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EXECUTIVE COMMITTEE OF  
THE MULTILATERAL FUND FOR THE  
IMPLEMENTATION OF THE MONTREAL PROTOCOL  
Ninety-first Meeting  
Montreal, 5-9 December 2022  
Item 9(d) of the provisional agenda<sup>1</sup>

**PROJECT PROPOSAL: ECUADOR**

This document consists of the comments and recommendation of the Secretariat on the following project proposal:

Refrigeration

- Conversion of the manufacturing of domestic and commercial refrigerators from HFC-134a to isobutane (R-600a) and propane (R-290) at Induglob

UNIDO

<sup>1</sup> UNEP/OzL.Pro/ExCom/91/1

## PROJECT EVALUATION SHEET – NON-MULTI-YEAR PROJECT

## Ecuador

## PROJECT TITLE

## IMPLEMENTING AGENCY

Conversion of the manufacturing of domestic and commercial refrigerators from HFC-134a to isobutane (R-600a) and propane (R-290) at Induglob	UNIDO
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<b>NATIONAL COORDINATING AGENCY</b>	Ministry of Production, Foreign Trade, Investments and Fisheries
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## LATEST CONSUMPTION REPORTED FOR SUBSTANCES ADDRESSED BY THE PROJECT

## A: ARTICLE-7 DATA (2021)

HFCs	845.93 mt	1,911,824 CO <sub>2</sub> -eq tonnes
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## B: COUNTRY PROGRAMME SECTORAL DATA (2021)

HFCs	860.56 mt	1,931,129 CO <sub>2</sub> -eq tonnes
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<b>HFC consumption remaining eligible for funding (mt)</b>	n/a
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CURRENT YEAR BUSINESS PLAN ALLOCATIONS	Enterprise	Funding (US \$)	Phase-out (mt)
	Induglob	0	0

Particular	Unit	HFC-134a	
		HFC used at enterprise	mt
	CO <sub>2</sub> -eq tonnes	14,901	
HFC to be phased out through this project	mt	10.42	
	CO <sub>2</sub> -eq tonnes	14,901	
HFC alternatives to be phased in	Unit	R-600a	R-290
	mt	0.15	5.59
	CO <sub>2</sub> -eq tonnes	0.45	16.77
Project duration (months):		24	
Initial amount requested (US \$):		328,935	
Final project costs (US \$):			
Incremental capital costs:		245,350	
Contingency (10 %):		22,535	
Incremental operating costs:		*0	
Total project cost:		267,885	
Local ownership (%):		100	
Export component (%):		0	
Requested grant (US \$):		267,885	
Cost-effectiveness	US \$/kg	25.71	
	US \$/CO <sub>2</sub> -eq tonne	17.98	
Implementing agency support costs (US \$):		18,752	
Total cost of project to Multilateral Fund (US \$):		286,637	
Counterpart funding (Y/N):		Y	
Project monitoring milestones included (Y/N):		Y	

\*Not requested

<b>SECRETARIAT'S RECOMMENDATION</b>	Individual consideration
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## PROJECT DESCRIPTION

1. On behalf of the Government of Ecuador, UNIDO has submitted a proposal for a project to convert the manufacturing of domestic and commercial refrigerators<sup>2</sup> at Induglob from HFC-134a to isobutane (R-600a) and propane (R-290), at a total cost of US \$1,283,977, as originally submitted, and an associated request for funding from the Multilateral Fund in the amount of US \$328,935, plus agency support costs of US \$23,025.

### Project objective

2. The project will eliminate 10.42 metric tonnes (mt) (14,901 CO<sub>2</sub>-eq tonnes) of HFC-134a consumed annually by one line manufacturing domestic and commercial refrigerators at Induglob, resulting in a total phase-out of HFC-134a consumed by domestic and commercial refrigeration enterprises manufacturing stand-alone unitary appliances in Ecuador.

### HFC consumption and sector background

3. In 2021, 860.56 mt of HFCs (pure and in blends) were consumed in Ecuador, including 427.17 mt of pure HFC-134a (50 per cent of overall consumption), 159.10 mt of R-410A (18 per cent), 137.16 mt of R-507A (16 per cent), 82.11 mt of R-404A (9.5 per cent), and 55.01 mt of other HFCs. Table 1 presents the consumption of HFCs in Ecuador over the past three years, as reported under the country programme (CP) implementation report.

**Table 1. HFC consumption in Ecuador in 2019–2021 (mt)\***

Substance	2019	2020	2021
HFC-134a pure	594.79	600.18	427.17
R-404A	114.23	108.43	82.11
R-410A	242.19	152.96	159.10
R-507A	115.90	40.65	137.16
Other HFCs and HFC blends	46.57	136.35	55.01
<b>Total</b>	<b>1,113.68</b>	<b>1,038.57</b>	<b>**860.56</b>

\* CP implementation data report has been used as reference as it provides the consumption of HFC-134a pure separately from HFC-134a contained in blends.

\*\* The difference between CP and Article 7 data (reported consumption of 845.93 mt) is due to an erroneous recording of an export and is pending correction by the Ozone Secretariat, as requested by the Government of Ecuador.

4. While Induglob is the only manufacturer of domestic and stand-alone commercial refrigerators in Ecuador consuming HFC-134a, other enterprises import similar equipment containing HFC-134a.

### Enterprise background

5. Induglob (formerly Indurama) is a locally owned enterprise producing a variety of appliances, including domestic and commercial refrigerators. The enterprise had formerly received Multilateral Fund assistance at the 26<sup>th</sup> meeting (in November 1998) to replace CFC-12 with HFC-134a.<sup>3</sup> The enterprise has been using HFC-134a to charge its products since project completion in September 2002.

6. Pursuant to decision 78/3(g) on the consideration of a limited number of HFC-related projects in the manufacturing sector to allow the Committee to gain experience in incremental costs associated with

<sup>2</sup> For the purposes of this document, commercial refrigerators refer to stand-alone appliances containing HFC refrigerant charges below 500 gr, used in the commercial refrigeration sector.

<sup>3</sup> ECU/REF/26/INV/25. Induglob also received assistance to convert its foam panels from CFC-11 to water-based technology (later changed to HCFC-141b) at the 9<sup>th</sup> meeting (ECU/FOA/09/INV/10) and to convert from HCFC-141b to cyclopentane at the 65<sup>th</sup> meeting (ECU/PHA/65/INV/55).

phasing down HFCs in Article 5 countries, UNIDO submitted the present stand-alone investment project for Induglob to the 81<sup>st</sup> meeting. The Executive Committee did not approve it at the time,<sup>4</sup> noting that it could be resubmitted in accordance with the provisions of decision 81/53.<sup>5</sup> The current project proposal is submitted in line with decision 87/50(e) on assistance to Article 5 countries that choose to implement individual HFC investment projects in advance of submitting their stage I of the Kigali HFC implementation plan (KIP).

### Enterprise-level HFC consumption

7. Induglob has two manufacturing lines with two charging stations, working one ten-hour shift per day, with an average monthly output of 15,000-20,000 units of self-contained domestic refrigerators, as well as vertical and horizontal coolers with different operating temperature ranges. In 2018, the enterprise converted one of its manufacturing lines to R-600a with its own funding, reducing consumption in the manufacture of domestic equipment by 16.33 mt (23,352 CO<sub>2</sub>-eq tonnes) of HFC-134a. HFC-134a is still being used at the unconverted line to manufacture a range of commercial refrigerators (13 products) and a small percentage of domestic refrigerators that are exported to countries in the region.

8. In 2021, the enterprise produced 154,886 units of equipment using 6.86 mt of R-600a and 65,542 units using 10.42 mt of HFC-134a. Table 2 presents the 2019–2021 production data for both domestic and commercial refrigerators manufactured at Induglob using R-600a and HFC-134a, as well as the estimated number of HFC-134a-charged commercial refrigerators imported by other enterprises.

**Table 2. Refrigeration manufacturing data for Induglob and estimated imports by other enterprises**

Production sub-sector	Refrigerant used	Line #	Production output (equipment units)			Refrigerant consumption (mt)		
			2019	2020	2021	2019	2020	2021
Domestic	R-600a	1	160,381	139,344	154,886	6.56	5.81	6.86
<b>Total for R-600a</b>			<b>160,381</b>	<b>139,344</b>	<b>154,886</b>	<b>6.56</b>	<b>5.81</b>	<b>6.86</b>
Commercial	HFC-134a	2	46,638	27,300	62,082	7.17	4.09	9.90
Domestic			28,260	14,418	3,460	4.4	2.21	0.52
<b>Total for HFC-134a</b>			<b>74,898</b>	<b>41,718</b>	<b>65,542</b>	<b>11.60</b>	<b>6.30</b>	<b>10.42</b>
Estimated imports of commercial refrigerators by other enterprises			59,055	37,239	47,130	n/a	n/a	n/a

### Project description

9. As the enterprise has already converted one of its two manufacturing lines to R-600a, the present proposal only requests funds for the conversion of one line manufacturing commercial and domestic refrigerators.

10. The R-290 and R-600a refrigerants were selected for this project from among the currently available replacements for HFC-based capacity, including hydrocarbons (HCs), HFOs, and blends. Apart from having zero ozone-depleting potential and very low global-warming potential, R-290 and R-600a are proven, commercially available, and internationally accepted options that require 40 per cent less refrigerant charge, use mineral oil, have low corrosiveness, enhance overall technical reliability and performance, and reduce operating noise. In addition, Induglob has experience in manufacturing domestic refrigerators with R-600a. The flammability of R-290 and R-600a necessitates changes in the manufacturing process,

<sup>4</sup> Owing to concerns raised in the contact group established for the discussion of HFC investment projects. In the case of Induglob, some members did not support the proposal as the Executive Committee had decided not to approve preparatory funding for that project (decision 80/51(b)(i)).

<sup>5</sup> Decision 81/59

refrigerant storage and supply, and the products themselves, described in the following section.

### Project costs

11. Funds are requested for the adaptation of the assembly line, replacement of manufacturing equipment in the refrigerant charging area, training, installation, safety certification, and contingencies. The proposal does not request funds for redesigning products for use with new refrigerants, nor for the pilot production of appliances manufactured on the line. The incremental capital costs (ICCs), as originally submitted, stood at US \$328,935 as shown in table 3.

**Table 3. ICCs proposed for the conversion of one refrigerator manufacturing line at Induglob**

Item	Unit quantity	Unit cost (US \$)	Total cost (US \$)
<b>Manufacturing equipment – Refrigerant charging area</b>			
Adaptation of assembly line	1	9,000	9,000
Charging machine for R-600a/R-290, explosion-proof	1	52,000	52,000
Safety ventilation	1	16,400	16,400
Safety control system for charging area	1	42,000	42,000
Leak detector HLD6000 detecting R-600a/R-290 plus calibration	1	15,000	15,000
Ultrasonic welding machine	1	30,000	30,000
Refrigerant booster pump, pneumatic	1	8,150	8,150
Antistatic floor	1	4,300	4,300
HC recovery machine, explosion-proof	1	12,100	12,100
Helium charging unit	1	25,550	25,550
Helium recovery/recycling unit	1	24,150	24,150
Helium leak detector, plus calibration	1	22,200	22,200
Handheld HC leak detectors	4	500	2,000
Training and installation	1	18,000	18,000
<b>Sub-total for the manufacturing equipment</b>			<b>280,850</b>
Contingency (10% of investment costs)			28,085
Safety certification by TÜV Süd	1	20,000	20,000
<b>Total ICCs</b>			<b>328,935</b>

12. No funding for the incremental operating costs (IOCs) is being requested from the Multilateral Fund. The submission included an indicative estimation of IOCs at US \$15 per unit converted from HFC-134a to HC, based on incremental costs related to changes in the compressor (US \$5.00 per unit) and electrical components (US \$10 per unit). Assuming a production output of 62,082 units, the IOCs calculated for a 12-month period amount to US \$931,230.

13. Based on the funding request, the overall cost-effectiveness of conversion from the use of HFC-134a to R-290 and R-600a at one line manufacturing domestic and commercial refrigerators at the enterprise Induglob, implemented over a period of 24 months, amounts to US \$31.57/kg and is set to eliminate 10.42 mt (14,901 CO<sub>2</sub>-eq tonnes) of HFC-134a. Table 4 presents a summary of project costs and expected outcomes, as submitted.

**Table 4. Total costs requested for the conversion of one refrigerator manufacturing line at Induglob**

Item	Cost in US \$
ICCs	328,935
IOCs	0
<b>Total requested</b>	<b>328,935</b>
HFC phase-out from the funded line (mt)	10.42
Cost-effectiveness (US \$/kg)	31.57
(US \$/CO <sub>2</sub> -eq tonne)	22.08

Gender mainstreaming considerations

14. The project aims to foster gender mainstreaming initiatives at Induglob by creating access to opportunities, ensuring working conditions favorable to an increased participation by women, and strengthening women's technical capacities through training and hiring policies.

**SECRETARIAT'S COMMENTS AND RECOMMENDATION**

**COMMENTS**

Relation to stage I of the KIP and sustainability of HFC reductions

15. The Secretariat acknowledges that the Induglob project proposal, submitted in line with decision 87/50(e) in advance of stage I of the KIP, has been formulated without preparatory funding. UNIDO confirmed that the KIP for Ecuador, scheduled to be submitted in the second half of 2023, would support the Induglob project by including in its servicing sector strategy the provision of equipment and tools to handle R-600a and R-290 in self-contained domestic and commercial refrigeration equipment, as well as technician training and certification activities. Since HFC reductions associated with the conversion at Induglob can take place as soon as the project is completed, there is no need to await the finalization of the KIP preparation. The Government of Ecuador has already developed a ban on the import and manufacturing of domestic refrigerators using HFC-134a, which is expected to enter into force upon completion of the Induglob conversion project and further include the import and manufacturing of HFC-134a-based commercial stand-alone units.

16. Even though the reduction in HFC consumption proposed by the project is small in comparison to overall national consumption, the Secretariat considers that it can be sustained through the ban on the import and manufacturing of similar equipment. The ban should further prevent the establishment of HFC-134a banks in this sub-sector, whether from newly manufactured or imported equipment, and any future associated consumption of this substance in servicing.

17. Regarding potential risks to the enterprise's capacity to complete the project, the Secretariat recognizes that Induglob has previously converted one of its domestic refrigerator manufacturing lines to R-600a with its own funds and proceeded to achieve product sales both nationally and region-wide. No market uptake issues have been identified as yet for either domestic or commercial stand-alone refrigerators using HCs, and at least one neighboring country has also issued a ban on the import of HFC-134a-based equipment.

Deduction of HFC reductions from the starting point

18. The phase-out of 14,901 CO<sub>2</sub>-eq tonnes (10.42 mt) of HFC-134a resulting from the approval of the present project would count against the consumption eligible for funding identified in the KIP. Accordingly, once the starting point for sustained aggregate reduction in HFC consumption is established, the reductions proposed by this project would need to be deducted in accordance with the methodology agreed under the HFC cost guidelines (currently under discussion).

Second conversion

19. Induglob had previously received Multilateral Fund assistance to replace CFC-12 with HFC-134a in its manufacturing process at the 26<sup>th</sup> meeting (1998). This second conversion falls under paragraph 18(b)

of decision XXVIII/2 of the Parties,<sup>6</sup> making the enterprise eligible to receive funding from the Multilateral Fund to cover the agreed incremental costs.

#### Proposed costs

20. Upon discussion with UNIDO, costs for the charging machine, several safety items and helium management system were adjusted to reflect the most recent prices; the number of handheld leak detectors was reduced from four to two based on the needs of the line; and the training and installation costs were modified, noting that the enterprise had already gained knowledge in manufacturing with flammable refrigerants with its conversion of the first line. The revised costs of the conversion of the domestic and commercial refrigeration manufacturing line at Induglob are shown in table 5.

**Table 5. Agreed costs of the conversion of one refrigerator manufacturing line at Induglob**

Item	Proposed cost (US \$)	Agreed cost (US \$)	
<b>Manufacturing equipment – Refrigerant charging area</b>			
Adaptation of assembly line	9,000	9,000	
Charging machine for R-600a/R-290, explosion-proof	52,000	35,000	
Safety ventilation	16,400	16,400	
Safety control system for charging area	42,000	27,000	
Leak detector HLD6000 detecting R-600a/R-290 plus calibration	15,000	12,500	
Ultrasonic welding machine	30,000	30,000	
Refrigerant booster pump, pneumatic	8,150	8,150	
Antistatic floor	4,300	4,300	
HC recovery machine, explosion-proof	12,100	5,000	
Helium charging unit	25,550	25,000	
Helium recovery/recycling unit	24,150	20,000	
Helium leak detector, plus calibration	22,200	20,000	
Handheld HC leak detectors	2,000	1,000	
Training and installation	18,000	12,000	
<b>Sub-total for the manufacturing equipment</b>	<b>280,850</b>	<b>225,350</b>	
Contingency (10% of investment costs)	28,085	22,535	
Safety certification by TÜV Süd	20,000	20,000	
<b>Total ICCs</b>	<b>328,935</b>	<b>267,885</b>	
IOCs	0	0	
HFC consumption phase-out (mt)	10.42	10.42	
HFC consumption phase-out (CO <sub>2</sub> -eq tonnes)	14,901	14,901	
Cost-effectiveness	(US \$/kg)	31.57	25.71
	(US \$/CO <sub>2</sub> -eq tonne)	22.08	17.98

21. As IOCs have not been requested, their calculation was not discussed in detail. The Secretariat, however, noted that it might be possible to procure R-290 and R-600a compressors at the price of HFC-134a compressors, and that savings achieved through replacing HFC-134a as heat exchanger and refrigerant (at US \$12/kg) with R-290 (at US \$10/kg), noting the latter's lower charge and price, were not reflected in the calculation. It was also acknowledged that at present the incremental costs of electrical components are difficult to assess.

22. Considering the remaining uncertainty about some costs, especially the IOCs, UNIDO agreed, on an exceptional basis, to collect information on the ICCs and IOCs incurred during the project, and to include it in a final report once the conversion was completed. UNIDO also confirmed that, in line with

<sup>6</sup> Enterprises that have already converted to HFCs in phasing out CFCs and/or HCFCs will be eligible to receive funding from the Multilateral Fund to meet the agreed incremental costs in the same manner as enterprises eligible for first conversions.

decision 22/38 and subsequent decisions of the Executive Committee, the replaced equipment would, as part of the project, be destroyed or rendered unusable.

23. The revised incremental costs requested for the conversion of one commercial and domestic refrigerator manufacturing line at Induglob to phase out 10.42 mt (14,901 CO<sub>2</sub>-eq tonnes) of HFC-134a amount to US \$267,885, with a cost-effectiveness of US \$25.71/kg (US \$17.98/CO<sub>2</sub>-eq tonne).

24. The Secretariat notes that in the absence of the cost guidelines for HFC phase-out, this project has been reviewed on a case-by-case basis. Based on the information available at the time of review, the Secretariat considers that the agreed costs are the best estimate of the overall incremental costs of conversion; however, these estimates might change, according to the specific characteristics of participating enterprises, as more information becomes available. The Secretariat considers that approval of the project at the levels proposed above would not constitute a precedent.

#### Energy efficiency considerations

25. Regarding energy efficiency improvements considered in the formulation of this proposal, UNIDO reported that Induglob had achieved a mean of 4 per cent improvement in R-600a-based domestic refrigerators manufactured in the already converted line. Enhancement in the commercial refrigeration equipment will depend on the components and materials used in the production process. At present, due to limitations related to providers of components and materials (including cost and supply chain considerations), it is difficult for Induglob to develop more energy-efficient equipment under this project. To improve the energy efficiency of the new HC-based product, the enterprise would need to have access to better priced and higher-quality components and materials (such as glass doors, compressors, and ventilators) provided by a wider range of providers, as well as to train its research and development department on product redesign for better performance.

#### 2022–2024 business plan

26. This project is not included in the 2022–2024 business plan of the Multilateral Fund.

### **RECOMMENDATION**

27. The Executive Committee may wish to consider:

- (a) Noting the project proposal for the conversion of one commercial and domestic refrigerator manufacturing line at Induglob from the use of HFC-134a as the refrigerant to propane (R-290) and isobutane (R-600a);
- (b) Approving the project proposal indicated in sub-paragraph (a) above in the amount of US \$267,885, plus agency support costs of US \$18,752 for UNIDO, on the understanding that:
  - (i) 14,901 CO<sub>2</sub>-eq tonnes (10.42 mt) of HFC-134a would be deducted from the starting point for sustained aggregate reductions in HFC consumption once it had been established, and that this deduction would be undertaken in accordance with the methodology agreed under the HFC cost guidelines currently under discussion;
  - (ii) On an exceptional basis, a comprehensive completion report with detailed information on the eligible incremental capital costs, incremental operating costs, any possible savings incurred during the conversion, and relevant factors that facilitated implementation would be submitted within six months of project completion;

- (iii) The present project would be integrated into stage I of the Kigali HFC implementation plan for Ecuador, once the plan had been fully formulated and submitted for consideration by the Executive Committee; and
- (c) Further noting the commitment of the Government of Ecuador to establish a ban on the import and manufacturing of domestic refrigerators and commercial stand-alone refrigeration units using HFC-134a upon completion of the Induglob conversion project.

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