Technology and Economic Assessment Panel (TEAP)

Responses to Decisions:

XXXV/6: Updated information on very short-lived substances

XXXV/8: Feedstock uses

XXXV/9: Abating emissions of carbon tetrachloride

MCTOC Co-chairs
Takeshi Eriguchi
Helen Tope
Jianjun Zhang

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Dec. XXXV/6: Updated information on very short-lived substances (VSLS)

To request the Technology and Economic Assessment Panel, in cooperation with the Scientific Assessment Panel, to include in its 2024 progress report, for consideration by the Open-ended Working Group of the Parties to the Montreal Protocol at its forty-sixth meeting:

a) Updated information on very short-lived substances, including their ozone-depleting potential and the impact of each of the very short-lived substances on the stratospheric ozone layer, in quantifiable terms;

b) Information on alternatives to very short-lived substances in the main applications for which they are currently used, including information on availability, technical feasibility, economic viability, safety and sustainability.

Dec. XXXV/8: Feedstock uses

To request the Technology and Economic Assessment Panel, in cooperation with the Scientific Assessment Panel as appropriate, to provide in its 2024 progress report an update on the emissions from feedstock production, as by-products and from feedstock use of controlled substances, including the following:

a) Sources of such emissions, including percentage increases with respect to increased production of controlled substances to be used for feedstock applications;

b) A comparison of estimates of annual global emissions of controlled substances by species based on bottom-up calculations and estimates made by the Scientific Assessment Panel on the basis of atmospheric observations;

c) Methodology adopted for estimating the emissions;

d) Updated information on alternatives, including information on technical feasibility, economic viability, safety and sustainability;

e) Information on best practices and technologies for minimizing emissions.

Dec. XXXV/9: Abating emissions of CTC

To request the Technology and Economic Assessment Panel, in consultation with the Scientific Assessment Panel, to provide in its 2024 progress report an update on the emissions of carbon tetrachloride, including the following:

a) Emissions by source categories, including emissions as a percentage of total production of carbon tetrachloride with a description of the methodology used by the Panel;

b) Updated information on alternatives for carbon tetrachloride use as feedstock applications including information on technical feasibility, economic viability, safety, and sustainability;

c) Updated information on best practices and technologies for minimizing carbon tetrachloride emissions.

Development of response to decisions

- TEAP and its MCTOC Chemical experts developed the responses to these decisions in consultation and cooperation with the Science Assessment Panel (SAP), as appropriate.
- SAP provided updated science information, as presented, including:
  - Annual mean mole fraction and global emissions estimates for dichloromethane (DCM) for 2021 and 2022, and revised values for 2020 (Decision XXXV/6)
  - Annual mean mole fraction and global emissions estimates for CTC for 2021 and 2022, and revised values for 2020 (Decision XXXV/9)
- 2022 SAP Assessment Report used as main reference, including for:
  - Estimates of annual global emissions of controlled substances based on atmospheric observations (Decision XXXV/8)
- Recent science papers included, e.g., Western *et al*., 2023 for CFC-114a, as agreed in consultation with SAP.
- TEAP, MCTOC, SAP reviewed draft and final reports.

Dec. XXXV/6: Updated information on VSLS (1)

- Many chlorinated hydrocarbons with very low but non-zero ODPs are not controlled under the MP and are monitored by atmospheric scientists.
- Collectively they are known as very short-lived substances (VSLS, chlorinated VSLS or Cl-VSLS) because of their atmospheric lifetimes of less than 6 months.
- The report focuses on 5 Cl-VSLS that are very high-volume chemical products: dichloromethane (DCM), trichloromethane (chloroform, CFM), 1,2-dichloroethane (ethylene dichloride, EDC), trichloroethylene (TCE), and perchloroethylene (PCE).
- Parties are not required to submit data on production of VSLS to the Ozone Secretariat.
- Information in the report was obtained from industry experts, publicly available government and industry data, and SAP as described.

Cl-VSLS production and top-down emissions for DCM

Cl-VSLS	Estimated production, 2022 (ktonnes)
DCM	1,750-1,900
CFM	1,700-1,900
EDC	53,000-55,000
TCE	400-410
PCE	590-610

SAP estimated top-down DCM emissions, 2022 (ktonnes):

AGAGE 1,149 (±226)

NOAA 1,412 (±263)

Cl-VSLS uses

- Each of these 5 chemicals is used as feedstock; some also have emissive uses as solvent or foam blowing agent.
- Feedstock usage of EDC is close to 100% and of CFM is more than 90%.
- EDC's main feedstock application is the production of vinyl chloride monomer to polyvinyl chloride (PVC), the third largest of the global plastics production.
- CFM is also used as a process agent solvent in the pharmaceutical industry.
- DCM is predominantly used in emissive uses such as solvent and foam blowing. Emissive DCM use has been banned in some regions due to health risks.
- TCE and PCE are also partly used as solvents.

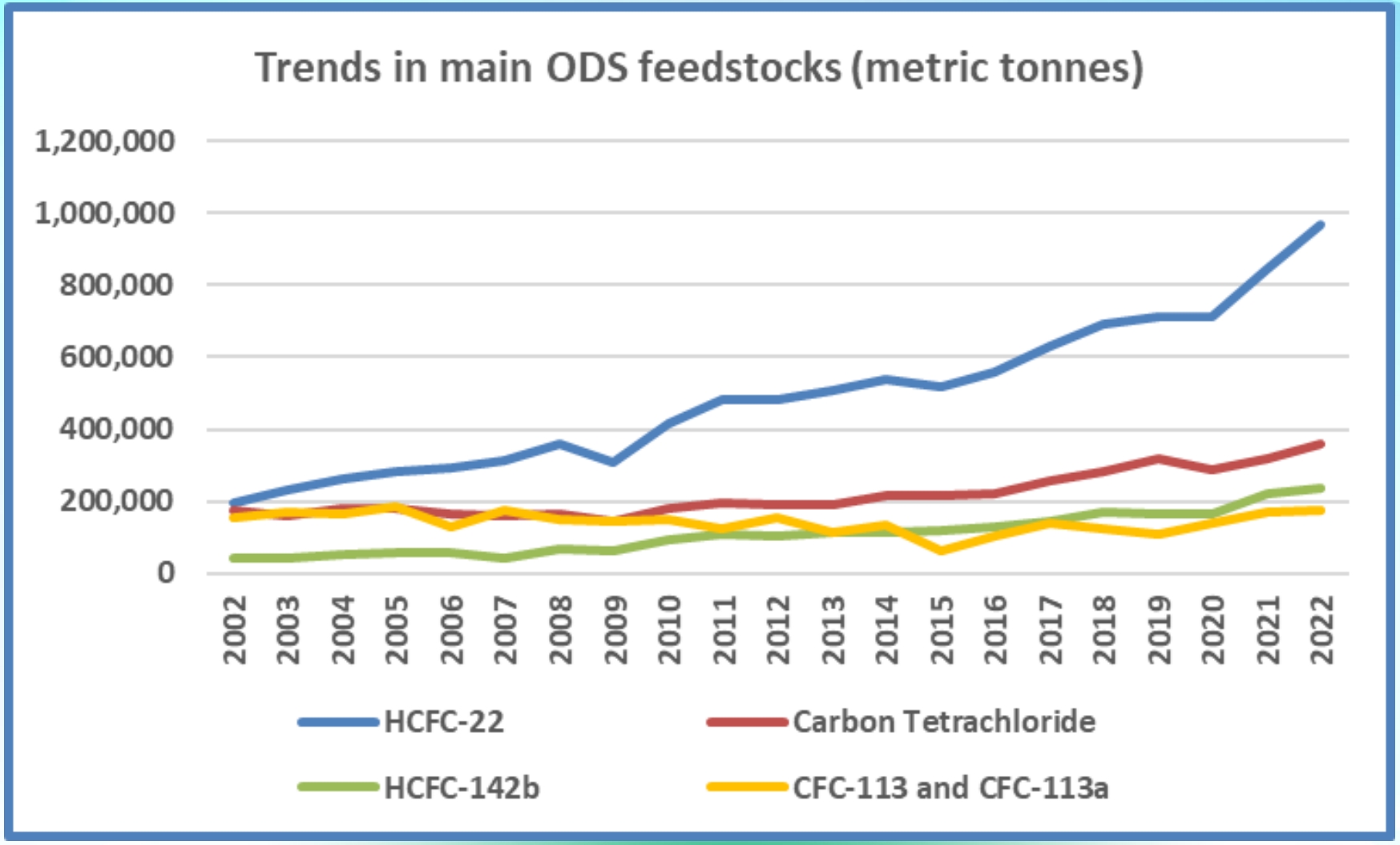
Alternatives to the use of Cl-VSLS

- Alternatives for these VSLS were reviewed and have been reported previously by MCTOC, FTOC, STOC, MLF agencies for similar emissive halocarbon uses in these sectors.
- Selection is on a case-by-case basis for specific applications.
- For solvents, in order of preference, aqueous and hydrocarbon-surfactant (semi-aqueous) cleaning; hydrocarbon solvent cleaning (where toxicity is lower than halogenated solvents, e.g., acetone); halogenated solvents (e.g., HFEs, HFOs, HCFOs); hydrocarbon solvent cleaning (where toxicity is higher than halogenated solvents, e.g., toluene, DMF).
- For foam blowing, DCM use is increasingly banned due to human health risks; alternatives are well documented.
- Refer 2022 TOC Assessment Reports for latest solvent and foam blowing alternatives.
- Examples of alternative feedstock routes are provided. Chlorinated hydrocarbons are generally chosen because the chlorine atom is readily replaced, and the chemical structure is amenable to the desired end-product.

Dec. XXXV/8: Feedstock uses

- In 2022, 15 parties reported feedstock use of ODS, and 10 of these parties also produced ODS for feedstock uses.
- In 2022, total reported ODS production/import for feedstock uses was 1,943,134 metric tonnes (685,204 ODP tonnes); 66% increase over the decade.
- Increase over decade has been mostly due to increase in feedstock uses of HCFCs, particularly HCFC-22.
- HCFC-22 is mainly used to produce tetrafluoroethylene (TFE), which is polymerised to make fluoropolymers with many applications.
- Increasing demand for HCFO/HFOs and PCE is driving the more recent increase in carbon tetrachloride (CTC) feedstock use.
- There has also been an increase in reported feedstock use of HCFC-244 and HCFC-21, used as feedstocks for different routes to HFO-1234yf.
- HFC-152a is the largest HFC feedstock use, e.g., for vinyl fluoride/polyvinylfluoride.

Feedstock uses – production trends



% changes over 1 year and 5 years and CAGR over 10 years are available in the Progress Report

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Feedstock uses – emissions estimates and comparisons

- Emissions of controlled substances during production, distribution, feedstock use contribute to overall global emissions.
- Some feedstocks and by-products have non-feedstock uses or have emissions from banks of RACHP equipment or foams, which can prevent direct comparison of estimates of annual global emissions from feedstock production/use with estimates from atmospheric observations.
- Comparison was made of estimates of annual global emissions of controlled substances based on bottom-up calculations, where these could reasonably be made with currently available data, and annual global emissions estimated by SAP based on atmospheric observations (2022 SAP AR).
- Bottom-up calculations were made using emissions factors for feedstock production, supply chain, and feedstock use, developed by MCTOC (2022 MCTOC AR). *Most likely emission factors* were applied to the amount of production for each substance.
- With available data, substances selected for comparison were:
  - 1,1,1-trichloroethane
  - CFC-113 and CFC-113a; CFC-114 and CFC-114a
  - HCFC-124, HCFC-133a
  - CFC-115 as a by-product

Comparison of estimated annual global emissions

- For several substances, such as 1,1,1-trichloroethane and CFC-113, there is reasonable agreement between bottom-up calculations and top-down estimates; although, according to SAP, top-down emission estimates for CFC-113 may have some small contribution from CFC-113a that is not yet well characterised.
- For some substances, such as CFC-114, HCFC-124, HCFC-133a, there are differences between bottom-up calculations and top-down emission estimates.
- In some cases, possible reasons for these differences have been proposed.
  - Emissions of HCFC-124 intermediate from HFC-125 production appear to make a significant contribution to total HCFC-124 emissions.
  - Over 90% of reported HCFC-133a emissions are suggested to be due to emissions of intermediate HCFC-133a from the production of HFC-134a.
- However, for at least one substance, Halon 1301 (CF_3Br), a representative bottom-up calculation was not considered possible with the data currently available to TEAP. FSTOC will provide more information in the Progress Report presentation.

Alternatives to feedstock uses of controlled substances

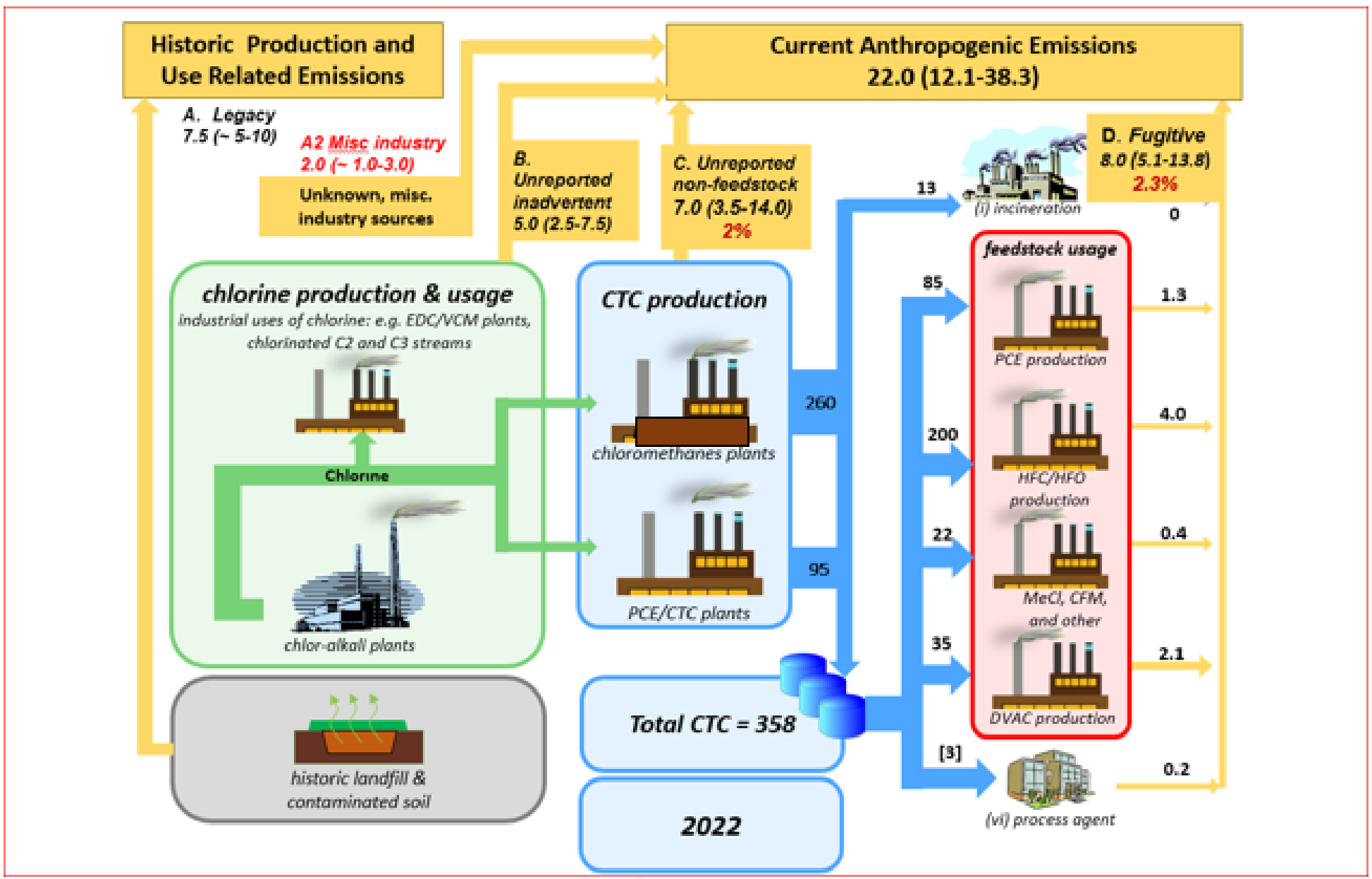
- MCTOC has reviewed and updated the list of available alternatives to ODS feedstock, together with including alternatives to HFC feedstock use. The list of alternatives to ODS feedstock uses has not changed significantly.
- Additional information on technical feasibility, economic viability, safety and sustainability is provided for large scale (>100,000 tonnes per year) feedstock uses.
- The outcome of the review indicates:
  - Only a few technically and commercially possible alternatives to the controlled substance feedstocks currently used have been identified and these alternatives do not cover all of those controlled substances.
  - Those that are available are likely to require significant economic and/or technical hurdles to be overcome to be able to compete with, or replace, existing processes, equipment and supply chains that use controlled substance feedstocks.
  - The absence of switching production to alternative (non-controlled substances) feedstocks suggests that in many cases these hurdles do not make them attractive.

Dec. XXXV/9: Abating emissions of CTC

MCTOC estimated CTC emissions, 2022 (ktonnes): 30 (17-48)

SAP estimated top-down CTC emissions, 2022 (ktonnes):
AGAGE 43.6 (±14.1)

NOAA 33.8 (±14.2)



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Dec. XXXV/9: Abating emissions of CTC – methodology

- Methodology is based on SPARC (2016) and Sherry *et al.* (2018) using available updated information on CTC pathways, reported production and use, and estimated emission factors.
- Examples of potential and existing alternatives to current CTC feedstock uses to make products are provided in the response to decision XXXV/7.
- CTC usage is quite specific in its main feedstock applications. Available alternatives are not as technically and/or economically feasible.

Best practices are available for minimizing emissions from feedstock production, by-production, and use, including CTC

- Best practices are available to control emissions, including:
  - Optimising plant design, equipment, operation, maintenance; instrumentation and monitoring of process and emissions; training and instruction for plant operators; periodic mass balancing; technologies for destruction or for separation and chemical transformation to treat unwanted co-products or by-products and abate their emissions; and regulatory controls to provide the economic framework to ensure any or all of the above emissions mitigation measures are implemented by operators, and to require emissions and other reporting.
- Best practices have been reported in the 2022 MCTOC Assessment Report, the 2023 and 2024 TEAP Progress Reports.
- This information remains unchanged.

Concluding remarks

- TEAP has reviewed all available information on CI-VSLS, feedstock uses, CTC.
- For CTC and DCM, bottom-up and top-down emissions estimates are generally in good agreement within uncertainties, and for feedstock uses, where there are differences, these are explained.
- Any further information provided by parties or other information that becomes available will be reviewed and included for the 2026 Assessment.