activities, the project further demonstrated the need to carry out Observing System Simulation Experiments for a specific site before setting up a station; the importance of carrying out an initial flask sampling survey to check the suitability of the station (and the possible extension of this activity for a longer timescale, if appropriate) and the effect of the meteorological interannual variability; and the need for data-sharing among the scientific community.

30. In terms of a future collaboration plan for site set-up and operation, the lessons learned from the pilot project and from other scientific groups that have established stations in remote locations and collaborated with the countries involved have highlighted some key elements to be taken into consideration, namely the following:

(a) The willingness, enthusiasm and competence of the scientists involved are key factors in a successful collaboration. The partnership, when properly designed, can overcome many problems that will likely be encountered during the course of the programme;

(b) It is important to plan for known obstacles and unknown challenges. A considerable initial effort to draw a detailed collaboration plan, in which responsibilities are clearly assigned to the various parties involved, is vital for the success of the project;

(c) It is essential to build in flexibility in timelines, resource allocation and personnel changes to deal with issues that will inevitably arise and as demands shift;

(d) A collaboration is best served with a group of experts playing an advisory role. These experts must possess the necessary detailed knowledge, be committed to a successful project outcome and have no conflicts of interest with regard to fiscal matters;

(e) It is essential to pair the relevant institution in a party operating under paragraph 1 of Article 5 of the Montreal Protocol with an institution with the necessary expertise and willingness in a party not so operating. This enables bidirectional knowledge transfer, often through one-on-one encounters, while frequent meetings (in-person and online) between the involved institutions can facilitate quick information exchange. In addition, the institutions and experts involved should be part of a global monitoring network.

31. In the light of the lessons learned, as summarized in the preceding paragraphs, and the existing and potential funds, informal consultations were also carried out by the group of experts on possible approaches for the establishment and operation of three stations for monitoring controlled substances in undersampled regions, as part of an initial phase to expand the network for monitoring controlled substances. The suggested approach at selected sites involves an initial flask-sampling survey, with chemical analysis at an existing analytical facility, for roughly six months, followed by flask sampling and analysis for a two-year period before long-term monitoring starts at the selected site, either through high-frequency flask sampling or a high-frequency in situ station.

32. The outcomes of the informal consultations of the Advisory Committee's group of experts will inform the discussions of the Advisory Committee at its nineteenth meeting, which will be held online on 2 October 2025. At that meeting, the Advisory Committee will also discuss the results of the Observing System Simulation Experiments for the identification of suitable locations for future controlled substance monitoring. The outcomes of the meeting will be presented to the Thirty-Seventh Meeting of the Parties.

D. Updated cost estimates and options for long-term financing

33. Initial cost estimates for the establishment and operation of stations for monitoring controlled substances (referred to as "the 2024 model"), carried out with the assistance of a financial expert, were provided by the Secretariat to the parties at the forty-sixth meeting of the Open-ended Working Group, held in 2024, in response to decision XXXV/14.[3] In those estimates, two types of monitoring stations were considered:

(a) A high-frequency measurement station, involving on-site (in situ) collection of air samples every two hours, with analysis performed by an on-site laboratory using an analytical instrument, calibrated using established calibration scales and shared across all measurement stations of the relevant network;

(b) A low-frequency flask-sampling station, involving regular (daily to weekly) collection of samples in canisters (flasks) and the shipment thereof to specialized central analytical laboratories for analysis of their constituents.

[3] See document UNEP/OzL.Pro.WG.1/46/2/Add.1, paras. 41–76.

34. Cost estimates were carried out for the following two approaches: (a) a step-by-step approach involving the establishment of a single site and its operation for five years; and (b) a programmatic approach involving the establishment and operation of a mix of high-frequency in situ and low-frequency flask-sampling stations. Estimates were then presented for low-cost scenarios, in which the availability of the necessary infrastructure was assumed, and high-cost scenarios, in which it was assumed that there was no available infrastructure.

35. Cost calculations were focused on capital and operating costs. For other costs, termed “preparatory and capacity-building costs”, broad assumptions were made: an annual lump sum of $400,000 was assumed for site identification and evaluation, capacity-building for site and laboratory staff and the costs associated with external support. Contingency costs were calculated at 10 per cent of the total cost of monitoring. Programme management costs, incurred in the implementation of project activities, were calculated at 10 per cent of the total cost of monitoring plus contingency costs. Programme support costs were calculated at 13 per cent of the total cost of monitoring plus contingency costs plus programme management costs, which were based on a standard United Nations rate applicable to many international organizations.

36. The Secretariat’s response to the parties’ request in decision XXXVI/1 for updated cost estimates was prepared with the assistance of a financial expert and involved the development of a costing model (referred to as “the 2025 model”), which builds on a phased programme design, informed by technical reports, workshop outcomes, cost tables, funding models, expert consultations and the reports produced under the above-mentioned European Union-funded pilot project. These sources provided the necessary detail to revisit and refine cost categories, test alternative implementation scenarios and attempt to incorporate previously missing cost variables, such as costs for personnel for running measurement programmes.

37. Importantly, model development was substantially guided by Advisory Committee members and other atmospheric monitoring experts. Following the approach suggested during the Committee’s informal discussions (see para. 31 above), the 2025 model provides estimates of costs for the implementation of the following steps:

(a) **Step 1**: Observing System Simulation Experiments analysis to assess site suitability on the basis of atmospheric transport patterns;

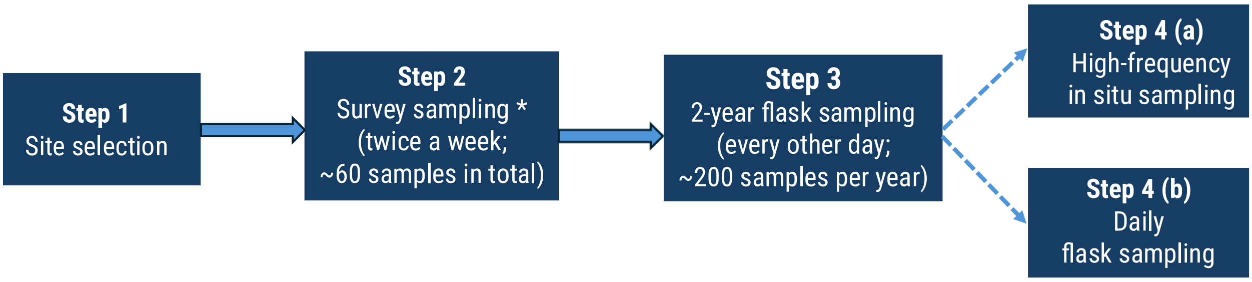
(b) **Step 2**: after the selection of a site based on the Observing System Simulation Experiments analysis, start of the measurement programme with a survey period for the collection of six months’ worth of data through flask sampling at a frequency of two samples per week (approximately 60 samples, including some duplicate samples to check reproducibility) to verify operability, site representativeness and basic logistics;

(c) **Step 3**: subject to satisfactory performance after the survey period, continue the measurement programme with flask sampling for two years at a frequency of every two days (approximately 200 samples per year), regarded by Advisory Committee experts as the default operational setting in view of the need for balance between data value and cost/logistics;

(d) **Step 4**: transition to high-frequency in situ measurements (approximately 4,400 samples per year) or daily flask sampling (approximately 440 samples per year), provided that the programme objectives have been justified during the survey and the two-year flask sampling period (steps 2 and 3).

38. During its informal discussions, the group of experts also considered the possibility of a station transitioning to a high-frequency in situ station after six months of data have been collected, provided that the site is deemed suitable and the expertise, willingness, key infrastructure and resources are available. A schematic presentation of the phased atmospheric monitoring programme is presented in figure 1.

Figure 1
Schematic presentation of the phased atmospheric monitoring programme



* Collection of six months' worth of data to verify operability, site representativeness and basic logistics.

39. On the basis of expert consultations, the original cost categories of the 2024 model were reviewed, revised and expanded from six to nine categories in the 2025 model (i.e. access and utility infrastructure; sampling tower; site building and shelter facilities; analytical instrumentation and laboratory equipment; hardware, sampling equipment and laboratory consumables; shipping and sample transportation; calibration and standardization; staffing and site operations; miscellaneous, data processing and reporting systems) to improve clarity and consistency in the revised cost estimates. The revised categories, which include 36 costing items, are aimed at better capturing the full range of expenses involved in establishing and operating atmospheric monitoring stations under the Montreal Protocol. They also provide more precise definitions to support data collection, scenario planning and long-term financial modelling.

40. A more detailed description of the current version of the costing model, including item-level definitions, ranges and specific assumptions, will be provided in an information note prepared by the Secretariat (UNEP/OzL.Pro.37/INF/6). While significant progress has been made to refine the original cost model, the Secretariat intends to further develop it into a user-friendly online tool, which will be available on its website for use by the parties. Interactive adjustments of costing elements would then enable cost estimates to be customized to reflect various circumstances.

1. Measurement programme options implemented for five years

41. The revised 2025 capital and operating cost estimates for a measurement programme resulting in the establishment and operation of a high-frequency in situ station or a daily manual flask-sampling station at one monitoring site over a five-year period are presented in tables 1 and 2, respectively, following the approach described in paragraph 37 above.

42. Table 1 (on p. 8) shows that the total revised cost estimates for the low-cost and high-cost scenarios (see notes to table 1), leading to the establishment and operation of a high-frequency in situ station over a five-year period, range from $1.082 million to $2.437 million. This range reflects the costs of the disaggregated capital and operating components based on inputs from experts on updated assumptions regarding infrastructure and service requirements.

43. The total costs derived from the 2025 model are higher than those of the 2024 model, which, for a high-frequency in situ station, were estimated at between $665,000 and $1,420,000, based on a different approach (i.e. establishment of and continuous monitoring at a high-frequency in situ station) and fixed aggregated capital and operating costs. These higher costs stem largely from the incorporation into the 2025 model of certain additional capital elements for towers, operating costs for each cost item and personnel costs.

Table 1
Estimates of the five-year costs in a phased approach leading to the establishment and operation of a high-frequency in situ monitoring station (2025 model)
(United States dollars)

Scenario	*Costs*	*Preparatory phase (OSSE)*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Total*
Low-cost								
	Capital costs	13 000	140 000	–	481 000	–	–	634 000
	Operational costs	–	61 700	44 400	114 000	114 000	114 000	448 100
	Total	**13 000**	**201 700**	**44 400**	**595 000**	**114 000**	**114 000**	**1 082 100**
High-cost								
	Capital costs	26 000	663 700	–	682 000	–	–	1 371 700
	Operational costs	–	121 600	82 900	287 000	287 000	287 000	1 065 500
	Total	**26 000**	**785 300**	**82 900**	**969 000**	**287 000**	**287 000**	**2 437 200**

Abbreviation: OSSE – Observing System Simulation Experiments.

Notes:

- Low and high values reflect the range provided by experts in atmospheric monitoring activities, capturing the variability in costs of procurement, construction, personnel, etc., depending on site location and available infrastructure.
- Capital costs include items such as procurement and construction associated with establishment of a station.
- Operational costs include items such as personnel costs, consumables and shipping to and from the station.
- In the year immediately prior to the first year of monitoring, costs are allocated to Observing System Simulation Experiments for site identification and evaluation.
- Year 1 includes costs for a flask-sampling survey collecting six months' worth of data (with two samples per week for approximately 26 weeks) to assess the logistical suitability of the site, followed by flask sampling every other day if the site is deemed suitable (approximately 200 samples).
- Year 2 includes costs for continued flask sampling every other day for another year (approximately 200 samples).
- For years 3–5, higher-frequency sampling may be implemented through the installation of an in situ gas chromatography-mass spectrometry instrument, which would collect and analyse samples every two hours (approximately 4,400 samples per year).

44. Table 2 (on p. 9) shows that the total revised costs for the low-cost and high-cost scenarios (see notes to table 2), leading to the establishment and operation of a daily manual flask sampling station over five years, range from $548,400 to $1,432,800. This range reflects the costs of the disaggregated capital and operating components based on inputs from experts on updated assumptions regarding infrastructure and service requirements.

45. The total costs derived from the 2025 model are lower than those of the 2024 model, which were estimated at between $1,091,000 and $2,527,000 for a daily manual flask-sampling station, assuming a different approach (i.e. establishment of and continuous monitoring through daily manual flask sampling) and fixed aggregated capital and operating costs. The reduction in low-cost estimates reflects assumptions about infrastructure reuse and phased capacity-building.

46. Although the estimated costs of the 2024 model have been provided for reference (see paras. 43 and 45 above), it is important to note that the costs estimated using the 2024 and 2025 models are not directly comparable, as the monitoring approaches modelled in deriving those estimates and the costing elements detailed differ. In particular, while the 2024 model assumed a continuous measurement programme at a station throughout the five-year period, the 2025 model provides for a survey period and a two-year flask-sampling programme before a definite sampling method is determined (either high-frequency or daily flask sampling). Furthermore, the capital and operating costing elements in the 2025 model are disaggregated, allowing adjustments and refinements to be made to reflect specified conditions.

Table 2
Estimates of the five-year costs in a phased approach leading to the establishment and operation of high-frequency (daily) manual flask-sampling monitoring station (2025 model)
(United States dollars)

Scenario	*Costs*	*Preparatory phase (OSSE)*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Total*
Low-cost								
	Capital costs	13 000	140 000	–	11 800	–	–	164 800
	Operational costs	–	61 700	44 400	92 500	92 500	92 500	383 600
	Total	**13 000**	**201 700**	**44 400**	**104 300**	**92 500**	**92 500**	**548 400**
High-cost								
	Capital costs	26 000	663 700	–	32 800	–	–	722 500
	Operational costs	–	121 600	82 900	168 600	168 600	168 600	710 300
	Total	**26 000**	**785 300**	**82 900**	**201 400**	**168 600**	**168 600**	**1 432 800**

Abbreviation: OSSE – Observing System Simulation Experiments.

Notes:

- Low and high values reflect the range provided by experts in atmospheric monitoring activities, capturing the variability in costs of procurement, construction, personnel, etc., depending on site location and available infrastructure.
- Capital costs include items such as procurement and construction associated with establishment of a station.
- Operational costs include items such as personnel costs, consumables and shipping to and from the station.
- In the year immediately prior to the first year of monitoring, costs are allocated to Observing System Simulation Experiments for site identification and evaluation.
- Year 1 includes costs for a flask-sampling survey for collecting six months' worth of data (with two samples per week for approximately 26 weeks) to assess the logistical suitability of the site, followed by flask sampling every other day if the site is deemed suitable (approximately 200 samples).
- Year 2 includes costs for continued flask sampling every other day for another year (approximately 200 samples).
- For years 3–5, higher-frequency sampling may be implemented through daily flask sampling (approximately 440 samples per year).

2. Revised costs for a programmatic approach

47. In the 2024 model, the programmatic approach of expansion scenarios produced total cost estimates ranging from \$9.0 million to \$31.9 million depending on the scenario (a modest expansion involving two high-frequency and three daily flask-based sampling systems; and an aggressive scenario involving four high-frequency and six daily flask-based sampling systems).

48. The 2025 model refines those figures on the basis of the phased approach and the disaggregation of capital and operating costs as described above. Under this updated framework, the projected five-year budgets range from \$5.2 million in the low-cost modest expansion scenario to \$25 million in the high-cost aggressive expansion scenario, as shown in table 3. The reduced totals are attributed to the phased approach adopted in the 2025 model. For example, in the case of the establishment and operation of a high-frequency in situ station in the 2025 model, measurements would be carried out for three years, in contrast to the five years assumed in the 2024 model. Additional cost savings can be achieved if automated flask sampling is implemented.

Table 3
Costs of expanding the monitoring network for a five-year period for a phased approach (2025 model)
(United States dollars)

	Two high-frequency in situ and three daily manual flask sampling systems		*Four high-frequency in situ and six daily manual flask sampling systems*	
	Scenario 1: low cost	*Scenario 2: high cost*	*Scenario 3: low cost*	*Scenario 4: high cost*
High-frequency	2 164 200	4 874 400	4 328 400	9 748 800
Daily flask sampling	1 645 200	4 298 400	3 290 400	8 596 800
Total costs of monitoring[a]	**3 809 400**	**9 172 800**	**7 618 800**	**18 345 600**
Contingency costs (10 per cent)[b]	380 940	917 280	761 880	1 834 560
Programme management costs (10 per cent)[c]	419 034	1 009 008	838 068	2 018 016
Subtotal	**4 609 374**	**11 099 088**	**9 218 748**	**22 198 176**
Programme support (13 per cent)[d]	599 219	1 442 882	1 198 438	2 885 763
Grand total	**5 208 593**	**12 541 970**	**10 417 186**	**25 083 939**

Notes:

- Phased sampling approach starting with manual flask sampling surveys collecting six months' worth of data followed by two years of manual flask sampling every other day, followed by either high-frequency Gas Chromatography-Mass Spectrometry sampling or a daily manual flask sampling.
- Low- and high-cost values include the low and high ranges of both the capital and operational costs for establishing a manual sampling atmospheric monitoring station with a 30 m tower.

[a] Including preparatory and capacity-building costs: preparatory costs include costs to support site identification and evaluation; capacity-building costs may include costs for training and knowledge transfer for site and laboratory staff and costs associated with external support for that purpose.

[b] Contingency costs are calculated as 10 per cent of the total cost of monitoring.

[c] Programme management costs, incurred in the implementation of project activities, are calculated as 10per cent of the total cost of monitoring plus contingency costs.

[d] Programme support costs are calculated at 13 per cent of the total cost of monitoring plus contingency costs plus programme management costs, based on a standard United Nations rate applicable to many international organizations. The figures are rounded to the nearest whole number.

3. Infrastructure scenarios

49. The cost of establishing or expanding a monitoring station depends heavily on the level of existing infrastructure at the chosen site. In the case of a site with infrastructure in place (e.g. buildings, power supply, Internet connectivity and a sampling tower), the cost savings are estimated to reduce the total low-cost estimates (i.e., the low-cost ranges of capital and operating costs) by up to 22 per cent for a high-frequency in situ station and by up to 58 per cent for an automated daily flask-sampling station, compared to cases where such infrastructure is not in place.

50. For a site requiring renovation or expansion (e.g. moderate works, such as refurbishing the flask-sampling space, installing a prefabricated pole, instead of a full tower, and Internet connectivity), total low-cost estimates may be reduced by up to 6 per cent for a high-frequency in situ station and by up to 16 per cent for an automated daily flask-sampling station.

51. In addition, a "piggyback" approach is recognized, whereby monitoring activities are integrated into existing monitoring programmes and resources operated by other institutions or networks. This approach can significantly reduce start-up costs and accelerate deployment, although its feasibility depends on local partnerships, compatibility of the infrastructure and institutional arrangements. By sharing infrastructure such as towers, buildings, power supply and site Internet connectivity, significant savings can be realized, particularly on capital-intensive items that otherwise account for the bulk of start-up costs. For example, avoiding the need to construct a new tower or laboratory space can reduce station costs by 20–30 per cent or more, depending on site conditions. Additional efficiencies may also be achieved by relying on existing logistics, staffing, and sample-shipping systems.

4. Information on potential collaborations for shared use of infrastructure and funding sources

52. In its response to decision XXXV/14, the Secretariat had suggested the leveraging of existing international initiatives and funding mechanisms, noting in particular the Global Chemicals Monitoring Plan under the Global Environment Facility, the monitoring network of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, and the Global Environment Monitoring System of the United Nations Environment Programme.

53. At the time of the preparation of the present addendum, the Secretariat had managed to obtain additional information through consultations held with representatives of the Preparatory Commission. The information obtained is summarized below.

54. The Preparatory Commission operates the International Monitoring System, which, when complete, will comprise 321 stations and 16 laboratories across nearly 90 countries. The International Monitoring System includes seismic, hydroacoustic, infrasound and radionuclide stations, many of which already have secure building facilities, reliable electricity supply with backup, towers or masts, and robust communications. These characteristics make International Monitoring System sites potential candidates for the co-location of flask-sampling or high-frequency monitoring equipment.

55. During the consultations, the Secretariat examined the map of International Monitoring System stations[4] at which co-location might be technically feasible, taking into account the availability of infrastructure (power, building, mast height). If a site is found to be of interest for potential collaboration, the Preparatory Commission will have to conduct a legal review to clarify information on the International Monitoring System station and the possibility of access to the site, given that those stations are owned by the States parties to the Comprehensive Nuclear-Test-Ban Treaty. Such an approach could possibly open a pathway to collaboration on co-located monitoring programmes that draw on the Preparatory Commission's available infrastructure and/or extensive experience in the logistics of handling and shipping dangerous goods, and the possible sharing of resources for atmospheric transport modelling.

56. In terms of the Global Environment Monitoring System programme, a preliminary analysis by the Secretariat on the infrastructure available under the programme revealed that the stations in question are largely located in populated areas, which makes them unsuitable for the purposes of monitoring controlled substances under the Montreal Protocol. The potential for collaboration therefore seems to be minimal.

E. Workplan under funding streams in support of the atmospheric monitoring of controlled substances

57. The existing and potential financial options that are currently available to support work on atmospheric monitoring of controlled substances are the following:

(a) **2025 budget of the Trust Fund for the Montreal Protocol – cash balance ($400,000)**. At the time of preparation of the present addendum, $60,000 had been used for work carried out by experts. It is hoped that the unspent balance can be carried forward to 2026 for expert support not covered by other funding sources;

(b) **European Union grant to the General Trust Fund (€4.5 million, or approximately $5.2 million)**. Assuming that the grant is approved in the first half of 2026, it is expected to support:

(i) Work regarding site selection for three selected locations (i.e. Observing System Simulation Experiments), in 2026, estimated to last about six months. Although experiments have already been carried out for 10 locations under the European Union-funded pilot project, a decision on the exact location of a site, in consultation with the host country, may require additional experiments;

(ii) Survey sampling for six months' worth of data at the three selected sites to ensure their suitability;

(iii) Flask sampling every other day for two years at the three selected sites, or possible early transition to the establishment of a high-frequency in situ station if one of the sites is found to be exceptionally good;

[4] Available at https://www.ctbto.org/sites/default/files/2024-12/IMS%20Map_NOVEMBER_2024_Final_Web.pdf.

(iv) Continuation of the measurement programme (through high-frequency in situ or daily flask sampling) subject to the availability of the grant funds;

(c) **Funding window under the Multilateral Fund.** In line with paragraph (c) of decision 96/56, the Executive Committee of the Multilateral Fund will consider establishing a funding window for three pilot projects to enhance regional atmospheric monitoring of controlled substances. Provided that the funding window is established, the Multilateral Fund would support:

(i) Preparation of preparatory funding requests for three proposals by the Multilateral Fund bilateral and implementing agencies on behalf of developing parties operating under Article 5 of the Montreal Protocol (Article 5 parties) based on possible sites suggested by the Advisory Committee in 2027;

(ii) Sampling survey of candidate sites based on periodic flask sampling conducted over the course of approximately two years to confirm the suitability of the site and determine whether regular flask sampling or high-frequency in situ measurements would be more appropriate;

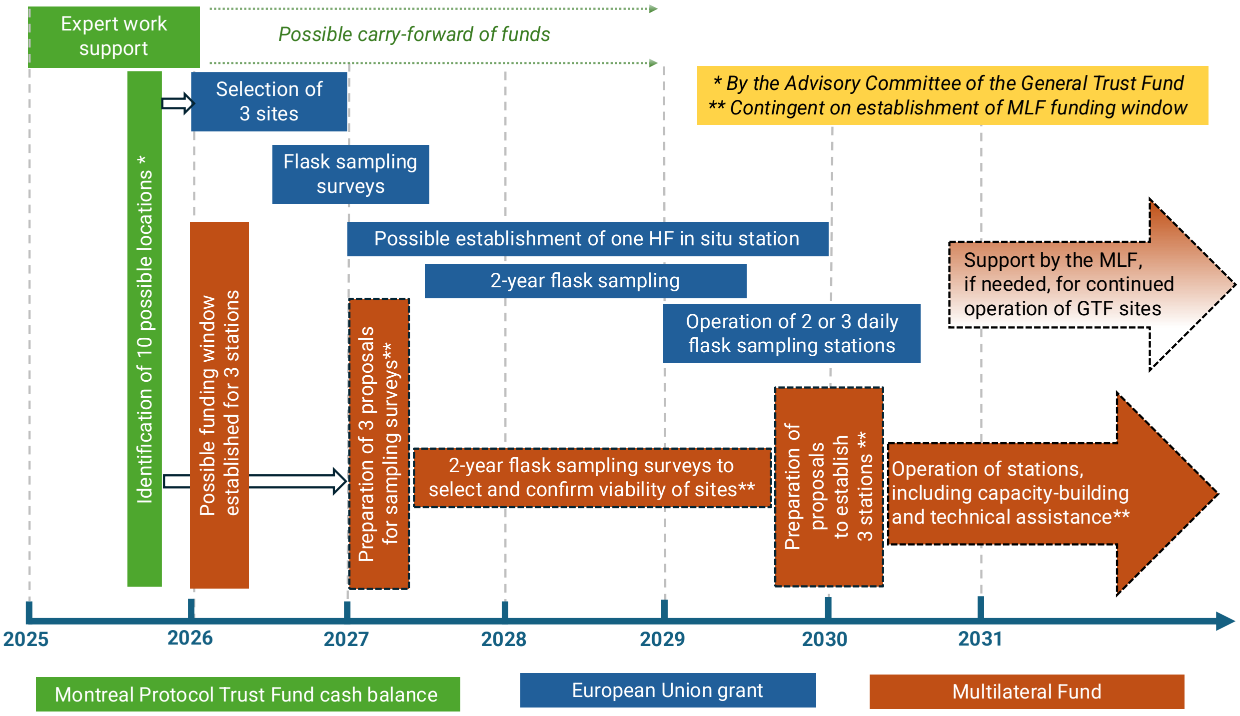
(iii) Submission of proposals in 2030 by the bilateral and implementing agencies on behalf of three Article 5 parties to establish atmospheric monitoring stations on the basis of the sampling survey results;

(iv) Upon approval by the Executive Committee, establishment in late 2030 or 2031 of three atmospheric monitoring stations (with a high-frequency in situ instrument or flask sampling) and support for their operation. Support would also be provided for capacity-building (e.g. related to calibration, data archiving and stewardship, support for participation in meetings led by the Advanced Global Atmospheric Gases Experiment (AGAGE) or other international halocarbon scientific research meetings, etc.);

(v) Upon completion of the European Union grant and if necessary, support could be provided by the Multilateral Fund for the continued operation of the three stations established under the General Trust Fund.

58. A schematic presentation of the action areas and estimated timeline of the three funding streams is presented in figure 2.

Figure 2
Action areas and estimated timeline of the three existing and potential funding streams to support the establishment and operation of stations for the atmospheric monitoring of controlled substances



Abbreviations: GTF – General Trust Fund; HF – high frequency; MLF – Multilateral Fund.

59. It is envisaged that the approach illustrated in figure 2 will avoid duplication of work and ensure the sustainability of the planned atmospheric monitoring measurement programmes.

60. During the preparatory segment of the Thirty-Seventh Meeting of the Parties, parties may wish to consider the information provided and recommend a way forward.

F. Technology and Economic Assessment Panel organizational issues (item 11 of the provisional agenda for the preparatory segment)

Changes in the membership of the Technology and Economic Assessment Panel (item 11 (b) of the provisional agenda for the preparatory segment)

61. Information about the status of membership of the Technology and Economic Assessment Panel and its technical options committees, including an outline of the nomination process, is set out in the note by the Secretariat (UNEP/OzL.Pro.37/2, paras. 73–80 and annexes I and II). Pursuant to decision XXXI/8, parties wishing to nominate experts for appointment to the Panel are requested to use the Panel's nomination form, available on the Secretariat's website, and are urged to follow the terms of reference of the Panel, consult the co-chairs of the Panel and refer to the matrix of needed expertise prior to making nominations.

62. At the time of the preparation of the present addendum, the Secretariat had received submissions from the following parties:

(a) Australia, nominating Ian Porter, currently co-chair of the Methyl Bromide Technical Options Committee, to continue to serve on the Technology and Economic Assessment Panel in that role for an additional period of two years, and Helen Tope, currently co-chair of the Medical and Chemicals Technical Options Committee, to continue to serve on the Panel in that role for an additional period of four years;

(b) Colombia, nominating Marta Pizano, currently co-chair of the Methyl Bromide Technical Options Committee, to continue to serve on the Technology and Economic Assessment Panel in that role for an additional period of four years.

63. The completed nomination forms and curricula vitae of the nominees have been posted on the portal of the Thirty-Seventh Meeting of the Parties.

64. The parties may wish to consider the above-mentioned nominations, along with any other nominations that the Secretariat may receive prior to and during the Thirty-Seventh Meeting of the Parties.

65. The parties may also wish to note that, in July 2025, the co-chairs of the Technology and Economic Panel informed the Secretariat that Sergey Kopylov, whose term as co-chair of the Fire Suppression Technical Options Committee expires in 2025, has decided to step down and will therefore not be seeking renomination.

Annex I*

Report by the Scientific Assessment Panel

Response to decision XXXVI/3: Emissions of HFC-23

Executive Summary

This Supplemental Report serves as an update to the *Report of the Scientific Assessment Panel in response to Decision XXXV/7: Emissions of HFC-23* that was submitted to and posted by the United Nations Environment Programme Ozone Secretariat in September 2024 (Montzka et al., 2024, hereafter referred to as SAP, 2024). In that report, emissions estimates for HFC-23 were derived from atmospheric observations through 2022. In this Supplemental Report, emissions estimates are updated with atmospheric observations through 2023. The fundamental conclusions in this report remain unchanged based on the additional year of measurements, derived emissions, and updates to reported quantities and quantities derived from reporting that have become available for 2023.

During 2023 the global mean atmospheric abundance of hydrofluorocarbon-23 (HFC-23; CHF_3) continued to increase. The measured global mean abundance in 2023 was 36.8 ± 0.9 ppt, which was 0.97 ± 0.04 ppt greater than the 35.9 ± 0.9 ppt measured in 2022. This annual increase was slightly less than the mean change observed from 2015 to 2023 of 1.10 ± 0.13 ppt yr^{-1}.

Global HFC-23 emissions in 2023 derived from measured atmospheric abundances totaled 14.2 ± 0.7 kt yr^{-1} and were 2.7 ± 0.9 (16 ± 6%) lower than peak emissions derived for 2018-2019 of 16.9 ± 0.7 kt yr^{-1}. Emissions in 2023 were similar to emissions in 2022 (14.4 ± 0.6 kt yr^{-1}). The small change in emissions from 2022 to 2023 contrasts with the larger annual decline during 2019 to 2022 that averaged 0.8 kt yr^{-1}. Reported HCFC-22 production for all uses, which remains the largest known source of HFC-23 by-product, was 1.9% smaller in 2023 compared to 2022 (1197 kt in 2022 and 1175 kt in 2023).

New scientific results confirm that HFC-23 is produced in oxidation reactions of some fluorinated gases present in the atmosphere. This HFC-23 source is estimated to be less than 0.22 kt yr^{-1} in 2023. This revised value is smaller than estimated previously (SAP, 2024) and remains an upper limit, meaning that the actual value is likely smaller.

The difference or gap between global emissions derived from atmospheric measurements and those reported or estimated from information provided to the United Nations Framework Convention on Climate Change (UNFCCC), the Multilateral Fund for the Implementation of the Montreal Protocol (MLF), and the Ozone Secretariat persisted in 2023 and remains substantial.

With the small changes from 2022 to 2023 in emissions derived from global atmospheric abundance changes and available reported emissions, the gap in our understanding of HFC-23 emissions in 2023 of 11.4 – 12.8 kt yr^{-1} is similar to the gap estimated for 2022 in the previous HFC-23 report (SAP, 2024) of 10.5 – 12.5 kt yr^{-1}.

The gap between reported HFC-23 emissions and those inferred from atmospheric abundances is not reconciled by considering all known sources beyond HCFC-22 production. An updated assessment by the Technology and Economic Assessment Panel (TEAP) (TEAP, 2025) estimates HFC-23 emissions from all known sources and reported abatements after 2020 to be in the range of 1.6 – 3.7 kt yr^{-1}, which is substantially smaller than the atmospherically-derived emission of 14.2 ± 0.7 kt yr^{-1} during 2023. Adding production from the atmospheric oxidation of fluorinated industrial gases to TEAP's updated estimates results in an emissions gap in 2023 of 9.6 – 13.3 kt yr^{-1}.

The increasing emission gaps between 2015 and 2018 coincide with increases in reported abatement of HFC-23 from a limited number of A5 countries. After 2019, the emission gap decreased from a high of 15 kt yr^{-1} to 11 – 12.5 kt yr^{-1} in 2023; reported abatements from all countries increased during these years to a value of 23 kt yr^{-1} in 2023.

The decrease in emission gaps after 2019 was concurrent with a declining ratio of emissions derived from global observations relative to reported total HCFC-22 production (E_{23}/P_{22}). The E_{23}/P_{22} ratio in 2023 of 1.1% is unchanged from 2022.

* The annex has not been formally edited.

The declines in the emission gaps and E_{23}/P_{22} values after 2019 are consistent with an increase in overall abatement of HFC-23 emissions, improved optimization of HCFC-22 production to further minimize HFC-23 by-product generation and associated emission, or reduced emissions of HFC-23 from sources that are unknown or not accurately accounted for.

Our understanding of regional contributions to global HFC-23 emissions remains incomplete. The sum of all available observationally derived regional emission estimates accounted for only 6.1 ± 0.7 kt yr^{-1} of HFC-23 in 2023, or 43 ± 10 % of global emissions in that year. These estimates include emissions for a number of countries or portions of countries that have been updated through 2023 based on continued atmospheric measurements. HFC-23 emission estimates from a significant number of regions remain unavailable because of gaps in atmospheric monitoring.

From continued measurements made at the Gosan Station in the Republic of Korea: HFC-23 emissions in 2023 were estimated to be 5.6 ± 0.7 kt yr^{-1} from the eastern portion of China; 0.23 ± 0.02 kt yr^{-1} from the Republic of Korea (ROK); 0.10 ± 0.07 kt yr^{-1} from the western portion of Japan; and 0.01 ± 0.01 kt yr^{-1} from the Democratic People's Republic of Korea (DPRK).

HFC-23 emissions from eastern China in all years after 2019 were smaller than the peak value derived for 2019 of 8.0 ± 0.4 kt yr^{-1}. Emissions from eastern China in 2023 were 4.7 ± 0.7 kt greater than the 0.9 kt reported to the Ozone Secretariat for all of China in that year, and this emission accounts for 40 ± 10% of the global emission gap in 2023. The sum of emissions for the ROK, western Japan, and the DPRK were notably smaller in 2023 than they were during 2018–2022 and remained greater than reported to the Ozone Secretariat or UNFCCC in recent years, by approximately 0.3 ± 0.07 kt, accounting for 1.5 to 3% of the global emission gap.

From continued atmospheric measurements at a network of sites in Europe: HFC-23 emissions in 2023 were estimated to be 0.15 ± 0.04 kt yr^{-1} from the sum of countries in the north-western Europe including Ireland, the United Kingdom (UK), France, the Netherlands, Belgium, Luxembourg, and Germany. This emission was 0.13 ± 0.04 kt greater than reporting to the UNFCCC in 2022 (latest available year), and this region accounts for 0.7 to 1.5% of the global emission gap.

From continued atmospheric measurements made at the Cape Grim Baseline Air Pollution Station in southern Australia, HFC-23 emissions in 2023 from Australia were estimated to be 0.025 kt yr^{-1} (no uncertainty specified), which is 0.03 kt yr^{-1} less than reported to the UNFCCC in that year.

The countries or portions of countries for which regional emissions in 2023 have been estimated, i.e., China, the ROK, the DPRK, Japan, the European Union and the UK, accounted for the majority (93%) of reported generation of HFC-23 in that year. For the countries that accounted for the remaining HFC-23 generation reported to the Ozone Secretariat during 2023 (Argentina, India, Mexico, the Russian Federation, and the United States of America (USA)), atmospherically derived HFC-23 emission estimates remain unavailable in the Kigali era (i.e., after 2019).

Annex II*

2025 Report by the Technology and Economic Assessment Panel, Volume 2

Response to decision XXXVI/3: Emissions of HFC-23

Executive Summary

This report includes sections responding to each of the following sub-paragraphs of decision XXXVI/3, relating to emissions of HFC-23:

> 5. To request the Scientific Assessment Panel and the Technology and Economic Assessment Panel to update their decision XXXV/7 reports on HFC-23 to reflect any additional or new information that becomes available, and to submit their reports on the matter to the Thirty-Seventh Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer;
>
> 6. To also request the Technology and Economic Assessment Panel to provide information on and a comparison of best practices and guidelines relating to measuring, estimating, reporting and verifying HFC-23 by-product emissions and their destruction.

The report includes additional contextual information on other HFC-23 generation and/or emissions, i.e., from chemical pathways used in the production of substances that are not Annex C, Group I substances (hydrochlorofluorocarbons or HCFCs), or Annex F substances (hydrofluorocarbons or HFCs), and from feedstock and consumptive uses. This additional contextual information was considered useful in understanding the relative importance of chemical pathways used in the production of Annex C, Group I, and Annex F substances that may generate HFC-23 as a by-product, which is the focus of this decision.

ES.1 Compilation of information on the amount of HFC-23 generation and emissions

In 2023, the TEAP response to the previous decision XXXIV/7, paragraph (b), provided a compilation of information on the amount of HFC-23 generation and emissions from facilities that manufacture Annex C, Group I, or Annex F substances. It drew on several sources for this information, including United Nations Framework Convention on Climate Change (UNFCCC) submissions by Annex I parties; the Intergovernmental Panel on Climate Change (IPCC); Article 7 data reported under the Montreal Protocol; data reported to the Executive Committee of the Multilateral Fund (ExCom); and the Scientific Assessment Panel (SAP).

In 2024, in its response to decision XXXV/7, the TEAP provided updated information on other HFC-23 consumptive and emissive uses, including as a by-product from the production of other Annex C, Group I substances (HCFCs) and Annex F substances (HFCs).

In this 2025 report responding to the present decision XXXVI/3, these data have been updated as follows:

- Data for both HFC-23 by-product generation and for HFC-23 emissions have been reported by parties under Article 7 to the Ozone Secretariat for HCFC-22 production and integrated into an annual figure (individual party data are confidential). These data are incomplete for 2019, 2020, 2021 and 2022 due to the timing of reporting obligations consequent upon when parties ratified the Kigali Amendment. However, the dataset for 2023 is considered as complete.
- The consolidated data for HFC-23 by-product generation from HCFC-22 production (without abatement) in 2022 was 23,769 tonnes (incomplete dataset) and in 2023 was 24,376 tonnes (complete dataset).
- The consolidated data for HFC-23 emissions reported as by-product from HCFC-22 production was 696 tonnes (incomplete dataset) in 2022, and 959 tonnes (complete dataset) in 2023.

* The annex has not been formally edited.

TEAP estimates on annual HFC-23 emissions from other industrial sources remain unchanged from its 2024 report and are in the range of ~340 to 1240 tonnes including the following:

- Pyrolysis of HCFC-22 to produce TFE/HFP (~100–1,000 tonnes, based on estimated associated HFC-23 by-product generation without possible emissions abatement);
- Feedstock use of HFC-23 (~10 tonnes);
- HFC-23 present as an impurity in other chemicals that are used in emissive uses (e.g., ~40 tonnes HFC-23 emissions arising from the HCFC-22 and HFC-32 bank);
- Fire protection (~50 tonnes);
- Low temperature refrigerant (~ 50 tonnes);
- Semiconductor and electronics manufacturing (~90 tonnes).

The combination of reported HFC-23 emissions as a by-product from the production of other Annex C, Group I substances (HCFCs) and Annex F substances (HFCs), plus the best available annual estimate of HFC-23 emissions from other known emissions sources, is in the range of 1,600–3,700 tonnes. These estimates exclude the potential additional source of HFC-23 from atmospheric oxidation of less than 430 tonnes per year in recent years, as reported by the Scientific Assessment Panel.[1]

The SAP in 2025 has estimated HFC-23 emissions, derived from atmospheric monitoring, of 14.4 ± 0.7 Gg yr–1 (14,400 tonnes) in 2022, and 14.1 ± 0.7 Gg yr–1 (14,100 tonnes) in 2023. The maximum global emissions that have been reported by SAP were 17.0 ± 0.7 Gg yr–1 (17,000 tonnes) in 2019.[2]

This report identifies substantial discrepancies and uncertainties for global HFC-23 generation and emissions based on currently available data. The differences between the SAP and TEAP estimates of global HFC-23 emissions cannot currently be explained. SAP has described in its methodology elsewhere the uncertainties in the derivation of emissions estimates from atmospheric observations. However, these uncertainties do not bridge the differences between the SAP and TEAP estimates.

There are unknowns and uncertainties surrounding the TEAP estimations for sources other than HFC-23 emissions from HCFC-22 production; however, inaccuracy in estimations of these relatively smaller emissions is unlikely to bridge the difference with atmospheric-derived emissions. TEAP has identified all the major sources that are likely to contribute most of the HFC-23 emissions and these are outlined in the report. Any smaller unknown sources are unlikely to bridge the large difference with SAP estimates.

ES.2 Best practices available to measure, estimate, report and verify HFC-23 by-product emissions

In response to decision XXXVI/3, paragraph 6, the report provides a summary of information on best practices available to control emissions of HFC-23 by-product from facilities that manufacture Annex C, Group I substances (HCFCs) or Annex F substances (HFCs). These best practices to control emissions of HFC-23 are consistent with those used to control other emissions associated with chemical manufacturing.

In previous reports, TEAP has cited guidance for facilities in measuring, estimating, and reporting emissions under the UNFCCC Guidelines and from national governments. Decision XXXVI/3, paragraphs 3 and 4, invited parties “that have HCFC-22 production facilities to submit to the Ozone Secretariat…their current methodologies for estimating and reporting of HFC-23 emissions from HCFC-22 production” and invited “those parties that have adopted best practice technologies to reduce HFC-23 emissions to provide information thereon to the Ozone Secretariat.” This report summarises a sample of the above measures implemented or being implemented by parties based on information submitted to the Ozone Secretariat.

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[1] UNEP 2024, September 2024 Report of the Science Assessment Panel, Response to Decision XXXV/7: Emissions of HFC-23.

[2] The scientific community typically use grams with the appropriate prefix to measure emissions, whereas the industrial community typically use tonnes. The reader might find this helpful: Mg = tonnes, Gg = kilotonnes, Tg = megatonnes.