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Executive Committee of
the Multilateral Fund for the
Implementation of the Montreal Protocol

Twelfth Meeting
Montreal, 28-30 March 1994

THE USE OF TRANSITIONAL SUBSTANCES AS SUBSTITUTES FOR OZONE DEPLETING SUBSTANCES

1. At its Eleventh Meeting, the Executive Committee requested the Secretariat in consultation with the implementing agencies to examine more fully the issues related to the cost effectiveness of transitional substances and present a report to the Committee at its Twelfth Meeting. This paper is prepared in response to that request and also to provide background information regarding Decision IV/30 paragraph 4 of the Fourth Meeting of the Parties to the Montreal Protocol, reproduced in paragraph 11 below.

2. To facilitate the preparation of the paper, the Fund Secretariat developed a questionnaire which was distributed to some 21 Parties to the Montreal Protocol. The questionnaire asked for data that could be used to determine production and forecast the possible phase-out of the use of HCFCs particularly in the developed countries and how these could affect future availability and status of projects that would use such substitutes in Article 5 countries. Ten countries, Austria, Belgium, Denmark, France, Japan, the Netherlands, Norway, Poland, Singapore and Sweden responded. France provided data reflecting the situation in the European Union. In addition, approved country programmes and projects were also reviewed for necessary data to facilitate analysis of the situation.

Background

3. The request of the Executive Committee resulted from a discussion on a paper circulated by the representative of Norway on behalf of Austria and Switzerland requesting the Executive Committee to take into full consideration their recommendations regarding the use of transitional substances in the light of the following:

- cost effectiveness,
- environmental impact considerations, and
- principles of sustainable development.

4. The Executive Committee further considered that issues relating to the use of transitional substances were of a broader policy nature and suggested that this be brought to the attention of the Parties.

5. At the Fifth Meeting of the Parties to the Montreal Protocol, held subsequent to the Eleventh Meeting of the Executive Committee, several delegations through declarations submitted to the Meeting called for early phase-out of HCFCs while others in their statements drew attention to the earlier approval of their use by the Parties and the need to use them pending availability of proven and reasonably prized alternatives.

Rationale for the Use of Transitional Substances

6. The need to accelerate the phase-out of CFCs in the developed countries has necessitated the search by industry for safe, economically viable substitutes and substitute technologies that would, at the same time, ensure product quality. Thus HCFC having lower ODPs (2%-11% of those of CFCs) as well as lower GWP have been found suitable to be used as transitional substitutes, while the search for zero-ODP substitutes continues. HCFC-22 for instance has been produced by plants producing CFC-11 and CFC-12 and has long been in use alongside CFC-11 and CFC-12.

7. Several developing countries are also making efforts to phase-out the CFCs at the same pace as the developed countries either to maintain their export markets or to avoid high cost of servicing and maintaining their industrial infrastructure as scarcity drives up the prices of CFCs and other ODS. Hence, several projects in which HCFCs are used as transitional substitutes have been approved.

Control Measures Under the Montreal Protocol and Actions Taken by the Parties

8. Article 2F adopted as amendment to the Protocol at the Fourth Meeting of the Parties controls the consumption of HCFCs and provides a phase-out schedule which aims at a complete phase-out on 31 December 2029 (See Fig. 1).

9. Article 2F (paragraph 7) further enjoins each Party to ensure that:

a. the use of HCFCs is limited to those applications where other more environmentally suitable alternative substances or technologies are not available.

b. the use of HCFCs is not outside the areas of application currently met by ODS except in rare cases for the protection of human life or human health.

c. HCFCs are selected for use in a manner that minimizes ozone depletion, in addition to meeting other environmental, safety and economic considerations.

10. The Parties decided to consider, at its Sixth Meeting in 1994, these issues which are now being addressed. This will be based on the findings of the Technology and Economic Assessment Panel (TEAP) and the recommendations of the Open-Ended Working Group (OEWG) arising from the TEAP findings. The Executive Committee was authorized to consider incremental costs of projects utilizing HCFCs while at the same time conducting ongoing review of their need.

11. Consequently Decision IV/30 of the Fourth Meeting stipulates:

"1. To request the Technology and Economic Assessment Panel:

a. To evaluate alternative substances and technologies to the application for HCFCs as refrigerant and as insulation gas in rigid foam;

b. To identify other applications for HCFCs, if any, where other more environmentally suitable alternatives or technologies are not available; and

c. To submit its findings to the Open-Ended Working Group of the Parties to the Montreal Protocol no later than 31 March 1994;

2. To request the Open-Ended Working Group to consider the report of the Technology and Economic Assessment Panel with respect to HCFCs; to consider the possible need for specific provisions for the implementation of the regulation on the applications for HCFCs, taking into account the special circumstances of Parties operating under paragraph 1 of Article 5 of the Protocol; and to make any appropriate recommendations for consideration by the Parties at their Meeting in 1994 and following subsequent reviews taking place under Article 6 of the Protocol;

3. To ensure that, notwithstanding the new status of HCFCs as controlled substances, the incremental costs to Parties operating under paragraph 1 of Article 5 of the Protocol of making the transition from CFCs to HCFCs consistent with the regulation on the applications for HCFCs will continue to be met by the Fund and to request the Executive Committee to function in the light of this decision;

4. To request the Executive Committee to estimate, on an ongoing basis, the amount of HCFCs required by Parties operating under paragraph 1 of Article 5 of the Protocol and to recommend the methods of meeting such needs in full, simultaneously with the exercise to estimate the amounts of controlled substances needed, as well as to estimate the production available to meet those needs, as requested by the Open-Ended Working Group at its seventh meeting;"

12. At the Fifth Meeting the Parties further elaborated the conditions for the use of HCFCs and assigned the TEAP further tasks aimed at providing concrete information to be used to select suitable alternatives including HCFCs. Decision V/8 thus provides as follows:

"1. That each Party is requested, as far as possible and as appropriate, to give consideration in selecting alternatives and substitutes, bearing in mind, *inter alia*, Article 2F, paragraph 7, of the Copenhagen Amendment regarding hydrochlorofluorocarbons, to:

a. Environmental aspects;

b. Human health and safety aspects;

c. The technical feasibility, the commercial availability and performance;

d. Economic aspects, including cost comparisons among different technology options taking into account:

i. All interim steps leading to final ODS elimination;

ii. Social costs;

iii. Dislocation costs, etc.

e. Country-specific circumstances and due local expertise;

2. To note that the Executive Committee is taking the above considerations into account as far as information is available;

3. To request the Technology and Economic Assessment Panel and its Technical Options Committees in the context of finalizing its report, to provide information on which alternatives and substitutes best satisfied the above considerations, and to update this information on an annual basis;"

National Measures

13. Concern for the impact on global warming and relatively significant ozone depleting potential of the HCFCs, e.g. HCFC-22 (ODP 0.055, GWP 0.36), HCFC-141b (ODP 0.11, GWP 0.12) and HCFC-142b (ODP 0.065, GWP 0.42) have driven NGOs, governments and industry to search for more environmentally safe alternatives to the use of HCFCs with the view to bringing forward their phase-out. Thus the European Union regulations, for instance, seek to achieve complete phase out by 1 January 2015 with substantial reduction (65%) from 1 January 2004 and 80% reduction from 1 January 2010, while the use in certain applications such as in flexible foams and rigid non-insulating foams could be completely phased out in the immediate future. Some European countries are likely to phase-out even earlier, e.g. Denmark (current consumption 1207 tonnes) would completely phase-out by 2005 and Norway (current consumption 800 tonnes) and other Nordic countries are considering complete phase-out between 2000-2005. In Sweden, total ban of the use of HCFCs as foam blowing agents is expected by 1 January 1998, while the use as refrigerant could be banned by February 1994.

14. The phase-out regulations in the USA is more substance and use-specific. The proposed phase-out schedule is as follows:

January 1, 2003	HCFC-141b	
January 1, 2010	HCFC-142b	
	HCFC-22	(new equipment)
January 1, 2020	HCFC-22	(existing equipment)
	HCFC-123	(new equipment)
January 1, 2030	HCFC-123	(existing equipment)

15. It appears that the higher ODP and longer lasting HCFCs such as HCFC-141b would be phased out earlier. In terms of their uses, the foam blowing agents (HCFC-141b and HCFC-142b) would be phased out earlier than those used as refrigerants (HCFC-22 and HCFC-123). These phase-out schedules in developed countries could have an impact on their long-term availability and sale prices and hence their cost-effectiveness as substitutes.

Production and Use of HCFCs in Developed Countries

16. The major HCFC-producing countries are USA, Japan, countries of the European Union (notably UK, Germany, the Netherlands, Spain and Greece), Canada and the Republic of South Africa. HCFC-22 is the most widely produced HCFC. The current production in the developed countries is estimated to be 245,715 tonnes. The total production of HCFC in the European Union in 1992 was reported to be 106,200 tonnes with HCFC-22 accounting for 76,000 tonnes and HCFC-141b and 142b making up 5,000 tonnes and 15,000 tonnes respectively. In Japan, the total production for the same year was 44,155 tonnes, 38,500 tonnes of which was HCFC-22 while 4,700 tonnes and 350 tonnes were HCFC-142b and HCFC-141b respectively. HCFC-123 production in the European Union and Japan in 1992 was about 100 tonnes and 420 tonnes respectively.

17. In spite of the low volumes of output of the HCFCs other than HCFC-22, there are indications that their production, particularly of HCFC-141b and HCFC-142b are gaining in prominence. The installed capacity of HCFC-141b and 142b is estimated at 212,000 tonnes per annum (TPA). In the USA, for instance, one HCFC-141b producing facility increased its production capacity two-fold to 22,000 TPA between 1992 and 1993.

18. HCFC-22 is the most commonly-used HCFC both in the developed and developing countries. It is used mainly as refrigerant in a variety of refrigeration and air conditioning systems and to a lesser degree as foam blowing agent. In 1992, the total consumption of HCFC-22 in the European Union was 41,300 tonnes out of which 31,500 tonnes and about 6,500 tonnes were used as refrigerant and as foam blowing agent respectively. In Japan, the total consumption was 32,430 tonnes, 31,600 tonnes of which was used as refrigerant and only 830 tonnes as foam blowing agent. Total HCFC consumption in Denmark, in Netherlands and in Norway was 1,207 tonnes, 258 tonnes and 798 tonnes respectively.

19. In recent times, HCFC-141b and HCFC-142b used mainly as foam blowing agents and HCFC-123 used as refrigerant in centrifugal chillers, particularly in North America, are finding increasing application as substitutes for CFCs. In 1992, the total consumption of HCFC-141b and HCFC-142b in the European Union was 2,100 tonnes, which was only about 15% of the year's production. The remaining 85% (about 28,000 tonnes) was probably exported for use in other countries. The continued use of HCFCs in the countries surveyed appears to be dictated by a number of factors which include the price of HCFC relative to CFC-11 and CFC-12, safety in their application, their environmental impact and national and regional (in the case of the countries of the European Union) regulations.

Production of HCFCs in Article 5 countries

20. Production of HCFCs is currently not widespread in the Article 5 countries and is limited to the production of HCFC-22 only mainly in CFC-11 and CFC-12 swing plants. Current producing countries include Argentina, Brazil, China, India, Mexico and Venezuela. The production of HCFC-22 in Article 5 countries is reported to be 15,000 tonnes in 1990, while the installed capacity is estimated to be over 20,000 TPA. In Mexico, nearly 3,000 tonnes were produced in 1991, while in Venezuela the production was nearly 2,000 tonnes in 1992 with installed capacity of 5,000 TPA. It should be expected that in the countries where CFC-producing facilities which can be used for co-production or switched over to production of HCFC-22 are available, these facilities will be fully converted to produce HCFCs. In China it is planned to convert CFC-12 plants to HCFC-22 producing plants, while HCFC-123, HCFC-141b and HCFC-142b production will be developed in the long term. In India, plants for the manufacture of HCFC-123, HCFC-141b and HCFC-142b are planned to be established when demand for them increases.

Use of HCFCs in Article 5 countries

21. From the country programmes so far approved, it is evident that currently only HCFC-22 is used significantly in almost all Article 5 countries and that this use has been market-driven. HCFC-22 is used mainly as refrigerant in home air conditioning (window, split units) which in many Article 5 countries are imported or assembled or manufactured to specifications of the major manufacturers. Detailed information on the use of HCFC-22 is not available in the country programmes approved to date, however indirect references made to its use underline its growing importance as a refrigerant substitute of choice. Where data are available, it can be seen that consumption of HCFC-22 (in metric tons) is about 50% of the total consumption of ODS. In India, one company manufactured 95,000 HCFC-22 compressors in 1992, in Thailand all home air-conditioners run on HCFC-22, in Philippines 35,000 HCFC-22 compressors were produced in 1989. HCFC-22 is forecast to be used as refrigerant for water coolers, cold storage, walk-in coolers, refrigerated transportation and other commercial refrigeration units.

22. Although not used widely currently, HCFC-123, HCFC-141b and HCFC-142b are considered in the country programmes as medium term substitutes. In the refrigeration sector, HCFC-123 is envisaged as the refrigerant for CFC-11 centrifugal chillers, while HCFC-141b and HCFC-22/HCFC-142b blend are foreseen as foam blowing agents. Table 1 which indicates forecast demand in India and China of the common HCFCs illustrates the potential significance of HCFCs in the ODS phase-out strategies of Article 5 countries.

Table 1: Forecast demand for HCFCs in
Two Major ODS-consuming countries (India & China)
(Tonnes)[1]

Substance	Country	1996	2000	2005	2010
HCFC-22	China	—	5,500	22,000	35,400
	India	4,000	7,300	15,000	32,000
HCFC-123/ 141b/142b	China	2,300	600	1,300	2,500
	India	No	data	available	
HFCs HFC-134a, 152a	China	300	6,400	14,400	14,400
	India	0	880	7,600	15,500

Analysis of HCFC Use in Article 5 Countries

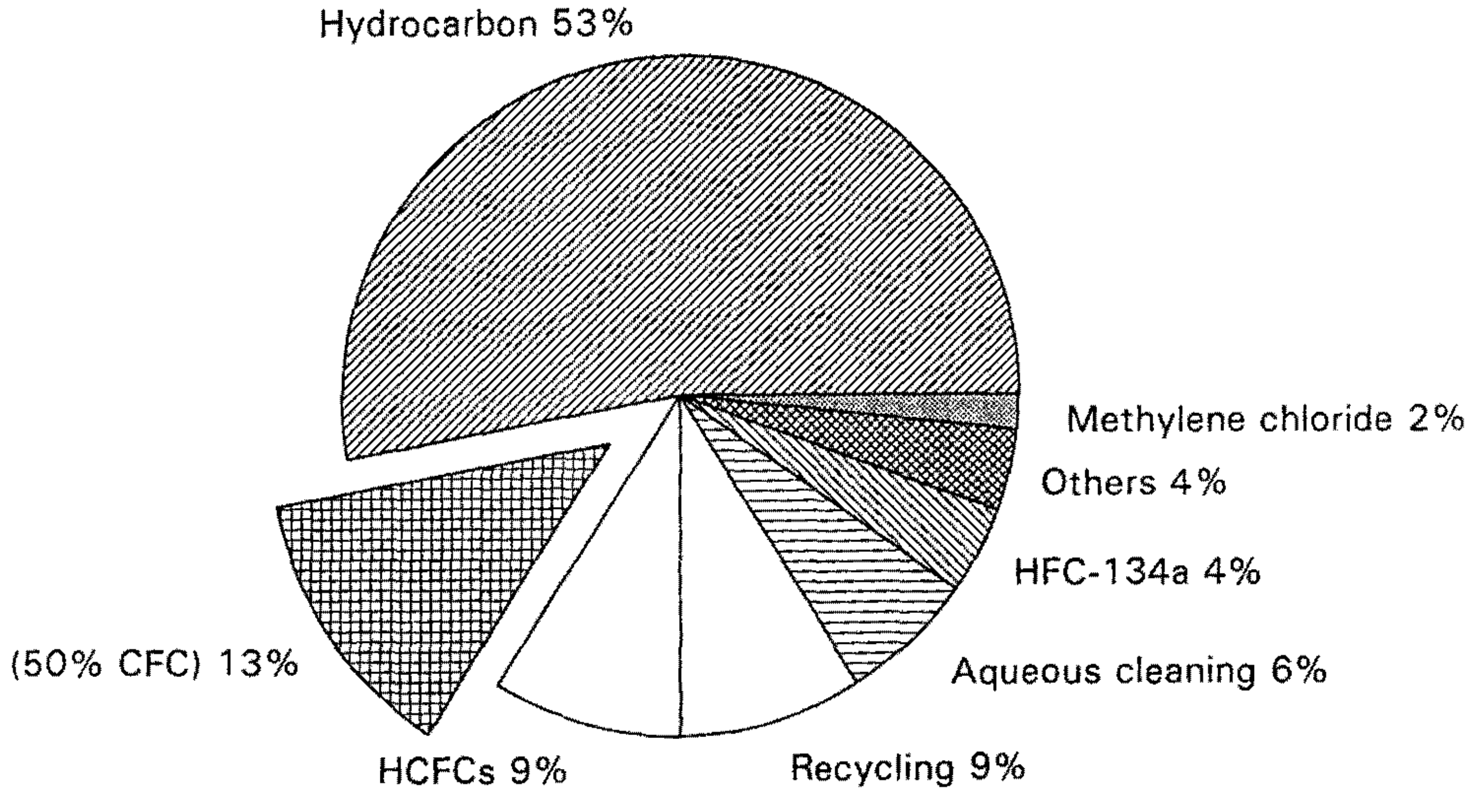
23. 218 projects worth US $99.3 million, for the phase-out of 30,800 tonnes per year of ODS in all sectors have been approved. Of this quantity of ODS to be phased out, 53% will be phased out using hydrocarbons as substitutes, while 9% will be phased out by using HCFCs and 13% by reduced CFC technology. Figure 1 shows the types of substitutes being applied in the Multilateral Fund approved projects.

24. The residual ODP of this quantity of HCFCs is 7 per cent. Thus 2,550 ODP tonnes per year would be eliminated leaving 220 ODP tonnes per year to be phased out using zero-ODP substitutes. HCFCs are used where they are considered the best possible alternative that would meet the required product standards and the phase-out schedules of the recipient countries. Thus about 50 per cent of the HCFC-substituted projects are for the use of about 1,700 tonnes per year of HCFC in producing insulation foam for domestic refrigerators, mainly in Thailand (4 projects) where 600 tonnes/year of HCFC-141b is to be used and the Philippines (4 projects) where initially 50% reduced CFC technology is to be used followed by the use of 86 tonnes per year of HCFC, possibly HCFC-141b.

25. 25 per cent of the projects are those that will utilize mainly HCFC-141b (over 100 tonnes per year) for producing rigid polyurethane insulation, packaging or spray foam. Two projects producing extruded polystyrene (and polyethylene) foam will utilize 120 tonnes HCFC-22 per year while another polystyrene foam project will utilize 196 tonnes per year of HCFC-142b/HCFC-22 blend. Table 2 shows a matrix of substitutes used in all the projects.

[1] Source: China Country Programme (UNEP/OzL.Pro/ExCom/9/13) p.40 and India Country Programme (UNEP/OzL.Pro/ExCom/11/20) p.27.

ODS substitutes



Total ODS to be replaced: 30,800 tonnes

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Table 2: Matrix of the Use of Substitutes or Substitute Technologies in Approved Multilateral Fund Projects											
User Sector	ODS Substitute or Substitute Technology										
	HCFC-22	HCFC-123	HCFC-141b	HCFC-22/ HCFC-141b	50% Reduced CFC	CO_2	CO_2/Water Water Blown	Butane	Isobutane	Isopentane	HFCs (HFC-134a)
Refrigeration: — Insulation Foam			○	◊	○		◊				
— Chillers (Refrigerant)		◊									◊
— Compressors (Refrigerant)	◊										□
Rigid PU Foam			□		◊						
Rigid PU Insulation Panel					◊						
Moulded PU Foam					◊		◊				
Integral Skin PU Foam	◊						◊				
Extruded PS/PE Foam	◊			◊		◊		□	◊	◊	

<u>LEGEND</u>

○	Use as substitute/substitute technology in more than 20% of the projects
□	Use as substitute/substitute technology in 5 to 20% of the projects
◊	Use as substitute/substitute technology in less than 5% of the projects
	Not used

PE : Polyethylene
PU : Polyurethane
PS : Polystyrene

Cost-effectiveness

26. The cost-effectiveness of these options depends on the one time cost and operational cost of the option. Another factor that affects the cost-effectiveness is the plant capacity and output, since the cost of equipment for two plants using the same substitute technology could be the same regardless of the differences in output. Table 3 shows the types of projects and their levels of cost-effectiveness.

27. In foam blowing, for instance, one time cost includes replacement or modification of production equipment, e.g. modifications for low boiling blowing agents such as HCFC-22 or cyclopentane, modifications for co-extrusion of liner sheet in the case of HCFC-141b, changes in jigs for HCFC-22 or HFC-134a due to thicker walls, production safety modifications as in the case of cyclopentane, training, materials for trials and laboratory equipment or facility. Operational cost involves mainly the cost of the blowing agents, which are affected by prevailing international prices, level of use and foam densities. The number of steps involved in the complete phase-out may increase costs and reduce its overall economic cost-effectiveness if the final stage involves additional operational and/or one time costs.

28. The hydrocarbons and CO_2 are readily available. HCFC-22, HCFC-141b, HCFC-142b and HFC-134a are also now commercially available and their availability could improve, at least in the medium term judging by the response during the survey on HCFCs. However, there is some price differential between the HCFCs and hydrocarbon substitutes. There also exists substantial price differential between HCFCs and HFCs, the price of HFC-134a being about 1.5 to 3 orders of magnitude higher than that of HCFC-141b. The fluctuations in the price differential would eventually influence the relative cost-effectiveness of the different options.

29. The cost-effectiveness of the use of HCFCs as substitute in projects could also be time-dependent. It is believed that a delay of one year in implementing a project, while, for example, waiting for development of a zero-ODP technology, is equivalent to 9 years or more use of HCFC, i.e. the ODP is increased nine-fold. Furthermore, the use of HCFC for blowing refrigerator insulation foam would mean that the HCFC is contained in the refrigerator for the life of the refrigerator which in a developing country could be as long as 20 to 30 years. By that time if the progress in implementing the Montreal Protocol continues, the emission of a small amount of ODS may have less consequences on ozone depletion than the same amount released today.

Table 3: THE COST-EFFECTIVENESS OF TRANSITIONAL SUBSTANCES

1. Project	2. CFC Phased-out (Tonnes)		3. HCFCs Used (Tonnes)		4. Incremental Costs (US $1,000)	5. Cost Effectiveness[2] (US $/Kg)
I. Foam						
(1) Polyurethane Foam						
• Refrigerator Insulation (Appliance, Philippines	CFC-11	120	HCFC	60	2,900	24.2
• Refrigerator Insulation (Conception), Philippines	CFC-11	35	HCFC	18	790	22.6
• Refrigerator Insulation (Sanyo), Philippines	CFC-11	9	HCFC	5	943	104.7
• Refrigerator Insulation (Federal), Philippines	CFC-11	5	HCFC	3	770	154
• Low and Non-CFC (Refrigeration), Tunisia	CFC-11	175	HCFC-142b/22	88	300	1.7
• Rigid PU Insulation (Insofoam), Malaysia	CFC-11	30	HCFC-141b	15	310	10.3
• Rigid PU Insulation (Technic), Thailand	CFC-11	50	HCFC-141b	43	174	3.5
• Rigid PU Foam (Specialized), Egypt	CFC-11	15	HCFC-141b	8	85	5.7
• Moulded Rigid PU Foam (Olympic), Egypt	CFC-11	75	HCFC-141b	38	940	12.5
• Rigid PU Spray Foam (BCMF), China	CFC-11	30	HCFC	15	435	14.5
• Moulded Flex and Rigid Foam (Taki Vita), Egypt	CFC-11	50	HCFC	25	588	11.8
• Moulded Integral Skin, Rigid Spray and Rim Foam (Dosa), Indonesia	CFC-12	125	HCFC-22	22	1,733	13.9
• Integral Skin Foam (Key), Malaysia	CFC-11	50	HCFC-22	15	690	13.8
Domestic Refrigerator						
• (Toshiba), Thailand	CFC-11 CFC-12	42 12	HCFC-141b HFC-134a	42 12	1,510	30.0
• (Kang Yang), Thailand	CFC-11 CFC-12	101 19	HCFC-141b HFC-134a	101 19	1,900	15.8
• (Sanyo), Thailand	CFC-11 CFC-12	350 136	HCFC-141b HFC-134a	350 136	2,868	5.9
• (Hitachi), Thailand	CFC-11 CFC-12	108 36	HCFC-141b HFC-134a	108 36	1,084	7.5
• (Arcelic), Turkey	CFC-11 CFC-12	550 200	HCFC HFC-134a	300 200	4,900	6.5
• Iran	CFC-11 CFC-12	589 108	HCFC-141b HFC-134a	589 169	3,228	4.6
• Cold Storage, Kenya	CFC-11 CFC-12	12 6	HCFC-141b HFC-134a	12 6	381	21.1
(2) Polyolefin Foam						
• Extruded PS Foam (Advechem), Egypt	CFC-12/22	196	HCFC-142b/22	196	904	4.6
• Extruded PS Foam (Tulus), Indonesia	CFC-12	100	HCFC-22	100	416	4.2
• Extruded PS/PE Foam (Muliatuma), Indonesia	CFC-12	120	HCFC-22 CO_2	20	774	6.5
II. Refrigeration						
• Centrifugal Chillers, India	CFC-11	36	HCFC-123	36	567	15.8
• Refrigeration (Koldair), Egypt	CFC-12	18	HCFC-22 HFC-134a	12 6	272	15.1

[2] Cost effectiveness is assessed as the ratio of the incremental cost and the quantity in Kg of the ODS to be phased out. CFC to be phased out takes account of the residual ODP of the HCFC used. Where the HCFC is not specified, the assessment is based on HCFC-141b.

30. Beside the cost effectiveness calculated in economic terms there are other comparative advantages/disadvantages that could also influence the selection of one or other option. Two key disadvantages relating to the use of HCFCs and hydrocarbons are the residual ODP of HCFCs that need to be phased out and the inflammability of the hydrocarbons respectively. In the approved projects using HCFC-141b, HCFC-22 or HCFC-142b/HCFC-22 as well as those using 50 per cent reduced CFC technology, high pressure equipment suitable for use of HFC and other zero ODP substitutes are to be procured. This could thus obviate possible increases in the one-time (capital) cost of the final phase of the projects. However, if the prices of HFCs do not fall during the transition period to below the current prices of HCFCs, then additional operational costs could be incurred and the option could be less cost effective. On the other hand, though environmentally sound, the fire risk relating to the use of hydrocarbons and restrictions imposed by such risk become a drawback on its acceptability. Given the problems associated with zoning and physical planning in some developing countries, resulting in absence of properly segregated industrial activities, this factor could be quite significant in some Article 5 countries. In two polystyrene foam projects, for instance, HCFC-22 had to be chosen over butane as substitute by the enterprises due to the location and layout of the enterprises, although one enterprise agreed to undertake the final phase-out at its own expense. Relocation in such instances would have made the project much more expensive and less cost-effective.

Conclusion

31. Within the milieu of technologies currently available for the phase-out of ODS in Article 5 countries, there are areas:

a. Where the use of HCFCs in the short term may be economically cost-effective with minimal environmental penalties (2-11% residual ODP). These include:

- Refrigerator insulation foam blowing
- Rigid Insulation foam
- Manufacture/conversion of centrifugal chillers
- Manufacture of compressors for air conditioners
- Manufacture/conversion of some commercial refrigerators

b. Where the use of hydrocarbons provide economically cost-effective and generally environmentally sound solutions. These include:

- Manufacture of extruded polystyrene and polyethylene foams and sheets.

c. Where the use of hydrocarbons hold considerable promise for increasing cost-effectiveness and environmental soundness of projects, but where there is need for further optimization or close co-operation between the technology supplier and the recipient enterprise. These include:

- The establishment/conversion of compressor plants
- The establishment/conversion of domestic refrigerator/freezer manufacturing plant
- Servicing of refrigerator/freezers.

d. Where the use of other substitutes or substitute technologies provide economically cost-effective and environmentally sound solutions. These include:

- The use of methylene chloride in flexible foam blowing
- Carbon Dioxide and water blown foaming process.

32. The reduced CFC foam blowing process appeared to provide a cost-effective and viable short term foam production technology and has been chosen as a cost-effective transition to zero ODP foam blowing technologies. In a number of projects (in China, Iran, Kenya, Indonesia, Philippines) in which this technology is to be used together with transitional technology, provision is made for further review of the phase-out options. These projects could be strategically implemented in such a way as to make use of the possibility for transition to zero ODP technologies without the necessity for the use of HCFCs, if analysis shows that such an approach would be more cost-effective in terms of the economics and environmental soundness of the project.

33. For refrigerant applications in the heating, ventilation and air conditioning (HVAC) sector, the choice between transitional substances and zero ODP substances as substitutes depends on the maturity of conversion process (for existing facilities), efficiency, reliability and perceived risk. In the domestic refrigeration sector, the focus is on zero ODP substances rather than transitional substances. While HFC-134a has found application in some approved projects as refrigerant in domestic refrigerator compressor projects and in chillers, there is likely to be some delay in similar applications of hydrocarbon refrigerants. In spite of their considerably lower cost (by a factor of 3-6) relative to HFC-134a, there are still considerable uncertainties arising from their inflammable nature and the fact that the technology is in a learning curve. There are no reliable estimates of the market penetration (10-20% of German market expected in 1994), lifetime tests for some manufacturers are still on-going, conversion costs vary widely (20-100% of the cost of conversion to HFC-134a), while there may not be enough conversion experience.

34. For other refrigerant applications, namely chillers, commercial and industrial refrigeration, the only zero ODP refrigerant (except where ammonia can be used) is currently HFC-134a. Transitional substances such as HCFC-123 or their blends with HFCs e.g., HFC-134a, HFC-152a and or hydrocarbons (propane) are being used in developed countries and are found to be cost-effective, particularly in North America. These technologies are being transferred to developing countries.

35. On the basis of responses to the survey on the production and use of HCFCs and considering the production phase-out schedules of the major producers, it may be concluded that there would be adequate supply of HCFCs in the short to medium term. The supply of HCFCs would mainly be from the developed countries, except HCFC-22 for which developing country producers could be sources of supply. Assuming that China's and India's demand for HCFCs would be about 30-40% of the total demand of Article 5 countries, the demand for HCFC-22 could be 30,000-40,000 tonnes while that of the other HCFCs (notably HCFC-123, HCFC-141b and HCFC-142b) could be 6,000-10,000 tonnes in the year 2000. Considering, for instance, the production forecasts in the European Union (80,000 tonnes of HCFC-141b and HCFC-142b) and the ratio of current internal consumption within the Community to production, it could be said that this projected level of demand or even higher demand of HCFCs could adequately be met

from production in the developed countries. This would make the use of HCFCs in the short to medium term viable and possibly with improved cost effectiveness as more experience is gained in the application of the technologies leading to possible reduction in incremental costs.

36. Traditional and historical trade and technological links between technology supplying countries and Article 5 countries, licensing agreements between enterprises in the developing countries and those of developed countries would also influence the choice of options by a particular Article 5 country, since national industrial strategies are taken into account in the consideration of phase-out projects. Projects approved for subsidiaries of trans-national companies, for instance, might usually apply substitute technologies used by the parent company in order to benefit from experience acquired by the parent company regardless of whether or not other options are considered to be more cost-effective.

Recommendations

1. In view of the ongoing review requested of the Technology and Economic Assessment Panel by the Parties to the Montreal Protocol, this paper may not be considered as a policy guideline but as a possible input to the work of the Open-ended Working Group of the Parties to the Montreal Protocol.

2. Meanwhile, consideration of the use of HCFCs in the Multilateral Fund projects should be sector-specific and approved for use only in areas where more environment-friendly and viable alternative technologies are not available.