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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eighty-fourth Meeting
Montreal, 16–20 December 2019

KEY ASPECTS RELATED TO HFC-23 BY-PRODUCT CONTROL TECHNOLOGIES: MEXICO (DECISION 83/67)

Background

1. At its 79th meeting, the Executive Committee decided to *inter alia* consider possible cost-effective options for compensation for HCFC-22 swing plants to allow for compliance with the HFC-23 by-product control obligations of the Kigali Amendment (decision 79/47(c)).

2. At its 83rd meeting, the Executive Committee considered a request for project preparation for the control of HFC-23 by-product emissions in the HCFC production sector in Mexico submitted as part of the UNIDO's work programme for 2019. Subsequent to a discussion in a contact group, the Executive Committee decided (decision 83/67):

(a) To approve US $55,000, plus agency support costs of US $3,850 for UNIDO to enable the agency to submit, to the 84th meeting, on behalf of the Government of Mexico, project proposal options that would enable the Government of Mexico to comply with the HFC-23 by-product control obligations under the Kigali Amendment, including data regarding costs and benefits and covering technical feasibility, economic viability, relevant credits that might be applicable in the country in the future, and logistical, legal and transactional issues in relation to the following:

(i) Resuming operation of both the integrated on-site incinerator and the non-integrated on-site incinerator at the HCFC-22 production swing plant Quimobásicos, on the basis of three independent estimates of the costs/savings of doing so for each, including in relation to operation of the incinerator, compliance with standards for the management of hazardous waste, and monitoring and verifying the destruction of the HFC-23 by-product;

(ii) Importing HCFC-22 to meet demand in the domestic market, including a comparison of the price of sourcing it locally and internationally;

(iii) Destroying HFC-23 by-product through irreversible transformation and other new conversion technologies, and storage options for HFC-23 management;

(iv) Shipping HFC-23 for off-site destruction by means of a technology approved by the Meeting of the Parties;

(v) Optimizing the HCFC-22 production to reduce the generation of the HFC-23 by-product;

(vi) Selling the HFC-23 for feedstock use or adapting the plant so that it could use HFC-23 for the production of HCFC-22;

(b) To request UNIDO to include, in its submission to the 84th meeting, information regarding the relationship between the country's control of HFC-23 by-product emissions and the nationally determined contributions of the Government of Mexico under the Paris Agreement;

(c) To request the Secretariat to present a document to the 84th meeting reviewing each of the project proposal options submitted, including the data provided pursuant to sub-paragraphs (a) and (b) above;

(d) To discuss the criteria for funding the activities related to the compliance obligations of Article 5 countries with respect to HFC-23 by-production emission controls at the 84th meeting; and

(e) To request UNIDO to return any remaining balances from the funding approved in sub-paragraph (a) above to the Multilateral Fund by the 86th meeting.

Scope of the document

3. In line with decision 83/67, on behalf of the Government of Mexico, UNIDO has submitted project proposal options to control and phase out HFC-23 emissions at Quimobásicos, at a total cost of US $9,669,876, plus agency support costs of US $676,891, as originally submitted.[1]

4. The present document consists of the following two parts:

I: Project proposal for Mexico
It presents a description of the project proposal, describes six options that were considered for addressing emissions of HFC-23 and presents the Secretariat's comments.

II: Summary of policy issues related to control of HFC-23 by-product emissions in Mexico[2]
To facilitate the review of the proposal by the Executive Committee, this part summarizes the following policy issues relevant to the project: eligibility of HFC-23 by-product associated with HCFC-22 exported to a non-Article 5 country; basis for HCFC-22 production to be used in determining IOCs; duration for which funding support is provided; eligibility of back-up systems to enable control of HFC-23 by-product emissions; level of agency support costs; and by-product generation rate. The document also includes a conclusion and recommendation.

[1] As per the letter of 9 September 2019 from the Ministry of Environment of Mexico to UNIDO.

[2] In line with decision 83/67(d), document UNEP/OzL.Pro/ExCom/84/70 presents policy issues related to the compliance obligations of Article 5 countries with respect to HFC-23 by-product emission controls.

5. The present document also contains the following two Annexes:

Annex I Description of two options identified by the Secretariat that might allow emissions of HFC-23 by-product to be minimized

Annex II Costs of options 1 and 4 (contained in the project proposal), and options A and B (proposed by the Secretariat) for addressing emissions of HFC-23 by-product

6. As the proposal by UNIDO contains information considered confidential, the present document summarizes the submission, and presents the Secretariat's comments. Executive Committee members wishing to review the submission may request it from the Secretariat on the understanding that the information and data contained therein is only for the evaluation of the project and not to be disclosed to a third party.

I PROJECT PROPOSAL FOR MEXICO

Project description

7. The project proposal submitted by UNIDO presents options that would enable the Government of Mexico to control HFC-23 by-product emissions from the HCFC-22 production lines at Quimobásicos.

Report on HCFC-22 production and consumption

8. The Government of Mexico reported a 2018 consumption of 321.07 ODP tonnes of HCFCs (i.e., 72 per cent below the baseline), with HCFC-22 accounting for 51 per cent of that consumption, and a production of HCFC-22 (for both controlled and feedstock uses) of 424.47 ODP tonnes. The 2014-2018 HCFC-22 consumption and production is shown in Table 1.

Table 1. HCFC consumption and production in Mexico in ODP tonnes (2014-2018 Article 7 data)

HCFC-22	**2014**	**2015**	**2016**	**2017**	**2018**	**Baseline**
Consumption	271.32	245.75	254.96	258.18	162.93	467.8
Production*	**506.77**	**260.09**	**262.51**	**328.09**	**424.47**	**

* Total production for controlled and feedstock uses.

** The HCFC production baseline for controlled uses is 697 ODP tonnes. HCFC production for controlled uses in 2018 is 74 per cent below the baseline for compliance.

9. Imports of HCFC-22 continue to decline; and consumption of HCFC-22 fell by 23 per cent between 2017 and 2018. HCFC-22 production is dominated by exports. In 2018, production of HCFC-22 at Quimobásicos was 7,718 mt (424.47 ODP tonnes), of which 5,619 mt (309.05 ODP tonnes) were exported to a non-Article 5 country for feedstock uses (representing 73 per cent of the total production), 665 mt (36.58 ODP tonnes) were exported to Article 5 countries for consumptive uses, and 1,433 mt (78.82 ODP tonnes) were consumed domestically.

Enterprise background

10. Quimobásicos is the only HCFC producer in the country; is 51 per cent locally owned, with the remaining 49 per cent is non-Article 5 owned. The enterprise produces HCFC-22 and imports and sells gases for refrigeration, propellants, foaming agents, and other emissive and non-emissive applications on the Mexican, Latin American, North American, and Asian markets.

11. The enterprise has two HCFC-22 production lines (line #1 and line #2), each with a capacity of approximately 10,000 metric tonnes (mt) (550 ODP tonnes) per year. Line #1 is currently in operation, while line #2 was last used in 2015. The last time the enterprise operated both lines was in 2012; the last time the enterprise's production was above the capacity of a single line was in 2011.

12. Quimobásicos participated in a project under the Clean Development Mechanism (CDM) to destroy HFC-23 by-product between 14 June 2006 and 31 December 2012.[3] For that project, Quimobásicos purchased in 2006 a second-hand plasma-arc destruction unit (PDU) that was integrated with line #1. In addition, in 2008, the enterprise purchased a second PDU to avoid venting HFC-23 in case PDU-1 temporary became non-operational. PDU-2 was not integrated with either production line but is a stand-alone unit that has been used from time-to-time to destroy fluorinated gases as a separate business activity. PDU-2 was last used in 2015 to destroy 74 tonnes of refrigerants, including CFCs and HCFCs, under a demonstration project funded by the Multilateral Fund.[4] In addition, Quimobásicos established a wastewater treatment plant to exclusively treat the effluent from the PDUs.

13. Prior to the CDM project described above, Quimobásicos had submitted a project design document to the CDM to destroy HFC-23 by-product at a hazardous waste treatment facility in Texas, United States of America. Prior to its approval under the CDM, Quimobásicos voluntarily started the project on 1 January 2006. The project was terminated after about six months as proposals for destruction of HFC-23 in a country not signatory to the Kyoto Protocol could not be accepted. The credits associated with that destruction were verified by Det Norske Veritas, which issued a certificate for 727,841 verified emission reduction credits (VERs),[5] and TÜV, which issued a certificate for 255,707 VERs.[6]

14. Quimobásicos currently vents all of the HFC-23 by-product it generates. The enterprise has taken steps to reduce its HFC-23 by-product generation rate, from a high of 2.55 per cent, to a minimum of 1.30 per cent; in 2018, the generation rate was 1.67 per cent.[7]

Options for addressing emissions of HFC-23 by-product

15. In line with decision 83/67, UNIDO submitted the following six options for addressing emissions of HFC-23 by-product:

Option 1	Resuming operation of the integrated on-site incinerator and the non-integrated on-site incinerator
Option 2	Importing HCFC-22 to meet demand in the domestic market
Option 3	Destroying HFC-23 by-product through irreversible transformation and other new conversion technologies, and storage options for HFC-23 management
Option 4	Shipping HFC-23 for off-site destruction by means of a technology approved by the Parties
Option 5	Optimizing the HCFC-22 production to reduce the generation of the HFC-23 by-product
Option 6	Selling the HFC-23 for feedstock use or adapting the plant so that it could use HFC-23 for the production of HCFC-22

[3] The total certified emission reduction credits (CERs) generated by Quimobásicos under the CDM was 13,593,573 mt-CO_2eq. At US $5/mt-$CO_2$, this represents a revenue of approximately US $68 million.

[4] Final report contained in document UNEP/OzL.Pro/ExCom/80/12

[5] In contrast to CERs, which are generated under CDM projects, VERs are used in the voluntary carbon markets.

[6] A portion of the VERs verified by TÜV also included on-site destruction, which commenced prior to approval of the on-site CDM project.

[7] The HFC-23 waste stream is composed of 85 per cent HFC-23, 5 per cent HCFC-22 and 10 per cent non-condensables, mostly air. As any substances that cannot be separated from the HFC-23 are co-destroyed, the effective generation rate of this by-product waste stream ranged from a high of 3.0 per cent, to a minimum of 1.52 per cent; in 2018, it was 1.96 per cent.

16. The analysis of relevant options for addressing emissions of HFC-23 by-product, are based on a HCFC-22 production forecast for 2019-2030 based on the production in 2018, market trends and the estimated 2019 sales, as shown in Table 2.

Table 2. HCFC-22 production forecast by use (mt)

Use	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic consumption	2,000	2,000	2,000	2,000	2,000	2,000	2,000	1,700	1,360	952	571	75
Exports to Article 5	1,200	1,504	1,504	1,354	1,218	1,096	987	839	671	470	282	50
Exports to non-Article 5	6,813	8,505	10,695	11,191	11,710	12,255	12,825	13,424	14,052	14,710	15,401	16,124
Total	**10,013**	**12,008**	**14,199**	**14,544**	**14,928**	**15,351**	**15,812**	**15,963**	**16,083**	**16,132**	**16,253**	**16,250**
Per cent Article 5	32	29	25	23	22	20	19	16	13	9	5	1

17. A summary of the six options for addressing emissions of HFC-23 by-product included in the project proposal is presented below.

Option 1: Resuming operation of the integrated on-site incinerator and the non-integrated on-site incinerator

18. While PDU-1 is integrated in line #1, its connection to the HFC-23 waste stream was disconnected in 2013. The unit has been idle since then and has not been maintained; restarting the unit would require a comprehensive refurbishment. While PDU–2 is not integrated into either production line, connections could be established in a relatively short period of time. The unit has not been used since 2015 and would also require refurbishment in order to be restarted.

19. UNIDO would order the equipment, parts and services required to restart the two PDUs enabling Quimobásicos to operate the HCFC-22 plant and continuously incinerate the HFC-23 waste stream. The costs for this option include the costs to refurbish the PDUs, the variable and fixed operating costs of the PDUs, the costs to refurbish the local wastewater treatment facility, and costs associated with monitoring and verifying the destruction of the HFC-23 by-product.

20. In line with decision 83/67(a)(i), UNIDO tried to solicit three independent estimates to refurbish the PDUs; however, since the PDUs are based on Plascon's proprietary technology, and the key equipment items are unique, tailor-made products, only the original technology supplier was found to be able to offer the required services and supply the necessary parts. Plascon[8] reviewed the condition of both units and assessed the work required to refurbish and restart both units, considering at least ten years' continuous operation after restart, as reflected in Table 3.

Table 3. Capital costs to refurbish PDU-1 and PDU-2 (US $)

Item	PDU-1	PDU-2
PDU liquid effluent (alkaline train) starting from bottom of quench tank	66,904	14,000
NaOH (sodium hydroxide) supply train starting at existing caustic soda supply tank	107,605	36,268
Steam supply train or vaporizer vessel	6,860	3,500
Cooling water or deionized water	19,798	8,000
Torch assembly	65,000	65,000
Electrical train, including controls	244,652	341,472
Additional equipment and labour	89,510	13,860
Cooling tower maintenance update	0	1,185
Sub-total	**600,329**	**483,285**
Total		**1,083,614**

[8] Plascon's confidential report and quotation is available to Executive Committee members upon request.

21. In addition, UNIDO considered the spare parts foreseen for 10 years of operation, not including consumables, like the torch (accounted for as part of the variable costs to operate the PDUs, i.e., IOCs). Those spare parts are only requested for one PDU. UNIDO also estimated the cost to repair and refurbish the wastewater treatment facility to treat the effluent, as reflected in Table 4.

Table 4. Capital costs for spare parts and to refurbish the effluent treatment facility (US $)

Item	Cost
Spare parts for PDU operation through 2030	
Replacement of HFC-23 meter in 2025	21,344
Replacement of DSC-800 controller in 2027	47,200
Replacement of torch power cables in 2029	33,500
Replacement of power supply in 2030	247,500
Sub-total	**349,544**
Effluent treatment facility	
Effluent treatment facility refurbishment	154,551
Total	**504,095**

22. The total incremental capital costs (ICCs) of option 1 are US $1,746,480, consisting of US $1,083,614 to refurbish PDU-1 and PDU-2, US $349,544 for spare parts needed between 2025-2030, US $154,551 to refurbish the wastewater treatment facility, and 10 per cent contingency on those costs (for a total of US $158,771).

23. UNIDO estimated IOCs based on the production forecast, the 2018 HFC-23 waste stream generation rate, and the estimated costs to operate the PDUs based on data available from the CDM. The average 2006-2012 consumption of caustic soda, steam, argon, potable water, deionized water, electricity, lime, and replacement torches were calculated per tonne of HFC-23 destroyed; variable costs are then determined as the product of the HFC-23 waste stream to be destroyed, the per unit consumption of each item, and the 2019 price of the item. Wages and salaries, electricity services, insurance and bonds, maintenance, monitoring and other costs were estimated based on 2006-2012 historic data, scaled at 2019 prices. UNIDO estimated that between six and nine months would be required to refurbish the PDUs; accordingly, IOCs for 2020 were calculated for six months; HFC-23 by-product would be emitted to the atmosphere for the first six months of the year. On that basis, the total IOCs for 2020-2030 is US $16.78 million, as shown in Table 5.

Table 5. IOCs of HFC-23 destruction for 2020-2030 (US $)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
HCFC-22 production (mt)	12,008	14,199	14,544	14,928	15,351	15,812	15,963	16,083	16,132	16,253	16,250
HFC-23 waste stream (mt)*	117.92**	278.87	285.65	293.19	301.49	310.55	313.51	315.87	316.83	319.22	319.14
PDU variable cost (US $/kg)											
Variable costs	3.95	3.96	3.97	3.97	3.97	3.98	3.99	3.99	4.00	4.00	4.00
PDU fixed cost (1,000 US $)											
Wages and salaries	83.63	83.63	83.63	83.63	83.63	83.63	83.63	83.63	83.63	83.63	83.63
Electricity services	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13
Insurance and bonds	5	5	5	5	5	5	5	5	5	5	5
Maintenance	241	241	241	241	241	241	241	241	241	241	241
Monitoring	42	42	42	42	42	42	42	42	42	42	42
Other	20	20	20	20	20	20	20	20	20	20	20
Fixed costs	197.67**	395	395	395	395	395	395	395	395	395	395
Total costs (1,000 US $)											

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Variable costs	466.22**	1,104.70	1,132.68	1,163.07	1,197.31	1,236.60	1,251.30	1,261.86	1,266.33	1,275.88	1,275.58
Fixed costs	197.67**	395.35	395.35	395.35	395.35	395.35	442.55	395.35	395.35	395.35	395.35
Total	**663.89****	**1,500.05**	**1,528.03**	**1,558.42**	**1,592.66**	**1,631.95**	**1,646.65**	**1,657.21**	**1,661.68**	**1,671.23**	**1,670.93**

*The HFC-23 waste stream is composed of 85 per cent HFC-23, 5 per cent HCFC-22 and 10 per cent (non-condensable) air. As the HCFC-22 and air cannot be separated from the HFC-23, it is co-destroyed.

**Six months only, since investments will finish earliest six months after project approval. During those months, 100 mt of HFC-23 would be vented to the atmosphere.

24. The total cost of option 1 is US $18,529,168, as submitted. After taking into account the 49 per cent non-Article 5 ownership, the total cost to the Multilateral Fund of option 1 would be US $9,449,876.

Option 2: Importing HCFC-22 to meet demand in the domestic market

25. Between 2016 and 2018, import prices and net bulk prices increased every year; while packaging cost remained constant. Quimobásicos produces high-quality HCFC-22, while low-quality refrigerants have a limited market share in Mexico. The supply of HCFC-22 offered by the four main importers is becoming limited with the rise of imports of diverse quality from different origins. The price of HCFC-22 reported under Mexico's country programme implementation report is substantially higher than the international market price; the same applied to Quimobásicos' sales price for domestic use.

26. According to Quimobásicos, production costs have always been competitive, in part because the enterprise purchases anhydrous hydrogen fluoride (AHF) locally and chloroform from regional suppliers. The enterprise does not find it economically viable to only import HCFC-22 for the following reasons: loss of market share and positioning, cancellation and/or renegotiation of contracts with raw material suppliers with established business relations with the enterprise, closures of established workplaces and layoffs of specialized workers, which in turn would create social tensions. In addition, converting from production to importing takes time and has a negative effect on the country's economy.

27. For the above-mentioned reasons, the Government of Mexico and Quimobásicos consider option 2 not to be feasible.

Option 3: Destroying HFC-23 by-product through irreversible transformation and other new conversion technologies, and storage options for HFC-23 management

28. UNIDO could not identify any irreversible transformation or viable conversion technologies that could be implemented in the time available.

Option 4: Shipping HFC-23 for off-site destruction by means of a technology approved by the Parties

29. UNIDO based its proposal for off-site destruction on the voluntary off-site destruction of HFC-23 that Quimobásicos undertook in 2006. The off-site destruction took place at a rotary kiln located in Port Arthur, Texas, United States of America,[9] which is about 950 km from Quimobásicos and can be reached by truck within a day. The cooperation in 2006 was successful and no major problems from regulations, logistics, technicalities, destruction-efficiency or from a commercial point of view.

30. For the destruction of HFC-23 generated by Quimobásicos, the hazardous waste facility confirmed its interest in participating, with a destruction cost of US $4.00/kg of the HFC-23 waste stream, which contains 85 per cent HFC-23, 5 per cent HCFC-22 and 10 per cent non-condensable (mainly air, CO_2). The cost of freight is advantageous; the simplicity of logistics, as well as the past experience using this method,

[9] The rotary kiln is an authorized hazardous waste destruction facility that has the necessary permits to destroy HFC-23 in the United States of America.

work in favor of this option, compared to destruction at any other facilities abroad. In Mexico no such facility is available.

31. Off-site destruction would require refurbishing the on-site Polaris cryogenic condensing separation unit, which was last used in 2006 and is in disrepair, leasing or purchasing tube-containers for transport, and purchasing a new ambient vaporizer skid to be used at the rotary kiln incinerator to feed the HFC-23 waste stream into the kiln under controlled conditions. In addition, a cryogenic tank would be needed in case there was a delay during transportation and off-site destruction.

32. The Polaris cryogenic condensing separation unit is a specialized piece of equipment; accordingly, only a quotation from the equipment supplier was provided. Similarly, a single quotation was provided for the purchase of a cryogenic tank, which could be shipped from a distributor located in Texas, United States of America, within twelve to fifteen weeks from the receipt of order. UNIDO estimated that the duration of repairs to the Polaris cryogenic unit, and the purchase and installation of the ambient vaporizer skid at the rotary kiln was between six to nine months. Table 6 shows the capital costs of option 4.

Table 6. Capital costs of option 4 off-site destruction of HFC-23

Item	Cost (US $)
Repair and installation of cryogenic condenser	304,337
On site cryogenic tank, 11,000 gallons, double wall, with re-condensing cooling coil, stainless steel inner wall	212,658
Equipment for U.S.-based rotary kiln (Unloading skid, tank, instrumentation, heater) in conformity with rotary kiln's specifications	429,541
Total capital cost	**946,536**

33. The costs of off-site destruction between 2020 and 2030, the period for which funding is requested, are shown in Table 7, for a total of US $21.19 million.

Table 7. Cost of off-site destruction from 2020-2030 (US $)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
HCFC-22 production (mt)	12,008	14,199	14,544	14,928	15,351	15,812	15,963	16,083	16,132	16,253	16,250
HFC-23 waste stream (mt)*	118**	279	286	293	301	311	314	316	317	319	319
Variable HFC-23 off site Destruction cost (US $/mt)											
Nitrogen***	528	528	528	528	528	528	528	528	528	528	528
Electricity***	37	38	38	38	39	40	42	42	42	42	42
Freight	440	440	440	440	440	440	440	440	440	440	440
Off-site destruction	4,744	4,744	4,744	4,744	4,744	4,744	4,744	4,744	4,744	4,744	4,744
Customs	42	42	42	42	42	42	42	42	42	42	42
Total variable off site destruction cost	**5,791**	**5,792**	**5,792**	**5,792**	**5,793**	**5,794**	**5,795**	**5,796**	**5,796**	**5,796**	**5,796**
HFC-23 off site destruction fixed costs (1,000 US $)											
Wages and salaries	21	42	42	42	42	42	42	42	42	42	42
Insurance and bonds	3	3	3	3	3	3	3	3	3	3	3
Maintenance	95	95	95	95	95	95	95	95	95	95	95
Monitoring cost	50	50	50	50	50	50	50	50	50	50	50
Tube - trailer lease	79	79	79	79	79	79	79	79	79	79	79
Total HFC-23 off site fixed costs	**134**	**268**	**268**	**268**	**268**	**268**	**268**	**268**	**268**	**268**	**268**
Total destruction costs (1,000 US $)											
Variable costs	683**	1,615	1,655	1,698	1,747	1,799	1,817	1,831	1,836	1,850	1,850
Fixed cost	134**	268	268	268	268	268	268	268	268	268	268
Total cost	**817****	**1,883**	**1,923**	**1,966**	**2,015**	**2,068**	**2,085**	**2,099**	**2,104**	**2,118**	**2,118**

*The HFC-23 waste stream is composed of 85 per cent HFC-23, 5 per cent HCFC-22 and 10 per cent (non-condensable) air. As the HCFC-22 and air cannot be separated from the HFC-23, it is co-destroyed.

**Six months only, since investments will finish earliest six months after project approval. During those months, 100 mt of HFC-23 would be vented to the atmosphere.

***Used by the Polaris cryogenic condensing separation unit.

34. Combined with the capital costs, the total cost of option 4 is US $22,135,738. After taking into account the 49 per cent non-Article 5 ownership, the total cost to the Multilateral Fund of option 4 would be US $11,289,226.

Option 5: Optimizing the HCFC-22 production to reduce the generation of the HFC-23 by-product

35. In the past 17 years, the HFC-23 waste stream generation rate has varied between 1.52 and 3.00 per cent; that rate is (weakly) correlated with production volume, where lower production tends to lead to lower generation rates. However, if the low production is the result of less operating days characterized by high production during those days, the generation rate may be higher. Moreover, the number of plant shut-downs and start-ups also influences the generation rate, where the more frequent the shut-downs and start-ups, the higher the generation rate.

36. Additional measures to reduce the quantity of HFC-23 waste stream include: improving the design of the product distillation column, which would improve the separation of HCFC-22 from the waste stream and therefore reduce the quantity of material destroyed; and to improve the connectors in jugs and change automatic valves in HCFC-22 filling stations in order to reduce HCFC-22 packing losses.

37. Accordingly, UNIDO proposed:

(a) To cap production from the nameplate capacity of 30 tonnes per day to 25 tonnes per day. Given the forecast production, this would require the second production line to be operated approximately 50 days earlier to be able to cover all the orders for the given years. The incremental cost of this action is the daily plant fixed costs multiplied by the additional days of operation of the second production line. Based on the forecast production between 2020-2024; starting in 2025, at least one production line would be operated at full capacity to meet the forecasted demand;

(b) To replace the HCFC-22 product distillation column with a new one of increased diameter and with higher efficiency packing material. This, with improved operating conditions, would reduce the concentration of HCFC-22 in the HFC-23 waste stream by 62.5 per cent (i.e., the HFC-23 waste stream would be composed of 88 per cent HFC-23, 2 per cent HCFC-22, and 10 per cent non-condensables); and

(c) To improve connectors in jugs and change automatic valves (with better seal) in HCFC-22 filling stations in order to reduce packing losses.

38. UNIDO estimated that the three-above mentioned activities would cost US $713,625 as outlined in Table 8.

Table 8. Cost of activities for optimizing the HCFC-22 production to reduce generation of the HFC-23

Item	Cost (US $)
Additional cost to operate second production line for 50 days for 2020-2024	364,125
Engineering	26,700
New distillation column	213,500
New packing for the distillation column	3,500
Civil works	15,000
Pipes	15,000
Structural steel	20,000
Special connectors in filling stations	11,000
Automatic on/off valves	44,800
Total	**713,625**

39. The estimated savings from the reduced quantity of HFC-23 by-product to be destroyed by implementing the measures between 2020 and 2030 is US $1.5 million.

Option 6: Selling the HFC-23 for feedstock use or adapting the plant so that it could use HFC-23 for the production of HCFC-22

40. HFC-23 can be used as low temperature refrigerant gas, as fire suppression agent and for etching of silicon materials in the semi-conductor industry. All of these are emissive applications. Quimobásicos generates HFC-23 as a waste of HCFC-22 production. It is not equipped to process the HFC-23 stream mixed with HCFC-22 and non-condensable gases to meet the quality requirements of those applications, nor would such processing and purification be economically justifiable given the low volumes of HFC-23 generated.

41. Some researchers have suggested that HFC-23 could be used as a fluoromethylation agent for compounds valuable as agrochemicals, pharmaceuticals and other potential chemical specialties. However, available information suggests this potential use has not reached maturity or commercial scale, nor is a change expected in the foreseeable future given the risk and approval process of any new agrochemical or drug that comes into the market. Another obstacle is that it would take more time to find an enterprise that can use the HFC-23, while the control obligation under the Kigali Amendment is 1 January 2020. Accordingly, option 6 was not considered feasible.

Summary of the six options for addressing emissions of HFC-23 by-product

42. Table 9 presents a summary of the six options for addressing emissions of HFC-23 by-product considered in the project proposal.

Table 9. Summary of the six options for addressing emissions of HFC-23 by-product

Option	Description	Observations
1	Resuming operation of the integrated on-site PDU and the non-integrated on-site PDU	Total cost amounts to US $18,529,168; after taking into local ownership, the total cost to the Fund amounts to US $9,449,876
2	Importing HCFC-22 to meet demand in the domestic market	Not feasible. Not economically viable for Quimobásicos to only import HCFC-22 due to loss of market share and positioning, cancellation of contracts with suppliers, closures of workplaces and lay off of workers
3	Destroying HFC-23 by-product through irreversible transformation and other new conversion technologies, and storage options for HFC-23 management	Not feasible. Irreversible transformation or viable conversion technologies that could be implemented in the time available could not be identified
4	Shipping HFC-23 for off-site destruction by means of a technology approved by the Parties	Total cost amounts to US $22,135,738; after taking into local ownership, the total cost to the Fund amounts to US $11,289,226
5	Optimizing the HCFC-22 production to reduce the generation of the HFC-23 by-product	Cost of activities for optimizing the HCFC-22 production to reduce generation of the HFC-23 amounts to US $713,625. The total savings between 2020 and 2030 have been estimated at US $1.5 million
6	Selling the HFC-23 for feedstock use or adapting the plant so that it could use HFC-23 for the production of HCFC-22	Not feasible. Quimobásicos is not equipped to process the HFC-23 stream mixed with HCFC-22 and non-condensable gases to meet the quality requirements; not economically feasible given the low volumes of HFC-23 generated

Mexican Emission Trading Initiative

43. The Executive Committee had *inter alia* requested UNIDO to include in the submission data regarding relevant credits that might be applicable in the country in the future (decision 83/67(a)). A pilot emission trading system will be introduced from 1 January 2020 for a period of two years; HFC-23 is not included in that system. The system is planned to become fully operational in 2023, and it is unclear whether or not carbon credits via the destruction of HFC-23 will be accepted in the system. Accordingly, the earliest funding might be available to support the destruction of HFC-23 by-product emissions under the local emission trading system, if at all, would be in 2023.

44. Quimobásicos has been supporting the initiative and hopes to use the system to support the phase-out of HFC-23 by-product emissions should that be possible under the system. Quimobásicos is offering to forgo assistance for the control of HFC-23 by-product emissions from the Multilateral Fund once the local carbon market accepts eligibility of HFC-23 control measures and makes the destruction economically viable.

Relation to nationally determined contributions (NDC) under the Paris Agreement

45. The Executive Committee had *inter alia* requested UNIDO to include in its submission information regarding the relationship between the country's control of HFC-23 by-product emissions and the NDC of the Government of Mexico under the Paris Agreement (decision 83/67(b)). UNIDO clarified that Mexico had not included any actions in its NDC regarding HFCs since the HFC phase-down is expected to be funded through the Multilateral Fund.

Option selection and proposed Agreement

46. Based on the options presented by UNIDO, Quimobásicos and the Government of Mexico selected option 1 as the most technical and economical viable option for addressing emissions of HFC-23 by-product. While option 5 (i.e., optimizing HCFC-22 production) is likely to provide additional environmental benefits and be more cost-effective in the long-term, it would require an up-front investment of US $349,500 and carries risks since the proposed technological solutions are not yet mature.

47. UNIDO proposed that financing be provided through a performance-based Agreement with the following principles and schedule, as shown in Table 10:

(a) The destruction cost is agreed at the time the Agreement is approved;

(b) Taking into account the non-Article 5 ownership of the enterprise, the first tranche would constitute 51 per cent of the capital cost and the cost to destroy the estimated amount of HFC-23 waste stream generated in 2020. In addition, US $40,000 was requested to independently verify the control of HFC-23 emissions in 2020 and 2021;

(c) In February of every year starting from 2021 through 2030, the amount of HFC-23 waste stream destroyed and/or vented in the previous year would be independently verified and the verification report submitted to the Secretariat for review. The cost of such independent verification is proposed at US $20,000 per year, starting in 2022;

(d) No tranches would be requested in 2020 and 2021;

(e) At the first meeting of the year, starting in 2022 and ending in 2030, the Executive Committee would approve funding for Mexico based on the verified amount of HFC-23 destroyed in the previous year and the agreed destruction cost;

(f) In case the verification reveals venting of HFC-23, a penalty will be levied in the amount equal to three times of the agreed destruction cost multiplied by the amount of waste stream vented; and

(g) Quimobásicos would forgo assistance for the control of HFC-23 by-product emissions from the Multilateral Fund once the local carbon market accepts eligibility of HFC-23 control measures and makes the destruction economically viable.

Table 10. Estimated funding (US $) and proposed schedule

Year	Total cost	Eligible cost*	Verification	Funds requested
2019	2,060,827	1,051,022	40,000	1,091,022
2020	-	-		-
2021	-	-		-
2022	1,500,048	765,025	20,000	785,025
2023	1,528,029	779,295	20,000	799,295
2024	1,558,423	794,796	20,000	814,796
2025	1,592,660	812,257	20,000	832,257
2026	1,653,290	843,178	20,000	863,178
2027	1,693,846	863,862	20,000	883,862
2028	1,657,207	845,176	20,000	865,176
2029	1,661,680	847,457	20,000	867,457
2030	1,704,726	869,410	20,000	889,410
2031	1,918,431	978,400	-	978,400
Total	**18,529,168**	**9,449,876**	**220,000**	**9,669,876**

* After accounting for 49 per cent non-Article 5 ownership.

Secretariat's comments

48. The Secretariat reviewed the project proposal for options to control HFC-23 by-product at Quimobásicos in light of the compliance obligations under the Kigali Amendment to the Montreal Protocol; the environmental impact of HFC-23-by product emissions into the atmosphere; and technically viable and economical feasible options to control HFC-23 by-product emissions.

49. Since the adoption of the Kigali Amendment in 2016, the Secretariat has acquired experience on various matters related to Amendment, through *inter alia* the preparation of policy documents as requested by the Executive Committee, several of which were prepared with technical and economic inputs from experts with extensive experience in chemical production processes; the verification of the production facility Frio Industrias Argentinas (FIASA), in Argentina, and the associated project proposal submitted to the 83rd meeting, providing a set of options to control HFC-23 by product emissions, including closure of the HCFC-22 production facility; the verification of production at Quimobásicos submitted under the HCFC phase-out management plan (HPMP) of Mexico; and the review of the present project proposal submitted to the 84th meeting.

50. Noting that Quimobásicos will continue producing HCFC-22 for controlled uses at levels allowed under the Montreal Protocol until the phase-out in 2030, as well as for feedstock applications at the levels demanded by its clients, during the totality of the project review process the Secretariat sought technical advice from an expert with well-established technical and financial qualifications related to fluorochemical production processes. All technical and cost proposals suggested by the Secretariat to UNIDO and reflected in the present document were extensively discussed with the Secretariat's technical expert.

51. Noting that all of the options proposed by UNIDO include the continued venting for six months of HFC-23 to the atmosphere after 1 January 2020, that one kilogramme of HFC-23 by-product emitted into the atmosphere is equivalent to 14,800 kg CO_2, and that the emissions of this substance generated as a

by-product of the production of HCFC-22 by Quimobásicos amounts to approximately 1.6 million mt CO_2-eq from the moment the project proposal was submitted until the options proposed by UNIDO could be implemented, the Secretariat explored whether Quimobásicos could, with its own funding, undertake actions prior to the Executive Committee meeting so as to minimize the HFC-23 that would be vented to the atmosphere. However, neither Quimobásicos nor the Government had a budget for such activities; moreover, it was unclear which of the control options requested in decision 83/67(a) the Executive Committee might select.

52. Accordingly, in order to assist the Government of Mexico to be in compliance with its newly acquired obligations under the Kigali Amendment at the earliest time possible, the Secretariat considered whether technically feasible options were available that would minimize HFC-23 by-product emissions to the atmosphere. Table 11 presents a brief description of the two options identified by the Secretariat that might allow emissions of HFC-23 by-product to be minimized (options A and B); a detailed description of these two options is contained in Annex I to the present document. Table 11 also summarizes the Secretariat's review of the on-site and off-site option proposed by UNIDO (options 1 and 4); details of those reviews are provided below.

Table 11. Options for the control of HFC-23 by-product emissions in Quimobásicos

Option/ Description	Advantages	Disadvantages
UNIDO: Refurbish both PDUs, destroy on-site (option 1)		
-Refurbish both PDUs and destroy HFC-23 on-site	-Technically sound option using existing equipment -Destruction of all HFC-23-by product as soon as the refurbishment of either of the PDUs is completed. -No additional permits would be required -Does not require a change in production operating parameters at Quimobásicos	-HFC-23 by-product would be vented until either of the PDU is refurbished (i.e., for about six months) -More expensive than off-site option proposed by UNIDO
UNIDO: Refurbish Polaris destruction unit, destroy off-site (option 4)		
-Refurbish the Polaris cryogenic condensing separation unit -Installation of a cryogenic tank -Lease three tube trailers -Destroy HFC-23 off-site	-Technically sound option using existing equipment (i.e., Polaris unit) -Does not require a change in production operating parameters at Quimobásicos	-HFC-23 will be vented until the Polaris unit is refurbished (i.e., for about six months) -Require permits for off-site destruction, for which the necessary time is uncertain -No backup if the Polaris unit fails or needs maintenance
Off-site destruction of HFC-23 with HCFC-22 process change (option A)		
-Installation of a pump to transfer the AHF from the railcar to the storage tank and installation of a water scrubber on the storage tank to avoid the separation of non-condensables from the HFC-23 waste-stream -Installation of an industrial gas cryogenic liquefaction unit and tank -Lease three tube trailers	-Destruction of HFC-23 could start as soon as soon as the transfer and cryogenic systems are installed; the tube trailers are available; and the permits for off-site destruction are secured. -Allows for destruction of HFC-23 in less than six months -Is the cheapest option assessed by the Secretariat	-Requires a change in production operating parameters at Quimobásicos, to which the enterprise does not agree -Requires permits for off-site destruction, for which the necessary time is uncertain -Risk that there may be minor emissions of HFC-23 should small quantities of air need to be vented prior to destruction -Potential minor losses of AHF that have not been quantified

Option/ Description	Advantages	Disadvantages
Off-site destruction that switches to on-site once PDU is refurbished, with HCFC-22 process change (option B)		
-Installation of a pump to transfer the AHF from the railcar to the storage tank and installation of a water scrubber on the storage tank to avoid the separation of non-condensables from the HFC-23 waste-stream -Installation of an industrial gas cryogenic liquefaction unit and tank -Lease three tube trailers for off-site destruction (one year) -Refurbish one PDU, with on-site destruction once the PDU is operational	-Destruction of HFC-23 could start as soon as soon as the transfer and cryogenic systems are installed; the tube trailers are available; and the permits for off-site destruction are secured. -Allows for off-site destruction of HFC-23 in less than six months -Allows for in on-site destruction once the PDU is refurbished	-Requires a change in production operating parameters at Quimobásicos, to which the enterprise does not agree -Require permits for off-site destruction, for which the necessary time is uncertain -Risk that there may be minor emissions of HFC-23 should small quantities of air need to be vented prior to destruction -Offside destruction would we required during maintenance and service of the PDU -Most expensive option assessed by the Secretariat -Potential minor losses of AHF that have not been quantified

Comments on option 1 to refurbish both PDUs, destroy on-site

53. Option 1 entails the refurbishment of both PDUs. All HFC-23 is destroyed on-site, except for the first six months of 2020, when it is vented to the atmosphere.

54. The costs to refurbish PDU-1 and PDU-2 were taken as submitted except for the following minor adjustments:

(a) Decision 83/67(a)(i) requested UNIDO to *inter alia* provide three independent estimates for the cost to resume operation of the on-site incinerator. While only the technology provider can provide an estimate for the specialized equipment needed for the PDUs, this is not the case for the following standard industrial equipment: pumps and pump spare parts, pit reparation, sodium hydroxide tank, meters and valves, tanks, piping, pH 1analyzers, an air compressor, and a desktop computer. For those components, a 20 per cent reduction was applied;

(b) Several items were not mentioned in Plascon's (confidential) report and quotation and were unclear (e.g., ionized water pump and flowmeter), for which a 50 per cent reduction was applied; for others that were not mentioned in the body of the report (e.g., starter for motor, water rotameter, etc.) a 20 per cent reduction was applied; and

(c) US $50,000 was requested for start-up technical support for both PDU-1 and PDU-2. This was rationalized to US $25,000 per PDU.

55. Only one estimate was provided to refurbish the wastewater treatment facility dedicated to cleaning the effluents from the PDUs. Consistent with the approach above, a 20 per cent reduction was applied to the costs as submitted, resulting in a cost of US $123,641.

56. Similarly, the requested spare parts to operate the PDU in 2025-2030 were taken as submitted except for a 20 per cent reduction to the price of the HFC-23 meter to be replaced in 2025, noting that the Secretariat is seeking the Executive Committee's guidance on the eligibility of this cost.

57. Operating costs for option 1 are based on the following:

(a) The 2018 level of HCFC-22 production and by-product generation rate;

(b) The price of raw materials, by-product and utilities prices, as well as the consumption factors, were taken as submitted;

(c) Maintenance and wages and salaries were taken, as submitted; and

(d) Monitoring and other costs were set at US $10,000/year.

58. In line with the submission, operating costs for 2020 were based on operating the PDU for six months (i.e., assuming HFC-23 was vented for six months).

59. UNIDO requested US $20,000/year for the independent verification. Should the Executive Committee decide to consider those costs as project costs,[10] the Secretariat recommends to take into account the US $12,500/year for the verification of HCFC production already approved under the stage II of the HPMP of Mexico for 2020-2022. Accordingly, the independent costs of verification for 2020-2030 would be US $182,500.

60. Table 12 presents a comparative analysis between the costs of option 1 as submitted and as revised by the Secretariat.

Table 12. Comparative analysis of costs of option 1 (refurbish both PDUs) (US $)

Item	Secretariat	UNIDO	Difference
PDU-1 refurbishment	529,633	600,329	(70,696)
PDU-2 refurbishment	438,630	483,285	(44,655)
PDU capital cost in 2025-2030 (one unit only)*	345,275	349,544	(4,269)
Effluent treatment facility refurbishment	123,641	154,551	(30,910)
Sub-total ICC	1,437,179	1,587,709	(150,530)
IOCs for on-site destruction for 11 years*,**	9,820,932	16,782,690	(6,961,758)
ICC + IOC	11,258,111	18,370,399	(7,112,288)
Contingency	143,718	158,771	(15,053)
Sub-total	11,401,829	18,529,170	(7,127,341)
51 per cent Article 5 eligibility	5,814,933	9,449,877	(3,634,944)
Independent verification*,***	182,500	220,000	(37,500)
Total**	5,997,433	9,669,877	(3,672,444)
HFC-23 destroyed (mt)	1,353	2,696	(1,343)
Cost-effectiveness (CE) (US $/kg)	4.43	3.59	

* Duration of funding support to be determined by Executive Committee.
** Six months of on-site destruction assumed for 2020.
*** Whether verification costs are considered project or agency support costs to be determined by Executive Committee.
**** Eligibility of HFC-23 associated with non-Article 5 exports to be determined by Executive Committee.

61. UNIDO did not agree to the costs proposed by the Secretariat. However, UNIDO noted that under this option it could undertake a sole-source procurement and thus accelerate the time required for the award of the contract; nonetheless approximately six months would be required for the refurbishment of the PDUs. An additional benefit of this option was that there would only be one contracting party.

62. The Secretariat also considered, rather than refurbishing both PDUs, to only refurbish one PDU and use as a back-up the Polaris cryogenic condensing separation unit, which would be refurbished, and a cryogenic tank, which would be purchased. HFC-23 by-product would continue to be vented to the

[10] Agency support costs and whether to include the costs of verification therein are discussed in document UNEP/OzL.Pro/ExCom/84/70.

atmosphere until the Polaris unit was refurbished (estimated time: six months). The ICCs of this option are US $12,638 lower than those of option 1; however, the costs to operate and maintain the Polaris cryogenic condensing separation unit bring the total costs slightly above those of option 4 and, therefore, this option is not further considered.

63. Refurbishing only one PDU would provide more than enough destruction capacity given current HCFC-22 production levels, as well as those forecast through 2030, and the 60 kg/hr capacity of the PDUs. In its assessment, the Secretariat nonetheless considered the refurbishment of the second PDU eligible given the need to have a back-up system for those times when the PDU is brought down for maintenance or is in need of service. The eligibility of such back-up equipment is further discussed in document UNEP/OzL.Pro/ExCom/84/70.

Comments on option 4 to refurbish the Polaris unit, destroy off-site

64. Option 4 entails the refurbishment of the Polaris cryogenic separation unit, the purchase of a cryogenic tank, the lease of three tube trailers, and off-site destruction. Given the presence of air in the HFC-23 waste stream, HFC-23 can only be transferred to the tube trailer or the cryogenic tank after the Polaris unit has been refurbished, which is assumed to take six months. During those six months, HFC-23 would be vented to the atmosphere.

65. The costs to refurbish the Polaris unit (US $304,337) and to purchase the cryogenic tank (US $212,658) were taken as submitted.

66. The rotary kiln is located in the United States of America and already has the equipment necessary to feed refrigerants into its rotary kiln; no information is available on the baseline equipment that would suggest additional equipment is needed; and no information is available on whether the rotary kiln has destroyed HFC-23 since 2006. Accordingly, the unloading skid is not considered incremental. Moreover, as the enterprise is non-Article 5-owned, it is not eligible.

67. Destruction costs were taken at US $4.00/kg of waste as submitted, as were the off-site destruction fixed costs (i.e., wages and salaries, insurance and bonds, maintenance, monitoring, tube trailer lease). The 2018 level of HCFC-22 production and by-product generation rate were used to determine the quantity of HFC-23 waste stream to be destroyed taking into account the removal of the non-condensables in the Polaris unit, with destruction of HFC-23 in 2020 for six months, resulting in total destruction costs of US $10,195,651 between 2020 and 2030 as shown in Table 13.

Table 13. Comparative analysis of costs of option 4 (refurbish Polaris unit, purchase cryogenic tank, off-site destruction) (US $)

Item	Secretariat	UNIDO	Difference
Repair and installation of Polaris cryogenic unit	304,337	304,337	0
Cryogenic tank + installation + auxiliary equipment	212,658	212,658	0
Unloading skid for U.S.-based rotary kiln	0	424,541	(424,541)
Sub-total ICC	**516,995**	**941,536**	(424,541)
Off-site destruction for 11 years[*,**]	10,195,651	21,194,202	(10,998,551)
Sub-total	**10,712,646**	**22,135,738**	(11,423,092)
51 per cent Article 5 eligibility	5,463,449	11,289,226	(5,825,777)
Independent verification[*,***]	182,500	220,000	(37,500)
Total cost[****]	**5,645,949**	**11,509,226**	(5,863,277)
HFC-23 destroyed (mt)	1,353	2,696	(1,343)
CE (US $/kg)	4.17	4.27	

* Duration of funding support to be determined by Executive Committee.
** Six months of on-site destruction assumed for 2020.
*** Whether verification costs are considered project or agency support costs to be determined by Executive Committee.
**** Eligibility of HFC-23 associated with non-A5 exports to be determined by Executive Committee.

68. UNIDO did not agree to the costs proposed by the Secretariat, and noted that the U.S.-based rotary kiln that had been identified required the unloading skid. Moreover, as further discussed in Annex I, UNIDO raised concerns about whether the permits required for off-site destruction could be secured in less than nine months.

69. An 11,000 gallon (41.6 m^3) cryogenic tank would provide over three months of storage at 2018 HCFC-22 production levels. Accordingly, a substantially smaller (and less expensive) tank, and only two tube trailers (vice the three requested) could suffice. In its assessment, the Secretariat nonetheless considered the requested equipment eligible given the need to have a back-up system for those times when there may be delays in the off-site destruction. The eligibility of such back-up equipment is further discussed in document UNEP/OzL.Pro/ExCom/84/70.

70. At the present meeting, the Executive Committee is considering a project to control HFC-23 by-product emissions at FIASA, including an option to close that HCFC-22 production facility.[11] FIASA has a cryogenic tank[12] that could be used at Quimobásicos. Given Argentina's regulations, it is unclear whether the trace quantities of HFC-23 that may remain in the tank would prevent its export; moreover, it is not yet known whether FIASA would continue operating or shut down. Accordingly, this option was not further considered.

Optimizing the HCFC-22 production to reduce the generation of the HFC-23 by-product

71. Consistent with the report presented at the 81st meeting,[13] UNIDO proposed improvements to the HCFC-22 product distillation column to improve the separation of HCFC-22 from the HFC-23 waste stream. Consistent with the findings of that report, the savings from implementing the proposed measures are larger than the required investments; however, the Secretariat did not assess the payback period. Measures related to reducing packing losses of HCFC-22 make business sense independent of the control of HFC-23.

Performance-based financing Agreement

72. UNIDO proposed to use a performance-based financing Agreement whereby every year starting in 2022 and finishing in 2030, the Multilateral Fund would provide funding based on the actual amount of HFC-23 destroyed multiplied by the agreed destruction costs. Under this approach, if HCFC-22 production was below that forecasted, funding would be reduced; in contrast, if HCFC-22 production increased beyond that forecasted, funding would be above that requested. The Executive Committee has never used such an approach, which would have uncertain future financial obligations and which could make business planning, as well as estimating the needs for the replenishment of the Multilateral Fund, difficult.

73. Accordingly, the Secretariat proposes to use an approach consistent with the decision in paragraph 32(b) of document UNEP/OzL.Pro/ExCom/16/20, i.e., to use as a basis for determining costs the last year or the average of the last three years preceding project preparation. In the case of Quimobásicos, the last year is more advantageous to the enterprise and, therefore, was the basis used by the Secretariat for the maximum level of compensation that could be provided.

[11] UNEP/OzL.Pro/ExCom/84/71.

[12] Maximum working pressure rating of 23 bar, which is higher than the tank requested by Quimobásicos; the working temperature of the tank is as low as -196 °C, well below the temperature at which the tank would be operated.

[13] UNEP/OzL.Pro/ExCom/81/54.

Mexican Emission Trading Initiative

74. The Secretariat was unclear whether the planned emission trading system in Mexico will have a requirement for additionality,[14] as was the case under the CDM. Accordingly, should the Executive Committee wish to ensure that funding under the emission trading system could be used, the Executive Committee may wish to consider specifying that funding from the Multilateral Fund would cease to be provided once the emission system was established and it was confirmed that HFC-23 credits would be allowed in the system.

Relation to NDCs under the Paris Agreement

75. The Secretariat was not clear whether reductions in HFC-23 by-product emissions that were not funded by the Multilateral Fund would be considered under the country's NDC, including those reductions associated with the non-Article 5 ownership of Quimobásicos and, should the Executive Committee so decide, associated with exports to non-Article 5 countries or beyond the duration for which funding support was provided.

II POLICY ISSUES RELATED TO CONTROL OF HFC-23 BY-PRODUCT EMISSIONS IN MEXICO

76. In line with decision 83/67(d), document UNEP/OzL.Pro/ExCom/84/70 presents policy issues related to the compliance obligations of Article 5 countries with respect to HFC-23 by-production emission controls. To facilitate Executive Committee members' review, those policy issues relevant to the project in Mexico are identified here. Annex II to the present document summarizes the costs of the options 1 and 4 (from UNIDO) and options A and B (from the Secretariat) based on the policy issues identified below.

Eligibility of HFC-23 by-product associated with HCFC-22 exported to a non-Article 5 country

77. The Secretariat seeks the Executive Committee's guidance on whether HFC-23 by-product emissions associated with HCFC-22 that is produced for export to a non-Article 5 country would be eligible under the Multilateral Fund. The Secretariat is presenting two options for the Executive Committee's consideration, noting that the Executive Committee could choose either of the options, something in-between, or decide to use a different approach:

(a) To consider all HFC-23 by-product to be eligible, irrespective of whether the HCFC-22 from which it was generated was exported to a non-Article 5 country, and

(b) To deduct that portion of the HFC-23 by-product associated with HCFC-22 exported to a non-Article 5 country. In the case of Quimobásicos, that deduction would be 72.8 per cent.

78. The Government of Mexico did not agree with the latter option.

Basis for HCFC-22 production to be used in determining IOCs

79. As in the Secretariat's review of the HFC-23 project in Argentina, the Secretariat considered using the year, or the average of the three years, immediately preceding project preparation as the basis for HCFC-22 production, and selected the more favorable for the enterprise, in line with the decision in

[14] A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (decision 3/CMP.1 of the Parties to the Kyoto Protocol).

paragraph 32(b) of document UNEP/OzL.Pro/ExCom/16/20. UNIDO has used its forecasted HCFC-22 production as the basis.

Duration for which funding support is provided

80. Executive Committee members have expressed varying views on the duration for which funding support should be provided to control HFC-23 by-product emissions.

81. Quimobásicos is not anticipating closing its HCFC-22 production before 2030. Accordingly, funding was requested to control HFC-23 by-product emissions from 2020 through 2030. In the case of FIASA, the Secretariat was able to present cost estimates to the Executive Committee based on a lump sum payment and as a function of the number of years for which funding support is provided. For the case of Quimobásicos, Annex II presents the costs to control HFC-23 annually through 2030 so that the Executive Committee can determine the eligible incremental costs based on its determination of the duration for which funding support is provided.

82. The Secretariat sought confirmation that no further funding would be requested to enable the country to comply with the HFC-23 by-product control obligations even if production of HCFC-22 continued after 2030. In this regard, UNIDO clarified that the Government of Mexico was of the view that the Multilateral Fund was the agreed financial mechanism for the implementation of the Kigali Amendment, which does not allow release of HFC-23 by-product emissions after 2030. Accordingly, the Government considered that the funding after 2030 should be decided by the Parties and regulated by the Executive Committee at a later stage, while noting that the Government would stop requesting financial assistance from the Multilateral Fund for the destruction of HFC-23 once the local carbon market accepts the eligibility of HFC-23 control measures and makes the destruction economically viable.

Eligibility of back-up systems to enable control of HFC-23 by-product emissions

83. The Executive Committee may wish to clarify that the implementation of a back-up system for HFC-23 by-product destruction (i.e., refurbishment of the second PDU, for the on-site destruction option, and three tube trailers and the 11,000 gallon cryogenic tank, for the off-site destruction option) is "practicable" and, hence, eligible.

Level of agency support costs

84. The Executive Committee may wish to consider providing guidance on the appropriate level of agency support costs for HFC-23 by-product control projects in Article 5 countries, including whether the costs of independent verification should be included in such costs or in the project costs, and whether the agency support costs should differ between on- or off-site destruction of HFC-23 by-product.

By-product generation rate

85. UNIDO used the 2018 HFC-23 waste stream generation rate (i.e., 1.96 per cent) to determine the costs to control HFC-23 by-product. The Secretariat recalled that another Article 5 country had reported continued reductions in the by-product generation rate with time. The Secretariat also recalled the concerns expressed by some Executive Committee members regarding the potential for perverse incentives. Noting that the enterprise in Mexico had achieved lower by-product generation rates, the Secretariat is including in Annex II an additional option based on the minimum HFC-23 waste stream generation rate achieved in the three years preceding project preparation, i.e., 1.52 per cent. Other approaches, such as a generation rate that decreases with time, could also be considered.

86. UNIDO noted that the by-product generation rate will vary by year and based on different factors, which the enterprise may not always be able to fully control. Moreover, measures to reduce the by-product generation rate have a cost, and those costs should be considered.

Conclusion

87. Notwithstanding the excellent collaboration by UNIDO, the Government of Mexico and the Quimobásicos, the Secretariat is not able to recommend a single option, nor to propose an agreed cost for each option as the options and costs depend on Executive Committee policy choices. Noting the uncertainties that this provides, and the climate benefits that would be achieved through the approval of a project at the present meeting, the Secretariat has compiled the options and their costs in Annex II. In addition, a model is available should the Executive Committee wish to consider adjustments to any of the options presented during the meeting.

Recommendation

88. The Executive Committee may wish to:

(a) Note the key aspects related to HFC-23 by-product control technologies: Mexico (decision 83/67) contained in document UNEP/OzL.Pro/ExCom/84/72; and

(b) Consider any technical and financial assistance it wishes to provide to the Government of Mexico to allow for compliance with the HFC-23 by-product control obligations of the Kigali Amendment of the Montreal Protocol in light of the information contained in document UNEP/OzL.Pro/ExCom/84/72 and the policy issues raised in document UNEP/OzL.Pro/ExCom/84/70.

Annex I

DESCRIPTION OF TWO OPTIONS IDENTIFIED BY THE SECRETARIAT THAT MIGHT ALLOW EMISSIONS OF HFC-23 BY-PRODUCT TO BE MINIMIZED

1. In order to assist the Government of Mexico to be able to meet the targets specified under the Kigali Amendment at the earliest time possible, and in order to minimize the quantity of HFC-23 that would be emitted to the atmosphere after 1 January 2020, the Secretariat undertook a literature review, including data available from projects undertaken under the Clean Development Mechanism (CDM) to control HFC-23, consulted industry experts, and sought the advice of an independent technical expert to identify whether technically feasible options were available that would reduce the time needed to control HFC-23 by-product emissions.

Technical considerations

2. The HFC-23 waste stream at Quimobásicos contains approximately 10 per cent air, which is non-condensable. Air enters the HCFC-22 production process through its use to transfer anhydrous hydrogen fluoride (AHF) from a railcar to the AHF storage tank. Dry air is used at approximately 2.5 bar. It is the presence of the air in the HFC-23 waste stream that prevents a more rapid implementation of HFC-23 by-product control measures as either the HFC-23 waste stream needs to be piped directly to the (plasma arc unit) PDU, or specialized equipment (i.e., the Polaris cryogenic separation unit) is needed to separate the air. In either case, approximately six months is required to refurbish the necessary equipment.

3. Given the composition of the HFC-23 waste stream, at 10 bar it is necessary to cool the HFC-23 waste stream to approximately -115 °C to ensure that all the HFC-23 is removed from the air before it is vented. While higher temperatures (e.g., -40°C, which can be achieved in standard, commercially available condensing units) will still result in separation of the HFC-23 and air, given the relatively high concentration of air in the waste stream, that separation will not be as effective, and will therefore result in some HFC-23 being vented with the air to the atmosphere.

4. The air serves no purpose in the HCFC-22 production process, but it also does not impede it. The price of AHF is approximately three times that of chloroform, so it is the most expensive raw material used in the HCFC-22 production process. Accordingly, Quimobásicos has to date not had an economic incentive to remove the air.

Possible options

5. The fastest and most cost-effective approach to minimize emissions of HFC-23 to the atmosphere would be not use air pressure to transfer the AHF from the railcar to the storage tank but to instead use an appropriate industrial chemical pump (e.g., approximately 30 m^3/h capacity multistage pump with seal-less magnetic drive, Kynar plastic, encapsulated impeller and carbon bushing suitable for use with AHF) as is common in the industry. The HFC-23 waste stream, which now would comprise 94 per cent HFC-23 and 6 per cent HCFC-22, could then be destroyed off-site for the duration of the project (option A) or until the PDU was refurbished (option B), at which point on-site destruction could commence.

6. However, it should be noted that the use of dry gas, such as air nitrogen, cannot be completed avoided. AHF railcars typically only have top outlets, for inherent safety reasons. These top outlet railcars typically have a valve allowing access to the head space and a valve connected to a dip-pipe that allows the contents to be removed as a liquid. In such case, it is usual practice to pad out the AHF to the on-site AHF storage tank by adding dry air (or dry nitrogen) to the head space as the padding gas, thereby forcing the AHF out through the dip pipe. Moreover, it is preferable to operate AHF storage tank at slightly above atmospheric pressure in order to minimise the risk of moist air ingress into the storage tank, thereby

preventing the formation of hydrofluoric acid. Accordingly, 0.5 bar of dry air could be used to pad out the AHF (vice the 2.5 bar currently used by Quimobásicos); some of that air may be soluble in the AHF. In order to remove it, the Secretariat would recommend installing a water scrubber on the AHF tank through which excess air could be vented.

Option A

7. For this option, it is assumed that the AHF pump and water scrubber can be purchased and installed within three months; the tube trailers leased and delivered within two months; the necessary permits required for the off-site destruction within two to three months; and the cryogenic tank delivered and installed within three to four months. HFC-23 is assumed to be vented for the first three months of 2020.

Costs of option A

8. An industrial AHF pump and pipework, valves, pump recycle loop, supports, design, civil engineering is estimated at US $100,000. A water scrubber, including installation, pipework, valves, design and civil engineering, is estimated at US $50,000. Such pumps and water scrubbers are commercially available and in stock.

9. The Secretariat identified a commercially available industrial gas cryogenic liquefaction unit[1] that costs US $143,667; a unit could be shipped within three months. The cryogenic tank, installation and auxiliary equipment is taken as US $212,658, as submitted. At the time of finalization of the present document, the independent consultant was trying to locate a comparable, in-stock industrial gas cryogenic liquefaction unit and an in-stock (new or used) cryogenic that could be immediately shipped; an update, if available, will be provided during the 84th meeting.

10. The unloading skid for the U.S.-based rotary kiln is not considered incremental nor is the non-Article 5-owned kiln eligible. Destruction costs were taken at US $4/kg of HFC-23 waste stream (composed of 94.4 per cent HFC-23 and 5.6 per cent HCFC-22). The costs to operate the cryogenic condensing unit were assumed to be comparable to those of the Polaris condensing unit. Off-site destruction fixed costs (i.e., wages and salaries, insurance and bonds, maintenance, monitoring, tube trailer lease) were taken as submitted, though costs for 2020 were assumed for nine months (vice six in the proposal). The 2018 level of HCFC-22 production and by-product generation rate was used to determine the quantity of HFC-23 to be destroyed, with destruction of nine months of HFC-23 in 2020 (vice six in proposal), resulting in total destruction costs of US $10,300,556 between 2020 and 2030. After taking into account the non-Article 5 ownership, the total cost of option A is US $5,719,832, as show in Table 1.

Table 1. Option A (AHF transfer pump, commercial liquefaction unit, off-site destruction for entire project)

Item	Cost (US $)
Industrial AHF pump (multistage pump, approximately 30 m^3/h capacity), including pipework, valves, pump recycle loop, supports, design, civil engineering	100,000
Water scrubber for AHF tank, including installation, pipework, valves, design and civil engineering	50,000
Purchase of new cryogenic liquefaction unit	143,667
Cryogenic tank + installation + auxiliary equipment	212,658
Unloading skid for the U.S.-based rotary kiln	-
Sub-total ICC	**506,325**
Off-site destruction for 11 years*,**	10,300,556
Contingency	50,632
Sub-total	**10,857,513**

[1] Sterling Cryogenics SPC-1.

Item	Cost (US $)
51 per cent Article 5 eligibility	5,537,332
Independent verification[**,***]	182,500
Total cost[****]	**5,719,832**
HFC-23 destroyed (mt)	1,385
Cost-effectiveness (CE) (US $/kg)	4.13

* Eleven months of destruction assumed for 2020.
** Duration of funding support to be determined by Executive Committee.
*** Whether verification costs are considered project or agency support costs to be determined by Executive Committee.
**** Eligibility of HFC-23 associated with non-Article 5 exports to be determined by Executive Committee.

Option B

11. Similar to option A, except that PDU-2 would be refurbished while HFC-23 was destroyed off-site; once the PDU was refurbished, on-site destruction would commence. For this option, it is assumed that HFC-23 would be vented for the first three months of 2020.

Costs of option B

12. Same costs as option A for the AHF pump, water scrubber for the AHF tank, cryogenic liquefaction unit, and cryogenic tank. All costs related to the refurbishment of the PDUs are the same as under option 1, except that only PDU-2 would be refurbished. Off-site destruction was assumed to take place for three months (April – June 2020), after which on-site destruction would commence. The off-site destruction costs for those three months were calculated as under option A, resulting in off-site destruction costs for those three months of US $420,155; in those three months, an additional 8.95 mt of HFC-23 would be destroyed (at a CE of US $3.17/mt$CO_2$e). On-site destruction costs were the same as under option 4 after accounting for the removal of air from the HFC-23 waste stream, resulting in additional costs of US $9,190,201. The total cost of option B is US $5,876,963, as shown in Table 2.

Table 2. Option B (AHF transfer pump, commercial liquefaction unit, off-site destruction for five months, on-site destruction thereafter)

Item	Cost (US $)
PDU-2 refurbishment	438,630
PDU capital cost in 2025-2030[*]	345,275
Effluent treatment facility refurbishment	123,641
Industrial AHF pump (multistage pump, approximately 30 m^3/h capacity), including pipework, valves, pump recycle loop, supports, design, civil engineering	100,000
Water scrubber for AHF tank, including installation, pipework, valves, design and civil engineering	50,000
Purchase of new cryogenic liquefaction unit	143,667
Cryogenic tank + installation + auxiliary equipment	212,658
Unloading skid for the U.S.-based rotary kiln	0
Sub-total ICC	**1,413,871**
IOCs for on-site destruction for 11 years[*,**]	9,190,201
Off-site destruction for three months	420,155
ICC+IOC + 3 month off-site destruction	11,024,227
Contingency	141,387
Sub-total	**11,165,614**
51 per cent Article 5 eligibility	5,694,463
Independent verification[*,***]	182,500
Total cost[****]	**5,876,963**
HFC-23 destroyed (mt)	1,385
CE (US $/kg)	4.24

* Duration of funding support to be determined by Executive Committee.
** Six months of on-site destruction assumed for 2020.

*** Whether verification costs are considered project or agency support costs to be determined by Executive Committee.
**** Eligibility of HFC-23 associated with non-Article 5 exports to be determined by Executive Committee.

Additional considerations

13. The Secretariat understands that the use of an AHF pump is the standard industry practice used to transfer AHF to the on-site storage tank. During the time that Frio Industrias Argentinas (FIASA) destroyed HFC-23 under the CDM, it was able to store HFC-23 in its on-site cryogenic tank prior to its destruction without needing specialized equipment to separate non-condensables from its waste stream. Similarly, the Secretariat is aware of several other projects that destroyed HFC-23 under the CDM and used a storage tank.[2] The Secretariat also reviewed data from monitoring reports submitted under the CDM and, of the fifteen projects examined, the project at Quimobásicos was the only project that consistently reported a purity of HFC-23 waste stream below 90 per cent;[3] only two consistently reported a purity below 95 per cent (Quimobásicos and FIASA); and most reported a purity of 98 per cent or higher, suggesting that the practice of using air to transfer AHF may be unique to Quimobásicos.

14. UNIDO emphasized that the two options proposed by the Secretariat were theoretical and that neither the Government nor Quimobásicos agreed to their feasibility. In particular, UNIDO indicated that:

(a) It could take between six to nine months to secure the necessary approvals for off-site destruction;

(b) Leasing the tube trailers for one year (option B) was not possible; reducing the lease time of the tube trailers to five years would increase the lease price to US $2,400/month per tube trailer; and delivery of the tube trailers would require six months as they need to be fabricated; and

(c) As its current HCFC-22 production process worked well, Quimobásicos did not want to change its operating parameters given the substantial risks such a change could entail. Moreover, an engineering study, industrial trials, and permitting by industrial safety and environmental authorities would be required, which would take additional time. In addition, the process change could result in some losses of AHF, an expensive raw material.

15. The Secretariat recognizes that any change to a chemical facility's production process must be carefully evaluated; accordingly, the Secretariat is sympathetic to the concerns expressed by Quimobásicos. As pointed out by UNIDO, industrial trials, and permitting by industrial safety and environmental authorities would be required; at the time of finalization of the present document, the Secretariat is unclear how much time those steps would require and which could be done in parallel and which must be done sequentially.

16. UNIDO also indicated that six to nine months may be required to secure the necessary approvals for off-site destruction; however, at the time of finalization of the present document, several uncertainties remained. In particular, it was unclear whether in 2006 Quimobásicos exported the HFC-23 as a hazardous waste or as a substance; whether under current regulations HFC-23 waste would be considered a hazardous; and the time that would be required to secure the necessary permits if HFC-23 is hazardous, and if it is not. In case HFC-23 waste is determined to be hazardous by the Government of Mexico, regulatory approval for export would be predicated on the principle to eliminate the waste as close as possible to the source of

[2] See, for example, https://cdm.unfccc.int/filestorage/C/7/1/C71S3S0NXMHFZ9VBQSJ0NOXOE0DRHA/SRF_PDD_Oct15%20ver5%20clean.pdf?t=MzB8cTE0cjJ4fDBzYG1jWAbvrSZPMOcDd4mD and https://cdm.unfccc.int/filestorage/Q/8/X/Q8XZHDIMLNY2BEJFT0VAC3SPG47KUW/1867%20PDD_after%20corr.pdf?t=UmF8cTE0cjRmfDDsNeLFwLGjkwi0duW24s5G

[3] In its last reporting period in 2012, the enterprise reported the purity of the HFC-23 waste stream was 89.36 per cent.

generation. It is unclear whether the Government would take into consideration that there are no currently functioning approved destruction facilities in Mexico. Under option B, destruction would switch from off-site to on-site as soon as the refurbishment of a PDU was completed. Accordingly, it might be possible to approve the export of HFC-23 for destruction only for the period where there was no functioning approved destruction technologies in Mexico.

17. Regarding the availability of the tube trailers, the independent consultant had identified a supplier with available tube trailers; however, at the time of finalization of the present document, it is unclear whether those tube trailers would be available for lease, or would need to be purchased (US $230,000/tube trailer).

Annex II

SUMMARY OF THE COSTS OF OPTIONS 1 AND 4 (FROM UNIDO) AND OPTIONS A AND B (FROM THE SECRETARIAT)

Table 1. UNIDO Option 1, w_{mix} = 1.96 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	1,201,094					18,783		51,920		36,850	272,250	**1,580,897**
Pure HFC-23 (mt)	64.4*	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	**1,353**
IOC (US $)	467,663	935,327	935,327	935,327	935,327	935,327	935,327	935,327	935,327	935,327	935,327	**9,820,932**
Total cost (US $)	1,668,758	935,327	935,327	935,327	935,327	954,110	935,327	987,247	935,327	972,177	1,207,577	**11,401,829**
51 per cent Article 5 (US $)	***851,066***	***477,017***	***477,017***	***477,017***	***477,017***	***486,596***	***477,017***	***503,496***	***477,017***	***495,810***	***615,864***	***5,814,933***
Non-Article 5 export (US $)	***231,457***	***129,730***	***129,730***	***129,730***	***129,730***	***132,335***	***129,730***	***136,932***	***129,730***	***134,841***	***167,491***	***1,581,439***
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Six months of on-site destruction assumed for 2020.

Table 2. UNIDO Option 1, w_{mix} = 1.52 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	1,201,094					18,783		51,920		36,850	272,250	**1,580,897**
Pure HFC-23 (mt)	49.8*	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	**1,046**
IOC (US $)	399,611	799,222	799,222	799,222	799,222	799,222	799,222	799,222	799,222	799,222	799,222	**8,391,830**
Total cost (US $)	1,600,705	799,222	799,222	799,222	799,222	818,005	799,222	851,142	799,222	836,072	1,071,472	**9,972,727**
51 per cent Article 5 (US $)	***816,360***	***407,603***	***407,603***	***407,603***	***407,603***	***417,182***	***407,603***	***434,082***	***407,603***	***426,397***	***546,451***	***5,086,091***
Non-Article 5 export (US $)	***222,019***	***110,852***	***110,852***	***110,852***	***110,852***	***113,458***	***110,852***	***118,054***	***110,852***	***115,964***	***148,614***	***1,383,222***
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

** Six months of on-site destruction assumed for 2020.

Table 3. UNIDO Option 4, w_{mix} = 1.96 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	516,995											**516,995**
Pure HFC-23 (mt)	64.4*	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	**1,353**
IOC (US $)	613,310	957,620	957,757	957,893	958,029	958,166	958,302	958,439	958,575	958,712	958,848	**10,195,651**
Total cost (US $)	1,130,305	957,620	957,757	957,893	958,029	958,166	958,302	958,439	958,575	958,712	958,848	**10,712,646**
51 per cent Article 5 (US $)	***576,456***	***488,386***	***488,456***	***488,525***	***488,595***	***488,665***	***488,734***	***488,804***	***488,873***	***488,943***	***489,012***	***5,463,449***
Non-Article 5 export (US $)	***156,774***	***132,822***	***132,841***	***132,860***	***132,879***	***132,898***	***132,917***	***132,936***	***132,955***	***132,974***	***132,993***	***1,485,849***
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Six months of off-site destruction assumed for 2020.

Table 4. UNIDO Option 4, w_{mix} = 1.52 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	516,995											**516,995**
Pure HFC-23 (mt)	49.8*	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	**1,046**
IOC (US $)	535,297	801,594	801,699	801,805	801,910	802,016	802,121	802,227	802,332	802,438	802,543	**8,555,982**
Total cost (US $)	1,052,292	801,594	801,699	801,805	801,910	802,016	802,121	802,227	802,332	802,438	802,543	**9,072,977**
51 per cent Article 5 (US $)	**536,669**	**408,813**	**408,867**	**408,920**	**408,974**	**409,028**	**409,082**	**409,136**	**409,189**	**409,243**	**409,297**	**4,627,218**
Non-Article 5 export (US $)	**145,953**	**111,181**	**111,196**	**111,211**	**111,225**	**111,240**	**111,255**	**111,269**	**111,284**	**111,298**	**111,313**	**1,258,426**
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Six months of off-site destruction assumed for 2020.

Table 5. Secretariat Option A, w_{mix} = 1.96 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	556,958											**556,958**
Pure HFC-23 (mt)	96.6*	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	**1,385**
IOC (US $)	718,215	957,620	957,757	957,893	958,029	958,166	958,302	958,439	958,575	958,712	958,848	**10,300,556**
Total cost (US $)	1,275,173	957,620	957,757	957,893	958,029	958,166	958,302	958,439	958,575	958,712	958,848	**10,857,513**
51 per cent Article 5 (US $)	**650,338**	**488,386**	**488,456**	**488,525**	**488,595**	**488,665**	**488,734**	**488,804**	**488,873**	**488,943**	**489,012**	**5,537,332**
Non-Article 5 export (US $)	**176,867**	**132,822**	**132,841**	**132,860**	**132,879**	**132,898**	**132,917**	**132,936**	**132,955**	**132,974**	**132,993**	**1,505,942**
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Nine months of off-site destruction assumed for 2020.

Table 6. Secretariat Option A, w_{mix} = 1.52 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	556,958											**556,958**
Pure HFC-23 (mt)	74.7*	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	**1,071**
IOC (US $)	668,445	801,594	801,699	801,805	801,910	802,016	802,121	802,227	802,332	802,438	802,543	**8,689,130**
Total cost (US $)	1,225,403	801,594	801,699	801,805	801,910	802,016	802,121	802,227	802,332	802,438	802,543	**9,246,088**
51 per cent Article 5 (US $)	**624,955**	**408,813**	**408,867**	**408,920**	**408,974**	**409,028**	**409,082**	**409,136**	**409,189**	**409,243**	**409,297**	**4,715,505**
Non-Article 5 export (US $)	**169,964**	**111,181**	**111,196**	**111,211**	**111,225**	**111,240**	**111,255**	**111,269**	**111,284**	**111,298**	**111,313**	**1,282,436**
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Nine months of off-site destruction assumed for 2020.

Table 7. Secretariat Option B, w_{mix} = 1.96 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	1,175,456					18,783		51,920		36,850	272,250	**1,555,258**
Pure HFC-23 (mt)	96.6*	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	128.8	**1,385**
IOC (US $)	857,784*	875,257	875,257	875,257	875,257	875,257	875,257	875,257	875,257	875,257	875,257	**9,610,356**
Total cost (US $)	2,033,239	875,257	875,257	875,257	875,257	894,040	875,257	927,177	875,257	912,107	1,147,507	**11,165,614**
51 per cent Article 5 (US $)	**1,036,952**	**446,381**	**446,381**	**446,381**	**446,381**	**455,960**	**446,381**	**472,860**	**446,381**	**465,175**	**585,229**	**5,694,463**
Non-Article 5 export (US $)	**282,011**	**121,399**	**121,399**	**121,399**	**121,399**	**124,004**	**121,399**	**128,600**	**121,399**	**126,510**	**159,160**	**1,548,676**
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Three months of off-site destruction followed by nine months of on-site destruction assumed for 2020.

Table 8. Secretariat Option B, w_{mix} = 1.52 per cent

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
HCFC-22 (mt)	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	7,718	**84,898**
ICC (US $)	1,175,456					18,783		51,920		36,850	272,250	**1,555,258**
Pure HFC-23 (mt)	74.7*	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	**1,071**
IOC (US $)	796,536*	752,763	752,763	752,763	752,763	752,763	752,763	752,763	752,763	752,763	752,763	**8,324,164**
Total cost (US $)	1,971,992	752,763	752,763	752,763	752,763	771,545	752,763	804,683	752,763	789,613	1,025,013	**9,879,422**
51 per cent Article 5 (US $)	**1,005,716**	**383,909**	**383,909**	**383,909**	**383,909**	**393,488**	**383,909**	**410,388**	**383,909**	**402,703**	**522,757**	**5,038,505**
Non-Article 5 export (US $)	**273,516**	**104,409**	**104,409**	**104,409**	**104,409**	**107,014**	**104,409**	**111,610**	**104,409**	**109,520**	**142,170**	**1,370,280**
Verification (US $)	7,500	7,500	7,500	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	**182,500**

* Three months of off-site destruction followed by nine months of on-site destruction assumed for 2020.