Technology and Economic Assessment Panel

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

Takeshi Eriguchi, Jianjun Zhang and Nick Campbell
Medical and Chemical Technical Options Committee (MCTOC)

Decision XXXVI/3: Emissions of HFC-23

3. To invite parties that have HCFC-22 production facilities to submit to the Ozone Secretariat, on a voluntary basis, by 31 March 2025, their current methodologies for estimating and reporting of HFC-23 emissions from HCFC-22 production;
4. To also invite parties that have adopted best practice technologies to reduce HFC-23 emissions to provide information thereon to the Ozone Secretariat, on a voluntary basis, by 31 March 2025;
5. To request the SAP and the TEAP 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 37th Meeting of the Parties;
6. To also request the TEAP 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.

Decision XXXVI/3: Emissions of HFC-23

- Paragraphs 3 and 4 – Five parties submitted information which was considered by TEAP: China, EU, India, Japan, and US.
- Paragraphs 5 and 6 – Requests addressed in the TEAP and the SAP reports.
- This presentation will provide an update on our previous report on HFC-23 under decision XXXV/7.
- The 2025 TEAP response to decision XXXVI/3 provides a comparison of best practices and guidelines relating to measuring, estimating, reporting and verifying HFC-23 by-product emissions and their destruction. This will not be covered in this presentation.

Relevant Previous TEAP Reports on HFC-23

- MCTOC Assessment Report 2022
- TEAP September 2023: Response to decision XXXIV/7: Strengthening institutional processes with respect to information on HFC-23 by-product emissions (volume 6)
- TEAP September 2024: Response to decision XXXV/7: Emissions of HFC-23 (volume 5)

TEAP's Response to Decision XXXVI/3

- MCTOC led preparation of the report on behalf of TEAP.
- MCTOC and SAP collaborated closely in preparation of their comprehensive reports and conclusions that support further consideration by parties.
- For additional context, consistent with previous TEAP reports, updated information is provided on other HFC-23 emissions from consumptive and emissive uses of HFC-23, including as by-product from the production of other Annex C, Group I, and Annex F substances.
- TEAP also reviewed and considered available information including submissions from five parties under the decision and reported production and emissions data by 14 parties.

Background

- There are several chemical mechanisms that can generate HFC-23 as a by-product in chemical production processes, including:
  - ***Over- or under-reaction of chemicals*** present in the reaction vessel enroute to the intended product, e.g., HFC-23 is an over-fluorination of HCFC-22.
  - ***Presence of impurities in the feedstocks that are being reacted***, e.g., chloroform impurity in dichloromethane feedstock, used to produce HFC-32, is hydro-fluorinated to HFC-23.
  - ***Unintended side reactions***, where the feedstock follows a different reaction path than the one that is desired to make the product, e.g., cleavage of carbon–carbon bond in the production of HFC-125 from perchloroethylene, with subsequent hydro-fluorination of the resulting mono-carbon molecule to form HFC-23.

Quantity of HFC-23 by country and by sector (1)

- Information on consumption is not always readily available to the level of detail required for the decision, i.e., by country and by sector.
- HFC-23 consumption and feedstock use data are not available for all parties, prior to 2023, due to the timing of reporting obligations associated with ratification of the Kigali Amendment.
- Some data are available from other sources relating to the quantities used for each of the applications.

Quantity of HFC-23 by country and by sector (2)

- HFC-23 is produced and consumed for feedstock, and, separately, in very small quantities, for emissive uses for fire suppression, very low temperature refrigeration, and semiconductor and electronics manufacturing.
- Several parties that manufacture Annex C, Group I and/or Annex F substances capture the HFC-23 that is generated and use for feedstock and/or emissive uses, or divert it for destruction.

Quantity of HFC-23 by country and by sector (3)

Reported global HFC-23 consumption was between 1000 and 10,000 tonnes in 2023.

There has been a significant increase in consumption of HFC-23 in the period 2021-2023.

- 707 tonnes was reported for feedstock use (Article 7 for 2023).
- Fire protection: Small consumption compared to HFC-227ea.
- RACHP: Very small consumption in ultra-low temperature refrigeration.
- Etchant and chamber cleaning in semiconductor and electronics manufacturing: Average annual growth rate has been approximately 15%, with global consumption of 277 tonnes in 2013 increasing to 720 tonnes in 2020.

Updated estimates on quantities of HFC-23 generated at, and emissions* from F-gas production facilities (1)

- To update estimates, the methodology and information used by MCTOC was:
  - Article 7 data on quantities of **HCFC-22 production** and **HFC-23 emissions** are reported by parties under mandatory obligations.
  - Data on quantities of **HFC-23 generated** from F-gas production are reported by parties on a voluntary basis and are not published by party in the report. HFC-23 generation data are not reported by all parties known to produce HCFC-22.
  - MCTOC applied estimated HFC-23 by-product generation rates to A7 reported HCFC-22 production quantities to estimate the quantities of HFC-23 generated as a by-product.

*Emissions are defined as the total HFC-23 emitted from a facility that generates HFC-23 as a by-product after any abatement

Updated estimates on quantities of HFC-23 generated at, and emissions from F-gas production facilities (2)

- Total HCFC-22 production reported under A7 for 2023 was 1,174,751 tonnes.
- Estimated HFC-23 by-product generation from HCFC-22 production is in the range of 18,000 to 36,000 tonnes (1.5% - 3% HFC-23 generated/tonne HCFC-22 manufactured). This is consistent with the HFC-23 generation data reported by parties on a voluntary basis.
- The consolidated reported data for HFC-23 by-product **generation** from F-gas production (without abatement) in 2023 was **24,376 tonnes** (2% HFC-23 generated/tonne HCFC-22 manufactured).
- The consolidated data for HFC-23 **emissions** reported as by-product from F-gas production was **959 tonnes** in 2023. (0.08% HFC-23 emitted/tonne HCFC-22 manufactured).

Updated TEAP estimates of HFC-23 emissions from known emissions sources (1)

- Updated estimates of global HFC-23 emissions are provided, including from facilities that manufacture Annex C, Group I, or Annex F substances and emissive uses, as previously presented in the September 2023 TEAP Report in response to decision XXXIV/7.
- Current best estimates of HFC-23 emissions are based on known sources and updated available information included in the report and from the September 2023 TEAP Report.
- Some of these are broad estimates where further information to improve their accuracy is currently not available.

Compilation of annual reported and available best estimates of HFC-23 emissions from known emissions sources (tonnes)

Sources of HFC-23 (for the year with available data to make estimates)	**Estimated HFC-23 emissions (tonnes)**
Reported HFC-23 emissions under Article 7	
HCFC-22 production (2023)	~959
Estimated HFC-23 emissions	
TFE/HFP manufacture (estimated, 2023)[35]	100–1,000
HCFC-22 plant waste and product streams (estimated, 2023)[36]	10–1,000
Other fluorochemical manufacturing (estimated, 2024)[37]	<300
Semiconductor/electronics manufacturing (WSC data, 2020)[38]	92
Fire protection (estimated, 2022)[39]	50
Impurity released from HCFC-22 bank (estimated, 2020)[40]	40
Feedstock use (estimated based on A7 reported consumption data, 2022)[41]	22
Electrochemical fluorination (estimated, 2020)[42]	10–100
Low temperature refrigeration (estimated, 2020)[43]	10–100
Total reported and estimated HFC-23 emissions from known sources	1,600–3,700

Note: Estimated total reported emissions take into account the ranges in the Table and contains data reported under Article 7and those estimated in this and previous TEAP reports. See report for footnotes.

Updated TEAP estimates of HFC-23 emissions from known emissions sources (2)

- TEAP estimates HFC-23 emissions from known emissions sources at about **1,600–3,700 tonnes per year** in recent years.
- SAP has made an estimate of the potential additional source of HFC-23 from atmospheric oxidation (**less than 220 tonnes per year** in 2023). This is not included in our data.
- In comparison, based on atmospheric observations, SAP reports estimated global HFC-23 emissions of **14,200 ± 700 tonnes** for 2023.
- The difference between these estimates cannot be explained by uncertainties in atmospheric-derived estimates or by using the data reported under A7 and other sources.

Summary, uncertainties, and inferences from differences in HFC-23 emissions estimates (1)

- The TEAP bottom-up estimate of global HFC-23 emissions is 1,600–3,700 tonnes and the SAP top-down estimate of global HFC-23 emissions is 14,200 ± 700 tonnes.
- TEAP has identified all the major sources likely to contribute most of the HFC-23 emissions and these are outlined in the report.
- Any unknown smaller sources are unlikely to bridge the large difference between TEAP and SAP estimates.

Summary

- **A substantial shortfall remains in our understanding of global emissions of HFC-23 derived from measurements in the remote atmosphere despite the new information provided in this Supplemental Report.**
- The gap between reported emissions and those inferred from atmospheric abundances is between 11.4 and 12.8 kt yr^{-1}
- The gap between emissions from all known sources estimated by TEAP (2025) and from atmospheric oxidation is between 9.6 and 13.3 kt yr^{-1}.

THANK YOU

Background Slides

- The generation of HFC-23 as a by-product during HCFC-22 production is far greater than the amount of HFC-23 required for use as feedstock or for consumption.
- Parties to the Kigali Amendment in which HCFC-22 is produced are required to destroy HFC-23 using a destruction technology, e.g., incineration, approved by the Montreal Protocol.
- Operation and maintenance of incineration facilities to destroy HFC-23 by-product is a cost to the companies responsible for its generation, particularly as HCFC-22 is a low profit margin product.

Information from Parties on measurement, estimation, reporting and verification of emissions of HFC-23

- Several parties have provided detailed information on measuring, verifying and reporting of HFC-23 emissions. These are consistent with guidance under UNFCCC Guidelines for reporting Greenhouse Gas emissions.
- These have been compared in the report under the following headings:
  - Estimation/Calculation of HFC-23 Generation and/or Emissions
  - Annual Verification
  - Regulation/Enforcement
  - Reporting
  - Specific Best Practice indicated in submissions
  - Additional Learning