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IMPACT ON THE FUND OF VARIOUS OPERATIONAL COST DURATIONS IN THE DOMESTIC REFRIGERATOR SECTOR

(Draft)

INTRODUCTION

1. The Executive Committee, at its Twelfth Meeting, "requested the Fund Secretariat to prepare an overview paper showing the impact on the Fund of various operational cost durations in the domestic refrigerator sector." The request manifests the concern of the Executive Committee for the magnitude of the potential operational costs as currently estimated for the ODS phase-out in the sub-sector and its likely impact on the Fund's total resource requirement.

2. This paper is a response to this request, and aims at addressing this concern by taking stock of the phase-out requirement of this sub-sector and putting the magnitude of operating costs into the right perspective. The paper also tries to assess the impact of the operating costs on the Fund, under the current three-year period, in particular.

3. The issue of operating costs in the domestic refrigeration sub-sector is determined by two factors: the choice of technology and the duration of the eligible operating costs.

4. In Part I, Background, a profile of the domestic refrigeration industry in Article 5 countries and a review of the current technological options in the domestic refrigeration sub-sector are discussed. Also in Part I, there is an analysis of the investment projects approved so far by the Executive Committee in this sub-sector.

5. In Part II, the paper projects estimates of operating costs calculated for different time durations in the domestic refrigeration sector based on the current technological options and current prices.

6. Part III applies sensitivity analysis to the estimates in Part II.

7. Part IV assesses the impact of the different durations of operating costs on the current three-year period of the Fund's operation.

8. In Part V, issues in this analysis are identified.

I. Background

A profile of the domestic refrigeration industry in Article 5 countries

9. In 1993, the domestic refrigeration industry in Article 5 countries consumed about 4,000 tonnes of the refrigerant CFC-12, and about 16,000 tons of CFC-11 as a blowing agent in the manufacture of polyurethane insulating foam.

10. More than forty Article 5 countries have domestic refrigeration industry. The pattern and configuration of the industry varies from country to country and sometimes from plant to plant within the same country. Those producers may be grouped in three distinct groups:

(a) Large producers where the installed capacities in each country is one million units per year or more;

(b) medium producers, with installed capacity of more than 500,000 but less than one million units per year;

(c) small producers having installed capacity of less than 500,000 per year.

11. Large producers have usually a more diversified industry which caters for the manufacture of all the refrigerator components including compressors and foam ingredients (e.g. polyol), usually with technical backing from leading refrigerator manufacturer in industrialized countries. Refrigerators and compressors production in this category is geared for both the local and external markets.

12. Medium-sized producers manufacture some of the refrigerator components and, at the same time, produce under license components like compressors or import these components either from developed or developing countries.

13. Small producers import all the refrigerator components to be assembled locally.

A review of the current technological options in the sub-sector

14. This section addresses both the refrigeration system and the insulation foam with the purpose of identifying operational cost components.

A. Refrigeration System

15. The most prevalent substitute for CFC-12 is HFC-134a; however, more recently hydrocarbon refrigerants became also commercially available. Other technologies based on refrigerants such as HFC-152a and blends are being tested. The latter is currently being commercialized in some European countries.

16. The substitute refrigerants require different kind of compressors designed to be compatible with both the new refrigerant and sometimes the new lubricant. Such design necessitates material changes in the compressor which are costed on a unit by unit basis.

B. Insulation Foam

17. The cabin of a domestic refrigerator consists of a double-walled shell filled with a polyurethane foam as the insulator. The insulating foam must meet certain physical properties in order to ensure the insulating efficiency and sustainability of refrigeration.

18. The foam is produced from polyol, MDI, and a blowing agent mixed according to specific formulation to meet specific requirements in terms of processing (filling the cabinet, jig dwell time) and foam performance (strength, adhesion, insulation).

19. Polyol is an integral component of polyurethane insulating foam. It must be compatible with new non-CFC foam formulations. Some Article 5 countries have formulation production as well as polyol production facilities and would therefore need to convert.

20. CFC-11 is the prevalent blowing agent in use. Replacing CFC-11 with zero or near zero ODP substitutes will require change in the formulation in addition to modifications to or replacement of foam delivery system.

21. The 50 per cent reduced CFC-11 technology allows for the reduction of CFC-11 concentration by up to 6-7 per cent by weight. The conversion to 50 per cent reduced CFC-11 technology requires minimum changes in the manufacturing process. However, this technology is being replaced with non-CFC technologies.

22. HCFC-141b is preferred in North America, Japan and some Article 5 countries as the foam blowing agent of choice. Conversion to HCFC-141b foam blowing technology may involve replacement of low pressure foaming machines with high pressure machines. High pressure machines are required to handle higher viscosity formulation. It allows also to achieve the same foam insulation values as to that of CFC-11 blown foam. Application of HCFC-141b

does not require increasing the thickness of the insulation foams. HCFC-141b is an aggressive solvent. A special resistant inner liner material is required to withstand the interaction with the blowing agent.

23. Enterprises choosing HCFC technology are aware that HCFCs constitute an interim replacement technology. The new equipment are, however, designed in such a way that future developments in ODS-free technologies can be introduced with some equipment modification.

24. Cyclopentane (zero-ODP) has recently emerged as a viable blowing agent and is being widely used in Europe. Cyclopentane is a flammable chemical and requires stringent plant and other safety measures.

An analysis of approved projects in the domestic refrigeration sub-sector

Overview

25. The Executive Committee approved 26 projects and gave permission to proceed to 11 projects to totally or partially convert to non-CFC technology in the sector. In addition the Committee also approved or gave permission to proceed to projects in the sectors feeder industries, i.e., non-CFC based compressor manufacture and foam chemicals.

26. Of the 26 projects approved by the Executive Committee in this sub-sector, only two projects were approved with incremental operating costs for refrigeration and foam systems. The duration of operating costs approved for these two projects are four months of one year's operating costs (in the case of Iran) and one year (in the case of Malaysia)[1]. Four projects have been approved for 50 per cent reduced foam formulation for China with four-year operational cost duration.

27. In the early approvals, and due to some residual uncertainties associated with the widely acclaimed HFC-134a refrigerant, a phased-in approach was accepted to be the most prudent way to effect the phase out of the refrigerant CFC-12 and to reduce the blowing agent CFC-11 in the foam system. This was based on the recommendation of the OORG in 1992, which has been reemphasized in 1994.

28. The phased-in approach calls for prototyping and extensive testing of only the new refrigeration system. Testing associated with the use of new foam formulation based on non-CFC-11 would be done at a subsequent stage, with the exception of one project developed by US EPA and being implemented presently in China where both systems will be tested.

29. The capital cost claimed in this category of projects is usually high and introduces a totally new capacity since the equipment provided are add on rather than replacement of existing equipment.

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[1] This project has a foreign ownership by transnational corporation of 50 per cent.

30. Requests for incremental operating costs are anticipated in the future once full conversion of the manufacturing line is contemplated.

31. Lately, proposals promoting full conversion from CFCs 12 and 11, including requests for incremental operational costs, were approved by the Committee.

32. These two classes of proposals are still being submitted for the Committee's consideration.

33. The incremental costs required for conversion of a domestic refrigeration sector may involve costs of refrigerator making equipment, production of compressors, production of chemicals for the foam system and operational costs.

34. To estimate the incremental costs associated with the conversion of domestic refrigerator industry, the following combinations of technologies are selected based on projects approved recently by the Executive Committee:

(a) HFC-134a (refrigerant) and HCFC-141b (insulation foam blowing agent)

(b) HFC-134a (refrigerant) and cyclopentane (insulation foam blowing agent)

Incremental Capital Costs

35. Irrespective of the number of units produced, each refrigerator manufacturing line would require new refrigerant charging and ancillary equipment, modification or replacement of foam injection system and associated equipment, safety equipment and testing and quality control equipment.

36. Capital costs of the approved projects varied from country to country and sometimes within the same country. Capital costs are generally high when testing equipment and extensive prototyping are included. The addition of the cost of license fees further augments the capital costs. Some Implementing Agencies do not deem it necessary because they believe that there is enough expertise to assist in developing prototypes and optimising efficiency of the refrigerant circuit and insulating foam without having to pay a license fee.

37. Depending on the scope of the project (conversion of the refrigeration system or foam insulation system, or both), the production capacity and the requirements for testing and quality control equipment, the incremental capital costs per project range between US $550,000 to US $4.9 million.

Incremental operating costs

38. To date, the Executive Committee has approved only two projects with incremental operating costs in the domestic refrigeration sub-sector. The per unit operating cost for these

two projects are US $16.5 (Iran) and US $8.00 (Malaysia). While the cost figures of these two projects do not represent a range they do, however, seem to indicate the low and high points of operating costs for the new projects currently being submitted to the Executive Committee. These costs are distributed as follows:

Refrigeration system

39. Operating costs are associated with:

A. Compressors

40. The compressor producer incurs both capital and operational costs when converting to HFC-134a compressors. Operational costs are related to changes to upgraded metal and organic material of the pump kit, electrical motor, insulation materials, and a new lubricant charge. Better quality cleaning is also required.

B. Refrigerant circuit

41. Incremental operating costs of refrigerant conversion are related to the higher costs of HFC-134a condenser and evaporator modification, new filter/drier, longer capillary pipe and the higher cost of new refrigerant. The average incremental operational costs calculated on the basis of projects presented by the implementing agencies are estimated to be US $8.45 per unit.

Insulation foam

42. Operating costs are associated with:

Polyol

43. Incremental operational costs for conversion of polyol production plants to new polyol compatible with non-CFC foam formulations are associated with higher costs of chemical ingredients used in the production process i.e. initiator, alkaline oxide, catalyst and neutralizing agent.

Blowing agent

44. Incremental operational costs for conversion to HCFC-141b insulation foam occur due to higher density foams, more expensive blowing agent and higher costs of inner and door-liner material compatible with HCFC-141b. These incremental operational costs are estimated currently between US $2-3.65 per unit.

45. Incremental operational costs for conversion to cyclopentane occur due to increased foam density. However they are expected to be partially offset by lower price of cyclopentane in some Article 5 countries. The incremental operational costs are estimated currently at US $1.28-1.5 per unit provided that the thickness of foams remains unchanged and no incremental costs are expected to be incurred for the inner liner material.

II. Estimates of operating costs calculated for different time durations

46. To estimate the incremental operating costs, the following assumptions are considered:

- number of refrigerators currently produced annually in Article 5 countries is 20 million units out of an installed capacity of 30 million units;
- all of these 20 million units will be converted immediately;
- the current technological options and current pricing are applicable; and
- a range of US $10-12 per unit in operating costs is used.

Duration of Operating Costs	Number of Units	Incr. Operating Cost (per unit) (US $)	Total (US $million)[2]
1 year	20 million	10-12	200-240
2 years	20 million	10-12	400-480
3 years	20 million	10-12	600-720
4 years	20 million	10-12	800-960

III. Sensitivity analysis

47. It is highly unlikely that the annual production capacity of 20 million refrigerators will be converted immediately. It is to be recalled that the Fund's Three-Year Plan and Budget indicated that about 40 projects would be submitted to the Committee for consideration by the end of 1996. These 40 projects represent a production capacity of about 8 million refrigerators.

48. Although the technological options which are being considered currently as proven options are still "young" technologies, the current suppliers of such technologies in developed countries are still going through technological optimization process. A large part of the cost

[2] These figures are not discounted.

items or the cost itself will become unnecessary or will be reduced after completion of this optimization process.

49. The demand and supply of CFCs and their substitutes will continue working against the CFC users. This means that the price of CFC will continue to go up, with the substitutes going on the downward trend. At the same time, the demand for HFC-134a compressors will certainly attract more producers to the market which will adjust downward the current price of HFC-134a compressors, and drive the price of CFC-12 compressors upward.

IV. Impact of the incremental operating costs in the sub-sector on the Fund's Three-Year Operation

50. Although it is predictable with confidence that the operating costs will be on a downward trend, it is difficult, however, to determine the time frame and the magnitude of the price downward movement, because of the ongoing technological optimization process and the movement of market forces. At the same time, the phase-out operation of the Fund has to continue under certain cost assumptions. It is therefore necessary to assess the impact of the estimates presented in Part II of the paper on the Fund on the basis of the following assumptions:

(a) as estimated in the Three-Year Plan and Budget, 40 projects with the production capacity of about 8 million refrigerators would be submitted by the end of 1996. In this regard, it is to be noted that about 25 projects in the domestic refrigeration and related sub-sectors were/are to be considered at the 12th and 13th Meetings of the Executive Committee;

(b) the US $10-12 per unit incremental operational cost as used for the estimates in Part II are valid for the foreseeable future.

Duration of Operating Costs	Number of Units	Incr. Operating Cost (per unit) (US $)	Total[3] (US $million)
4 months	8 million	10-12	27-32
6 months	8 million	10-12	40-48
1 year	8 million	10-12	80-96
2 years	8 million	10-12	160-192
3 years	8 million	10-12	240-288
4 years	8 million	10-12	320-384

[3] These figures are not discounted.

V. Issues identified

A. Benefits accruing to Article 5 Countries

51. Article 5 countries enterprises are provided with new commercial prospects when old, often outdated and worn out, equipment are being replaced with modern and more efficient equipment. This is a benefit that they would not otherwise have acquired. To date, this fact has not been taken into account in netting out benefits for the computation of incremental costs. The Fund supported projects replace this and other equipment with new **and** high efficiency equipment, which will inevitably lead to some enhancement of production capacity and quality. These clear benefits are not currently accounted for.

52. Several projects requesting considerable testing and quality control equipment were approved by the Executive Committee. Testing and quality control equipment are required for a transition period for testing non-CFC refrigerators. Following the completion of the pilot stage, the testing equipment will afford the companies with expanded testing capacity. On the other hand, however, test could be performed commercially or testing equipment could be rented.

53. There is an excess unutilized capacity in most of refrigerator manufacturing companies covered by conversion projects approved by the Executive Committee. The replacement of existing equipment in plants with excess unutilized capacity would result in Multilateral Fund expenditures that are greater than would be strictly necessary to phase out the existing consumption of ODS.

B. Duration of Incremental Operating Costs

54. The two approved projects referred to above and some thirteen projects to be considered by the Executive Committee at its Thirteenth Meeting claim incremental operating costs with various durations ranging from four months to two years. While the incremental operating costs per refrigerator is estimated with a certain measure of accuracy at the time of preparing the project, such estimates may be volatile when the project is actually implemented, due to the reasons mentioned in Part III. Furthermore, the Implementing Agencies involved in preparation of projects in the sub-sector are sceptical regarding the actual total incremental operating costs to be incurred by an enterprise.

55. In this context, one Implementing Agency recommends that 10 per cent of the incremental capital cost be added to each domestic refrigeration project as incremental operational costs.

C. Double-Counting

56. The Indicative List of Categories of Incremental Costs states inter alia that "Consideration of project proposals for funding should involve the careful scrutiny of cost items listed in an effort to ensure that there is no double-counting".

57. The risk of double counting may occur in multi-stage industry, where higher costs translate into higher prices at the next stage. Thus, the higher costs incurred by manufacturers of compressors, polyols and CFC-substitutes could be claimed as incremental costs by a refrigerator manufacturer.

58. The issue of double counting in the domestic refrigeration sector in Article 5 countries is very difficult to deal with for the following reasons:

- In the few Article 5 countries that have multi-staged refrigeration industries, none of these countries submitted integrated projects addressing the needs of the different stages;

- Compressors, polyols and ODS substitutes produced in one Article 5 country with support from the Fund may be exported to other Article 5 countries who in turn can claim the incremental costs associated with the import of these items.

D. Export Component

59. The issue concerns enterprises producing non-CFC compressors and new foam chemicals which receive financial assistance from the Fund who export part of their products to developed countries. Manufacturing of non-CFC compressors and new foam chemicals do not result in ODS phase-out until they are used by refrigerator manufacturers. Providing incremental costs (either capital or operational) to units exported to developed countries creates some issues. If the units are reduced in price to account for the grant received, the Fund would be subsidizing developed country consumers. The Fund would also put the developed country manufacturers in an unfair competitive position since these plants have to absorb the conversion costs. On the other hand, if the grant were given and the subsidy were not passed along, the producer could be getting a windfall.

E. Two Different Implementation Approaches

60. Evidently, the current portfolio of projects approved by the Committee indicates two different approaches adopted by implementing agencies in the conversion of domestic refrigeration industries that is the phase-in and full conversion approaches.

61. While it is not the intention to pass any judgement on the validity of either of these approaches, it is a fact that the phase-in approach involves:

- costs such as testing and experimenting which are not directly related to ODS phase-out;

- uncertainty about the full costs of the projects at the time when the Committee approved them because Phases II and III will be known only after Phase I is completed.

CONCLUSION

62. The Executive Committee may want to consider the matters included in this paper in the context of establishing standard treatment in the domestic refrigeration sector.