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# ADDITIONAL ACTIVITIES TO MAXIMIZE CLIMATE BENEFITS IN THE HCFC PRODUCTION SECTOR (DECISION 71/51(b))

## Background

1. At the 71st meeting, the Executive Committee considered the issue of how to implement decision XXV/5 through which the Executive Committee was requested *inter alia* to consider whether additional demonstration projects to validate low global-warming potential (GWP) alternatives and technologies, together with additional activities to maximize the climate benefits, would be useful in assisting Article 5 parties in further minimizing the environmental impact of HCFC phase-out. Following the discussion, the Committee decided, *inter alia*, to consider at the 72nd meeting issues related to the additional activities to maximize climate benefits in the HCFC production sector (decision 71/51(b)).

2. Pursuant to decision 71/51, the Secretariat has prepared this document, which briefly describes the environmental issues associated with the production of HCFCs, and discusses possible additional activities to maximize climate benefits in the HCFC production sector.

## HCFC production sector

3. The HCFC production sector consists of 38 plants in seven Article 5 countries (28 in China, five in India, and one each in Argentina, the Democratic People's Republic of Korea, Mexico, the Republic of Korea and Venezuela (Bolivarian Republic of)). The total aggregated HCFC production baseline has been established at 501,266 metric tonnes (mt), consisting of 375,262 mt of HCFC-22, 95,368 mt of HCFC-141b, 27,669 mt of HCFC-142b, 2,529 mt of HCFC-123 and 437 mt of HCFC-124. China produces 86 per cent of all the HCFCs and 81 per cent of HCFC-22. Plants in all other countries produce only HCFC-22.

**Environmental wastes associated with the production of HCFCs**

4. The most relevant environmental impacts of HCFC production is the emission of three HFC by-products, with significant climate implications: the ones that are being widely used and produced intentionally for meeting the demands (HFC-143a (GWP of 3,800) and HFC-125 (GWP of 2,800)); and the others that have limited usage and are being emitted as a waste gas (HFC-23 (GWP of 11,700))[1].

5. HFC-143a is a by-product of HCFC-141b or HCFC-142b production, and can be used as a component (47-52 per cent) of refrigerant blends such as R-404A, R-408A and R-507. HFC-125 is a by-product of HCFC-123 or HCFC-124 production, and is a component of various refrigerant blends including R-410A (50 per cent), R-407C (25 per cent), R-404A (44 per cent) and R-408A (7 per cent). HFC-125 can also be used as fire extinguishing agent to replace halon-1301. Since HFC-143a and HFC-125 are components of various refrigerant blends which are currently being widely used as alternatives to HCFCs, they are to be considered products in their own right. HFC-125 is also produced in large quantities and used in other applications. Consequently, their emission reduction may be considered in the context of emission reduction efforts targeting the use of refrigerants or other applications (for HFC-125).

6. HFC-23 is an unavoidable by-product of HCFC-22 production. HFC-23 was previously recovered and used as a feedstock to produce halon-1301; however, this use has ceased. While a small amount of HFC-23 is used predominantly in plasma-etching processes in semi-conductor manufacturing, as a fire suppressant, and either pure or as a blend component in cryogenic refrigeration, the vast majority of HFC-23 produced is not used and is either emitted, captured or destroyed[2]. To the knowledge of the Secretariat, there is no feedstock use of HFC-23 that is technically and commercially viable. Using HFC-23 as feedstock in chemical reactions is becoming an active area of research and will continue to be so for some time[3].

7. Based on the amount of HCFC-22 production for controlled use by all Article 5 countries reported under Article 7 of the Montreal Protocol, the amounts of HFC-23 can be estimated. If all HFC-23 is emitted into the atmosphere, the potential climate impact[4] is shown in Table 1.

**Table 1. HFC-23 production and its potential climate impact**

| | 2008 | 2009 | 2010 | 2011 | 2012 | Baseline |
|---|---|---|---|---|---|---|
| HCFC-22 (ODP tonnes)* | 18,154 | 20,428 | 20,851 | 20,896 | 22,640 | 20,639 |
| HCFC-22 (mt) | 330,078 | 371,418 | 379,105 | 379,925 | 411,634 | 375,262 |
| HFC-23 (mt)** | 9,902 | 11,143 | 11,373 | 11,398 | 12,349 | 11,258 |
| $CO_2$ equivalent (tonnes) | 115,853,400 | 130,373,100 | 133,064,100 | 133,356,600 | 144,483,300 | 131,718,600 |

*HCFC-22 production for controlled use in all Article 5 countries, from Article 7 data.
**Assuming HFC-23 by-product is 3 per cent of HCFC-22 production in mt.

8. As one of the most potent greenhouse gases (GHG), HFC-23 emission has caused particular concerns and its emission abatement has been the focus of global efforts to combat climate change. Under the Clean Development Mechanism (CDM), a total of 19 HFC-23 abatement projects were funded with a maximum destruction of 6,928 tonnes of HFC-23 and emission reduction of 80,810,710 tonnes of $CO_2$ equivalent ($tCO_2eq$) per annum[5]. This amount accounts for 62 per cent of the total HFC-23 produced

[1] GWP value over a 100 year time horizon. Guidelines for the preparation of national communications by Parties, United Nations Framework Convention on Climate Change (UNFCCC).
[2] Benefits of phasing down HFCs under the Montreal Protocol, US Environmental Protection Agency (USEPA), May 2011.
[3] Fluoroform ($CF_3H$): An industrial waste or a useful raw material? Journal of Postdoctoral Research, September 2013, Loker Hydrocarbon Research Institute, University of Southern California.
[4] Using GWP value of 11,700 for HFC-23, the climate impact is calculated using the tonnage of HFC-23 multiplied by 11,700.
[5] Total carbon emission reduction of 19 HFC-23 abatement projects funded by CDM. The data was extracted from project design documents.

from HCFC-22 baseline production for controlled use[6] and 40 per cent of that for both controlled and feedstock use. The remaining HFC-23 is vented into the atmosphere. Given the scale of the global warming impact from HFC-23 emission, additional activities could be considered to reduce the HFC-23 production and its related GHG emission.

**Possible additional activities and challenges**

HFC-23 production monitoring and reporting

9. The level of HFC-23 production was monitored in plants and lines associated with CDM projects as a requirement of calculating carbon credits[7]. Additional activities could be considered to monitor HFC-23 emission in order to collect more accurate data, better monitor the production process, lay out a foundation for further improvement in reducing HFC-23 emission, and raise awareness among the industry and encourage best practice in managing HFC-23 emission.

10. The potential barriers of HFC-23 monitoring include the capital and operating costs of monitoring equipment (i.e., measuring equipment, installation and routine sampling, testing and data analysis). For example, in CDM projects, the emission of HFC-23 is measured through flow rate and a gas chromatograph. Another barrier is the lack of regulatory requirement for monitoring. Although HFC-23 is included in the GHG inventory, the reporting methodology[8] approved by UNFCCC allows the HFC-23 emission to be estimated based on HCFC-22 production. Given that there are no regulatory requirements for monitoring in Article 5 producing countries, HCFC-22 producers may not be willing to voluntarily monitor HFC-23 production.

Study on reducing emissions and optimizing production processes

11. HFC-23 waste generation rate varies from plant to plant, depending largely on process optimization and plant operating conditions. Research[9] showed that at plants not fully optimized to reduce HFC-23, the upper bound for HFC-23 emissions is 3 to 4 per cent of the HCFC-22 production. However, many plants that are currently operating have implemented process changes to reduce HFC-23 generation. At these plants, the likely range of emissions is about 1.5 to 3 per cent of production with 2 per cent being a reasonable average estimate. IPCC/TEAP report[10] also indicated that techniques and procedures to reduce the generation of HFC-23 through process optimization can reduce average emissions to 2 per cent or less of HCFC-22 production. The average of actual waste generation rates from the 19 CDM projects is 3.09 per cent[11] and 2.73 per cent for the rates applied for crediting purpose[12]. If HFC-23 production could be reduced from 3 per cent[13] to 2 per cent of HCFC-22 production for all the 26 HCFC-22 producing plants in Article 5 countries, applying to HCFC-22 production baseline as an example, this would mean a reduction of 3,753 mt of HFC-23 production and a GHG emission reduction of 44 million $tCO_2eq$[14].

12. A study on process optimization and emission reduction would review process design and operational status of HCFC-22 producing plants; identify potential factors that affect HFC-23 waste generation rate; and further propose measures that could be introduced to improve process design and/or

[6] Assuming 3 per cent of HFC-23 generation rate.
[7] The approved baseline and monitoring methodology AM 0001"decomposition of fluoroform waste stream", by UNFCCC.
[8] Guidelines for national greenhouse gas inventories, IPCC, 2006.
[9] HFC-23 emission from HCFC-22 production, http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/3_8_HFC-23_HCFC-22_Production.pdf, IPCC.
[10] IPCC/TEAP special report: safeguarding the Ozone layer and the Global Climate System, 2005, page 79.
[11] Calculated based on an average of waste generation rates of all CDM production lines in three years period before crediting.
[12] This is the average of waste generation rates applied in 19 CDM projects, data extracted from CDM design documents.
[13] This is the average HFC-23 waste generation rate of 11 CDM projects in China.
[14] HFC-23 reduction is calculated multiplying the baseline production of HCFC-22 of 375,262 mt by 1 per cent, equalling to 3,753 mt. The GHG emission reduction is calculated multiplying 3,753 mt by HFC-23 GWP value (11,700), resulting in 43,910,100 $tCO_2eq$.

operating conditions with an aim to reduce HFC-23 emission and/or to increase system efficiency. This study could also provide information on the cost and benefit of process optimization and the impact on HCFC-22 output. Technical assistance may be provided to the plants involved in the study. Subsequent study recommendations can be implemented to improve the operation in other plants.

13. The potential obstacle for conducting the study on reducing emissions and optimizing production processes could be the lack of incentive for HCFC-22 producing plants to participate in the programme due to unavoidable disturbance to normal production if process changes are involved, the possible additional capital cost required for optimization, the prolonged period to benefit from the change, and the uncertainty of future HCFC-22 market. Confidentiality issues could also prevent plants from exposing plant design and operational conditions in the context of market competition for not only controlled use but also feedstock production. Moreover, selection of plants to implement optimization could be complicated. For example, plants that have poor operational conditions and could be greatly improved through optimization are likely to be less economically competitive. In this case, it could be more cost-effective to phase out HCFC-22 production rather than optimizing them. Optimization may be more cost-effective for plants that are competitive and have the potential to operate for longer period. In addition, assistance to selective producers might affect a fair market competition during HCFC phase-out. Considering the various factors discussed above, a demonstration project could be planned to conduct a trial on reducing emissions and the optimization study. Experience gained and lessons learned could be used for further actions on the course.

Policy and regulation

14. Policy and regulations could be considered to monitor HFC-23 emission levels, implement emission reduction standards or provide for HFC-23 destruction in all HCFC-22 producing plants supported by the Multilateral Fund as a best practice initiative for HCFC-22 phase-out. The development and implementation of such policy and regulations would require consent and support from the Governments of Article 5 producing countries.

15. Initiatives taken by plants to implement emission reduction of HFC-23 should be taken into consideration when prioritizing phase-out and closure of production capacity. HCFC-22 producing plants generally have a replacement lifetime of 15 years. Newly-established plants normally use optimized process and have lower HFC-23 waste generation rate than older ones. For climate benefits, HCFC-22 phase-out in production sector should start from older plants that have higher HFC-23 waste generation rates. Therefore the strategy of HCFC production phase-out should take into consideration not only the economic factor (less cost for closure) but also the environmental impact associated with the emission of HFC-23.

Destruction of HFC-23 through on-site/off-site incineration facilities

16. The most environmental sound approach for managing HFC-23 is through destruction. Among the 26 HCFC-22 producing plants in Article 5 countries, eight do not have destruction facilities, of which six are in China, and one each in the Democratic People's Republic of Korea and the Bolivarian Republic of Venezuela. Some incineration facilities in CDM plants do not cover all the production lines. For example, of 33 production lines in China, only 15 lines are covered under CDM projects.

17. The capital cost of incineration facilities varies from project to project. Based on the available information from the China production sector technical audit report, the capital cost of incineration facilities under CDM projects ranges from US $3.8 to US $8.0 million covering the costs of incinerator and associated auxiliary facilities. The report[15] by IPCC and TEAP indicated US $2.0 million to US $8.0 million total installed capital costs and US $189,000 to US $350,000 annual operating cost, and

[15] IPCC/TEAP special report: Safeguarding the ozone layer and the global climate system, 2005 (page 81 and 15).

that the cost of destruction of by-product emission of HFC-23 from HCFC-22 production is below US $0.2/t$CO_2$eq.

18. The main issue related to HFC-23 destruction is funding for capital and operating costs. With the ban of HFC-23 decomposition project by major carbon markets, such as European Emissions Trading System (EU-ETS) and Verified Carbon Standards (VCS), the future of CDM projects is uncertain. A demonstration project can be planned to explore potential financing models for HFC-23 incineration, for example, based on a shared responsibilities among the producers, Governments and the Multilateral Fund.

**Summary**

19. Demonstration of some of the aforementioned activities might be considered. There could be a demonstration project to establish monitoring system for HFC-23 production; a study to assess means of optimizing the process to minimize HFC-23 emission; an assessment of regulatory possibility for the management of HFC-23; or a study of alternative feedstock uses of HFC-23. There could also be a demonstration of HFC-23 destruction, which has never been funded by the Multilateral Fund.

**RECOMMENDATION**

20. The Executive Committee may wish:

(a) To note the document on additional activities to maximize climate benefits in the HCFC production sector (decision 71/51(b)) (UNEP/OzL.Pro/ExCom/72/41); and

(b) To consider whether any of the following activities might be considered as part of future business plans:

(i) HFC-23 production monitoring and reporting;

(ii) Study on reducing emissions and optimizing production processes;

(iii) Policy and regulation; and

(iv) Destruction of HFC-23 through on-site/off-site incineration facilities.

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